THE EFFECT OF MACROECONOMIC UNCERTAINTY ON FIRM DECISIONS

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Abstract: Using a new survey of firms in New Zealand, we document how exogenous variation in the macroeconomic uncertainty perceived by firms affects their economic decisions. We use randomized information treatments that provide different types of information about the first and/or second moments of future economic growth to generate exogenous changes in the perceived macroeconomic uncertainty of some firms. The effects on their decisions relative to their initial plans as well as relative to an untreated control group are measured in a follow-up survey six months later. We find that as firms become more uncertain, they reduce their prices, employment, and investment, their sales decline, and they become less likely to invest in new technologies or open new facilities. These ex-post effects of uncertainty are similar to how firms say they would respond to higher uncertainty when asked hypothetical questions.

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1 Introduction

The source of business cycle fluctuations has long stymied macroeconomists. Following a sequence of papers contradicting the notion that negative productivity shocks were the source of recessions (most prominently Gali 1999 and Basu, Fernald and Kimball 2000), macroeconomists turned to other possible explanations for business cycles including news shocks (Beaudry and Portier 2006), investment-specific shocks (Fisher 2006), and confidence shocks (Angeletos, Collard and Dellas 2020) among others. One of the most promising ideas emanated from Bloom (2009), when he proposed that uncertainty, a second moment, could be another candidate explanation for business cycles. Unlike most of the competing explanations, the uncertainty hypothesis could identify specific recognizable episodes (e.g., Black Monday) as "shocks" that seemed a priori exogenous to the aggregate economy. Consistent with this explanation, we provide new causal evidence that changes in uncertainty have clear effects on firm decisions.

Following Bloom (2009), a large literature set out to systematically measure uncertainty at the aggregate level (e.g., Jurado et al. 2015), in financial markets (e.g., Caldara et al. 2016), at the level of individual firms (e.g., Bachmann et al. 2013, Altig et al. 2022, Bloom et al. 2020, Handley and Li 2020) as well as uncertainty from specific sources (e.g., policy uncertainty in Baker, Bloom and Davis 2016). Many of these papers also tried to assess how exogenous variation in uncertainty affects aggregate economic outcomes, but as emphasized in Bloom (2014), the very high correlation between the first and second moments makes the identification of exogenous changes in uncertainty using standard time-series timing restrictions a difficult challenge.

A more recent literature has begun to tackle this identification issue by trying to more explicitly isolate exogenous variation in uncertainty to determine how this uncertainty affects outcomes. Bloom et al. (2019), for example, argue that Brexit was primarily an uncertainty shock so that this policy experiment can inform us about the economic consequences of higher uncertainty. Baker et al. (2020) instead use a large number of natural disasters, terrorist attacks and political shocks across countries as instruments that generate different relative changes in first and second moments to show that higher uncertainty reduces growth. Alfaro et al. (2021) exploit industries' differential exposure to first moment shocks (e.g. effects of oil prices on mining vs airlines) with their similar exposure to second moment shocks to identify the effects of exogenous variation in uncertainty on U.S. publicly-held firms' investment, employment, sales and balance sheet positions. Coibion et al. (2021a) apply information treatments about first and second moments of macroeconomic growth

forecasts to randomly selected survey participants in the Euro area to assess how exogenous variation in macroeconomic uncertainty affects ex-post household spending decisions.

Following in this spirit, we propose a new way to identify exogenous variation in firm-level uncertainty by implementing a randomized control trial (RCT) in a survey of firms in New Zealand. In this survey, randomly selected groups of firms were provided with different pieces of information about the aggregate economic outlook (or no information at all). These different information treatments, which include either average GDP forecasts of professional forecasters and/or the difference between optimistic and pessimistic forecasts of professionals, lead to different *relative* changes in firms' first and second moment expectations about future aggregate growth, thereby providing a powerful way to quantify the effects of uncertainty (net of first moments) on firms' decisions. We find that while first moment beliefs have very small effects on actions, exogenous changes in firms' macroeconomic *uncertainty* affect firms' beliefs and decisions statistically and economically significantly along a number of different dimensions.

Firms' decisions and expectations are measured using two separate surveys. The first survey, run between June and August of 2021, focused on measuring what firms were planning to do over the next six months in terms of employment, investment, wages and prices among others, measuring their aggregate expectations, and implementing the information treatment. The second survey, run six months later between November of 2021 and January of 2022, primarily asked firms to report what actions they had taken over the previous six months in terms of the same variables as measured in the first wave as well as some additional dimensions, and also measured their macroeconomic and microeconomic expectations again. Jointly, these survey waves provide us with a clear set of outcome variables that can be used to determine which channels matter in terms of how firms respond to changes in uncertainty.

We find clear *causal* evidence that exogenous changes in uncertainty affect firms' economic choices. Higher macroeconomic uncertainty on the part of firms leads them to reduce their prices, employment and investment over the next six months relative to their prior plans. These effects are economically large: the average effect from our information treatments moved firms from being "extremely uncertain" to "quite uncertain" on average which led them to raise prices by 0.5% and increase employment by 2.5% over six months relative to their prior plans. Changes in uncertainty affect other decisions and outcomes as well. With higher uncertainty, firms experience a decline in sales but increase their advertising. They report that information about the

aggregate economy becomes more valuable to them, both in absolute terms as well as relative to information about their industry. We also find that firms with higher uncertainty are less likely to invest in new technologies or develop new facilities. The effect on wages, however, is effectively zero. Higher uncertainty also does not make firms more or less likely to develop new products.

These results are broadly in line with how firms report they would respond to a *hypothetical* change in their uncertainty. On average, firms report that higher uncertainty would tend to make them more likely to lower prices, employment and investment, experience lower sales, but increase their advertising, consistent with the results of the RCT. They also report that they would be less likely to invest in new technologies or develop new facilities, again consistent with the RCT. A smaller fraction report that they would reduce wages and be less likely to develop new products, results which we could not statistically confirm or reject in the RCT. These results suggest that hypothetical questions can provide a useful alternative to RCTs to assess how agents would respond to different scenarios, consistent with Mei and Stantcheva (2022). Another advantage of these hypotheticals is that they can provide answers for additional margins of adjustment that are not easily observed in surveys. For example, firms in New Zealand report that higher uncertainty would make them less likely to seek out new export markets (we do not have enough variation along this margin in our survey to quantify this margin), as well as less likely to seek out new loans but more likely to hold cash, precautionary financial mechanisms that we did not otherwise ask firms about for the RCT due to space constraints.

Jointly, these results provide new evidence on how uncertainty affects firm decisions. But what do they mean about the specific types of uncertainty that matter? Previous work measuring uncertainty at the firm level has focused primarily on microeconomic uncertainty, e.g. uncertainty about future sales growth of the firm. Our survey measures both micro and macro uncertainty, and as one might expect they are generally quite strongly correlated. However, our information treatments lead to large changes in firms' macroeconomic uncertainty but only small changes in microeconomic uncertainty. Furthermore, when we control for these changes in firms' beliefs about their own future sales, both in terms of means and uncertainty, our results on the effects of macroeconomic uncertainty on firms' decisions are unchanged. This indicates that firms' perceptions about the future macroeconomic outlook matter above and beyond the implications for their own future sales. We interpret this as suggesting that when measuring firm-level uncertainty, it is important to not just capture firms' uncertainty about their outlook over their own

immediate sales but also to capture uncertainty about broader economic conditions and policies, as emphasized in Baker et al. (2016) and Alfaro et al. (2021). This interpretation can also help explain why some aggregate uncertainty shocks like Brexit can have broad contractionary effects on many firms, even when they are not directly exposed to trade with the EU (Bloom et al. 2019).

