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News and uncertainty about COVID-19: Survey evidence and short-run economic impact

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Abstract

We solicit household expectations about the economic costs of the COVID-19 pandemic. Households expect output to decrease by about 6 percent and inflation to increase by 5 percentage points in the 12 months following March 2020. We also document that the uncertainty about the overall effect is large, both at the level of individual respondents and in terms of the dispersion across respondents. To the extent that the economic fallout of COVID-19 has not fully materialized yet, but is still a) anticipated and b) uncertain it depresses private expenditure and pushes the natural rate of interest downward. In the second part of the paper we quantify this effect as we feed our the survey data in a standard business cycle model. We find that the natural rate drops by several percentage points and illustrate to what extent the short-run impact of COVID-19 depends on the response of monetary policy.

Keywords: COVID-19, Corona, Household expectations, Survey, News shocks, Uncertainty, Natural rate, Monetary Policy, Zero lower bound
JEL-Codes: C83, E43, E52

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"God gave economists two eyes, one to watch demand, one to watch supply."

Paul Samuelson (quoted in Davidson et al., 2020).

1 Introduction

In March 2020 the Federal Reserve lowered interest rates twice—in both cases outside regularly scheduled FOMC meetings. On March 3 the fed funds rate target was lowered by 50 basis points and, again, on March 15 by another 100 basis points, effectively all the way down to zero. These measures were taken in response to the "evolving risks to economic activity" posed by the outbreak of the corona virus. Markets seemed unimpressed by these measures. In fact, on the trading days following the Fed's announcements, the U.S. stock market lost some 3 and 12 percent, respectively.[1] Some commentators suggest that the market response was caused by the information content of the monetary policy surprise, a notion backed by influential recent research (Nakamura and Steinsson, 2018; Jarociński and Karadi, 2018; Melosi, 2017). According to this line of reasoning, the response of the Fed triggered a further downward adjustment of investors' assessment of the economic consequences of the corona outbreak, even if the monetary accommodation *as such* might provide a boost to economic activity (for instance, Washington Post, 2020).[2] Other observers argue that the Corona outbreak represents a supply shock such that monetary policy is simply ill equipped to contain its economic consequences (for instance, Reuters, 2020).

In this paper, we challenge these views and put forward an alternative interpretation. Central to our argument is new survey evidence on household expectations about the economic fallout from the COVID-19 pandemic. We have been running a survey of households that are representative of the U.S. population since March 10. Recall that at this point the pandemic had just started to arrive in the U.S. with infections totaling at roughly 1,000. Asked about the average output loss caused by the pandemic during the next 12 months, the average forecast across respondents is basically zero. Three days later that number has been revised upward to 5.8 percent. Since then the average expected loss has stabilized at roughly that level. Hence, news about the potential economic fallout from the pandemic arrived basically at mid-March at the typical American Household. At the same time, as we document in detail below, the uncertainty about the output loss is large. We also provide a detailed summary of our survey and a first set of results that include inflation expectations, expectations about the

[1]Other central bank also lowered policy rates in early March 2020 in response to the corona outbreak, including the Bank of Canada, the Reserve Bank of Australia, the Malaysian central bank, and the Bank of England.

[2]Consistent with this interpretation of recent events, Enders et al. (2019) find that the information effect increases in the size of the monetary surprise.

duration of the pandemic as well as questions about behavioral responses to the pandemic.

In the second part of the paper, we feed the expectations data into a standard business cycle model to assess the short-run economic impact of the news and uncertainty about the economic fallout from the COVID-19 pandemic. Our basic idea is that the pandemic operates first and foremost as a supply shock. There can be little doubt that it reduces the production potential of the global economy in various ways. However, our survey data highlight two additional features that are essential to understand the economic impact of the COVID-19 pandemic, at least in the short run. First, upon impacting the U.S. in March 2020, it is largely a *news shock* in the sense that the worst is still to come—in terms of infections and even more so in terms of economic consequences. Second, there is huge uncertainty about the extent of the disruption of production potential caused by the COVID-19 outbreak in the medium term. In this sense it also represents an *uncertainty shock*. Both features are bound to depress private sector expenditures—in addition to constraints on consumption opportunities which are imposed in order to contain the spreading of the virus. As a result, there is an endogenously emerging downward pressure on aggregate demand and economic activity may fall well before the full consequences of the COVID-19 pandemic materialize.[3]

In the first part to the paper we document the response of household expectations to the COVID-19 outbreak. For this purpose we rely on an online survey that we initiated in March 10. By now we have solicited some 2,300 responses. As stressed above, by now the average expected output loss over the next 12 month that respondents expect as a result of the COVID-19 pandemic amounts to some 6 percent. At the same time, we find that the uncertainty of the overall output effect is large. For once, there is large variation in the point estimates across respondents. But we also ask respondents to assign probabilities to alternative outcomes in terms of the output loss due to COVID-19. At the level of individual responses the uncertainty is also large, with a standard deviation of 6 to 7 percentage points.

We also ask households about the expected duration of the COVID-19 outbreak and find that most respondents expect it to last less than 6 month. However, on average households expect the economic consequences of the COVID-19 outbreak to be fairly persistent. The 3-year ahead output loss is estimated to be close to 1 percent. Households also expect COVID-19 to impact inflation strongly. In the first year the inflation effect is expected to be about 5 percentage points. Also here the uncertainty is large and the effect is expected to be very persistent. The 3-year head inflation prediction is 5 percentage points.

We use our survey data to quantify the short-run economic impact of the COVID-19

[3]Fornaro and Wolf (2020) analyze the COVID-19 outbreak in the context of a model which features multiple equilibria and stagnation traps. They find that even if COVID-19 represents a supply shock it may cause a demand-driven slump provided it is expected to be sufficiently long lasting.

outbreak. In a first step, we quantify the implication of both the expected output loss and the uncertainty thereof for the natural rate of interest within a basic standard asset-pricing framework (Lucas, 1978; Mehra and Prescott, 1985; Barro, 2006). The natural rate is the (real) interest rate that would be observed if prices were completely flexible. Expectations about future output translate into expectations about future consumption and the natural rate adjusts in order to ensure a consumption profile over time in line with the potential output of the economy. The natural rate drops in response to bad news about the future in order to stimulate today's consumption. This ensures that the good market clears while output is still high. We feed our survey data about the expected output loss due to COVID-19 into to model and compute the implications for the natural rate. In our baseline specification the natural rate drops by about 800 basis points. About one quarter of this effect is due to uncertainty, three quarters are due to the expected average output loss of 6 percent. In the model, this implies a consumption drop of 6 percent, too. To put this into perspective, we note that consumption declined in the U.S. by 16 percent in 1921. This may have been partly a result of "Spanish flu" pandemic in 1918–1920 (Barro and Ursua, 2008; Grammig and Sönksen, 2020), although recent work by (Barro et al., 2020) suggest a rather moderate contribution of the "Spanish flue" of 2.1 percentage points.

Finally, we turn to the implications for monetary policy. For this purpose we rely on the New Keynesian workhorse model and study how the economy adjusts over time to an adverse productivity shock. The key assumption is the productivity shock is anticipated. It is, in other words, a news shock (Schmitt-Grohé and Uribe, 2012). On impact productivity is still unchanged, the adverse effects unfold over a couple of months only. It is in this early period that the shock impacts aggregate demand adversely, well ahead of the adverse impact on supply. It is also during that period that monetary policy has key role to stabilize the economy. This becomes clear as we contrast alternative scenarios for monetary policy.

In the first scenario we assume that monetary policy tracks the natural rate perfectly. This involves a sharp cut in the policy rate upon arrival of the news. This cut offsets the increased desire to save and stabilizes the economy at potential. The output gap is closed and inflation remains stable. However, as productivity actually declines output does decline as well. In the second scenario we assume that monetary policy follows a Taylor-type interest rate rule. This rule implies less accommodation in response to the bad news. As a result output declines on impact, the output gap turns negative. Nevertheless we find that the news are inflationary, because future output gaps are expected to be positive and firms set prices in a forward-looking manner. In the third scenario these effects are even stronger because here we assume that monetary policy is unresponsive to the shock during the first four months, say because it is constrained by the zero lower bound or feels it should not respond to the COVID-19 outbreak. Either way, if policy is unresponsive the recessionary impact of the shock is considerably stronger in the short run.

Our paper relates to various strands of research. Binder (2020) also surveys consumers' views about the coronavirus on March 5 and 6, 2020. Her interest is how consumers' view about inflation and unemployment changes as they are informed about the Fed's rate cut on March 3 and its FOMC statement. As far as economic activity is concerned she asks whether there will be more or less unemployment while we ask respondents about the economic costs of COVID-19 in percent of GDP. Earlier model-based work has shown that news shock can be an important source of business cycle fluctuations (Beaudry and Portier, 2006; Barsky and Sims, 2011, 2012). We also build on work which has shown that the effects of uncertainty shocks get amplified when monetary policy is constrained by the zero lower bound (Fernández-Villaverde et al., 2015; Basu and Bundick, 2017). Born et al. (2019) estimate the effect of the Brexit vote on the UK economy prior to actual Brexit. They find a significant output drop of about two percent over a two-year period as a result of both adverse news and, to a lesser extent, increased uncertainty. Lastly, Eichenbaum et al. (2020) model the interaction between economic decisions and epidemic dynamics and study the optimal government policy in the presence of an "infection externality".

The remainder of the paper is structured as follows. We introduce our survey in the next section and present results. Section 3 outlines the standard New Keynesian model, while Section 4 presents simulation results. We obtain these as we feed our survey data into the model. A final section offers some conclusions.

2 The Survey

In what follows we first provide some basis information regarding the nature of the survey. We present the main results afterwards.

