

# CORONAVIRUS PERCEPTIONS AND ECONOMIC ANXIETY

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**Abstract**—We provide one of the first systematic assessments of the development and determinants of economic anxiety at the onset of the coronavirus pandemic. Using a global data set on internet searches and two representative surveys from the United States, we document a substantial increase in economic anxiety during and after the arrival of the coronavirus. We also document a large dispersion in beliefs about the pandemic risk factors of the coronavirus and demonstrate that these beliefs causally affect individuals' economic anxieties. Finally, we show that individuals' mental models of infectious disease spread understate nonlinear growth and shape the extent of economic anxiety.

## I. Introduction

THE worldwide spread of the novel coronavirus (SARS-CoV-2) (Li et al., 2020; Wu, Leung, & Leung, 2020; Zhu et al., 2020) has led to a substantial disruption of global economic activity. This paper provides one of the first systematic assessments of the rapid emergence and causal determinants of economic anxiety at the onset of the coronavirus pandemic, when there was large uncertainty about the extent of its economic impact. We focus on how perceptions of pandemic risk factors shape economic anxieties. Understanding the development and causes of economic anxiety in the wake of the coronavirus pandemic is essential from both a scientific and practical perspective, particularly given recent empirical evidence demonstrating that perceptions and expectations about the macroeconomic environment substantially shape households' economic decisions (Bailey et al., 2019, 2018; Coibion, Georgarakos et al., 2019; D'Acunto, Hoang, Paloviita, & Weber, 2019; Kuchler & Zafar, 2019).

Predicting the development of economic anxiety and assessing its underlying mechanisms in the context of a pandemic is difficult when relying on historical accounts. Unlike regular economic downturns, which begin with a moderate but accelerating decline in economic activity, the arrival and rapid global spread of the coronavirus pose a rare, sudden shock (Maćkowiak & Wiederholt, 2018). Several as-

pects of human belief and expectation formation render the environment of the coronavirus pandemic distinct from that experienced during a conventional economic downturn. In particular, individuals have difficulty forming beliefs about the future in the wake of infrequent major events (Gallagher, 2014; Rabin, 2002). Moreover, when updating their beliefs, individuals place a disproportionate weight on the most recent events (Malmendier & Nagel, 2011), especially when these events are particularly salient (Bordalo, Gennaioli, & Shleifer, 2013; Tversky & Kahneman, 1973). As a consequence, belief formation may differ substantially in the unprecedented environment of the coronavirus pandemic as compared to more conventional economic shocks. Thus, relative to relying on historical accounts, employing contemporaneous data provides a more promising approach to assess the evolution of contemporaneous economic anxiety.

In this paper, we collect contemporaneous data to systematically investigate the development and determinants of economic anxiety at the onset of the coronavirus pandemic. We study the underlying psychological mechanisms that shape economic anxiety in the environment of a pandemic by assessing the role of beliefs and information about pandemic risk factors, as well as individuals' subjective mental models of infectious disease spread.

To set the stage for our analysis, we document a rapid increase in economic anxiety during and after the coronavirus has reached a country. Employing global data during the period of massive global spreading in January and February 2020, we show that Google search intensity for topics indicative of economic anxiety surged substantially after the virus has reached a country. To measure economic anxieties directly and in real time after the arrival of the coronavirus, we conducted two survey experiments with representative samples of the U.S. population on March 5, 2020, and March 16, 2020. In this eleven-day period, the United States saw massive within-country spreading, with a 26-fold increase in the number of confirmed cases from 176 to 4,576. Moreover, public communication of the severity of the crisis had shifted dramatically once the WHO declared it a pandemic on March 11. The data indicate a substantial increase in economic anxiety after the arrival of the coronavirus in the United States.

The rapid surge in economic anxiety sets the stage to study the underlying informational and psychological mechanisms that shape economic anxiety in the wake of a pandemic. First, we study individuals' beliefs about the mortality and contagiousness of the coronavirus, two key characteristics relevant for assessing pandemic risks and predicting the severity of the coronavirus crisis. We elicited these beliefs in our March 5 survey before any lockdown measures had been put in place and the crisis had not yet been declared a pandemic. We document substantial dispersion in beliefs about both mortality and contagiousness. Moreover, the median participant

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overestimates both the mortality and contagiousness of the virus relative to the upper bound of estimates available at the time of the experiment in the medical literature. We show that beliefs about mortality and contagiousness are associated with participants' economic worries about the aggregate economy and their personal economic situation.

To further understand the precise causal relationships between coronavirus perceptions and economic anxiety, we embedded two experiments in our March 5 survey that varied the framing of coronavirus mortality as well as a treatment that studied the role of information about contagiousness. These real-time experiments allow us to shed light on the influence of information and its framing in an environment marked by large uncertainty about the future extent of the crisis.

The first component of our experiment focuses on the framing of mortality risk. Participants were either truthfully informed, based on official estimates at the time of the survey, that the death rate from the coronavirus is "20 times higher than for the flu" (high mortality treatment) or "5 times lower than for SARS" (low mortality treatment). The wording was chosen to mirror the way such information is commonly communicated in the media.<sup>1</sup> We find that participants in the high-mortality treatment report significantly higher concerns, in both a statistical and economic sense, about the aggregate economy and their personal economic situation. These results highlight the influence of the framing of news on public perceptions and economic expectations in times of high uncertainty (Chong & Druckman, 2007; Prat & Strömberg, 2013).

To investigate the effect of information regarding contagiousness, participants in a treatment group were, based on scientific estimates at the time of the experiment (Li et al., 2020; Wu et al., 2020), informed that "approximately 2 non-infected people will catch the coronavirus from a person who has the coronavirus." Given that 81% of respondents overestimate this statistic, the information treatment should decrease the perceptions of the contagiousness of the virus. We find that treated respondents report significantly lower worries about their personal economic situation. These causal results underscore the role that information plays in shaping economic anxiety in an environment characterized by large uncertainty and highlight the importance of both factual and targeted communication during health crises (Person et al., 2004; Razum et al., 2003).

Second, besides taking information into account, forward-looking individuals also rely on their subjective mental models of the world to make predictions about the future (Andre et al., 2019). To understand the role of these mental models in shaping crisis beliefs and economic anxiety, we elicited participants' predictions of the growth of a fictitious disease in our March 16 survey. Consistent with exponential

growth bias (Levy & Tasoff, 2016; Stango & Zinman, 2009; Wagenaar & Sagaria, 1975), we document that the majority of individuals underestimate the nonlinear nature of infectious disease spread. Furthermore, we show that mental models of infectious disease spread are substantially associated with participants' beliefs about the severity of the current coronavirus crisis: respondents who show a better understanding of nonlinear disease spread anticipate a higher severity of the crisis and display higher worries about the aggregate U.S. economy.

We contribute to the literature by documenting the development and underlying determinants of economic anxiety in the wake of a global pandemic. In particular, we provide novel causal evidence on the impact of information about pandemic risk factors on the formation of economic anxiety. Furthermore, we demonstrate the role subjective mental models of infectious disease spread play in shaping heterogeneity in economic anxiety. Our paper is most closely related to concurrent work by Binder (2020), who conducted a survey using a sample from Amazon Mechanical Turk in early March. Binder (2020) documents cross-sectionally that greater concerns about the coronavirus are associated with higher inflation expectations and more pessimistic unemployment expectations. She also studies how information provision about the Fed's interest rate cut in response to the coronavirus affects inflation and unemployment expectations. Our paper complements Binder (2020) by documenting how the spread of coronavirus affects economic anxieties over time and by providing both descriptive and causal evidence on how perceptions of the pandemic risk factors affect economic anxiety. We also relate to subsequent work studying the impact of the coronavirus on the economy (Adams-Prassl et al., 2020; Bartik et al., 2020; Coibion, Gorodnichenko, & Weber, 2020; Hanspal, Weber, & Wohlfart, 2020).