Prior work in the uncertainty literature has long emphasized the importance of firms' decision-making under uncertainty (e.g., Guiso and Parigi 1999, Bloom et al. 2007, Baker et al. 2016, Gulen and Ion 2016). One of our contributions relative to these papers is to provide more direct identification of the causal effects of aggregate uncertainty on firms' decisions by relying on information treatments that are randomly allocated across firms. But in finding that higher uncertainty leads firms to reduce employment and investment, our results are in line with much of this prior evidence. After instrumenting by industry exposure to changes in the volatility of oil prices, exchange rates and policy uncertainty, Alfaro et al. (2021) similarly find that firms who experience higher stock market volatility, either implied or realized, tend to reduce their investment and employment, although we estimate much larger effects on decisions than Alfaro et al. (2021). A second contribution relative to this existing work is that we are able to assess the effects of uncertainty on many additional margins of adjustment, such as prices, advertising, and opening of new facilities or product lines as well as how much firms value information. The fact that uncertainty affects firms along a wide range of new dimensions suggests that there is a need for theoretical models of firm-level uncertainty to expand the scope of decisions that are included. Our third contribution is to identify the effect of uncertainty without changing ex-post volatility, whereas most empirical work identifies their joint effect (e.g. Bachmann et al. 2019). Aruoba et al. (2022) similarly are able to isolate the uncertainty effect using riots in Chile.

Our use of RCT methods to study a macroeconomic question is part of a growing literature. Early work in this spirit by Armantier et al. (2016) and Cavallo et al. (2017) studied how information about inflation affected households' inflation expectations. Subsequent work by Coibion et al. (2022) and Coibion et al. (2019) showed how to extend this strategy to characterize the effect of inflation expectations on household spending. RCT methods were also used by Coibion et al. (2018) to study how firms' inflation expectations affect their subsequent pricing, investment and employment decisions. In the uncertainty literature, however, the use of RCTs is much less common. The closest paper to ours in that context is Coibion et al. (2021a), who apply a similar set of information treatments as ours to households in an ECB survey to study the effect

of uncertainty on household spending. Roth and Wohlfart (2020) use information treatments about the economic outlook to study how households' expectations about future growth affect their consumption plans. We expand on this earlier body of work by bringing this RCT methodology to *firm-level* decision-making under uncertainty. This is a key innovation because RCTs on firms are difficult to implement on firms in advanced economies and require significant resources (see Candia et al. 2022 for a discussion of challenges).

2. Data and Survey Design

We ran two new waves of a survey of firms in New Zealand, similar in structure and design to previous surveys described in Coibion et al. (2018) and Coibion et al. (2021b). The first wave of the survey, implemented between June and October of 2021, included approximately 4,000 firms that are broadly representative of the New Zealand economy in terms of sectors and employment coverage by firm size, although agriculture, energy, mining, and community and public administration services were excluded. The second wave of the survey was conducted between November 2021 and February 2022 and included approximately 2000 firms. We conducted the survey through Auckland Field Research Consulting Limited (AFRCL), which is a private limited company specializing in conducting firm-level surveys.

The population of firms in the survey is around 25,000 and their basic details were supplied by AFRCL.[1] Following the Australia and New Zealand Standard Industrial Classification 2006 (ANZSIC06), firms were classified into two broad industries: manufacturing and services. The latter included firms from sectors such as professional and financial services, trade, construction, communication and transportation. Firms included in the survey employ at least six workers. Around 60 percent of the population in the survey are firms from the manufacturing and the professional and financial services sector. All the firms from these two sectors were included in the population. The remaining 40 percent of the firms in the population were randomly selected from other sectors such as construction, trade, and transportation.[2] Within each sector, firms are classified as small (6-19 employees), medium (20-49 employees) and large (50 or more employees). Appendix B Tables B.1-7 provides the details of the population of firms included in the survey as well as the general population of firms in New Zealand.

[1] AFRCL has compiled a comprehensive database of private firms in New Zealand.

[2] The other sectors included all firms that employ at least 20 workers and the balance of firms was randomly selected.

We invited firms in the population to participate in the survey. The respondents of the survey were firm managers, CEOs, or directors. As recruitment of survey participants is a challenging task, we hired independent recruitment specialists who were able to facilitate the recruitment process and help increase the response rate. In the first stage, the recruitment of participants was done by phone. Those who consented to participate in the survey were then sent an email including the survey questionnaire and information sheet. In the second stage, an appointment was made with the manager, CEO, or director to participate in a phone survey. Most of the survey was conducted from a call center in Auckland where temporary research assistants were hired to interview the firm managers. The research assistants recorded the responses by hand in the first instance and then recorded them later into a spreadsheet. The phone conversations between the research assistant and the respondent were electronically recorded and were deleted later upon verification. We received a 16% response rate in the first wave; see Appendix B Tables B.3-6 for details on response rates.

The second wave of the survey was a follow-up to firms that participated in the first wave. In terms of timing, firms participated in the follow-up survey approximately five or six months after the first wave. The response rate for the follow-up survey was around 49 percent. There is little predictability in terms of observable characteristics for which firms chose to participate or not in the second wave, as shown in Appendix Table 1-2. The follow-up survey gave respondents a monetary incentive of $30 worth of dinner or an entertainment voucher.

The quality of the survey data is reasonably high. We verified our survey data against publicly available online information, as in Coibion, Gorodnichenko and Kumar (2018) and Coibion et al. (2021b). First, we verified the manager's response about the age of the firm. To do this, we used the Companies Office register. For firms that do not appear on the Companies register, we investigated their year of establishment via their webpage. We find that the reported age in the survey matches exactly with the information available in the Companies Office or their webpage for 93 percent of the firms. Information about the firm age for the remaining 7 percent of the firms is not publicly available. Second, we verified the manager's response on whether the firm exports or not. This verification was done through the firm's webpage. For 92 percent of the firms that indicated they export, this information could be confirmed on their webpage. Third, the survey asked respondents to identify the main product of the firm. On this front, around 97 percent of the survey responses on the main product were consistent with the information available on the firm's webpage, that is, the main product is listed as the featured product on their webpage. Fourth,

we asked respondents to reveal the number of shareholders in the firm. To this end, 94 percent of the responses match exactly with the shareholding information available in Companies office. We were unable to verify the shareholding information for the remaining 6 percent of firms. Fifth, we asked respondents to tell us whether the firm is owned locally or overseas. For almost all of them, the firm ownership information is available online and matches their responses. Lastly, the survey asked respondents to indicate whether the firm invests in advertising or not. For around 83 percent of firms, we find their advertisements are available online. We expect that the remaining 17 percent of firms engage in advertising that is not through online sources. These assessments suggest that the overall quality of data is quite high.

We present some characteristics of firms and individual respondents in Table 1. Managers tended to be males (67%) and have extensive experience in both their firm (average tenure of 10 years) and their industry (average tenure in the industry of 27 years). Most managers/CEOs were college-educated or above (>50%), although 30% had only attended some college and 15% had only a high school diploma. The average firm in our sample was 25 years old with 31 employees, although the dispersion in both statistics is large. The largest firm in our sample had 2,300 employees. Managers reported that their firm faces 11 competitors on average, with most being focused exclusively on the New Zealand market (less than 5% of firms reported doing any exporting). Almost 70% of firms engaged in some advertising and 35% of firms reported investing in R&D.

From the point of view of measuring the effects of uncertainty on firm decisions, our survey has three crucial dimensions. First, one must measure the prior beliefs of firms about both their own future actions as well as their initial perceived levels of uncertainty. Second, one must implement randomized information treatments to generate exogenous variation in beliefs. Third, one must then be able to measure changes in beliefs (if any) from the treatments as well as the ex-post decisions of firms. We describe each of these steps in turn.

2.1 Measuring Prior Beliefs and Plans

The first wave of the survey aimed to measure the prior beliefs and plans of firms. Most of the firm-specific plans were measured as point forecasts. For example, firms were asked to provide specific values for their planned changes in prices, wages, employment and investment over the next 6 months as follows:

> *Over the next 6 months, by how much (in % changes relative to current levels) do you anticipate to change:*

a) The price of your main product: …… %
b) Total employment at your firm: …… %
c) Capital stock at your firm: …… %
d) Average wages at your firm: …… %

Table 1 reports average predictions of firms about each of these plans. In the summer of 2021, the average reported price change over the next six months was just 0.4% while the average predicted wage growth was just 0.2%. Employment growth was expected at 0.5% over the next six months, and the capital stock was expected to grow by 0.1% on average. The median response to each question was zero, indicating that most firms were not planning to adjust either prices, wages, employment, or their capital stock at all. Firms were also asked about how they expected their margins to change over the same time period, but because of the need to define what notion of margin was meant, this question was framed somewhat differently:

> *Now think of your percentage operating margin, i.e. the % by which your average price exceeds your average operating cost (the cost of material inputs if any plus labor costs but not overhead). By how many percentage points do you think this margin is likely to change over the next six months?*
>
> *I expect my operating margin to increase by ……. % points over the six months.*
> *I expect my operating margin to stay about the same over the next six months.*
> *I expect my operating margin to decline by ……. % points over the next six months.*

Note that this formulation of the question explicitly avoids asking firms about the level of their margins (which they are often very reticent to reveal). While most firms reported that they did not expect their margins to change at all over the next six months, the standard deviation of responses was one percentage point, indicating that some firms were expecting non-trivial increases or decreases in their margins.