2.1 Survey Description

We contracted Qualtrics Panels to provide us with a survey of 2291 nationally representative respondents. We required all respondents to be U.S. residents and have English be their primary language. Respondents were representative by matching several key demographic and socioeconomic characteristics of the U.S. population. In terms of demographics, respondents had to be male or female with 50% probability. Moreover, approximately one third of respondents were targeted to be between 18 and 34, another third between ages 35 and 55, and a final third older than age 55. We also required a distribution across U.S. regions in

Table 1: Survey Respondent Characteristics

	pct.		pct.
Age		**Race**	
18-34	33.09%	non-Hispanic white	68.44%
35-55	35.22%	non-Hispanic black	13.31%
older than 55	31.69%	Hispanic	8.16%
		Asian or other	10.09%
Gender			
female	50.20%	**Household Income**	
male	49.58%	less than 50k$	42.16%
other	0.22%	50k$ - 100k$	3985%
		more than 100k$	17.98%
Region			
Midwest	20.05%	**Education**	
Northeast	18.38%	some college or less	58.75%
South	41.77%	bachelors degree or more	41,25%
West	19.81%		
			N=2291

Description: This table presents data on the characteristics of participants in the survey administered by Qualtrics.

proportion to population size, drawing 20% of our sample from the Midwest, 20% from the Northeast, 40% from the South and 20% from the West. 66% of the sample were targeted to be non-Hispanic White, 12% non-Hispanic Black, 12% Hispanic and 10% Asian or other.

In terms of the socio-economic make-up, our sample was also representatively collected. In particular, we sampled representatively from the income distribution with a goal of 35% of respondents with a household income of less than 50k, 35% with an income between 50k and 100k, and the remaining 30% with an income above 100k. Half of our respondents had a bachelors degree or above, half some college or less. The survey also includes filters to eliminate respondents who write-in gibberish for at least one response, or who complete the survey in less (more) than five (30) minutes. Table 1 provides a detailed breakdown of our sample. It shows that our sample was approximately representative of the U.S. population according to the sampling criteria.

The main questions of the survey are modeled after the Survey of Consumer Expectations (SCE) by the New York Fed. This means we start with some identical questions about income and inflation as in the SCE. For example, to mimic the SCE setup, we use the same language to carefully explain before the actual questions the meaning of probabilities in plain English. Then, to elicit unconditional expectations for output and inflation over various horizons, we similarly follow the two-pronged approach in the SCE: First, we elicit point estimates. Second, we elicit the probability that respondents assign to a particular outcome, given a range of possible outcomes. In each instance, we use exactly the same questions as a baseline. When we ask for point estimates, we first ask whether respondents expect inflation or deflation (or output increases or decreases). Then we ask what their point estimates are. In the case of eliciting the entire distributions, we bin the support like the SCE into bins of decreases less than -12, -12 to -8, -8 to -4, -4 to -2, -2 to 0, and symmetrically for increase.

Our objects of interest are inflation and income, measured by GDP, or alternatively, by the "total income of all members of your household (including you)." While GDP is a new variable not included in the SCE, but closer to our modeling interest, we add it as a question with a very similar type of wording to that of household income. We elicit expectations at the 12-month horizon relative to today, and at the three-year horizon in between 2022 and 2023. All of these baseline questions as well as the ones that follow are listed in the Survey Appendix.

Our survey contains a set of questions that is unique to our survey and we use the answers to those questions in our calibration exercises in Section 4 below. These questions aim at extracting the conditional effect of the COVID-19 outbreak on expected point estimates and the entire distributions. We ask questions regarding both output and inflation over one-year and three-year horizons, with the exception of inflation for which we skip the distribution over a three-year horizon, to mitigate respondent cognitive burden.

When we ask about the inflationary impact of COVID-19, we start by asking about the impact on the point estimate first:

Over the next 12 months, do you think that the coronavirus will cause inflation to be higher or lower? Higher/Lower

Depending on the answer (Higher/Lower), we ask respondents to fill in their point estimates according to:

How much [higher/lower] do you expect the rate of to be over the next 12 months because of coronavirus? Please give your best guess.

I expect the rate of inflation to be _____ percentage points [higher/lower] because of coronavirus.

We similarly elicit inflation expectations over a three-year horizon. Next, we elicit the distribution over various inflationary outcomes:

In your view, what would you say is the percent chance that over the next 12 months, coronavirus will cause the rate of inflation to be . . .

and allow respondents to distribute 100 percent over a support that ranges from "Negative, by 12 percent or more ___" to "Positive, by 12 percent or more ___". The support is binned as described above. To eliminate careless responses, we drop respondents who place all weight in one bin, or two bins with empty bins surrounding them.

When we ask about the output impact of COVID-19, we proceed in an entirely analogous fashion. We start by asking about the impact on the point estimate first:

In your view, within 12 months from today, what will the overall economic impact of the coronavirus be positive or negative? Positive/Negative

Depending on the answer (Positive/Negative), we ask respondents to fill in their point estimates according to:

What do you expect the overall impact of the coronavirus to be over the next 12 months? Please give your best guess.

I expect the overall economic impact of the coronavirus to be [positive/negative] ___ percent of GDP.

As for inflation, we elicit expectations over a three-year horizon, as well. Next, we elicit the distribution over various outcomes for GDP:

What would you say is the percent chance that, over the next 12 months, the overall economic impact in percent of GDP will be . . .

and allow respondents to distribute 100 percent over a support that ranges from "Negative, by 12 percent or more" to "Positive, by 12 percent or more ___." The support is again binned as described above.

Our survey included a series of complementary questions. These questions do not elicit expectations. However, they cover a wide range of behavioral topics, usually in a yes/no style. These questions include savings and purchasing behavior and plans in response to COVID-19, the expected duration of the pandemic, and whether respondents have hoarded food, and medical supplies in response to COVID-19.

The survey embeds several treatments as we ask either about the effect of COVID-19 on GDP or personal income, and the position of our questions about the effect of COVID-19 can be swapped with the questions about another phenomenon not subject of this paper. We report the details of the 4 treatments in the Online Appendix along with further survey details.

2.2 Survey Results: COVID-19 and Expectations

The survey started on March 10. In what follows we evaluate a first wave of response based on data up to March 22. According to our survey results, the COVID-19 outbreak had a two-fold impact. First, the shock lowered growth expectations and increased inflationary expectations. The expected impact on output growth on a one-year horizon fell from between 0% and +0.4% at the onset of the crisis in the U.S. (March 10) to between -4.2% and -5.8% on March 13, and to -6.7% on average during March 13–March 25. The impact on inflation expectation increased from between -0.24pp and 1.75pp on March 13 to between 0.53pp and 5.54pp on March 16. Second, uncertainty about these effects is large and increased further during the period that we consider. These results are robust across our ways of eliciting expectations.

When we consider respondents' point estimates, we observe a rather sudden shift in GDP expectations. In addition, we note that there is considerable uncertainty. Figure 1 illustrates these findings. Panel A on the left displays the evolution of the expectations over time. On March 10, 2020, respondents expected an effect of essentially 0 of COVID-19 on GDP. Three days later, on March 13, expectations dropped to -5.82%.[4] Output expectations remain low, with an average of -6.7% during March 13-25, 2020. Panel B illustrates the shift in the distributions over that period. There is a pronounced leftward shift of the distribution on March 10, 2020, represented by the (blue) dashed line, to distribution of responses during March 13-25, 2020, represented by the (red) solid line. The mean shifts from +0.348% to -6.700% during the remainder of the sample period. Note also that the support on the left expands. While on March 10, 2020, the kernel shows no responses lower than -20%, the support reaches -40% on March 13-25. At the same time, quite a bit of mass on the right-hand side of the distribution disappears. Overall, while Panel A already suggests that there exists substantial uncertainty in expectations, Panel B shows an increase from 13 to 15 percentage points. Table 2 provides detailed day-by-day statistics for the point prediction of GDP (Panel A: left hand side).

We find similar results when we ask respondents about total household income rather than GDP. Figure A.4 in the Appendix displays the distribution of respondents' expectations over the next 12 months. We see that the mean respondent expects household income to drop by -4.138%. This number puts the expected drop into the range of the expected GDP decrease. Similarly, we see that there is substantial dispersion in expectations. Table 2, Panel C, shows the evolution of these household income expectations over time. While we unfortunately do not have data for March 10 for household income, on March 13, respondents expected only a

[4]There are no responses on March 11-12 as well as March 14-15.

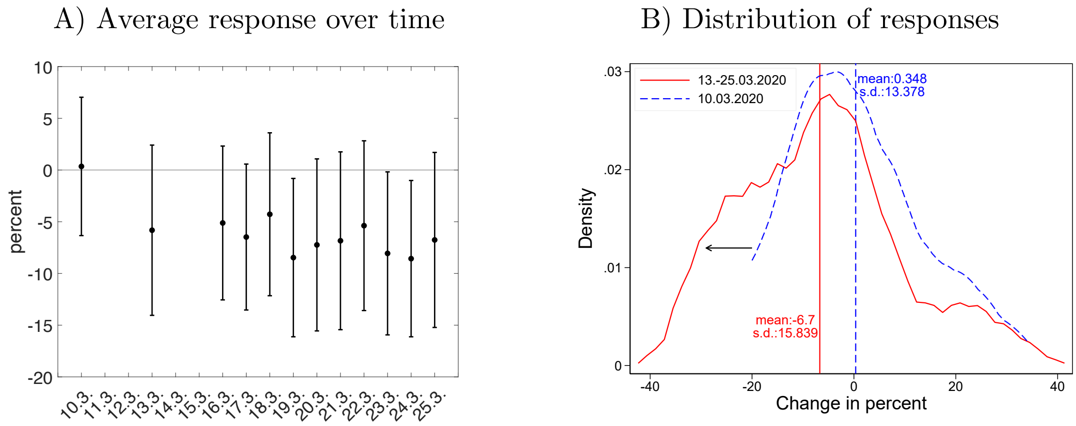

Figure 1: Expected GDP change due to COVID-19 over 12 month period
Panel A: average response over time, whiskers indicate one-standard deviation interval. Panel B: distribution of respondents answers, both on 10.03.2020 (blue, dashed) and afterwards (red, solid). Vertical line indicate means. Number of respondents: $N_{10.03.} = 23$, $N_{11.-25.03.} = 1410$.

mean contraction of -0.05%. On March 15, expectations for a very small sample are at -6.67% and at -5.3% on March 16. The delayed drop relative to the drop of GDP expectations is not inconsistent because we only ask either for household income or for GDP. Also note that the overall level of the expected drop, however, is very similar to the drop in GDP expectations.