More generally, our work is related to a growing literature investigating the formation of economic sentiment and expectations about the macroeconomy among households and firms (Binder & Makridis, 2018; Coibion & Gorodnichenko, 2012, 2015a, 2015b; Coibion, Georgarakos et al., 2019; Coibion, Gorodnichenko, & Kumar, 2018; Fuster, Hebert, & Laibson, 2012; Fuster, Laibson, & Mendel, 2010; Malmendier & Nagel, 2011). Relative to prior work, our evidence is unique in assessing economic sentiment and its drivers before and during a historic public health crisis in real time. We particularly relate to the literature studying the role of information in shaping economic sentiment and behavior (Armona, Fuster, & Zafar, 2018; Bailey et al., 2019, 2018; Binder & Rodrigue, 2018; Coibion, Gorodnichenko, & Ropele, 2020; D'Acunto, Hoang, Paloviita, & Weber, 2019; Roth & Wohlfart, 2020). We also relate to the literature studying the role of cognitive processes in forming economic sentiment and macroeconomic expectations (Andre et al., 2019; D'Acunto, Hoang, & Weber, 2019). We add to this literature by highlighting the importance of subjective mental models about infectious disease spread for shaping economic anxiety in the wake of a rare, unexpected, and unfamiliar public health shock.

<sup>1</sup>For instance, the *New York Times* and the *Telegraph* compared the coronavirus to the flu and SARS (<https://www.nytimes.com/2020/02/29/health/coronavirus-flu.html>; <https://www.telegraph.co.uk/news/2020/03/06/coronavirus-vs-sars-flu-mers-death-toll/>).

Finally, we also contribute to the broad literature on the perception of health risks (Carbone, Kverndokk, & Røgeberg, 2005; Fortson, 2011; Heimer, Myrseth, & Schoenle, 2019; Kerwin, 2018; Oster, Shoulson, & Dorsey, 2013). While existing evidence has primarily focused on individuals' beliefs about risks to their own health (Kan & Tsai, 2004; Liu & Hsieh, 1995; Winter & Wuppermann, 2014), we contribute to this literature by providing new evidence on the perception of factors relevant to pandemic in addition to individual risks.

## II. Emergence of Economic Anxiety

We begin by documenting the emergence of economic anxieties at the onset of the coronavirus pandemic. First, we focus on the period of the initial global spread of the coronavirus during January and February 2020. Leveraging global data on Google searches indicative of economic anxieties, we study the evolution of economic anxiety during the arrival of the coronavirus in a country. Next, we use survey data to study the development of economic anxiety within the U.S. after the arrival of the coronavirus.

### A. Observational Evidence from Internet Searches during Global Spread

*Data and empirical specification.* We leverage data on internet search intensity from Google Trends. These data have been used in the past to detect influenza epidemics (Ginsberg et al., 2009) and to nowcast economic activity (Choi & Varian, 2012).<sup>2</sup> The Google Trends platform provides an interface to query search data, providing for each query a measure of search intensity scaled from 0 to 100, with 100 representing the highest proportion among the queried terms within a selected region and time frame. Google Trends queries can be constructed based on individual search terms or search topics that encompass groups of related individual search terms. We employ queries by search topics, an approach that has the advantage of capturing a broader set of search terms and not requiring any translations across languages.

To study the development of economic anxiety, we extracted Google search activity for the topics "Recession" and "Stock Market Crash" for 194 countries and territories listed in online appendix table A1. We also leverage data on the search topics "Survivalism" and "Conspiracy Theory," which capture panic reactions among the public. We collected these data for January and February 2020 to study the develop-

ments during the initial global spread of the coronavirus when there was still significant uncertainty over whether a pandemic would emerge.<sup>3</sup> To make effect sizes interpretable, we normalize the search intensity at the country level by the mean search intensity prior to the arrival of the coronavirus in each country.<sup>4</sup>

To study the impact on search activity, we exploit the precise timing of coronavirus arrival in a country. The underlying coronavirus case data are from Dong, Du, and Gardner (2020). Econometrically, we perform the following difference-in-differences regression using daily data:

$$y_{c,t} = \alpha_c + day_t + \beta \times C_{c,t} + \epsilon_{c,t}, \quad (1)$$

where  $y_{c,t}$  measures the search intensity in country  $c$  on day  $t$  for a specific topic.  $C_{c,t}$  is a dummy variable indicating either having had at least one confirmed case or having had at least one human-to-human transmission of the coronavirus in country  $c$  at time  $t$ . The regressions control for country fixed effects  $\alpha_c$ , absorbing fixed and time-invariant differences in levels of search intensities across countries. The time fixed effects  $day_t$  absorb a level shifter for each day, capturing the global trend. We cluster standard errors at the country level. Intuitively, this analysis captures the impact of the local arrival of the coronavirus conditional on the global trend.

*Results.* The data indicate that the arrival of the coronavirus in a country substantially increased search intensity for topics related to economic recessions by 17.8% (SE = 7.3) relative to the pre-coronavirus search patterns (figure 1A and online appendix table A3). Similarly, search intensity for topics related to stock market crash rose by 58% (SE = 12.4). In addition, an increase of 20.4% (SE = 7.3) and 44.7% (SE = 9.1) can be observed for topics related to survivalism and conspiracy theories, respectively. Additionally, the response of search intensity to the first human-to-human transmission of the coronavirus in a country corroborates these results (figure 1B and online appendix table A3). In a placebo test, we find no impact of the arrival of the coronavirus on a series of unrelated Google searches such as "Dog," "Horse," "Insect," "Rain," or "Rainbow" (online appendix table A5).<sup>5</sup> In sum, this evidence indicates that the arrival of the novel coronavirus leads to a spike in economic anxieties.

<sup>3</sup>Online appendix figure A1 shows the time series for the four topics of interest at the global level.

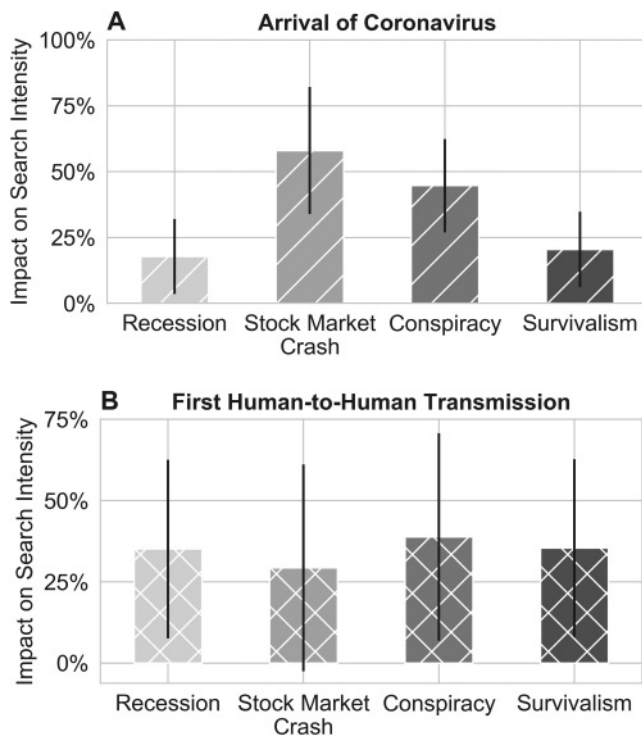
<sup>4</sup>Specifically, for the normalization, we use the mean search intensity between December 1, 2019, and the date of arrival of the coronavirus in a given country. This normalization makes the coefficient estimates interpretable as percentage changes relative to precoronavirus levels without having to resort to the mean of the dependent variable for interpretation. Results are not affected by this normalization; see online appendix table A4.