Some additional plans were measured solely using the extensive margin of adjustment, as per the following question:

> *Over the next 6 months, do you plan to do any of the following:*
>
> | | | |
> |---|---|---|
> | *Introduce any new major products or services* | *Yes* | *No* |
> | *Expand to new export markets* | *Yes* | *No* |
> | *Invest in major new technologies/equipment?* | *Yes* | *No* |
> | *Open new production, retail, or office facilities* | *Yes* | *No* |

Because these types of decisions are made infrequently, we focused only on the extensive margin of the decisions to conserve on survey space. As reported in Table 1, only 12% of firms reported that they were planning to introduce any new major products or services, 12% of firms reported that they were planning to invest in major new technologies and equipment, and 14% of firms

reported that they were planning to open new facilities. The fraction of firms reporting that they were planning to expand to new export markets was only 1%, consistent with the fact that almost all of the firms in the survey concentrate exclusively on the New Zealand market.

For some economic outcomes, firms were first asked about both whether they engage in this specific type of behavior, and if they responded in the affirmative, they were then asked for their plans over the next six months. For example, for advertising, the question posed to firms was:

> *Do you invest in advertising? If so, by how much do you expect your monthly advertising budget to change over the next 6 months? (please provide a quantitative answer as a % change)* *Yes No* *[If Yes]: ……. %*

As reported in Table 1, 68% of firms in our sample reported that they engage in any advertising. For these firms, the average expected change in their monthly advertising budget was 2.4% over the following six months. A similar question was asked for R&D, with 35% of firms reporting that they engaged in any R&D activities. Among those, the average expected change in R&D spending was 1.1%.

For expected sales growth, firms were asked to characterize a distribution of outcomes, so that we could measure both mean forecasts as well as their uncertainty about future sales, as done in many papers on firm-level uncertainty (e.g., Altig et al. 2022). In the first wave, this was done through the following questions:

> *Now we'd like you to think about what you perceive as the highest and lowest possible annualized growth rate in sales for your firm over the next 6 months. What do you think the lowest and highest growth rates might be for this time period? (please provide an answer as % per year).*
>
> *Lowest sales growth rate: ……. % per year*
> *Highest sales growth rate: ……. % per year*
>
> *What is the probability that annualized growth rate of your sales exceeds* [(min+max)/2] *% per year over the next six months? ……. %*

This type of question has been used extensively in the literature to provide measures of both first and second moments under the assumption of a triangular distribution (e.g., Manski 2004). The average growth rate of firms reported is 1.8% over six months, with a standard deviation of almost 2 percentage points (Table 1). We interpret answers to this question as providing us a measure of the microeconomic uncertainty faced by firms, since the variable is a firm-specific outcome. Note that unlike most of the other firm-level expectations collected, sales are not directly under the

control of the firm and reflect a combination of production decisions of the firm, their pricing and marketing decisions, and of course the demand for their products.

Because we are interested in measuring not just microeconomic but also macroeconomic uncertainty, we ask firms two additional questions using the same formulation but focusing on GDP growth as well as inflation. For example, the question for GDP is:

> *Now we'd like you to think about what you perceive as the most pessimistic and most optimistic economic outlooks for New Zealand over the next 6 months. What do you think the lowest annualized GDP growth rate might be for this time period and what do you think the highest might be? (please provide an answer as % per year).*
>
> *Lowest growth rate: ……. % per year*
> *Highest growth rate: ……. % per year*
>
> *You said that the lowest value is XXX and the highest value is YYY. The midpoint of this range is ZZZ=*[(min+max)/2] *% per year. What is the probability that the growth rate of the economy exceeds this midpoint at an annualized rate over the next six months?*
>
> *……. %*

As reported in Table 1, firms were expecting an average annualized growth rate of GDP of 3.3% over the next six months, with an average variance in their implied distribution of 1.8. As we will see shortly, this average forecast was broadly in line with the forecasts of professionals at the time. However, there was pronounced disagreement in these forecasts across firms: the cross-sectional standard deviation of expected GDP growth is 1.5 percentage points, indicating that some firms were much more optimistic than others. There is also disagreement in terms of uncertainty: the cross-sectional standard deviation of uncertainty is 1.7, so some firms were much more confident in their forecasts than others. Inflation expectations display a similar pattern, albeit with a higher mean forecast of 4.6%, a feature consistent with other surveys of firms' inflation expectations.

In addition to these quantitative questions about their macroeconomic expectations, firms were asked a qualitative question about how uncertain they were in their macroeconomic outlook.

> *How would you characterize the current macroeconomic outlook over the next 6-12 months in New Zealand?*
>
> a. *Extremely uncertain*
> b. *Quite uncertain*
> c. *Somewhat uncertain*
> d. *Not particularly uncertain*
> e. *Not uncertain at all*

The modal firm responded that their outlook was "extremely uncertain", with the range of answers going from "not uncertain at all" to "extremely uncertain." We describe the properties of these different macroeconomic and microeconomic expectations in more detail in section 2.4.

Finally, the survey included a number of questions meant to provide more nuance on how informed managers were about economic conditions in the New Zealand economy, where they received their information and how valuable they perceived that information to be. For example, we asked managers how much they would be willing to pay per year to have access to a monthly magazine of professional forecasts (answer: nearly $500 with a standard deviation of about $250). We also asked them whether they participated in any professional associations and if so, how many, in what type of association (e.g. union, trade organization), how often they attended meetings (weekly, monthly, etc.), and whether they contributed information to this association. We asked them similar questions about how often they contributed information about economic trends and conditions to peers outside of professional organizations, as well as with customers or suppliers. A related question we posed them was how many times per month they spoke to a typical customer, supplier, or peer firm about economic trends. On average, firms reported numerous conversations with customers (12 per month), as well as fewer but still frequent talks with suppliers (6.4 per month) and peer firms (4.3 per month). We also asked firms to place a dollar value of the information they received about economic trends from professional organizations, peer firms, customers and suppliers jointly. The average response was nearly $250 per year, with a large standard deviation of $176.

Finally, we tried to measure how firms valued information about aggregate conditions relative to information about their industry, both on average and at the margin. Firms were first asked the following question:

> *Suppose you are looking ahead to 2022. You are choosing how to allocate the first $100 to acquire information. You can learn about economic conditions in your industry and/or the aggregate New Zealand economy. How much would you allocate to acquiring information about each? The total should sum to $100.*
>
> *Your industry:* ……. *$*
>
> *New Zealand economy:* ……. *$*

On average, firms reported that they would allocate just over 25% to information about their industry and nearly 75% to the aggregate economy (with a standard deviation of about 20%). This indicates that overall, firms view information about the aggregate economy as very useful. They were then asked a follow-up question to assess the value of information at the margin:

Suppose you buy a $2 charity ticket and you enter into a draw to win a prize. If you win the ticket, you will be offered to choose one of the two prizes. Which prize will you choose from below (Please select one)?

a. *Annual subscription to a national newspaper*
b. *Annual subscription to your industry magazine*

Ninety percent of firms reported that they would pick a subscription to an industry magazine rather than a national newspaper (standard deviation of 30%). We interpret this as indicating that at the margin, firms are more interested in information about their sector.

2.2 Information Treatments

Following this initial set of questions in the first survey wave, firms were then allocated randomly to one of four groups. One group was not provided any information. This is the "control" group. Those firms instead immediately moved on to a set of follow-up questions described in section 2.3. The other three groups were each provided with a piece of information about the macroeconomic outlook. These are the "treatment" groups. Appendix Table 2 verifies that we cannot predict which group firms were assigned to based on any observable characteristics.

The first treatment group was provided with the most recent set of professional forecasts for the growth rate of New Zealand from Consensus Economics. Specifically, they were told:

"We are going to give you information from a group of leading experts about the economy. The average prediction among professional forecasters is that New Zealand's GDP will grow 4% in 2021."