When we analyze the individual forecast distribution of respondents rather than their point prediction, we also find a robust decrease in the mean GDP expectations and an increase in dispersion. To compute these statistics, we first estimate the best-fitting beta distribution that describes the distribution for each individual. In doing so, we follow the methodology in the SCE exactly (see Appendix C in the SCE methodology). We then compute, summarize and plot the individual means over time, with an emphasis on the shift after March 10, 2020. Figure A.1 in the Appendix shows the results: The (blue) dashed distribution for March 10, 2020 has a mean expected drop in GDP of -0.075%, with a standard deviation of 5.116%. The (red) solid-lined distribution for March 13-25, 2020 by contrast shows a mean expected drop of -3.324%. The standard deviation also shows an increase to 6.636%, just like the case of the point estimates. In Table 2, on the right hand side of Panel A), we provide detailed day-by-day statistics that characterize the distribution of GDP losses as provided by respondents (rather than their point estimate for which we report statistics on the left hand side).

We also ask about respondents about their inflation expectations and, in particular, how they change for the next 12 months because of the COVID-19 pandemic. Also here we see a large change in expectations: Figure 2 shows the results in a similar fashion as in the previous figure. Panel A on the left indicates the evolution of inflationary expectations over time. Even relative to March 13, 2020, one can see how inflationary expectations increased,

Table 2: Expected Economic Impact of COVID-19

	Point prediction				Distribution of respondents			
A) GDP								
Date	Mean	S.D.	Median	N	Mean	S.D.	Median	N
10.03.2020	0.35%	13.38%	-2.00%	23	-0.08%	5.33%	0.2%	14
13.03.2020	-5.82%	16.46%	-8.50%	50	-4.21%	7.59%	-4.22%	40
16.03.2020	-5.12%	14.87%	-5.00%	134	-3.68%	5.80%	-3.48%	90
17.03.2020	-6.48%	14.11%	-8.00%	133	-4.03%	7.01%	-4.04%	117
18.03.2020	-4.28%	15.75%	-5.00%	138	-2.84%	7.21%	-2.68%	120
19.03.2020	-8.47%	15.31%	-10.00%	143	-3.76%	6.93%	-3.62%	116
20.03.2020	-7.24%	16.63%	-8.50%	103	-1.97%	7.49%	-1.85%	125
21.03.2020	-6.84%	17.19%	-10.00%	141	-3.72%	7.27%	-3.60%	115
22.03.2020	-5.38%	16.41%	-5.00%	130	-2.20%	7.26%	-2.01%	120
23.03.2020	-8.06%	15.76%	-8.00%	140	-3.94%	6.89%	-3.94%	124
24.03.2020	-8.57%	15.11%	-10.00%	127	-3.50%	6.61%	-3.35%	96
25.03.2020	-6.76%	16.92%	-6.00%	131	-2.46%	6.38%	-2.37%	82
B) Inflation								
13.03.2020	1.75pp	18.46pp	3.00pp	77	-0.24pp	6.93pp	-0.19pp	53
16.03.2020	5.54pp	13.47pp	5.00pp	216	0.53pp	5.04pp	0.63pp	123
17.03.2020	6.02pp	18.40pp	5.00pp	166	1.26pp	6.80pp	1.27pp	109
18.03.2020	5.16pp	13.99pp	3.50pp	158	-1.09pp	6.54pp	-1.02pp	123
19.03.2020	3.62pp	16.57pp	3.00pp	167	-0.73pp	6.03pp	-0.58pp	113
20.03.2020	6.20pp	17.78pp	6.00pp	161	-0.11pp	7.19pp	0.13pp	125
21.03.2020	5.78pp	18.86pp	5.00pp	173	-0.52pp	6.56pp	-0.41pp	119
22.03.2020	3.06pp	18.21pp	5.00pp	161	-0.90pp	6.87pp	-0.92pp	107
23.03.2020	6.26pp	16.79pp	6.00pp	165	-0.39pp	6.30pp	-0.45pp	121
24.03.2020	5.38pp	17.14pp	5.00pp	172	-0.41pp	6.71pp	-0.41pp	87
25.03.2020	3.73pp	18.51pp	5.00pp	166	-1.67pp	5.89pp	-1.78pp	75
C) PHI								
13.03.2020	-0.05%	13.42%	0.50%	20	-3.15%	6.05%	-3.15%	12
15.03.2020	-6.67%	5.77%	-10.00%	3	-3.57%	3.93%	-3.56%	3
16.03.2020	-5.30%	10.16%	-5.00%	64	-2.72%	4.31%	-2.44%	27

Description: This table presents time series data on the impact of COVID-19 between 10.03.2020 and 16.03.2020 from survey participants individual distribution of expectations. We use the respondents probability answers to estimate an individual four parameter beta distribution over possible outcomes. The reported mean an standard deviation in the table below give the mean over individual distribution means and standard deviations.

from 1.75pp on March 13, 2020 to 5.78pp on March 21. Panel B on the right shows the distribution of the expectations. Clearly, inflation expectations are widely dispersed. The

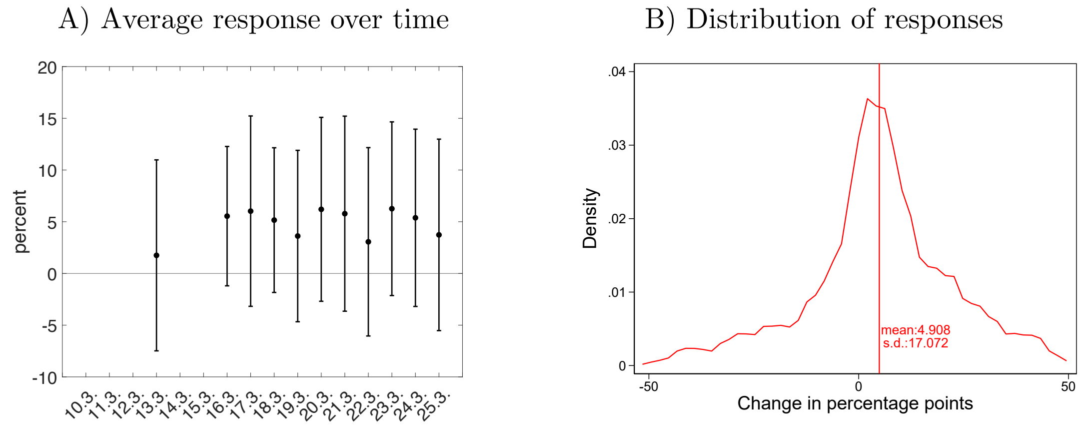

Figure 2: Expected change of inflation due to COVID-19 over 12 month period
Panel A: average response over time, whiskers indicate one-standard deviation interval. Panel B: distribution of respondents answers. Dashed line indicates mean. Number of respondents: $N_{13.-20.03.} = 1793$.

mean expectation is 4.908pp indicating an inflationary overall expectation due to COVID-19. Figure A.2 in the Appendix shows the distribution of inflation expectations when computed from the entire forecast distribution of respondents. We also see here that respondents expect an inflationary effect of COVID-19. On average they expect an inflationary impact of -0.334pp. Beliefs are dispersed as before with a standard deviation of 6.424pp. We summarize the responses regarding inflation in Panel B) of Table 2. The statistics on the left pertain to the point prediction of respondents, the statistics on the right, in turn, are computed on the best-fitting beta distribution, given the answers about the probabilities of specific inflation outcomes. Here we observe a certain discrepancy in that the point predictions suggest higher inflation expectations than the mean of the distribution that is implicit in the responses of the survey participants.

We also ask respondents to look farther into the future to get a sense of the expected duration of the COVID-19 pandemic and, in particular, its economic effects. In Panel A) of Figure 3 we show the distribution of responses once we ask participants how long they expect the "coronavirus outbreak" to last. Most respondents believe that the duration is shorter than 6 months. About 35% of respondents expect a one-year duration, 11% a two-year duration and a non-zero mass is on 3 years, or more than 3 years. Note that these are responses to a question regarding the duration of the pandemic.

Still, we also asked about its possible economic consequences. Specifically, in Panel B of the same figure, we show the distribution of expectations about the GDP loss in the period 2022 to 2023. Results are shown by the (blue) dashed line and contrasted to the distribution for the GDP expectations for the 12 month following March 2020. They are already shown in Panel B of Figure 1 and replicated here by the (red) solid line for means of comparison.