<sup>5</sup>Results are further robust to dropping each country in turn or to dropping all countries pertaining to any of the seventeen subregions globally in turn (see online appendix figures A2 and A3).

<sup>2</sup>Moreover, as shown by prior studies, such internet searches serve as a measure of economic sentiment among households and thus as a predictor of future economic demand and activity (Choi & Varian, 2012; Vosen & Schmidt, 2011). To qualify this claim, in online appendix table A2 we use quarterly data from 2015 to 2019 and show that real GDP growth and real growth in consumption and imports are significantly lower, in both a statistical and economic sense, in the quarters following increases in "Recession" topic searches.



FIGURE 1.—IMPACT OF CORONAVIRUS ARRIVAL ON INTERNET SEARCHES:  
GLOBAL EVIDENCE



The figure shows the impact of the arrival of the coronavirus (A) and first human-to-human transmission (B) in a country on Google search intensity for the topics “Recession,” “Stock Market Crash,” “Conspiracy Theory,” and “Survivalism” obtained from difference-in-differences regressions conditional on country and day fixed effects. The dependent variable measures Google search intensity by topic indicated in the column heading, normalized by the average search intensity in a country prior to the coronavirus arrival. The Google searches are collected for the time span between January 1 and February 29, 2020. In all panels, error bands indicate 95% confidence intervals obtained from standard errors clustered at the country level.

### B. Microevidence after Arrival of Coronavirus in the United States

Does economic anxiety increase further as the novel coronavirus spreads within a country after the first domestic case occurs? We provide real-time evidence on this question using two surveys that measure economic anxiety in the United States. The surveys were administered to broadly representative samples of the U.S. population on March 5 ( $n = 915$ ) and March 16, 2020 ( $n = 1,006$ ).<sup>6</sup> Within this eleven-day time span, the number of confirmed cases within the United States jumped by a factor of approximately 26, from 176 to 4,576. Hence, this time frame captures a period of substantial within-country spread.<sup>7</sup> In both surveys, we investigate participants’ beliefs about the severity of the crisis for the world and the United States as well as their worries about the aggregate economy and their personal economic situation. For

<sup>6</sup>Our sample is representative of the U.S. population in terms of income, region, gender, age, and education (see online appendix tables A6 and A7). We collaborated with an online panel provider (Lucid) that is widely used in the social sciences.

<sup>7</sup>In online appendix A we present cross-sectional results from the United States in mid-February, during a time in which the country reported only thirteen cases across the whole country. Respondents from states with any coronavirus cases exhibit significantly more pessimistic expectations (online appendix table A8).

the precise wording of the questions and response scales, see figure 2.

**Results.** The evolution of our survey measures over time between March 5 and 16 is visualized in figure 2. We document a substantial increase in participants’ beliefs about the severity of the crisis for the world (figure 2A) and the United States (figure 2B), as well as in their worries about the aggregate U.S. economy (figure 2C) and their personal economic situation (figure 2D). Quantitatively, these increases are sizable. For instance, the fraction of respondents who were worried about the impact on their personal economic situation increased from 47% to 74% ( $p < 0.001$ ) (see also online appendix table A9).<sup>8</sup>

In addition, in online appendix figure A4 we investigate heterogeneity across several subgroups, dividing the sample by gender (panel A), age (panel B), and political affiliation (panel C). We do not find any differences between women and men (online appendix figure A4, panel A). Similarly, old and young individuals do not differ strongly except that young people show substantially higher worries regarding their personal economic situation, potentially due to their higher unemployment risk (online appendix figure A4, panel B). Finally, we observe stark partisan differences (online appendix figure A4, panel C). Individuals who identify as Democrat hold substantially higher beliefs about the severity of the crisis and show higher economic concerns. However, independent of the specific demographics, we observe that beliefs about the severity of the crisis as well as economic worries increased for all subgroups between March 5 and March 16.

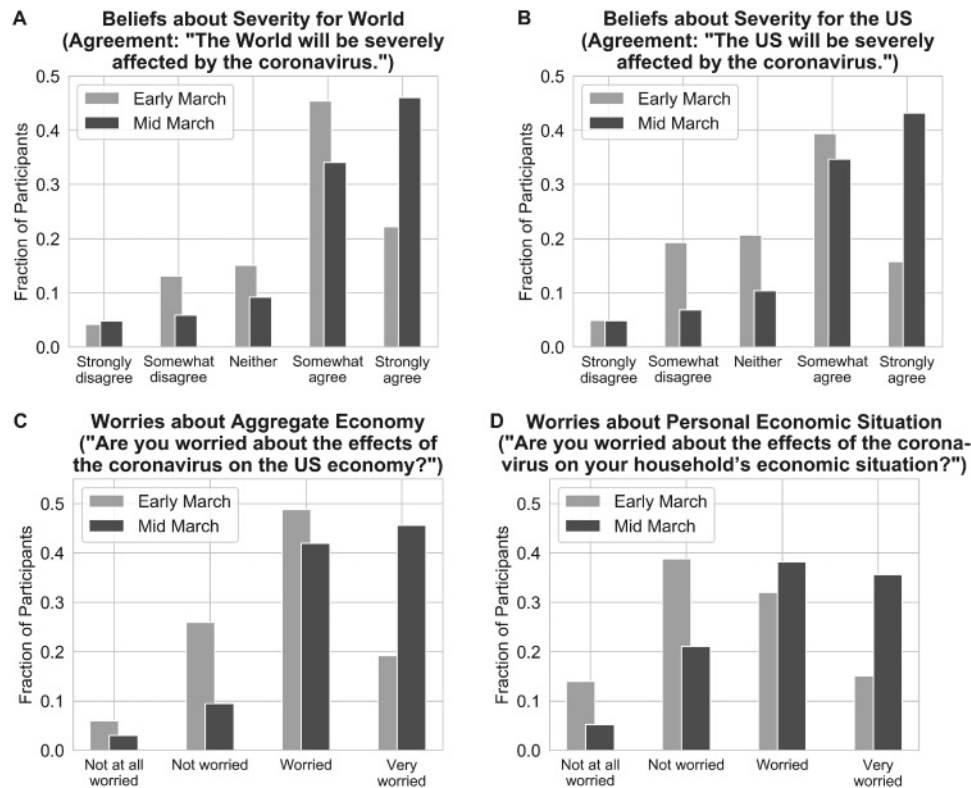
In sum, the data indicate that over eleven days, individuals’ perceptions of the severity of the crisis strongly intensified and their economic worries substantially increased. This finding is in line with results obtained using other data sources. Within the same time frame, aggregate Google search intensity for the “Recession” topic increased by a factor of 10 in the United States and by a factor of 5.5 on the global level (online appendix figures A5, panels A and B).<sup>9</sup> We also confirm our findings using other nationally representative opinion polls conducted March 5 to 8 and March 16 to 19, 2020 (online appendix figure A6).