Note that this average forecast of professional forecasters is somewhat higher than the average forecast of firms but covers the entire year whereas firms were forecasting the annualized growth over the second half of 2021.

The second treatment group was also provided with information about the New Zealand economy. However, in this case, they were told about the dispersion in growth forecasts of professional forecasters. Specifically, they were told

"We are going to give you information from a group of leading experts about the economy. These professional forecasters are quite uncertain about the outlook for the New Zealand economy. The difference between their optimistic forecast and pessimistic forecast is approximately 3.1 percentage points for the 2021 GDP growth rate."

Note that this treatment does not provide any explicit information about first moments and only describes the magnitude of the *difference* between the most optimistic forecaster and the most pessimistic forecaster. The treatment also does not explicitly provide information about the

uncertainty in professional forecasts but rather about the disagreement among professionals. This was a deliberate choice since traditional measures of uncertainty in macroeconomic forecasts such as the confidence interval around point forecasts are difficult to communicate to non-economists. The difference between optimistic and pessimistic forecasts, on the other hand, is more intelligible and, because it was presented shortly after firms were themselves asked to provide minimum and maximum values for GDP growth rates, it is immediately comparable to their own answers.

The third treatment group received information which was a combination of the information in the first two treatment groups. Specifically, they were told:

> *We are going to give you information from a group of leading experts about the economy. The average prediction among professional forecasters is that New Zealand's GDP will grow 4% in 2021. They are quite uncertain about the economic outlook for the New Zealand economy. The difference between their optimistic forecast and pessimistic forecast is approximately 3.1 percentage points for the 2021 growth rate.*

This group, thus, received information about both the level of professional forecasts of New Zealand's economic growth as well as the amount of disagreement among professionals about the outlook.

Subsequently, all firms—including those in the control group—were asked an identical set of follow-up questions that conclude the first wave of the survey.

2.3 Measuring Posterior Beliefs and Decisions

To discern whether the information treatments have any effect on the first and second moments of firms' macroeconomic expectations, it is necessary to re-measure firms' beliefs after the treatment. We did so twice: first, immediately after providing the information treatment and second, in the follow-up wave six months later. This allows us to assess both the instantaneous effect of the treatment as well as the persistence of any treatment effect on macroeconomic expectations.

Because survey participants strongly dislike being asked the same question multiple times, we measured the posterior expectations of firms in the first survey wave using a different question formulation than that used to measure the prior expectations. First, we changed the horizon over which expectations are measured to the next 12 months, rather than 6. Second, we changed the way in which the distribution of beliefs is measured. Specifically, we followed the approach developed in Altig et al. (2022) of first asking respondents to define what they consider to be maximum, minimum, medium, medium-high and medium-low outcomes for a variable of interest, before then asking them to assign probabilities to each of their specified list of possible outcomes. For GDP growth, the exact formulation is then:

What do you think the growth rate of the New Zealand economy will be over the next twelve months in each of the following scenarios:

Your most pessimistic outlook:	*% per year*
Your somewhat pessimistic outlook:	*% per year*
Your middle-of-the-road outlook:	*% per year*
Your somewhat optimistic outlook:	*% per year*
Your most optimistic outlook:	*% per year*

Once firms had provided these 5 different forecast values, they were asked the follow-up question:

Now, please tell us what probability you would assign to each of the five outlooks you just described. The probabilities should sum to 100.

Probability that your most pessimistic outlook comes true:	*%*
Probability that your somewhat pessimistic outlook comes true:	*%*
Probability that your middle-of-the-road outlook comes true:	*%*
Probability that your somewhat optimistic outlook comes true:	*%*
Probability that your most optimistic outlook comes true:	*%*

From the responses to the two questions, one can then readily construct implied mean forecasts as well as the implied standard deviation around the forecast. Furthermore, because the question asks firms to provide minimum and maximum forecast values, the spread between the two can be directly compared to the spread asked in the question that measures the prior beliefs. The question formulation designed by Altig et al. (2022) has a number of useful properties. First, it has respondents provide probabilities to a range of outcomes, so one does not need to assume something like a triangular distribution. Second, because the firms themselves define what the possible outcomes are, this formulation avoids the many possible biases associated with questions that predefine what the bins are. Third, as shown in Altig et al. (2022), the resulting measures of firms' first and second moment beliefs line up with ex-post measures of their actual outcomes and volatility in outcomes respectively.

We applied the same formulation to measure posterior beliefs about expected sales growth and expected inflation as well in the first wave. Table 1 indicates that the average predicted GDP growth rate of firms in the control group stemming from this follow-up question was 3.4%, very close to the 3.3% average from the first question. The cross-sectional dispersion in expected GDP growth rates from the control was also quite close to what was observed with the Manski (2004) question formulation: 1.7% vs 1.5%. However, the average uncertainty in GDP forecasts was significantly higher with the Altig et al. (2022) formulation: 5.0 vs 1.8. Part of this may reflect the longer time horizon for the forecast. But in addition, the Manski (2004) formulation imposes a probability mass

of zero on the minimum and maximum values whereas the Altig et al. (2022) formulation allows firms to assign positive probabilities to these questions. As a result, one should naturally expect higher implied uncertainty from the Altig et al. (2022) question than the Manski (2004) question. Indeed, we observe this property for inflation and sales growth forecasts as well, indicating that one needs to be mindful of this level effect in comparing the prior and posterior measures of uncertainty.

In addition to measuring posterior expectations, we need to measure the ex-post decisions and outcomes for firms to be able to determine whether changes in expectations had any effect on economic decisions. These outcomes are consistently measured in the follow-up wave, using question formulations that mimic as closely as possible those used to measure plans in the first wave. For example, for prices, wages, employment and capital, firms in the follow-up wave were asked:

> *Over the last 6 months, by how much (in % changes relative to current levels) did you change:*
>
> *a) The price of your main product:* ……. *%*
> *b) Total employment at your firm:* ……. *%*
> *c) Capital stock at your firm:* ……. *%*
> *d) Average wages at your firm:* ……. *%*

This is the exact same formulation as before but with timing referring to the previous six months. We applied the same strategy for other firm outcomes. For example, for decisions in which we had only measured the extensive margin of plans, we simply asked firms in the follow-up wave whether they engaged in any of those activities over the previous six months. The same logic was applied to questions involving change in margins or questions focusing on advertising and R&D. To measure macroeconomic expectations in the follow-up survey, we use the exact same questions as those used to measure posterior beliefs in the first survey wave, again asking for 12-month ahead forecasting horizons. Exact question formulations are in Appendix C. Appendix Table 1 shows that participation in the follow-up was not systematically different across treatment groups.

Prior work has documented that firms' answers to questions about their predicted actions are, on average, very strong predictors of their ex-post decisions (e.g., Coibion et al. 2018, Altig et al. 2022). This is the case here as well. As documented in Appendix Figure 1 which plots binscatters of the ex-post decisions of firms in the control group against their ex-ante forecasts for prices, employment, capital stocks and wages, the relationship between ex-ante plans and ex-post decisions lies very close to the 45° line. In other words, firms that claim that they are going to raise their prices more than other firms ex-post do end up on average having raised their price significantly more than other firms. Similar results can be seen for employment, investment and wage outcomes across

firms. This indicates that the quality of the information provided by firms is quite high despite the six-month difference in timing between the measurement of ex-ante plans and the ex-post outcomes.

2.4 Unconditional Properties of Firms' Expectations

To get an initial sense of the characteristics of firms' macroeconomic and microeconomic expectations, Figure 1 plots the cross-sectional correlation of firms' first and second moment expectations for GDP growth (Panel E), inflation (Panel F) and sales (Panel G). For both inflation and GDP growth, we observe a strong positive correlation between first and second moments. Those firms who initially expected higher GDP growth tended to be the same firms who were also more uncertain about future GDP growth, and similarly for inflation. With sales, the pattern is much more U-shaped, as also documented in Altig et al. (2022): high uncertainty firms tended to expect either quite negative or positive sales growth.