A) Expected duration of Covid19 B) Distribution of 3-Year Ahead Responses

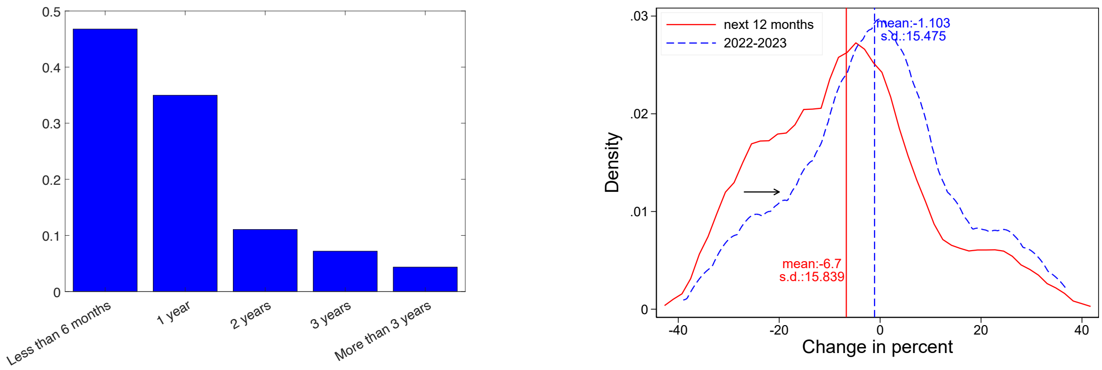

Figure 3: Expected Duration of Covid-19

Description: Survey participants expectations on the duration of Covid-19. $N = 2253$. Panel B shows the distribution of respondents point estimates on the GDP loss due to COVID-19 12 months ahead (red line, $N = 1410$) and between March 2022 and March 2023 in the blue line ($N = 1497$).

We see that the output effect three years down the road are expected to be considerably less negative, but they still imply an loss of 1.455% on average, with a standard deviation of 15.133%. Clearly, respondents expect the effect to die out but there is also some persistence since the effect is expected to be non-negligible three years into the future. The effects for inflation are expected to be even more persistent still, as Figure A.5 in the appendix shows.

As explained above, we also include a number of behavioral questions in the survey. Figure 4 summarizes these answers. In Panel A) we focus on the questions about savings and expenditures. 40% of respondents spend a larger fraction of their income in response to the COVID-19 pandemic, 68% have refrained from planned larger purchases, 60% report that their financial planning has changed, and 40% have increased their personal savings. In Panel B) we focus on additional aspects of economic behavior related to the COVID-19 pandemic. In particular, 46% of respondents report that they started to store larger quantities of medical supplies at home. 58% have started to store larger quantities of food supplies at home. 54% report avoiding products from China, and 44% fear they may lose their job due to the economic consequences of COVID-19.

We also assess whether expectations about the output loss caused by the COVID-19 pandemic as well as the uncertainty thereof can account for the behavioral responses we record in the survey. For this purpose run a number of probit regressions which relates, in each instance, the response to a behavioral question to individual characteristics such as demographics and socioeconomic status. In addition, and this is our main interest, we include the expectation of the GDP loss (over a one-year horizon) in the regression as well as the standard deviation of the best-fitting beta distribution given the individual probabilities

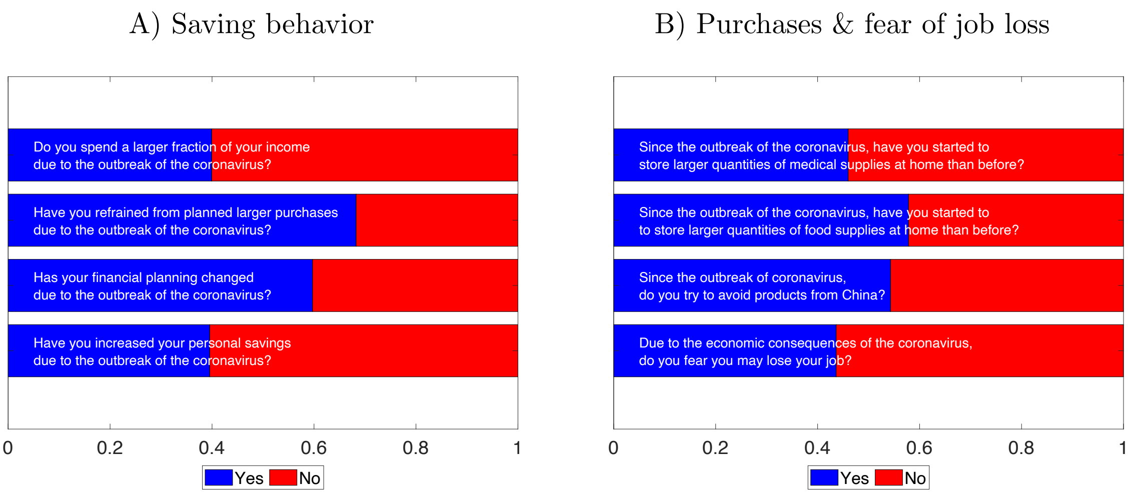

Figure 4: Reported behavioural adjustment
Description: This figure presents data on the behavioral adjustment due to Covid-19 reported by survey respondents. $N = 2291$.

assigned to different GDP losses (over a one-year horizon). The latter is our measure of the uncertainty of the expected GDP loss as reported by the individual respondent.

Table 3 shows the results. We find that the expected GDP loss has no significant effect on the reported behavior, but uncertainty matters. We find in particular, that higher uncertainty leads to higher savings and changes in financial planning. It also induces respondents to spend more. This may seem at odds with the fact that it also leads to higher savings. Note, however, that we ask respondents whether they increased spending because of the coronavirus. So, most likely, this question is understood as capturing expenditures related to the coronavirus. Consistent with this interpretation, we also find that the answer to this question is also positively correlated with the answer to the question about whether respondents store larger quantities of medical and food supplies. We find that people who are more uncertain about the GDP loss caused by the COVID-19 pandemic tend store more medical supplies and food. Lastly, we also note that they tend to avoid products from China.

Table 3: Probit Estimaiton Results on Behavioral Questions

	(1) Savings Increased	(2) Financial Plans Changed	(3) No Large Purchases	(4) Spend More	(5) Fear Un-employment	(6) Avoid Chinese Products	(7) Store Food	(8) Store Medical
Expectations on GDP	0.00959	-0.0134	-0.0130	0.00920	0.00301	0.0119	-0.00973	-0.0114
	(1.14)	(-1.63)	(-1.56)	(1.12)	(0.37)	(1.51)	(-1.19)	(-1.39)
Uncertainty	0.0352**	0.0361**	0.0200	0.0593***	0.0236	0.0517***	0.0635***	0.0673***
	(2.67)	(2.75)	(1.53)	(4.51)	(1.82)	(4.05)	(4.87)	(5.09)
Age	-0.00927**	-0.0131***	-0.00287	-0.0110***	-0.0240***	0.00789*	-0.00330	-0.00853**
	(-2.74)	(-4.04)	(-0.88)	(-3.30)	(-7.03)	(2.47)	(-1.04)	(-2.60)
Male	0.530***	0.334**	0.133	0.0411	0.0576	0.221*	0.358***	0.334**
	(4.93)	(3.21)	(1.25)	(0.38)	(0.55)	(2.16)	(3.46)	(3.17)
Less Than Bachelor	-0.410***	-0.306**	-0.135	-0.366**	-0.378***	0.0435	-0.0368	-0.242*
	(-3.63)	(-2.78)	(-1.21)	(-3.27)	(-3.39)	(0.40)	(-0.34)	(-2.19)
Low Income	-0.271	-0.249	-0.231	-0.340*	0.0371	-0.380*	-0.322*	-0.469**
	(-1.75)	(-1.60)	(-1.47)	(-2.22)	(0.24)	(-2.54)	(-2.10)	(-3.04)
Middle Income	-0.415**	-0.226	-0.167	-0.364**	0.0517	-0.374**	-0.278	-0.598***
	(-2.92)	(-1.55)	(-1.14)	(-2.58)	(0.37)	(-2.72)	(-1.94)	(-4.18)
White non-Hispanic	-0.381	-0.0536	-0.304	-0.263	0.102	-0.000604	-0.655**	-0.543*
	(-1.79)	(-0.24)	(-1.31)	(-1.27)	(0.49)	(-0.00)	(-2.80)	(-2.49)
Constant	0.417	0.818**	0.893**	0.520	0.747**	-0.465	0.605*	0.597*
	(1.45)	(2.80)	(2.96)	(1.83)	(2.63)	(-1.65)	(2.04)	(2.08)
Observations	721	724	724	724	724	724	724	724

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Description: Results of a probit model estimation for each of the behavioral questions towards adjustment to COVID-19. We use age, education, ethnicity, income and gender as demographic control variables. Individual standard deviations obtained from the beta distribution of individual survey participants responses on the COVID-19 impact on GDP used as a measure for personal uncertainty. Expectations on GDP are the individual mean of the beta distribution.

3 The model

In order to assess the short-run macroceconomic impact of the Covid-19 outbreak we feed private sector expectations as solicited in the survey into a standard New Keynesian model. In fact, for this purpose we rely on the textbook version. In what follows we provide a compact exposition following chapter 3 of (Galí, 2015). Readers familiar with the model, we directly move to Section 4 where we report results.

A representative **household** in country has preferences over private consumption, C_t^i, public and labor, N_t^i, given by

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma} - 1}{1-\sigma} - \frac{N_t^{1+\varphi}}{1+\varphi} \right) \tag{1}$$

In the expression above E_0 is the expectation operator, $\beta \in (0,1)$ is the discount factor, σ is the degree of relative risk aversion, and φ is the inverse of the Frisch elasticity of labor supply. Aggregate consumption is a bundle of varieties $C_t(i)$ with $i \in [0,1]$:

$$C_t \equiv \left[\int_0^1 C_t(i)^{1-\frac{1}{\epsilon}} di \right]^{\frac{\epsilon}{\epsilon-1}}. \tag{2}$$

In the expression above $\epsilon > 1$ is the elasticity of substitution across varieties. The household chooses consumption in order to maximize (1), (2) and a flow budget constraint:

$$\int_0^1 P_t(i) C_t(i) di + Q_t B_t \leq B_{t-1} + W_t N_t + D_t, \tag{3}$$

as well as a solvency constraint. Here $P_t(i)$ is the price index of good i B_t is a nominally riskless discount bond which trades at price Q_t, W_t are wages and D_t is the household's dividend income.