To further quantify the effects of the within-country spread of the coronavirus, we analyze the local arrival in a difference-in-differences analysis at the state level (described in section A of the online appendix), exploiting the fact that some states saw their first confirmed case in the time between our two surveys. The time fixed effects we include allow us to control for

<sup>8</sup>In our March 5 survey, we elicit economic anxieties after the relative mortality framing described in section IIIB. The descriptive patterns of an increase in economic anxiety from March 5 to March 16, however, hold in both cases: when we focus on respondents exposed to the high relative mortality framing or respondents exposed to the low relative mortality framing.

<sup>9</sup>The evolution of the search patterns for the topics “Stock Market Crash,” “Conspiracy Theory,” and “Survivalism” was qualitatively similar (online appendix figures A5, panels C–H).

FIGURE 2.—EVOLUTION OF BELIEFS ABOUT SEVERITY OF CRISIS AND ECONOMIC WORRIES BETWEEN EARLY AND MID-MARCH: EVIDENCE FROM THE UNITED STATES



The figure compares the levels of economic anxiety in the United States in surveys conducted on March 5 and March 16. (A) Beliefs about the severity of the coronavirus crisis for the world. (B) Beliefs about the severity of the coronavirus crisis for the United States. (C) Worries about the U.S. economy. (D) Worries about one's personal economic situation. Lighter columns indicate data collected on March 5, 2020, and darker columns indicate data collected on March 16, 2020.

aggregate developments, such as stock market movements. Online appendix table A10 shows that having at least one case is associated with significantly more pessimistic beliefs about the severity of the impact on the world (0.23 standard deviations,  $SE = 0.10$ ) and on the United States (0.26 standard deviations,  $SE = 0.09$ ). It is also associated with higher worries about the U.S. economy by 0.22 standard deviations ( $SE = 0.11$ ).

### III. Perceptions of Pandemic Risk Factors

The rapid increase in economic anxieties during and after arrival of the coronavirus sets the stage to test for the underlying determinants. In this section, we examine the role of perceptions of pandemic risk factors along two dimensions. First, we conducted two experiments that allow us to causally assess the impact of individuals' perceptions of coronavirus mortality and contagiousness on economic anxiety. Importantly, through experimental variation, we are able to isolate the direct effect of perceptions from other environmental variables that affect all participants symmetrically, such as stock market conditions. Second, we study respondents' mental models of infectious disease spread and the role of these mental models in shaping economic anxiety.

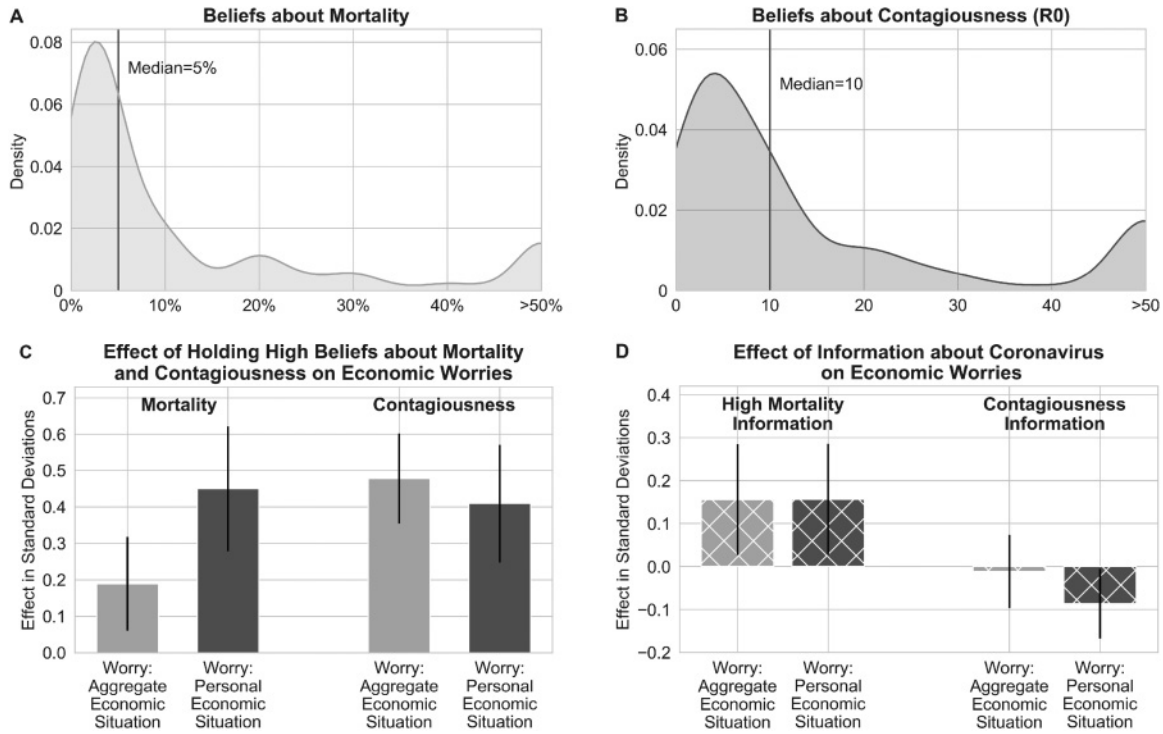
#### A. Descriptives: Perceptions of Coronavirus Mortality and Contagiousness

What beliefs did people hold about pandemic risk factors at the onset of the coronavirus crisis? At the time of our first survey on March 5, there was still substantial uncertainty and public disagreement about how severely the U.S. economy would be affected by the coronavirus. In our survey, we measured participants' beliefs about two key characteristics that are relevant for the pandemic threat of the coronavirus: mortality and contagiousness ( $R_0$ ): the expected number of infections directly caused by one infected person.

We elicited participants' beliefs about the mortality of the coronavirus using the following question: "Out of 100 people who are infected with the coronavirus, how many do you think will die as a result of catching the virus?" Beliefs about the contagiousness ( $R_0$ ) of the virus were elicited using the following question: "Think of a person who has the coronavirus. How many non-infected people do you think will catch the virus from this person?"

Our data indicate substantial heterogeneity in participants' beliefs about these characteristics of the coronavirus (see panels A and B of figure 3). On average, participants' beliefs about both the mortality from the coronavirus as well as its contagiousness were substantially higher than official and

FIGURE 3.—BELIEFS ABOUT CORONAVIRUS AND THE EFFECT OF INFORMATION ON ECONOMIC WORRIES



The figure displays perceptions of the novel coronavirus and the experimental results. The data were collected on March 5. (A, B) The distribution of beliefs about mortality and contagiousness ( $R_0$ ) of the coronavirus. (C) The effect of overestimating mortality and contagiousness relative to official numbers on worries about the aggregate U.S. economy and respondents' personal economic situation. (D) The effect of information about the coronavirus on economic worries. The two left-most bars in panel D show the effect of information suggesting high relative mortality as opposed to low relative mortality on worries about the aggregate economy and one's personal economic situation. The two right-most bars in panel D show the effect of information about contagiousness on worries about the aggregate U.S. economy and one's own personal economic situation. In all panels, error bars indicate 95% confidence intervals.

scientific estimates. The median participant estimated a mortality of 5% (mean of 14%) compared to an estimate of 3.4% provided by the World Health Organization (WHO) around the time of the surveys. Similarly, the median participant estimated a contagiousness ( $R_0$ ) of 10 (mean of 43) relative to scientific estimates at the time of the survey in the range of  $R_0 \approx 2$  (Li et al., 2020; Wu et al., 2020).