Are some firms systematically more uncertain about everything? Is microeconomic uncertainty related to firms' perceptions of macroeconomic uncertainty? Figure 1 presents cross-sectional correlations of firms' expectations about different variables, both for uncertainty (left column) and mean forecasts (right column). Panel A, for example, illustrates a rather strong positive correlation between micro and macro uncertainty: firms who were more uncertain about the aggregate economic outlook also tended to be more uncertain about their own sales outlook. However, this correlation is far from perfect. Among firms that were relatively confident about the macroeconomic outlook, there were some firms that perceived little uncertainty in their sales but many were very uncertain about the outlook for their firm. This is consistent with the notion that macroeconomic volatility is only one of many possible sources of volatility that firms face and some may be very uncertain about their outlook for reasons that have nothing to do with the aggregate economy. However, among firms that were very uncertain about the macroeconomic outlook, the vast majority were also quite uncertain about the outlook for their firm. This suggests that few firms considered themselves immune to macroeconomic uncertainty.

Panel C considers the correlation between firms' uncertainty about inflation and GDP growth. We can observe a strong positive correlation. There was a group of firms that was very confident in their outlook for both inflation and GDP growth. There was another group of firms that was less so but still relatively confident about both inflation and GDP. Finally, the remaining group of firms appeared very uncertain about both inflation and GDP growth. This suggests that

firms view macroeconomic volatility as closely related across real and nominal outcomes. This strong positive correlation also holds in levels (Panel D): firms who anticipated higher GDP growth systematically tended to anticipate higher inflation. A similar pattern holds for expectations of GDP growth and sales. Firms that expected higher aggregate growth tended to be the same firms that expected their sales to rise more sharply.

How should we interpret the magnitudes of uncertainty? Are these firms very uncertain or very confident overall? We do not have a time series for this measure of uncertainty, so it is difficult to make a quantitative statement about the level of uncertainty. However, because our survey also included a qualitative measure of uncertainty, we can get a sense of how different values for the variance of a forecast compare to qualitative descriptions. This is done in Figure 2 which plots the average uncertainty (measured by the variance of the posterior distribution) for inflation, GDP growth and sales reported by firms that select each of the qualitative uncertainty bins. For example, for firms who said they were not particularly uncertain (this corresponds to 5% of firms), their average uncertainty was about 0.3 in terms of inflation and real GDP growth and 0.8 for sales growth. For comparison, firms who selected that they are extremely uncertain about the economic outlook (about 55% of firms) had average uncertainty levels that ranged from almost 8 for GDP growth to about 3 for sales growth. On average, we see clear increases in the average variances of forecasts as qualitative descriptions of uncertainty increase, confirming that firms' quantitative forecasts speak to the actual uncertainty that they perceive. Overall, almost 75% of firms reported that they were quite or very uncertain about the macroeconomic outlook, which likely reflects the fact that the survey was run during the pandemic era when macroeconomic uncertainty was quite high worldwide.

Unconditional levels of uncertainty appear to be related to firms' economic decisions in ways that would be consistent with theoretical predictions. For example, when firms are more uncertain, their bands of inaction should be larger. Hence, we should expect firms to report that they are less likely to change prices, wages, employment or investment when they are more uncertain. Figure 3 presents binscatters of firms' macroeconomic uncertainty against the probability of firms in that bin reporting that they expect to change prices (Panel A), employment (Panel B), investment (Panel C), or wages (Panel D) over the next six months, after controlling for firm demographics and firms' expectations for the level of economic growth. In each case, we observe a clear negative correlation, consistent with more uncertain firms having larger inaction bands for each margin of adjustment. However, while consistent with theory, this relationship is

only a correlation. Establishing a *causal* relationship between uncertainty and firms' decisions requires an identification strategy that can isolate exogenous variation in firms' uncertainty.

3. The Effects of Information Treatments on Expectations

The key to characterizing whether and how uncertainty affects economic decisions is identifying exogenous variation in uncertainty. Our RCT approach was designed precisely for this purpose by using information treatments that provide different types of information about first and second moments of economic activity in New Zealand. In this section, we describe how information treatments affected the economic expectations of firms in our survey.

3.1 Treatment Effects on GDP Expectations

To characterize how the information affected beliefs, it is useful to recall how one would expect an agent to update their beliefs in response to new information. In a simple Bayesian learning context, agents form beliefs as a combination of their priors and the signals they receive. Heuristically, the posterior belief of agent *i* is

$$Post_i = (1 - G) \times Prior_i + G \times signal_i \quad (1)$$

where the weight assigned to new information is given by the Kalman gain G. If a signal is perceived as new, precise, and informative, the agent would place a large weight on the new information and therefore very little weight on their prior belief. In the extreme case where the information is fully revealing, the gain would be equal to 1 and priors would be irrelevant: everyone would form the same posterior belief in response to the signal. If instead the signal is perceived as noisy, irrelevant, or incredible, then the agent would instead continue to place a large weight on their prior and little weight on the signal. In the extreme case where the signal is perceived as completely uninformative, then posteriors would be exactly equal to priors.

For firms in the control group, no information is provided. As a result, one would expect that the expectations measured using the follow-up question about macroeconomic growth in New Zealand would be the same as the expectations measured using the initial question about expected growth, i.e. $Post_i^{control} = Prior_i^{control}$. However, for firms who were provided with information, one would expect their posteriors to be a weighted average of their priors and the provided information. To illustrate this graphically, Figure 4 plots a binscatter of firms' prior beliefs against their posterior beliefs. Panel A does so for first moments of expected GDP growth while Panel B does so for second moments. For visualization purposes of the latter, we use the difference between

the maximum and minimum forecasts provided for real GDP growth for both sets of questions (the Manski (2004) question for the prior and the Altig et al. (2022) question for the posterior) so that the scales are comparable for priors and posteriors. The min-max metric is also the most consistent with the information provided in treatments 2 and 3 involving the difference between optimistic and pessimistic forecasts of professionals.[3]

Consider Panel A with first moments. The regression line for the control group has a slope indistinguishable from one, indicating that firms' posteriors coincide with their priors on average, as one would expect for firms that are not provided any information. For treatment groups, on the other hand, we see that the relationship between posteriors and priors is much flatter. In the case of the first treatment group that is provided with the average forecast of professional forecasters for GDP growth, the line is almost flat. This indicates that firms were putting a lot of weight on the provided information and their beliefs, while still somewhat dependent on their priors, moved very close to the signal (4% growth). The same is true for firms in the third treatment group, that received information about both the mean forecast of professionals as well as the disagreement between optimistic and pessimistic forecasters. For the second treatment group which received no information about first moments but only information about the disagreement among forecasters, we see a much milder revision in beliefs. Those who had high expectations of GDP growth tended to lower their forecasts while those with low expectations of GDP growth tended to increase them. The slope is close to 0.5. This response could capture some confusion on the part of some firms in terms of distinguishing first and second moments or could reflect an anchoring effect of the treatment, as the average moves closer to the 3% value provided in the treatment. In either case, we see an adjustment of beliefs after this treatment which is much weaker than in the other two treatment groups.

Panel B plots the equivalent results for firms' prior and posterior uncertainty, as measured by the min-max range of their forecasts. Note that the relationship for the control group again is a line with a slope indistinguishable from one, as one might expect from the absence of any new information. However, in response to the information treatments, we see that the lines relating posteriors and priors are all much flatter, indicating that agents placed a lot of weight on the

[3] Bachmann et al. (2021) also utilize the span of scenarios as a benchmark measure of uncertainty. We provide the analogous figure in terms of variances in Appendix Figure 3. The result is qualitatively the same, but slopes are different because of the different scales of variances associated with the two questions, even for the control group. The correlation between the span of responses and the standard deviation from responses to 5-bins question is 0.99. Similar to Bachmann et al. (2021), we find that firms with unusually high or low growth of sales have more uncertainty about future growth of their sales.

information provided, and shifted down, indicating that the average uncertainty declined. The slopes are quite similar across treatments, indicating that firms were placing equivalent weight on the signals provided, but the mean treatment shifted average uncertainty down the most, whereas the treatment involving only forecaster disagreement had a smaller average effect on beliefs. Note that while most firms reduced their uncertainty on average, there were still many firms who raised their uncertainty in light of the information, especially in treatments 2 and 3.[4]

In the empirical analysis, we measure uncertainty using the variance of firms' posterior distributions. We, therefore, verify in Table 2 that the same qualitative results obtain for treatment effects when measured using variances as when using the range. To do so, we regress firms' posterior beliefs ($Post_i$) on their priors ($Prior_i$), indicators for their information treatment ($\mathbb{I}\{i \in Treat\ j\}$), and the interaction of the two:

$$Post_i = a_0 + b_0 Prior_i + \sum_{j=1}^{3} a_j \times \mathbb{I}\{i \in Treat\ j\} + \sum_{j=1}^{3} b_j \times \mathbb{I}\{i \in Treat\ j\} \times Prior_i + error_i, \quad (2)$$

This specification is equivalent to the visual evidence in Figure 4: firms place a lot of weight on information treatments when revising their first and second moments of GDP growth.