The households supplies labor and saves via the riskless bond in order to satisfy the following optimality conditions

$$\frac{W_t}{P_t} = C_t^\sigma N_t^\varphi \tag{4}$$

$$Q_t = \beta E_t \left\{ \left(\frac{C_{t+1}}{C_t} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \right\} \tag{5}$$

The optimal intertemporal allocation of consumption expenditures implies the demand function for a generic good i:

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\epsilon} C_t \tag{6}$$

where $P_t \equiv \left[\int_0^1 P_t(i)^{1-\epsilon} di \right]^{\frac{1}{1-\epsilon}}$ is the consumption price index.

There is a continuum of **firms**, indexed by $i \in [0,1]$; each firm produces a differentiated good operating under monopolistic competition. The production function of a generic firm i is given by

$$Y_t(i) = A_t N_t(i)^{1-\alpha},$$

where $Y_t(i)$ is the firm's output, $N_t(i)$ is labor employed by firm i, A_t is productivity. It is common across firms and determined exogenously. $\alpha \in [0,1)$ is a parameter.

Firms are constrained in their ability to adjust prices. In each period a fraction $\theta \in [0,1]$ is unable to adjust its price. Under this assumption the price level evolves as follows:

$$P_t = \left[\theta(P_{t-1})^{1-\epsilon} + (1-\theta)(P_t^*)^{1-\epsilon}\right]^{\frac{1}{1-\epsilon}}, \tag{7}$$

where P_t^* is the optimal price set by firms that are randomly selected to be able to adjust their price. Since they face an identical decision problem, they chose the same price. Specifically, P_t^* solves

$$\max \sum_{k=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} \left[P_t^* Y_{t+k|t} - \mathcal{C}_{t+k}(Y_{t+k|t}) \right] \right\},$$

where $Y_{t+k|t} = \left(\frac{P_t^*}{P_{t+k}}\right)^{-\epsilon} C_{t+k}$ is demand in period $t+k$, given prices set in period t and $Q_{t,t+k} \equiv \beta^k \left(\frac{C_{t+k}}{C_t}\right)^{-\sigma} \left(\frac{P_t}{P_{t+k}}\right)$. Here this assumption is that firms are ready to produce any amount demanded at the posted prices. The optimal price satisfies:

$$\sum_{t=0}^{\infty} \theta^k E_t \left\{ Q_{t,t+k} Y_{t+k|t} \left(P_t^* - \mathcal{M}\Psi_{t+k|t} \right) \right\} = 0,$$

where $\Psi_{t+k|t} = \mathcal{C}'_{t+k}(Y_{t+k|t})$ denotes marginal costs and $\mathcal{M} \equiv \frac{\epsilon}{\epsilon-1}$ is the markup in steady state.

If prices are completely flexible ($\theta = 0$), the optimal price implies a constant markup over marginal costs:

$$P_t^* = \mathcal{M}\Psi_{t|t}.$$

Market clearing requires for each variety i:

$$Y_t(i) = C_t(i).$$

Further, defining aggregate output $Y_t \equiv \left(\int_0^1 Y_t(i)^{1-\frac{1}{\epsilon}}\right)^{\frac{\epsilon}{\epsilon-1}}$, we also have

$$Y_t = C_t. \tag{8}$$

Further, labor market clearing implies

$$N_t = \int_0^1 N_t(i)di = \left(\frac{Y_t}{A_t}\right)^{\frac{1}{1-\alpha}} \int_0^1 \left(\frac{P_t(i)}{P_t}\right)^{-\frac{\epsilon}{1-\alpha}} di.$$

The riskless bond is zero net supply.

Monetary policy can undo the effect of price rigidities by making sure that inflation is zero at all times

$$\frac{P_t}{P_{t-1}} = 0. \tag{9}$$

In order to implement price stability it may adjust the short term nominal interst rate, $R_t = Q_t^{-1}$, that is, the inverse of the price of the discount bound. Assuming that this is feasible at all times (say, because the zero lower bound does not constrain short term rates), we can rewrite the Euler equation (5) as follows

$$\frac{1}{R_t^n} = \beta E_t \left\{ \left(\frac{Y_{t+1}}{Y_t} \right)^{-\sigma} \right\}. \tag{10}$$

Here we use equations (8) and (9) and add a superscript n to the short term interest rate since it is the natural rate of interest, that is, the interest that would be observed if prices were completely flexible.

4 Results

The responses to our survey show that starting on March 13 the expected economic loss due to the corona outbreak increased sharply, basically from an average value of zero to an average value of about 5 percent, across respondents. Likewise, the uncertainty increased markedly as well, both if measured by the cross-sectional variation in the responses as well as by at the level of individual responses. We now feed these data into the model. We proceed in two steps. First, we compute the response of the natural rate to the shift in expectations triggered by the corona outbreak. Here we take respondents' answers about the output loss at face value and remain agnostic about the specifics of transmission mechanism. Second, we develop a specific shock scenario and trace out the adjustment dynamics for alternative assumptions about monetary policy.

4.1 The response of the natural rate

We now quantify the response of the natural rate to Covid-19 news and uncertainty, as measured in our survey. The exercise is straightforward: we evaluate the Euler equation (10) on the basis of the survey responses regarding the potential output loss in the 12 month from March 2020 until February 2021. This exercise is inspired by Barro (2006) who uses the basic asset pricing model to explore the effect of expectations about rare disasters on the equity premium as well as on interest rates.

Equation (10) also shows that both the expected change in output matters as well as the uncertainty about this change. In our analysis we compute the total effect which includes both the shift in the mean expectations as well as the uncertainty. To quantify the contribution of the latter to the total effect, we also compute the response of the natural rate to a the average expected output loss.

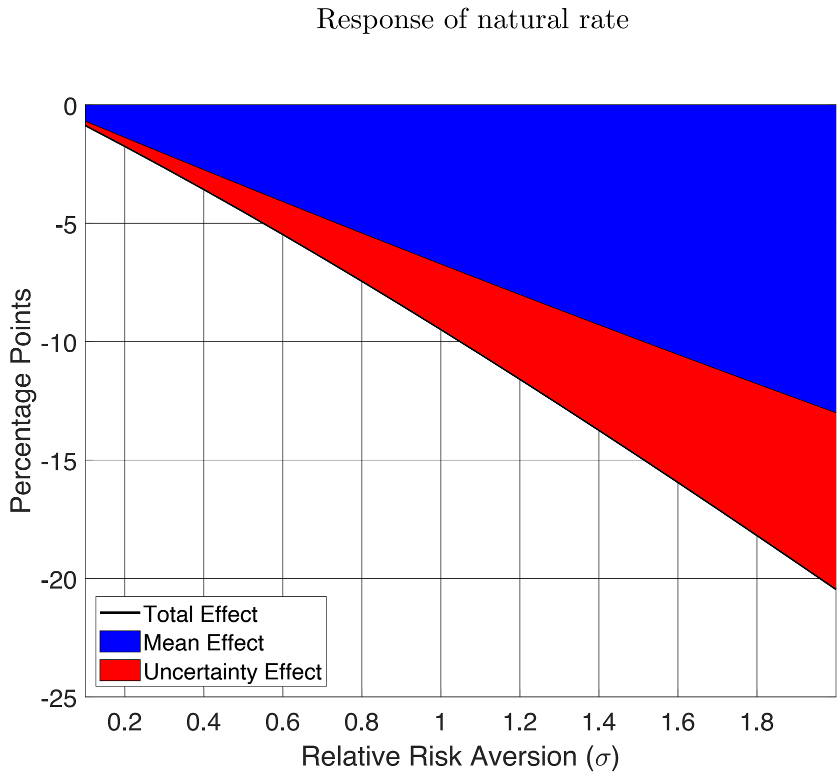

Figure 5: Effect of participants' beliefs (point expectations) about the output loss due to Covid-19 on the natural rate of interest. Computation based on equation (10) and the survey responses. Horizontal axis: alternative values for coefficient of relative risk aversion σ.

Figure 5 shows the results. The vertical axis measures response of the natural rate in basis points, the horizontal axis measures alterative values for the coefficient of relative risk aversion (σ). The larger the coefficient, the stronger the response of the natural rate. For $\sigma = 1$, we find that the natural rate drops by some 900 basis points. For larger values the drop amounts to more than 2000 basis points. Such larger values are certainly not unheard of. Barro (2006), for instances, uses a value of 4 in his baseline parameterization. In any case, there can be no doubt that the effect on the natural rate is large. The contribution of the mean effect dominates the contribution of uncertainty, but the latter also becomes increasingly important as the coefficient of relative risk aversion goes up.

4.2 Macroeconomic adjustment and monetary policy

Next we use the model to study the dynamic adjustment to the shock, using alternative assumptions for monetary policy. We will show in particular, how the adjustment of output and inflation to the shock depends on how closely monetary policy tracks the natural rate. For this purpose, we simulate the model after assigning parameter values. We assume that a period in the model corresponds to one month. We try to choose parameters that are as uncontroversial as possible. For the time-discount factor we set $\beta = 0.9993$. At the annual frequency, this implies a steady-state real rate of interest of 0.8 percent annualized, in line with the latest (pre-COVID-19) estimates using the Laubach and Williams (2003) methodology.[5] We set $\alpha = 1/4$. The own-price elasticity of demand is set to $\epsilon = 11$, a conventional value implying a markup of 10 percent. As for price-stickiness, we choose a monthly price stickiness of $\theta = 0.8^{(1/3)}$. It implies that prices are adjusted rarely, mirroring industrialized economies' inflation experience in the years following the financial crisis. At the same time, it allows for an inflation response that resembles the expected response in the survey. See, for example, the discussion in Corsetti et al. (2013) for the rationale for choosing a rather flat Phillips curve. We choose $\varphi = 1$, implying a Frisch elasticity of labor supply of one, at the upper end of values used in the literature, and in line with an extensive-margin view of the hours worked in the model. Moreover, we set $\sigma = 0.5$ a baseline that is conservative as far as the response of the natural rate is concerned. Last, we assume a steady-state inflation target of 1 percent annualized, so as to mimic the Fed's leeway for cutting interest rates prior to the March 2020 rate cuts.