These coronavirus beliefs are substantially positively associated with economic anxiety (figure 3C and online appendix table A11, panel A). For instance, holding mortality and contagiousness beliefs that are higher than the official WHO and scientific estimates (Li et al., 2020; Wu et al., 2020) is associated with higher worries about one's personal economic situation by a magnitude of 0.48 ( $SE = 0.063$ ) and 0.41 ( $SE = 0.082$ ) standard deviations, respectively. The quantitative results remain virtually unchanged when controlling for demographic and socioeconomic controls (online appendix table A11, panel B) and persist when using a continuous measure of perceptions rather than binary variables (see online appendix table A12). Following a complementary analysis, online appendix figure A7 visualizes nonparametric relationships, underscoring the substantial positive association with economic worries along the belief distribution.<sup>10</sup>

<sup>10</sup>The positive association is particularly pronounced for individuals who hold lower beliefs about coronavirus mortality and contagiousness, po-

## B. Experimental Treatments

To understand whether beliefs about the mortality and contagiousness of the coronavirus causally affect economic anxiety, we administered one framing treatment as well as an information treatment. The structure of the experiments was as follows. In the first component of the experiments, a random subset of respondents was assigned to receive the "high relative mortality" treatment, while the remaining respondents were assigned to receive the "low relative mortality treatment." Subsequently, we elicited participants' economic worries. In the second component of the experiments, we randomly assigned some respondents to get truthful information about the contagiousness and then reelicited participants' economic worries.

**Framing of relative mortality.** Our first experimental variation focuses on the framing of mortality risk. In the experiment, participants were truthfully informed, based on the same scientific estimate of coronavirus mortality at the time of the survey, that the death rate from the coronavirus is "20 times higher than for the flu" (high mortality treatment) or "5 times lower than for SARS" (low mortality treatment). The wording was chosen to mirror how information is

tentially because increases at low levels induce larger perceived marginal effects of the crisis on economic prospects.



commonly communicated in the media. We study how these different framings of mortality of the coronavirus affect participants' expectations about the severity of the effects of the coronavirus in general and their worries about the effects on the aggregate economy and their personal economic situation. Econometrically, we estimate treatment effects using the following specification:

$$y_i = \beta_0 + \beta_1 \text{highrelativemortality}_i + \varepsilon_i, \quad (2)$$

where  $y_i$  is the  $z$ -scored outcome of interest for individual  $i$  and  $\text{highrelativemortality}_i$  is a dummy variable indicating whether individual  $i$  was exposed to the high mortality framing.<sup>11</sup> In additional robustness tests, we also test for the robustness of the results when including demographic and socioeconomic controls, including gender, age bin dummies, log income, log income squared, dummies for having a high school diploma and having some college education, dummies for being unemployed, currently working, a student, and for self-identifying as Democrat or Republican.

Relative to the low mortality treatment, the high mortality treatment causally leads participants to hold higher beliefs about the severity of the crisis for the world and the United States: respondents in the high mortality treatment display 0.28 (SE = 0.066) and 0.23 (SE = 0.066) standard deviations higher beliefs about the severity of the crisis for the world and the United States, respectively (online appendix table A14).

These treatment differences also persist for participants' economic worries (figure 3D and online appendix table A15, panel A): relative to the low mortality treatment, respondents in the high mortality treatment increase their worries about the effects of the coronavirus on the U.S. economy by 0.16 (SE = 0.066) standard deviations and about their personal economic circumstances by 0.16 (SE = 0.066) standard deviations. The quantitative effect sizes correspond to 106% and 102% of the Republican-Democrat gap, respectively, and are virtually unchanged when controlling for demographic and socioeconomic controls (online appendix table A15, panel B). These results highlight the influence of framing of news stories on public perceptions (Chong & Druckman, 2007; Prat & Strömberg, 2013).

*Information about contagiousness.* Besides mortality, contagiousness is a key characteristic that influences the pandemic risk of an infectious disease. The higher disease contagiousness is, the larger is the risk of widespread and fast infection of the population, which can lead to an overload of the health care system (Massonnaud, Roux, & Crépey, 2020) and costly disruption of economic activity (Adda, 2016). To understand the causal effect of beliefs about contagiousness on economic anxiety, in the second part of the experiment, we administered an additional information treatment.

After eliciting participants' beliefs about the contagiousness (R0) of the coronavirus, the participants were randomly assigned to be either in a "contagion information group" or a control group that received no information. Based on scientific estimates (Li et al., 2020; Wu et al., 2020), respondents in the contagion information group were informed that "approximately 2 non-infected people will catch the coronavirus from a person who has the coronavirus." Given that 81.4% of respondents overestimate this statistic, the information treatment should decrease the perceptions of the contagiousness.

To test for the effect on economic anxieties, we reelicited participants' worries about the effects of the coronavirus on the U.S. economy and their households' economic situation as before. To analyze this treatment, we use an ANCOVA specification of the following form:

$$y_i = \delta_0 + \delta_1 \text{contagiousnessinfo}_i + \delta_2 y_{i,-1} + \varepsilon_i, \quad (3)$$

where  $\text{contagiousnessinfo}_i$  is a dummy variable indicating whether individuals were provided the treatment information.<sup>12</sup>  $y_{i,-1}$  is the outcome of interest measured in the same survey prior to the second experiment.<sup>13</sup>

Respondents in the contagiousness information treatment show 0.09 (SE = 0.041) standard deviations lower worries about the effects of the coronavirus on their personal economic situation and a small decrease in their worries about the aggregate U.S. economy (0.01 SD, SE = 0.043) (figure 3D and online appendix table A15, panel A). The quantitative effect sizes correspond to 57% and 7% of the Republican-Democrat gap, respectively, and are virtually unchanged when controlling for demographic and socioeconomic controls (online appendix table A15, panel B) or when controlling for a treatment indicator for the relative mortality treatment (online appendix table A16).<sup>14</sup>

In sum, the experimental evidence indicates that perceptions and information regarding coronavirus mortality and contagiousness are significant causal determinants that shape individuals' expectations about the aggregate economy and their personal economic situation at a time of high uncertainty.

### C. Mental Models of Infectious Disease Spread

The public health impacts associated with a pandemic vary as a disease spreads through space and time. We already documented that economic anxieties evolve dynamically with this spread. However, so far we have not analyzed how the anticipation of such developments shapes economic anxieties. Besides information about risk factors, forward-looking individuals rely on mental models of the world to make