The key takeaway from these results is that the treatments induced different *relative* movements in first and second moments of firms' GDP expectations. Treatments 1 and 3 both had very large effects on first moments, essentially moving most firms' expectations to the provided signal, while treatment 2 had a much milder effect on first moment beliefs. All three treatments had large effects on uncertainty, with similar slope effects but different average effects, with treatment 1 reducing average uncertainty much more than either treatment 2 or 3. These different relative movements in first and second moments of beliefs induced by the information treatments are the key ingredient that will allow us to separately identify the effects of uncertainty on firm decisions from those stemming from first moments of their beliefs.

3.2 Treatment Effects on Other Expectations

As emphasized in section 2, our survey includes several different measures of economic uncertainty. While the treatments were in terms of moments of GDP growth, these could also affect firms' other expectations, such as their perceptions of inflation risk or the future volatility in their sales.

[4] Appendix Table 9 verifies that uncertainty also tended to fall after treatment when we use qualitative questions to elicit the degree of uncertainty that firms report about their macroeconomic outlook.

To assess the effects of treatments on these other expectations, Panels C-F of Figure 4 plots equivalent results comparing posteriors and priors of first and second moments of firms' beliefs but now for the case of inflation expectations and expectations of future sales, as measured immediately after the treatments in the initial survey, while Table 2 presents the equivalent results when uncertainty is measured using the variance of the posterior distribution rather than the difference between the minimum and maximum possible outcomes. We find qualitatively similar results as for GDP growth, albeit with smaller quantitative magnitudes. For example, the information treatments all led to a flattening of the relationship between inflation posteriors and priors, both in terms of first and second moments. This indicates that as firms revised both the levels and uncertainty of their GDP forecasts, they adjusted their inflation forecasts in tandem. This is consistent with firms forming an expectation about aggregate uncertainty jointly across variables, as could also be seen in Figure 2. With sales growth for the firm, we again see a similar adjustment of second moments, but now even smaller than with inflation. And in terms of first moments, there is no economically meaningful response of expectations of future sales to the treatments. Even though firms engaged in very large revisions of their expectations of aggregate GDP growth, this did not lead them to change their own sales forecasts over the corresponding time period. However, changes in their uncertainty about future GDP growth did lead to some adjustment in their uncertainty about future sales, albeit not by large amounts. As a result, our information treatments can be interpreted as having generated large revisions in firms' perceptions of *aggregate* conditions, both in first and second moments, but with only limited consequences for firms' perceptions of their own sales outlook.

3.3 Persistence of Treatment Effects

Did the information treatments have any long-lasting effects on firms' economic expectations? Panel B of Table 2 reports results from re-estimating (2) but now using posterior beliefs measured in the follow-up wave, i.e., *six months* after the information treatments were done.[5]

Columns (1) and (2) in Table 2 report results for GDP expectations: we find that information treatments continued to have large effects on firms' expectations of GDP growth even after six months, both for first and second moments. We also find persistent effects on firms' inflation expectations, but these effects are much smaller in magnitude. The effects of the

[5] Appendix Table 3 reproduces the results of Table 2 but controlling for firm observables including managerial (age, education, tenure) and firm (age, size, industry, etc.) characteristics. The results are unchanged, consistent with treatments having been successfully randomized across firms.

information treatments had mostly but not completely faded out in terms of what firms expected for inflation. For firms' expectations of sales growth, the persistence of the effects is even smaller. We find no treatment effect on the level of sales expected after six months. For sales uncertainty, we can still identify an effect of the treatments after six months but again, the effect is much smaller than for GDP growth expectations. For the latter, the information treatments successfully generated variation in first and second moments that was both large and long-lasting.

4. The Effects of Uncertainty on Firm Decisions

Having shown that the information treatments generated changes in both first and second moments of firms' macroeconomic expectations, and different relative movements across treatments, we now turn to utilizing these exogenous changes in beliefs to assess how uncertainty affects the actual economic decisions of firms.

4.1 Uncertainty and Ex-Post Decisions

As discussed in section 2, for many of the firms' decisions, we have measures of both firms' ex-ante plans over the next six months from the initial survey wave and their ex-post decisions over the corresponding six-month period from the follow-up wave. For these variables, we assess the effect of uncertainty through the following empirical specification:

$$action_i^k - plan_i^k = \alpha_1 Post_i^{mean} + \beta_1 Post_i^{uncert} + Controls_i + error_i \quad (3)$$

where $action_i^k - plan_i^k$ denotes the difference between the ex-post action k (e.g. prices, employment, etc.) of firm i and its ex-ante plan for that action six months prior, $Post_i^{mean}$ denotes the posterior expectation of GDP growth from firm i as measured in the initial wave after the information treatments, $Post_i^{uncert}$ denotes the posterior uncertainty (measured in variance) from firm i, and $Controls_i$ is a vector of firm-level control variables. In general, we just include the firm's prior GDP expectations and uncertainty as controls but report equivalent results with a more augmented set of firm controls in Appendix Tables 4-6.

To identify exogenous variation in posterior first and second moment expectations, we employ an instrumental variable (IV) strategy in which instruments include indicator variables for each treatment group as well as the interaction of firms' priors with these indicators:

$$Post_i^{mean} = a_0 + \sum_{j=1}^{3} a_j \times \mathbb{I}\{i \in Treat\ j\} + \sum_{j=1}^{3} b_j \times \mathbb{I}\{i \in Treat\ j\} \times Prior_i^{mean}$$

$$+\sum_{j=1}^{3} c_j \times \mathbb{I}\{i \in Treat\ j\} \times Prior_i^{uncert} + error_i \quad (4')$$

$$Post_i^{uncert} = \tilde{a}_0 + \sum_{j=1}^{3} \tilde{a}_j \times \mathbb{I}\{i \in Treat\ j\} + \sum_{j=1}^{3} \tilde{b}_j \times \mathbb{I}\{i \in Treat\ j\} \times Prior_i^{mean}$$
$$+\sum_{j=1}^{3} \tilde{c}_j \times \mathbb{I}\{i \in Treat\ j\} \times Prior_i^{uncert} + error_i \quad (4'')$$

Intuitively, the instrumental variable strategy is similar to the visual description of the treatment effects in Figure 4, exploiting both the average effect of treatments on expectations and the slope effect on priors. However, the IV controls for slope effects on prior beliefs of first and second moments simultaneously, whereas Figure 4 showed effects for each set of priors separately.

Table 3 reports results from specification (3) applied to the firm level decisions for which we observe both ex-post outcomes and ex-ante plans, which includes prices for the main product, employment, capital stock, wages, advertising budget, R&D budget, and the profit margin.[6] Note first that the F-statistics for the first stage are very high (above 400) for both first and second moments: our information treatments provide a powerful source of exogenous variation in macroeconomic expectations of firms.