The shock scenario

In line with the arguments put forward above we assume that the exogenous driving force is an adverse productivity shock with a substantial news component. Specifically, we assume that productivity follows an AR(2) process

$$\log(A_t/A) = \rho_1 \log(A_{t-1}/A) + \rho_2 \log(A_{t-2}/A) + u_t^A, \tag{11}$$

with $\rho_1 = \rho + \gamma$, and $\rho_2 = -\gamma\rho$. Parameters γ and ρ both are $\in (0, 1)$ to ensure stationarity. Here ρ governs the persistence of the AR(2) process after the trough and α governs the propagation to the trough. Our experiment is to feed into the model a sequence of negative and anticipated productivity shocks. We assume that in March (period 0 of our simulations) households learn that $u_t^A = -0.5$ in April, May, June, July, and August 2020. That is, there are negative 0.5 percent innovations to productivity in each of these months. This is a judicious choice. Our goal, then is to use the survey evidence as targets for the TFP process. Toward this end, what we wish to match is an expected fall in average economic activity by 6.5 percent over the course of the first 12 months after the shock. Next to this, we aim for a shock that is persistent so that output is still 2 percent below steady state over the period from month 22 to month 33 after the shock (mimicking the period 2022–2023 for which we

[5] Available at https://www.newyorkfed.org/research/policy/rstar.

ask respondents to provide forecasts in the survey, see 3 above), with the peak effect a little over six months after the news breaks. This leads us to choose $\rho = 0.85$ and $\gamma = 0.9$.

Monetary policy baseline

The simulations require us to parameterize the monetary policy rule. We assume that the central bank follows a standard Taylor rule of the following form

$$i_t = \phi_\pi \pi_t + \phi_y (y_t - y_t^n). \tag{12}$$

We parameterize this as follows: a mild response to inflation $\phi_\pi = 1.2$ and a strong response to the output gap $\phi_y = 1/12$. Note that the model runs on a monthly frequency, so that $\phi_y = 1/12$ is a response as in Taylor-1999. This parametrization in part follows our perception that monetary policy is unlikely to put stronger weight on inflation after a shock that is as severe as the COVID-19 pandemic. Throughout, monetary policy is constrained by a lower bound, which we set at zero nominal interest rates.

Simulation results - baseline policy

We conduct the simulations under perfect foresight with the news about future TFP breaking in period 0. That is, under the assumption that in period 0 households learn about the sequence of shocks. We also use the linearized New Keynesian model for this exercise. In other words, the simulations capture the natural rate effect discussed above but not yet the additional uncertainty effect. Furthermore, it should be noted that this is a setting with a representative household. That is, the model implicitly assumes that insurance contracts exist (or are mimicked by the government) such that there is no idiosyncratic risk.

Figure 6 shows the responses in the baseline under the Taylor rule (12). It focuses on the short run adjustment over the 12 months following the shock. In each panel, the horizontal axis measures time in months, while the vertical axis measures the deviation from the steady state value. Shown are the response in the benchmark (black solid lines). The figure also shows two alternatives. One without the lower bound constraint blue dashed lines, and one if the central bank would not lower interest rates but otherwise follow the Taylor rule (red dash-dotted lines). The shocks, the natural level output, and the natural rate of interest are common to all three scenarios. We discuss these first.

The time path of the exogenous productivity process (11) is shown in the left panel of the second row. Productivity falls gradually, to a trough of -6 percent by the end of the year. Thereafter it gradually recovers (most of the recovery phase is not shown). In line with the analysis in the previous section, the natural rate of interest (third row, right panel) sharply falls in the earlier stages of the crisis; by 3.5 percentage points (annualized) on impact, and continues to fall subsequently, before it starts to recover 5 months after the shock. Averaged over a year this amounts to a fall of the natural rate of interest by 3.5 percent on impact (third row, left panel). Potential output (first row, right panel) tracks the exogenous productivity process. What this implies is that the natural level of output would barely fall on impact.

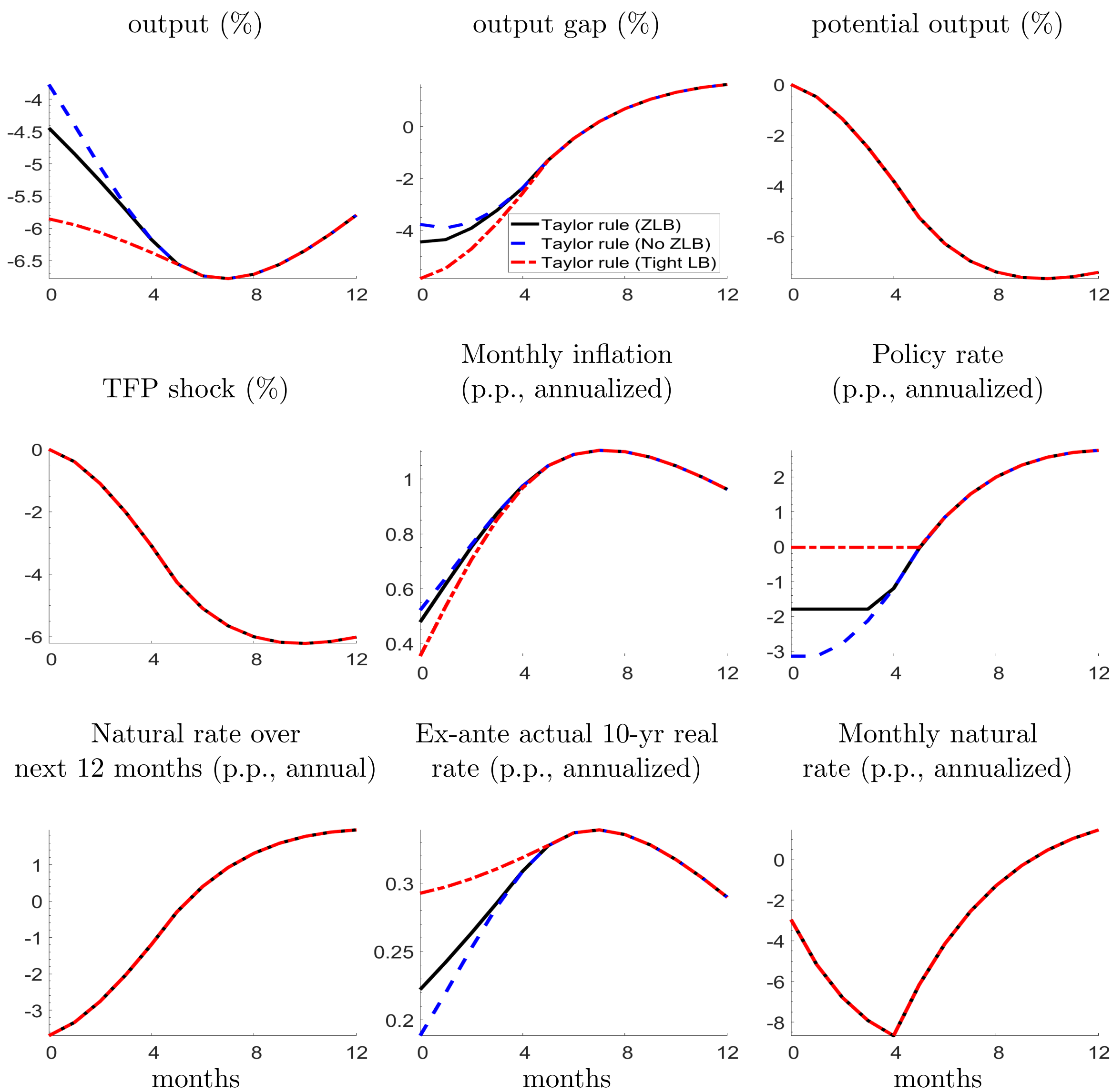

Figure 6: Response to negative productivity shock. Shown are responses under the Taylor rule. Black solid line: ZLB allows for 1.8 percent interest could on impact. Blue dashed line: response of the economy absent the lower bound. Red dashed-dotted line: response of the economy if interest cuts would not be possible.

The other panels show the evolution of the actual economy. We start with the baseline scenario (Taylor rule and ZLB, black solid line). On impact, the monetary policy rate falls by 1.8 percent, to the lower bound (middle row, center panel, black solid line). Still, the policy rate fails to mimic the fall in the natural rate. The cut is not sharp enough, though, to stabilize output in the initial phase (top row, left panel, black solid line). Rational expectations and a limited monetary response in the face of a strong drop in the natural rate mean that the adverse effect of the COVID-19 pandemic is moved forward in time. Output falls by 4.5 percent on impact and output losses average 6 percent over the course of the first 12 months. As a consequence, there is a large negative output gap (top row, center panel). Still, inflation rises on impact. In the context of the model, this is so because eventually, as the shock unfolds, monetary policy turns accommodative (the output gap turns positive, output exceeds potential). Price-setters subject to nominal rigidities anticipate the associated rise in marginal production costs and raise prices early on. The actual long-term real rate of interest (plotted here is a 10 year real rate, bottom row, center panel) increases on impact and more so over time, reflecting the path of future short-term rates.

Figure 6 also illustrates the effect that monetary constraints have on the simulation results. The figure shows two alternative scenarios. In one, there is no lower bound. This is shown as a blue dashed line. The real rate falls by more (see bottom panel, center), so output falls less on impact. Still, under the Taylor rule output falls. In the other alternative that Figure 6, initially there is no monetary accommodation, because policy rates cannot fall or policy makers do not choose to cut rates. This is shown as a dash-dotted red line. If monetary policy no longer accommodates the TFP shock, output considerably more on implact (top row, left panel, dash-dotted red lines).