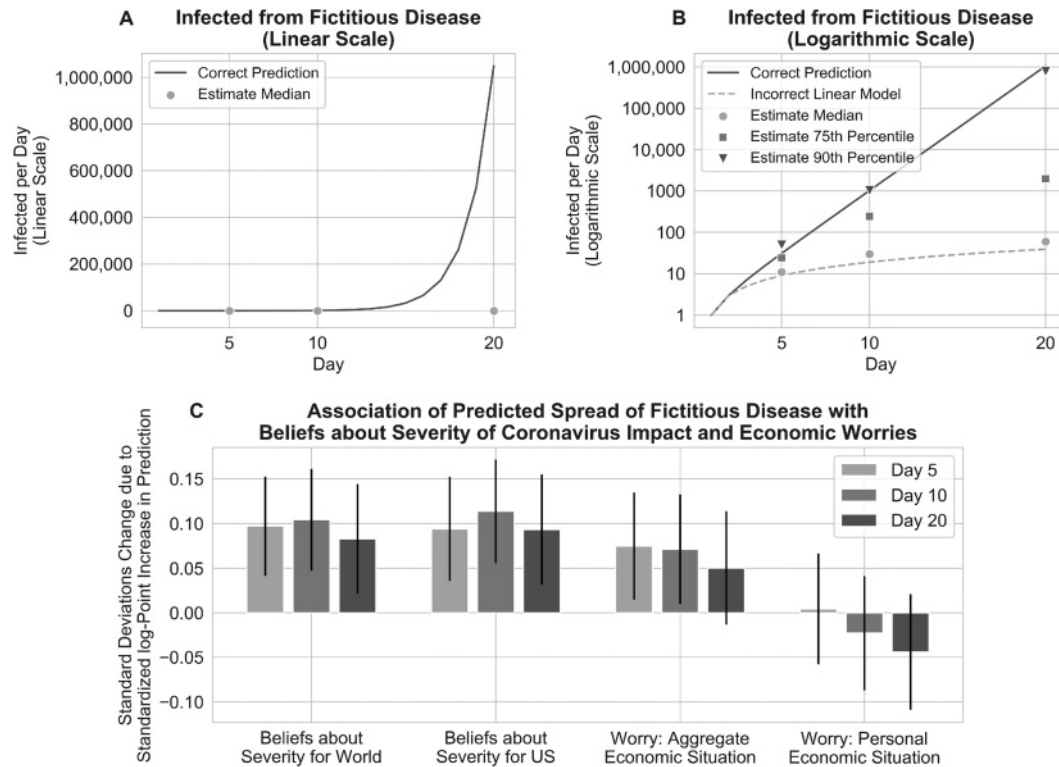
<sup>12</sup>Randomization achieved excellent balance (see online appendix table A13).

<sup>13</sup>We do not control for  $y_{i,-1}$  in the first specification because we did not collect any outcome data prior to the relative mortality treatment.

<sup>14</sup>As online appendix table A17 indicates, there are no significant interaction effects between the treatments.

<sup>11</sup>Randomization achieved excellent balance (see online appendix table A13).

FIGURE 4.—MENTAL MODELS ABOUT THE SPREAD OF INFECTIOUS DISEASES AND ECONOMIC WORRIES



The figure visualizes mental models of infectious disease spread and their association with economic anxieties. The data were collected on March 16. (A) Participants' median belief about the spread of a fictitious disease on a linear scale. (B) Participants' median, 75th percentile, and 90th percentile belief about the spread of a fictitious disease on a logarithmic scale. Participants were instructed to predict the number of cases of a fictitious disease on days 5, 10, and 20. They were informed that on day 1, one person has the disease and that each day a newly infected person infects two healthy people and then stops being contagious. In both panels, the solid line indicates the correct prediction. In panel B the dashed line indicates an incorrect linear model with a growth rate of 2 per day. (C) The association of predicted spread of the fictitious disease with participants' beliefs about the severity of the impact of the coronavirus pandemic on the world and the United States, as well as worries about the aggregate U.S. economy and their personal economic situation. In all panels, error bars indicate 95% confidence intervals.

predictions about the future and, in the context of a pandemic, the future extent of disease spread. To analyze this question, we investigate participants' subjective mental models of infectious disease spread to understand the role of cognitive processes and their limitations in shaping economic anxiety in response to the outbreak of the coronavirus pandemic.

As humans are organized in networks, disease spread typically follows a nonlinear (e.g., logistic or quasi-exponential) function, at least at the beginning of an outbreak (Keeling & Rohani, 2011; Kermack & McKendrick, 1927). Hence, a small number of cases can rapidly evolve into a widespread pandemic. Such a trajectory can be vastly underestimated if individuals do not take into account the nonlinear nature of disease spread but rather adopt a mental model of linear growth.

To systematically investigate this question, we asked participants in our March 16 survey to predict the spread of a fictitious infectious disease under simplifying assumptions. We elicited participants' predictions about the spread of a fictitious disease rather than asking participants for their estimates of the future number of coronavirus cases for three reasons. First, investigating the role of cognitive processes requires the elicitation of individuals' abstract mental models rather than their predictions for the specific case of the coronavirus pandemic. Second, predictions about the future

severity of the coronavirus pandemic will be crucially shaped by individuals' expectations about the extent of endogenous containment measures, as well as societal reactions, which are independent of the general nature of infectious disease spread. Third, no reliable benchmark is available for the future spread of the coronavirus, making it infeasible to assess the ex ante accuracy of estimates.

Participants were instructed to assume that on (a given) day 1, one person has a fictitious disease and that each day, a newly infected person infects two healthy people before stopping being contagious. To provide some guidance, participants were further informed that on day 2, three people will be infected as the person who had the disease on day 1 spread it to two other people on day 2. Participants were then asked to predict the total number of people infected with the fictitious disease on days 5, 10, and 20.

Figure 4A shows the median participant's estimates and the correct prediction values. The results indicate that the average individual highly underestimates the spread of the fictitious disease. In contrast to correct prediction values of 31 on day 5, 1,023 on day 10, and 1,048,575 on day 20, the median participant estimates a case number of 16 on day 5, 30 on day 10, and 60 on day 20. Inconsistent with nonlinear growth, the predictions of the median participant can be well approximated by a subjective linear growth model



(as exemplified by the dashed line in figure 4B for a linear growth rate of 2 per day). A linear mental model, however, is not uniformly present for the entire population. In particular, the 90th percentile prediction in our sample very well captures the correct quasi-exponential growth, indicating heterogeneity in individuals' mental models of infectious disease spread.<sup>15</sup>

To understand how contemporaneous economic anxiety is associated with individuals' mental models of the spread of infectious diseases, we correlate economic anxieties described in section IIB with participants' predicted number of people infected with the fictitious disease on days 5, 10, and 20 (figure 4C and online appendix table A19). To address outliers in participants' predictions, we use a *z*-scored transformation of the logarithm of the predicted number of infected people.

The data show statistically significant positive associations between participants' predictions and their beliefs about the severity of the crisis for the world and the United States, as well as their worries about the aggregate U.S. economy. For example, a 1 standard deviation increase in the estimate of infectious disease spread after ten days is associated with an increase of 0.11 standard deviations ( $SE = 0.03$ ) in participants' beliefs about the severity for the United States. The quantitative effect sizes are virtually unchanged when controlling for demographic and socioeconomic controls, including, importantly, education level. Interestingly, there is no significant association between participants' worries about their personal economic situation and the predicted number of infected people. This finding squares with previous evidence that individuals do not fully extrapolate their individual risk from aggregate societal risk (Bord, O'Connor, & Fisher, 2000; Weinstein, 1989).

To complement this analysis, we classify each individual's mental model by implementing a *k*-means clustering algorithm using three clusters on the log space of predicted cases on days 5, 10, and 20. Panel A in online appendix figure A8 indicates that the obtained three types can be summarized as a linear, exponential, or intermediate nonlinear model. Panel B reveals that around 64.8% of participants exhibit a roughly linear model, while 15.7% display a roughly exponential model, and 19.5% an intermediate nonlinear mental model. Finally, panel C confirms the previous results that holding a more accurate (nonlinear) mental model of infectious disease spread is associated with higher beliefs about the severity of the crisis, as well as higher worries regarding the aggregate economy.

In sum, the results indicate that individuals who exhibit a more accurate mental model of nonlinear growth of infectious disease spread are more worried about the aggregate effects of the coronavirus pandemic, potentially as they

foresee a greater potential for a widespread contagion of the population.