We find that changes in uncertainty led firms to change their behavior relative to their plans along a number of dimensions. First, their prices did not rise as much as anticipated when more uncertain. A one unit increase in uncertainty led firms to reduce prices by 0.1% relative to planned prices, consistent with earlier evidence from Bachmann, Born, Elstner, and Grimme (2019). On average, our information treatments reduced the variance of firms' GDP forecasts by 4 units relative to the control group, so the average effect on prices was to raise them by 0.4% over six months relative to prior plans. Another way to think about the magnitude is in terms of qualitative descriptions of uncertainty in Figure 4. Moving from "extremely uncertain" to "quite uncertain" entailed an average decline in the variance of firms' posterior distributions of about 5 units, corresponding to a 0.5% unexpected increase in prices. This change in variance is also comparable to a one standard deviation decrease in the cross-sectional distribution of posterior uncertainty in the control group. Second, employment declined by 0.6% for each unit increase in uncertainty so that the average (unexpected) increase in employment across treated firms due to changing uncertainty was approximately 2.5%. Changes in the capital stock were smaller: the capital stock declined about 0.1% for each unit increase in uncertainty over six months. This lower sensitivity likely reflects adjustment costs to capital. In terms of costs, we observe no change in wages in

[6] In Appendix Table 10, we apply the procedure of Romano and Wolf (2016) to address issues with multiple hypothesis testing and find no meaningful difference in results.

response to changes in uncertainty, with the effect being both statistically and economically insignificantly different from zero. We also do not observe any meaningful response in spending on R&D by firms. However, we do observe an increase in spending on advertising when uncertainty rises. Combined with the decrease in prices, this suggests that firms engaged in more aggressive pursuit of customers in the face of uncertainty. Finally, we find that margins rose somewhat as firms' macroeconomic uncertainty increased. The increase in margins, however, while statistically significant, is economically very small: the cross-sectional standard deviation of expected changes in margins is greater than 1 percentage point, so the estimated magnitude of the effect of uncertainty on ex-post margins is minuscule.

How large are these effects? The closest point of comparison is Alfaro, Bloom and Lin (2021), who estimate the effects of uncertainty on investment and employment decisions of U.S. publicly held firms. They find that a 2 standard deviation increase in uncertainty leads to a 0.18 standard deviation drop in investment across all firms and a 0.09 standard deviation drop in employment. For comparison, a two standard deviation increase in uncertainty according to our estimates yields a 0.61 standard deviation increase in investment and a 0.77 standard deviation increase in employment. Thus, our estimates entail much larger effects of uncertainty along these margins. Our estimates for prices are similarly large, a 0.61 standard deviation decline in prices for a 2 standard deviation change in uncertainty.

There are many possible sources for these differences in magnitude. We use an RCT to identify exogenous variation in firms' macroeconomic uncertainty as measured through their GDP expectations whereas Alfaro et al. (2021) use realized and implied stock return volatility to measure firm level uncertainty and exploit differential stock return responses to exchange rates, oil prices, and policy uncertainty to identify exogenous variation in uncertainty. The firms are also very different: large U.S. publicly traded firms in Alfaro et al. (2021) versus much smaller private companies in New Zealand in our survey. Consistent with this possibility, Alfaro et al. (2021) emphasize that the effects of uncertainty are larger for firms that are more financially constrained. Since on average small firms in New Zealand are much more likely to be financially constrained than large publicly traded firms in the U.S., this may go some way in reconciling our much larger estimated effects. While we do not have direct measures of financial constraints in our survey, a common proxy for financial constraints is firm size (Gertler and Gilchrist 1994). Section 4.4

documents that smaller firms, who are likely to be financially constrained, responded much more in terms of employment to uncertainty than did larger firms in New Zealand.

Table 4 provides additional results on decision variables for which we observe only the extensive margin. In this case, we estimate the following specification:

$$action_i^k = \alpha_1 Post_i^{mean} + \beta_1 Post_i^{uncert} + \gamma_1 plan_i^k + Controls_i + error_i \qquad (5)$$

in which we condition on ex-ante plans of whether an action was expected to be taken. We use this modification of specification (5) because it allows us to interpret α_1 and β_1 as changes in the probability that a given action is taken (recall that actions and plans are indicator variables). We find that higher uncertainty is associated with a reduced likelihood of firms adopting new technologies or opening up new facilities. The estimated effects are non-trivial: a one unit increase in our ex-post measure of uncertainty leads to an approximately 2-2.5% decline in the probability of new technologies being adopted or new facilities being opened, so our treated firms were on average more than 8-10% more likely to apply new technologies or open new facilities than untreated firms. While the estimated coefficient on new products has the same sign, it is not statistically different from zero and its size is small in economic terms.

Finally, our survey included some variables for which we did not consistently observe planned levels in the initial wave but only initial values in the first wave and new values in the second wave. Table 5, therefore, provides results from estimating:

$$value_i^{followup} - value_i^{initial} = \alpha_1 Post_i^{mean} + \beta_1 Post_i^{uncert} + Controls_i + error_i \qquad (6)$$

and applying the same instrumental variable strategy as before. For comparison, we also provide results from this specification using employment relative to its initial level and find almost identical results to those conditioning on plans. Column (2) presents results for the sales outcomes experienced by firms. We find that, when firms faced higher uncertainty, their sales tended to decline relative to their previous levels and did so by large amounts: a one unit increase in uncertainty reduced sales growth by almost one percentage point relative to the previous six months. Sales of treated firms, therefore, were nearly four percent higher than those of untreated firms due to the change in uncertainty, despite higher prices and reduced advertising. Unlike the variables in Table 3 and 4, sales are not directly under the control of the firm. While standard macroeconomic models assume that sales move inversely to a firm's price, there are a number of reasons why this need not be the case here. One is that firms were reporting the price change for their main product whereas sales reflect all their transactions and therefore need not necessarily

move in the opposite direction of the price of the main product. Furthermore, the increased sales of treated firms could reflect the introduction of new products, new retail shops, or a number of other margins than prices. Indeed, the response of employment and capital to uncertainty is consistent with the firm producing and selling more products when uncertainty is lower.

Table 5 also reports results for the effects of uncertainty on the value of information perceived by firms. Column (3) uses the dollar value that firms report being willing to pay for an annual subscription to a monthly magazine of professional forecasts of the aggregate economy. We find that firms were willing to pay more for professional forecasts when their macroeconomic uncertainty was high. Moving from being extremely uncertain to quite uncertain implied a reduced willingness to pay of over $20, or about 5% of their initial willingness to pay for forecasts. Column (4) considers the dollar value of the information that they receive from customers, suppliers, peer firms, and professional organizations. We again find that higher macroeconomic uncertainty increased the perceived value of information. In this case, moving from extremely uncertain to quite uncertain would lower the value of information by about 10% of firms' original valuation of this information. Finally, column (5) reports results for how firms would allocate 100$ across acquiring information about their industry versus the aggregate economy. More macroeconomic uncertainty increased the relative value of information about the aggregate economy, consistent with the logic of Mackowiak and Wiederholt (2009).[7]

Jointly, these results point to clear and strong causal effects of uncertainty on firm decisions and beliefs. We find that higher macroeconomic uncertainty leads firms to lower prices, reduce their employment and investment relative to plans, become less likely to introduce new technologies or open new facilities, and experience lower sales while they are more likely to engage in advertising. Increased macroeconomic uncertainty also makes firms value information about the aggregate economy, both in an absolute sense as well as relative to information about their industry.

In contrast, we find much more limited evidence that firms' expectations about the *level* of GDP growth had much influence on their decisions. Qualitatively, firms tend to lower prices when they expect higher GDP growth and experience greater sales, while possibly reducing employment and investment (the latter effects are not statistically significant). This response would be consistent with the behavior of firms facing sticky prices and believing that higher GDP growth stems from higher

[7] Another possible interpretation is that firms are learning from the treatment that it is relatively easy to access information about macroeconomic forecasts, which would reduce their average willingness to pay for forecasts.

productivity. For firms who cannot change their prices, higher productivity means that they can meet their demand with fewer inputs, so employment and investment would be expected to fall. For those firms that can change prices, they would tend to reduce their prices and therefore experience higher sales. Averaging across firms, one would therefore expect to see higher GDP growth forecasts be associated with lower prices, employment and investment but higher sales, which is qualitatively consistent with our results.

Quantitatively, the effects of changes in first moment macro expectations on decisions are very small. For example, a one standard deviation (in the cross-section) increase in the expected level of GDP growth (1.7% points) led to changes in prices or capital stock of less than 0.5% relative to plans, even though sales rose by over 5%. This could potentially reflect the time period of the exercise, namely the high uncertainty period following the COVID19 pandemic. Because high uncertainty can lead to wide inaction bands, first moment shocks can have very small effects during periods of high uncertainty. Bloom et al. (2018) provide evidence for this in the case of wage subsidies and Castelnuovo and Pellegrino (2018) do so for monetary policy shocks. Our results support this mitigation channel.