That is, even though the only shocks are shocks to productive capacity ("supply side shocks"), monetary accommodation is essential early on. This way, the central bank prevents the sharp drop in the natural rate of interest and subsequent reversal to translate into outsized effects on demand at a time when potential output has not yet fallen.

Simulation results - alternative policy assumptions

Figure 7 provides simulations under different policy assumptions. These serve to highlight that insufficient stimulus early can have notable costs. And they serve to highlight that monetary policy distributes the losses in productive capacity to output and inflation.

The black solid line in Figure 7 provides a natural benchmark for the exercise, namely, that of strict inflation targeting. In baseline New Keynesian model shown here, strict inflation targeting would be the optimal monetary policy to follow, if there are no constraints on monetary policy. This perfectly stabilizes inflation and implements the flex-price (natural) allocation. The response of the nominal rate (center row, right panel), therefore, is identical to the response of the natural rate (bottom row, right panel), and output falls along with

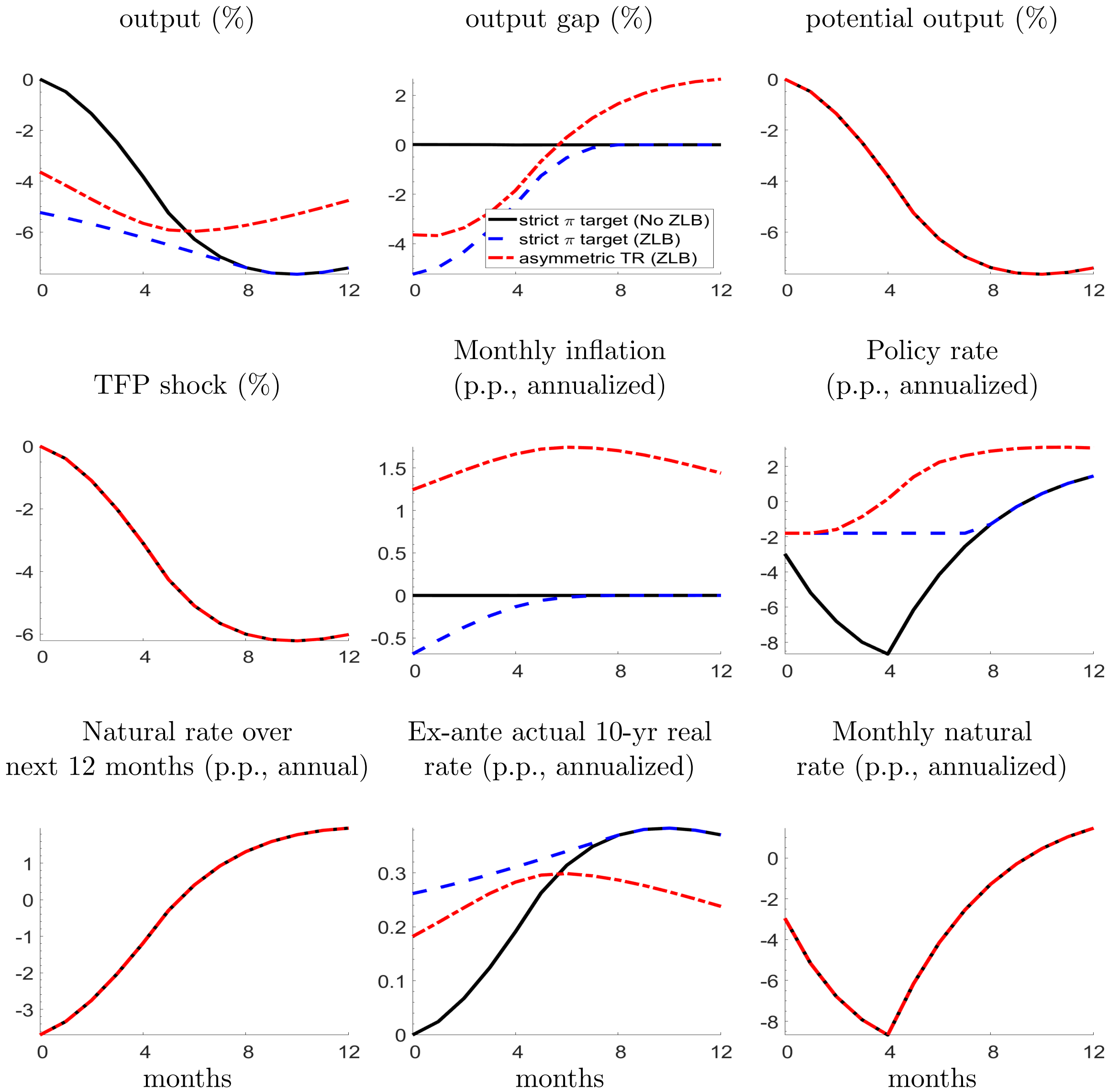

Figure 7: Response to negative productivity shock. Shown are responses for different policy rules under the ZLB. Black solid line: response of the economy with strict inflation targeting, and absent the ZLB (the flex-price allocation). Blue dashed line: strict inflation targeting, but with ZLB in place. Red dashed-dotted line: response of the economy with asymmetric Taylor rule.

potential. What is noteworthy is the size of the interest cuts in the first few months that would be needed to stabilize activity at the natural level. The necessary cuts would be well below those allowed for by the lower bound (still center row, right panel).

By the nature of the shock that we simulate, the productive capacity of the economy eventually is adversely affected. Absent the ZLB, the central bank can let output follow potential. With the ZLB, however, the central bank cannot follow that policy. Next, we implement the policy of strict inflation targeting through a large parameter ϕ_π in the Taylor rule but leave the lower bound in place. Results are shown as dashed lines in Figure 7. The figure shows that a policy of strict inflation targeting that is subject to implementability restrictions imposed by the lower bound, reduces output by more in the initial periods than under the Taylor rule (compare the blue dashed line here to the solid line of Figure 6, top row, left panel each). This scenario also illustrates that monetary policy shapes the effect of the shock on inflation. Instead of the baseline's inflation, disinflation would result (center row, center panel).

The Taylor rule in Figure 6 was tight early on (relative to the natural rate), but accommodative later. If the central bank continues to provide monetary stimulus to support aggregate demand, eventually demand surpasses potential output. In the baseline, Figure 6, this is what happens about half a year after the news of the impact of COVID-19 is realized and explains the inflationary pressures. To highlight this point more clearly, the current Figure 7 shows results under another, more alternative policy (as a red dash-dotted line). We assume that the central bank follows an asymmetric Taylor rule of the following form

$$i_t = \phi_\pi \pi_t + \phi_y (y_t - y_t^n) I(y_t - y_t^n < 0) + \phi_y/2 (y_t - y_t^n) I(y_t - y_t^n > 0).$$

This parametrization assumes that policy will not tighten as rapidly when the output gap turns positive (output exceeds potential) on the recovery path. That is, the policy is more accommodative later on than the baseline Taylor rule. This is inflationary (red dash-dotted line, center row, center panel of Figure 7), but serves to stabilize output in the face of the shock, inspite of the lower bound. The center panel in the bottom row shows that this has notable implications for long-term interest rates.

Yield curves

Figure 8 plots the model-implied change in yield curves for different policies against the changes witnessed in the data. In the left panel we show the yield curve at the beginning of March 2020 (blue dashed line) and the yield curve at the end of our sample (March 23: red solid line). We observe that the yield curved shifts downward at the short end, but much less so at the long end. Our model predictions align well with this observation: In the right panel of the figure we compare the shift of the yield curve in the data (black circles) to the model prediction.

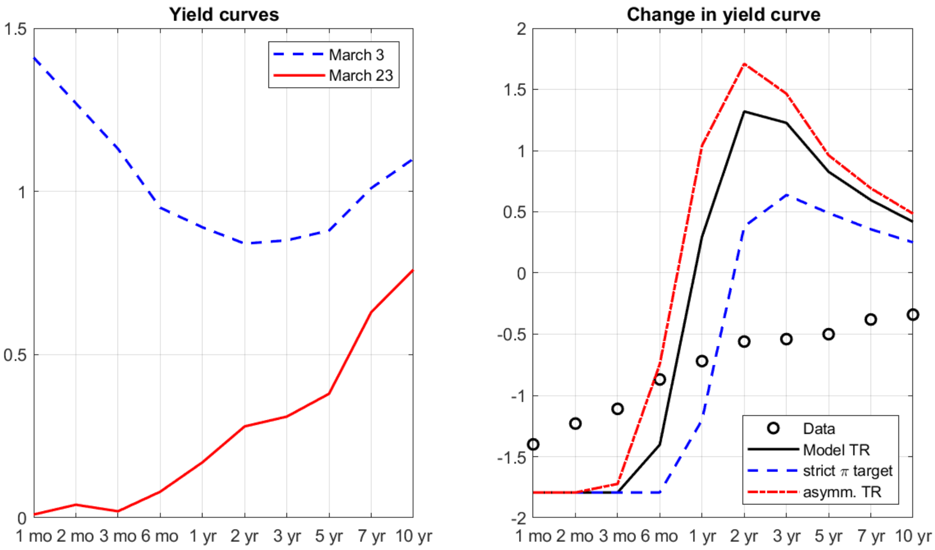

Figure 8: Yield curve. Left panel: financial market implied yield curves on March 3 and March 23 across different maturities ranging from 1 month to 10 years. Right panel: change in yield curves observed in the data (black circles) against effects on the yield curve implied by our simulations. Black solid line: the Taylor baseline shown in Figure 6. Blue dashed line: yield curve effects under strict inflation targeting. Red dash-dotted line: effects under the asymmetric Taylor rule. The latter two are the scenarios shown in Figure 7.