#### IV. Conclusion

Combining global data from internet searches and two online experiments with representative samples of the United States, this paper documents a rapid emergence of economic anxiety at the onset of a major pandemic and studies perceptions of pandemic risk factors as correlational and causal determinants.

Our results point to a critical role of subjective beliefs about pandemic risks as well as mental models of infectious disease spread in shaping public perception of the severity of the contemporaneous health crisis and economic anxiety. For the case of the coronavirus, we find substantial heterogeneity in beliefs about mortality and contagiousness, two key characteristics relevant for pandemic risk. In real-time experiments, we show that information provision regarding these characteristics causally shapes economic anxiety among the population. Our experiment also shows that framing of information about the coronavirus matters for the inferences that people make. Specifically, our experiment highlights that even if journalists base their comparisons on the same mortality statistics, the choice of comparison matters. These results speak to an important debate on how media coverage and public communication of disease outbreaks affect people's beliefs (Burszty et al., 2020).

Moreover, consistent with exponential growth bias (Levy & Tasoff, 2016; Stango & Zinman, 2009), for the majority of the population, subjective mental models understate the nonlinear nature of infectious disease spread. The heterogeneity in individuals' mental models crucially shapes their perception of the severity of a major global pandemic and affects their worries about the impact on the aggregate economy.

#### REFERENCES

- Adams-Prassl, Abi, Teodora Boneva, Marta Golin, and Christopher Rauh, "Inequality in the Impact of the Coronavirus Shock: Evidence from Real Time Surveys," IZA discussion paper 13183 (2020).
- Adda, Jérôme, "Economic Activity and the Spread of Viral Diseases: Evidence from High Frequency Data," *Quarterly Journal of Economics* 131 (2016), 891–941. 10.1093/qje/qjw005
- Andre, Peter, Carlo Pizzinelli, Christopher Roth, and Johannes Wohlfart, "Subjective Models of the Macroeconomy: Evidence from Experts and a Representative Sample," CESifo working paper 7850 (2019).
- Armona, Luis, Andreas Fuster, and Basit Zafar, "Home Price Expectations and Behaviour: Evidence from a Randomized Information Experiment," *Review of Economic Studies* 86 (2018), 1371–1410. 10.1093/restud/rdy038
- Bailey, Michael, Eduardo Dávila, Theresa Kuchler, and Johannes Stroebel, "House Price Beliefs and Mortgage Leverage Choice," *Review of Economic Studies* 86 (2019), 2403–2452.
- Bailey, Michael, Ruiqing Cao, Theresa Kuchler, and Johannes Stroebel, "The Economic Effects of Social Networks: Evidence from the Housing Market," *Journal of Political Economy* 126 (2018), 2224–2276. 10.1086/700073
- Bartik, Alexander W., Marianne Bertrand, Zoë B. Cullen, Edward L. Glaeser, Michael Luca, and Christopher T. Stanton, "How Are Small Businesses Adjusting to COVID-19? Early Evidence from a Survey," NBER working paper 26989 (2020). 10.3386/w26989

<sup>15</sup>To investigate the sources of heterogeneity, we explore the correlates of mental models in online appendix table A18. Across several specifications, we find that being older than 65 as well as having higher levels of education and income are positively associated with a more accurate mental model of infectious disease spread.