5 Conclusion

The short-run economic impact of the COVID-19 pandemic depends on what people expect its overall effect to be, and how much uncertainty there is about it. To measure household expectations and the extent of uncertainty about the economic impact of the COVID-19 pandemic, we run a survey of household expectations in the U.S, starting in March 10, 2020. This is a relatively early date as far as the spread of the virus in the U.S. is concerned. On that day the number of infections exceed just 1,000 cases but the pandemic had been raging in China for months.

Initially, that is, on March 10, we find that the average expected output loss is basically zero. However, as we ask about the expected output loss 3 days later, the average amounts to 5.8 percent. The responses in the following days are similar, although there is slight trend towards a larger expected loss in the days up to March 20. In this sense our survey captures the arrival of news about the economic fallout caused by COVID-19, as far as U.S. households are concerned. Moreover, and this our second main finding, the responses show a high degree of variation across respondents. Similarly, once we ask respondents to assign probabilities to specific outcomes, the standard-deviation at the level of the individual responses is also large.

This testifies to the uncertainty about the economic costs the COVID-19 pandemic.

In the second part of the paper, we uses the expectations data from the survey to infer the economic consequences in the short run. We feed the distribution of expected output losses into a standard asset-pricing equation and quantify the implications for the natural rate of interest. This exercise is relatively general to the extent that we are not required to make any assumptions beyond this asset-equations to compute the response of the natural rate to the COVID-19 induced expectations and uncertainty about the change of output in the 12 months following March 2020. We find that the natural rate declines by several percentage points–suggesting that monetary accommodation is warranted.

This is noteworthy not least in light of the experience during the 2007–2008 financial crisis. During that period, the Fed lowered short-term interest rates by about 500 basis points, starting in the second half of 2007. Rates were cut all the way to zero by the end of 2008. Clearly today's environment is different. Interest rates already were very low before the COVID-19 outbreak. For this reason, it likely is harder for central banks to accommodate the drop in the natural rate. As discussed in the introduction, the Fed lowered interest rates on March 3 and 15 by 150 basis points in two unscheduled FOMC meetings. Markets did not calm down afterward. Our survey evidence and the theory-based considerations above provide a clear narrative why that was. In this reading, the Fed's rate cuts helped, but they overlapped with the timing of the arrival of bad news and a notable rise in uncertainty.

Finally, we explore more systematically the role of monetary policy for the adjustment dynamics in the short run. For this purpose we rely on the conventional New Keynesian model which we calibrate to monthly frequency. We feed a shock process into the model which lowers potential output, but its peak effect is delayed by a couple of month. In the short-run, that is, prior to the peak effect monetary policy is key. If it is able to track the natural rate, it can stabilize the economy at its potential level. If instead monetary policy is unable or unwilling to lower policy rates, the actual output falls strongly and much more than potential output. This drop is a demand-driven recession which in turn is caused by bad news about medium-term potential output. Hence, we find that monetary is key in the short run. We also note, however, that monetary policy cannot offset the effect of the shock on potential output in the medium run.

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A Appendix

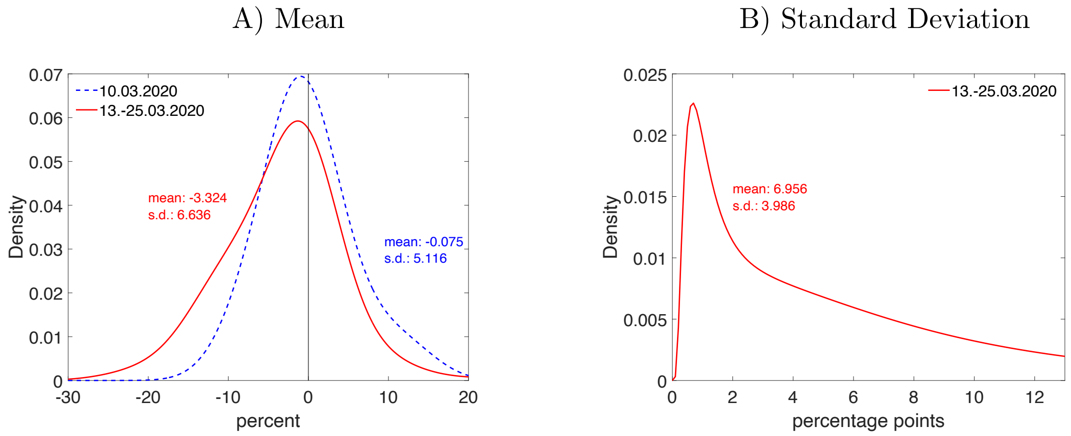

Figure A.1: Expected Output Loss Individual Distribution Data
Description: Kernel densities of survey participants' individual mean of expected output loss and individual standard deviations.

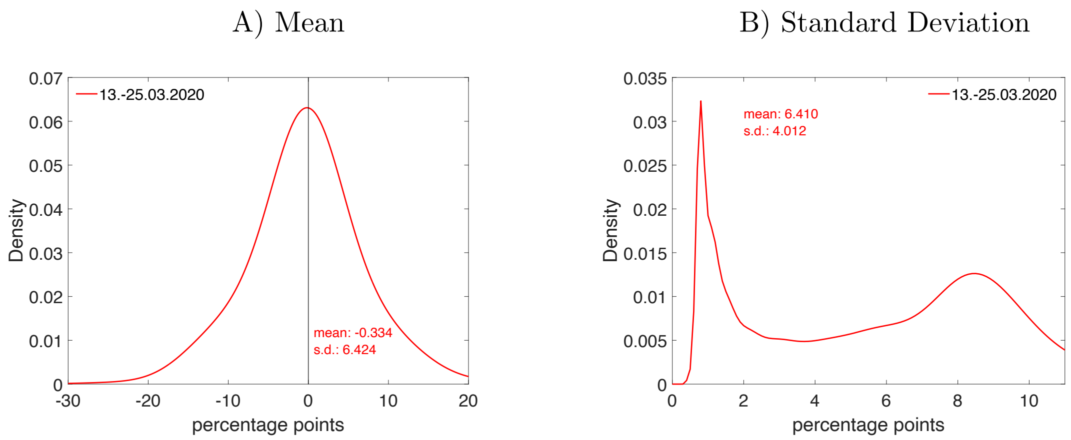

Figure A.2: Expected Inflation Effect Individual Distribution Data
Description: Kernel densities of survey participants' individual mean of expected output loss and individual standard deviations.

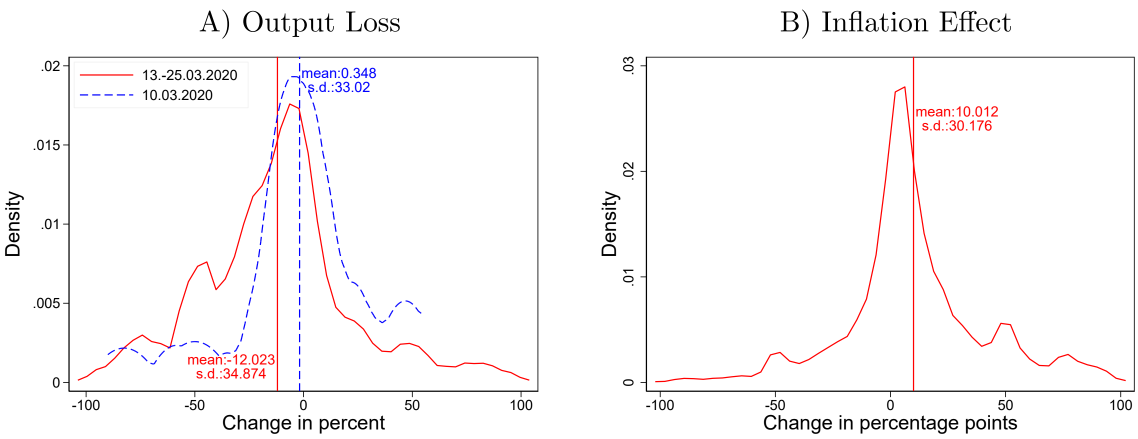

Figure A.3: Expected Output Loss and Inflationary Impact - Full Sample
Description: Kernel densities of survey participants' point expectations of Covid-19 effect on GDP and Inflation. Vertical lines give means. $N_{Y_{13.-22.3}} = 2051, N_{Y_{10.20}} = 31$, $N_{\pi} = 2174$. For GDP and Inflation: Responses between -100% and $+100\%$ included.

Figure A.4: Expected Household Income Loss
Description: Kernel densities of survey participants' point expectations of Covid-19 effect on PHI. Vertical line gives mean. $N_{PHI} = 87$.

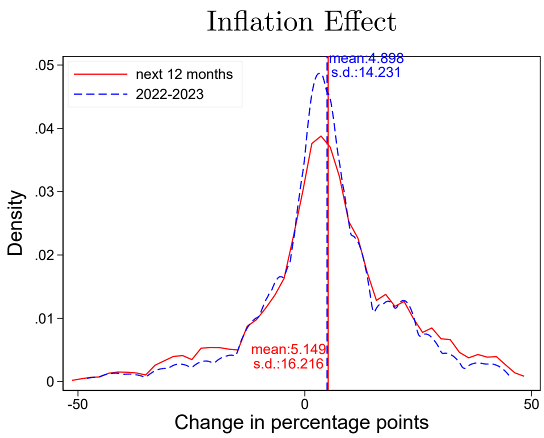

Figure A.5: Expected Inflation Effect - Horizons

Description: Kernel densities of survey participants' inflation expectations due to COVID-19 for the next 12 months (red, solid) and between March 2022 and March 2023 (blue, dashed). Vertical lines give mean. $N = 1294$.