- Binder, Carola, "Coronavirus Fears and Macroeconomic Expectations," this REVIEW 102 (2020), 721–730. 10.1162/rest\_a\_00931
- Binder, Carola, and Christos Makridakis, "Stuck in the Seventies: Gas Prices and Macroeconomic Expectations," working paper (2018), SSRN 3267721. 10.1162/rest\_a\_00944
- Binder, Carola, and Alex Rodrigue, "Household Informedness and Long-Run Inflation Expectations: Experimental Evidence," *Southern Economic Journal* 85 (2018), 580–598. 10.1002/soej.12306
- Bord, Richard J., Robert E. O'Connor, and Ann Fisher, "In What Sense Does the Public Need to Understand Global Climate Change?," *Public Understanding of Science* 9 (2000), 205–218. 10.1088/0963-6625/9/3/301
- Bordalo, Pedro, Nicola Gennaioli, and Andrei Shleifer, "Salience and Consumer Choice," *Journal of Political Economy* 121:5 (2013), 803–843. 10.3386/w17947
- Bursztyn, Leonardo, Aakaash Rao, Christopher Roth, and David Yanagizawa-Drott, "Misinformation during a Pandemic," Becker Friedman Institute for Economics working paper 2020-44 (2020). 10.3386/w27417
- Carbone, Jared C., Snorre Kverndokk, and Ole Jørgen Røgeberg, "Smoking, Health, Risk, and Perception," *Journal of Health Economics* 24 (2005), 631–653. 10.1016/j.jhealeco.2004.11.001, PubMed: 15960989
- Choi, Hyunyoung, and Hal Varian, "Predicting the Present with Google Trends," *Economic Record* 88 (2012), 2–9. 10.1111/j.1475-4932.2012.00809.x
- Chong, Dennis, and James N. Druckman, "Framing Theory," *Annual Review of Political Science* 10 (2007), 103–126.
- Coibion, Olivier, Dimitris Georgarakos, Yuriy Gorodnichenko, and Maarten van Rooij, "How Does Consumption Respond to News about Inflation? Field Evidence from a Randomized Control Trial," NBER working paper 26106 (2019). 10.3386/w26106
- Coibion, Olivier, and Yuriy Gorodnichenko, "What Can Survey Forecasts Tell Us about Information Rigidities?," *Journal of Political Economy* 120 (2012), 116–159. 10.1086/665662
- "Information Rigidity and the Expectations Formation Process: A Simple Framework and New Facts," *American Economic Review* 105 (2015a), 2644–2678. 10.1257/aer.20110306
- "Is the Phillips Curve Alive and Well After All? Inflation Expectations and the Missing Disinflation," *American Economic Journal: Macroeconomics* 7:1 (2015b), 197–232. 10.1257/mac.20130306
- Coibion, Olivier, Yuriy Gorodnichenko, and Saten Kumar, "How Do Firms Form Their Expectations? New Survey Evidence," *American Economic Review* 108 (2018), 2671–2713. 10.1257/aer.20151299
- Coibion, Olivier, Yuriy Gorodnichenko, and Tiziano Ropele, "Inflation Expectations and Firm Decisions: New Causal Evidence," *Quarterly Journal of Economics* 135 (2020), 165–219. 10.1093/qje/qjz029
- Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber, "Monetary Policy Communications and Their Effects on Household Inflation Expectations," NBER working paper 25482 (2019). 10.3386/w25482
- "Labor Markets during the COVID-19 Crisis: A Preliminary View," Becker Friedman Institute for Economics working paper 2020-41 (2020). 10.3386/w27017
- D'Acunto, Francesco, Daniel Hoang, Maritta Paloviita, and Michael Weber, "IQ, Expectations, and Choice," NBER working paper 25496 (2019). 10.3386/w25496
- D'Acunto, Francesco, Daniel Hoang, and Michael Weber, "Managing Households' Expectations with Simple Economic Policies," CESifo working paper 7793 (2019).
- Dong, Ensheng, Hongru Du, and Lauren Gardner, "An Interactive Web-Based Dashboard to Track COVID-19 in Real Time," *Lancet Infectious Diseases* 20 (2020), 53–54. 10.1016/S1473-3099(20)30120-1, PubMed: 32087114
- Fortson, Jane G., "Mortality Risk and Human Capital Investment: The Impact of HIV/AIDS in Sub-Saharan Africa," this REVIEW 93 (2011), 1–15. 10.1162/REST\_a\_00067
- Fuster, Andreas, Benjamin Hebert, and David Laibson, "Natural Expectations, Macroeconomic Dynamics, and Asset Pricing," *NBER Macroeconomics Annual* 26 (2012), 1–48. 10.3386/w17301
- Fuster, Andreas, David Laibson, and Brock Mendel, "Natural Expectations and Macroeconomic Fluctuations," *Journal of Economic Perspectives* 24 (2010), 67–84. 10.1257/jep.24.4.67
- Gallagher, Justin, "Learning about an Infrequent Event: Evidence from Flood Insurance Take-Up in the United States," *American Economic Journal: Applied Economics* 6 (2014), 206–233. 10.1257/app.6.3.206
- Ginsberg Jeremy, Matthew H. Mohebbi, Rajan S. Patel, Lynnette Brammer, Mark S. Smolinski, and Larry Brilliant, "Detecting Influenza Epidemics Using Search Engine Query Data," *Nature* 457 (2009), 1012–1014.
- Hanspal, Tobin, Annika Weber, and Johannes Wohlfart, "Income and Wealth Shocks and Expectations during the COVID-19 Pandemic," CEBI working paper 13/20 (2020).
- Heimer, Rawley Z., Kristian Ove R. Myrseth, and Raphael S. Schoenle, "YOLO: Mortality Beliefs and Household Finance Puzzles," *Journal of Finance* 74 (2019), 2957–2996. 10.1111/jofi.12828
- Kan, Kamhon, and Wei-Der Tsai, "Obesity and Risk Knowledge," *Journal of Health Economics* 23 (2004), 907–934. 10.1016/j.jhealeco.2003.12.006, PubMed: 15353186
- Keeling, Matt J., and Pejman Rohani, *Modeling Infectious Diseases in Humans and Animals* (Princeton: Princeton University Press, 2011).
- Kermack, William Ogilvy, and Anderson G. McKendrick, "A Contribution to the Mathematical Theory of Epidemics," *Proceedings of the Royal Society of London* 115 (1927), 700–721. 10.1098/rspa.1927.0118
- Kerwin, Jason, "Scared Straight or Scared to Death? The Effect of Risk Beliefs on Risky Behaviors," working paper (2018), SSRN 2797493.
- Kuchler, Theresa, and Basit Zafar, "Personal Experiences and Expectations about Aggregate Outcomes," *Journal of Finance* 74 (2019), 2491–2542. 10.1111/jofi.12819
- Levy, Matthew, and Joshua Tasoff, "Exponential-Growth Bias and Lifecycle Consumption," *Journal of the European Economic Association* 14 (2016), 545–583. 10.1111/jeea.12149
- Li, Qun, Xuhua Guan, Peng Wu, Xiaoye Wang, Lei Zhou, Yeqing Tong, Ruiqi Ren, Kathy S. M. Leung, Eric H. Y. Lau, Jessica Y. Wong, et al., "Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia," *New England Journal of Medicine* 26 (2020), 1199–1207. 10.1056/NEJMoa2001316
- Liu, Jin-Tan, and Chee-Ruey Hsieh, "Risk Perception and Smoking Behavior: Empirical Evidence from Taiwan," *Journal of Risk and Uncertainty* 11 (1995), 139–157. 10.1007/BF01067682
- Maćkowiak, Bartosz, and Mirko Wiederholt, "Lack of Preparation for Rare Events," *Journal of Monetary Economics* 100 (2018), 35–47. 10.1016/j.jmoneco.2018.07.007
- Malmendier, Ulrike, and Stefan Nagel, "Depression Babies: Do Macroeconomic Experiences Affect Risk Taking?," *Quarterly Journal of Economics* 126 (2011), 373–416. 10.1093/qje/qjq004
- Massonnaud, Clément, Jonathan Roux, and Pascal Crépey, "COVID-19: Forecasting Short Term Hospital Needs in France" (2020) medRxiv0. 10.1101/2020.03.16.20036939
- Oster, Emily, Ira Shoulson, and E. Ray Dorsey, "Optimal Expectations and Limited Medical Testing: Evidence from Huntington Disease," *American Economic Review* 103 (2013), 804–830. 10.1257/aer.103.2.804
- Person, Bobbie, Francisco Sy, Kelly Holton, Barbara Govert, Arthur Liang, Brenda Garza, Deborah Gould, et al., "Fear and Stigma: The Epidemic within the SARS Outbreak," *Emerging Infectious Diseases* 10 (2004), 358. 10.3201/eid1002.030750
- Prat, Andrea, and David Strömberg, "The Political Economy of Mass Media," *Advances in Economics and Econometrics* 2 (2013), 135.
- Rabin, Matthew, "Inference by Believers in the Law of Small Numbers," *Quarterly Journal of Economics* 117 (2002), 775–816. 10.1162/003355502760193896
- Razum, Oliver, Heiko Becher, Annette Kapaun, and Thomas Junghanss, "SARS, Lay Epidemiology, and Fear," *Lancet* 361 (2003), 1739–1740. 10.1016/S0140-6736(03)13335-1
- Roth, Christopher, and Johannes Wohlfart, "How Do Expectations about the Macroeconomy Affect Personal Expectations and Behavior?," this REVIEW 102 (2020), 731–748. 10.1162/rest\_a\_00867
- Stango, Victor, and Jonathan Zinman, "Exponential Growth Bias and Household Finance," *Journal of Finance* 64 (2009), 2807–2849. 10.1111/j.1540-6261.2009.01518.x
- Tversky, Amos, and Daniel Kahneman, "Availability: A Heuristic for Judging Frequency and Probability," *Cognitive Psychology* 5 (1973), 207–232. 10.1016/0010-0285(73)90033-9

- Vosen, Simeon, and Torsten Schmidt, "Forecasting Private Consumption: Survey-Based Indicators vs. Google Trends," *Journal of Forecasting* 30 (2011), 565–578. 10.1002/for.1213
- Wagenaar, William A., and Sabato D. Sagaria, "Misperception of Exponential Growth," *Perception and Psychophysics* 18 (1975), 416–422. 10.3758/BF03204114
- Weinstein, Neil D., "Optimistic Biases about Personal Risks," *Science* 246 (1989), 1232–1234. 10.1126/science.2686031, PubMed: 2686031
- Winter, Joachim, and Amelie Wuppermann, "Do They Know What Is at Risk? Health Risk Perceptions among the Obese," *Health Economic* 23 (2014), 564–585. 10.1002/hec.2933, PubMed: 23661580
- Wu, Joseph T., Kathy Leung, and Gabriel M. Leung, "Nowcasting and Forecasting the Potential Domestic and International Spread of the 2019-nCoV Outbreak Originating in Wuhan, China: A Modelling Study," *Lancet* 395 (2020), 689–697. 10.1016/S0140-6736(20)30260-9, PubMed: 32014114
- Zhu, Na, Dingyu Zhang, Wenling Wang, Xingwang Li, Bo Yang, Jingdong Song, Xiang Zhao, Baoying Huang, Weifeng Shi, Roujian Lu, et al., "A Novel Coronavirus from Patients with Pneumonia in China, 2019," *New England Journal of Medicine* 382 (2020), 727–733. 10.1056/NEJMoa2001017, PubMed: 31978945