Another reason for small effects of first moment macro expectations could be if the channel through which macro expectations affect outcomes is through micro expectations. Figure 4 illustrates that changes in the expected growth rate of GDP do not translate much into firms' expectations of their sales growth, as shown in Figure 4: even though firms' GDP forecasts changed dramatically, their sales expectations changed much less. In contrast, changes in macroeconomic uncertainty in Figure 4 led to similar, albeit somewhat smaller, changes in microeconomic uncertainty. This suggests that the channel through which *macroeconomic* expectations affect firms' decisions could be entirely through how they change firms' *microeconomic* expectations about their own sales, a possibility we now turn to.

4.2 Macro and Micro Uncertainty

As shown in Figure 1, we generally observe positive but imperfect correlations between firms' uncertainty about the aggregate outlook and their uncertainty about their own outlook. Do both matter independently for firms' decisions, or does macroeconomic uncertainty only matter to the extent that it affects the microeconomic uncertainty that firms perceive about themselves? To fully separate the effects of micro and macro uncertainty on firms' decisions, we would in principle

need multiple instruments that generate exogenous variation in one relative to another. We do not have such instruments in our context, so we cannot hope to separately identify the effects of both microeconomic and macroeconomic uncertainty on firm decisions. However, we can still assess whether the effects of macroeconomic uncertainty on firm decisions only exist to the extent that changes in macroeconomic uncertainty affect firms' perceived microeconomic uncertainty.

To do so, we estimate augmented versions of equation (3) as follows:

$$action_i^k - plan_i^k = \alpha_1 Post_{i,GDP}^{mean} + \beta_1 Post_{i,GDP}^{uncert} + \alpha_2 Post_{i,\pi}^{mean} + \beta_2 Post_{i,\pi}^{uncert} + \alpha_3 Post_{i,sales}^{mean} + \beta_3 Post_{i,sales}^{uncert} + Controls_i + error_i \quad (7)$$

This specification includes all three sets of posterior first and second moments simultaneously: GDP growth, inflation and sales growth. We then reapply our IV strategy for GDP expectations only, i.e. the first stage is:

$$\begin{aligned} Post_i^{mean} = {} & a_0 + \sum_{j=1}^{3} a_j \times I\{i \in Treat\ j\} \\ & + \sum_{j=1}^{3} b_j \times I\{i \in Treat\ j\} \times Prior_i^{mean} \\ & + \sum_{j=1}^{3} c_j \times I\{i \in Treat\ j\} \times Prior_i^{uncert} \\ & + d_1 Post_{i,\pi}^{mean} + d_2 Post_{i,\pi}^{uncert} + d_3 Post_{i,sales}^{mean} + d_4 Post_{i,sales}^{uncert} \\ & + Controls_i + error_i \end{aligned} \quad (8')$$

$$\begin{aligned} Post_i^{uncert} = {} & \tilde{a}_0 + \sum_{j=1}^{3} \tilde{a}_j \times I\{i \in Treat\ j\} \\ & + \sum_{j=1}^{3} \tilde{b}_j \times I\{i \in Treat\ j\} \times Prior_i^{mean} \\ & + \sum_{j=1}^{3} \tilde{c}_j \times I\{i \in Treat\ j\} \times Prior_i^{uncert} \\ & + \tilde{d}_1 Post_{i,\pi}^{mean} + \tilde{d}_2 Post_{i,\pi}^{uncert} + \tilde{d}_3 Post_{i,sales}^{mean} + \tilde{d}_4 Post_{i,sales}^{uncert} \\ & + Controls_i + error_i \end{aligned} \quad (8'')$$

In this scenario, if macroeconomic expectations only affect firm decisions through the channel of changing firms' microeconomic expectations, then controlling for the posterior sales growth expectations in specification (7) should eliminate the predictive power of macroeconomic uncertainty for firms' ex-post decisions.

We report results from this specification in Table 6. The key result is that none of the estimated effects of macroeconomic uncertainty on firm decisions are qualitatively different when we control for ex-post sales growth and inflation expectations of firms. This indicates that the effects of macroeconomic uncertainty on firms' decisions extend above and beyond their effects on firms' microeconomic expectations. The results documented in Tables 3-5, therefore, reflect the effects of

macroeconomic expectations of firms on their decisions. However, the fact that coefficients on inflation and sales growth expectations of firms are mostly insignificant in Table 6 should not be interpreted as indicating that these had no effects on firm decisions but simply the fact that we cannot identify exogenous variation in these beliefs due to the lack of separate instruments for each set of expectations. Indeed, when we estimate equation (3) by OLS for firms in the control group, we similarly observe insignificant coefficients on GDP expectations and uncertainty for all firm decisions (Appendix Table 7). Our ability to identify the effects of macroeconomic uncertainty on firms' decisions, therefore, hinges on the exogenous variation in expectations generated by the information treatments. Without more of these treatments, we cannot speak to the separate effects of inflation and sales growth uncertainty on firms' economic decisions.[8]

4.3 Hypothetical Responses to Uncertainty

How plausible are these estimated responses? The notion that higher uncertainty would lead firms to reduce employment and investment, among other margins, has long been emphasized in models of uncertainty shocks (e.g. Bloom 2009, Bloom et al. 2018) and is consistent with the aggregate effects of traditional measures of uncertainty shocks as identified in e.g. Bloom (2009) or Jurado, Ludvigson and Ng (2015). Here, we consider an alternative approach to assessing the plausibility of our identified effects of uncertainty: qualitative descriptions from firms as to how they would respond to hypothetical changes in aggregate uncertainty.

Specifically, in the initial survey, firms were all asked the following question early in the survey, prior to any information treatments:

> *"For this next question, we would like you to think about the ways in which uncertainty about the overall economy may (or may not) affect the decisions in your firm. In particular, for each of the following options, please provide an answer ranging from "much more likely" to "much less likely" that best describes how you would be affected by an [increase/decrease] in macroeconomic uncertainty."*

where half of the firms were randomly given the "increase" hypothetical and the other half received the "decrease" hypothetical. The options presented to firms included: *a*) to hire more employees, *b*) to raise my price(s), *c*) to purchase more machinery/physical equipment, *d*) to open/invest in

[8] In the same spirit, we cannot separately identify the effects of second from third moments (skew) of expectations. However, when we control for skewness of expectations in equation (7) instead of microeconomic expectations, we again find no difference in the estimated effects of uncertainty, which suggests an independent role for uncertainty in affecting decisions beyond implications for third moments.

new facilities, *e*) to increase average wages, *f*) to open new export markets, *g*) to apply for new loans, *h*) to increase cash reserves, *i*) to introduce new products/services, *j*) to make plans for ten or more years from now, *k*) to do more advertising, *l*) to engage in more R&D, and *m*) to see my operating margins increase. We rate firms' answers to each category on a scale of -2 to 2, with -2 corresponding to "much less likely" and 2 to "much more likely" with increments of 1 in between for each categorical answer. A response of 0 corresponds to "neither more nor less likely," i.e., the expected outcome when firms view macroeconomic uncertainty as having no impact on their decisions for a specific margin. Although these scales capture some variation in intensity of responses, one should be careful in mapping this measure of intensity to quantitative responses.

We present the average answers of firms for each category, separated into firms who were asked about an increase in uncertainty versus those who were asked about a decrease in macroeconomic uncertainty, in Table 7. There are several notable findings. First, for the margins in which the RCT identified clear statistically significant effects, firms' answers to hypotheticals also point toward strong responses. The average responses for prices, employment, investment, advertising, and opening new facilities are all greater than one in absolute value, indicating that firms were choosing "somewhat more likely" or "much more likely" to respond along these margins when macroeconomic uncertainty changes and the signs of adjustment correspond to those observed in practice after our information treatments. Second, for those variables for which we found little effect in our experiments, the quantitative responses tended to be much smaller in the hypotheticals. For example, the average response along the wage margin was just 0.6, between indicating no effect of uncertainty or a small effect of uncertainty. Along these metrics, the results from the hypothetical question line up closely with the RCT experiment, providing some validation for the exercise. The fact that hypothetical questions can provide answers similar to those obtained from full-blown policy or RCT experiments was emphasized in Mei and Stantcheva (2022) and we view our results as providing further corroborating evidence on this point.

In addition, the hypothetical question allows us to consider margins of adjustment that were not measured or not easily measurable in the survey. For example, firms reported that they were less likely to apply for new loans and more likely to increase cash reserves when they face more uncertainty. This is consistent with the financial precautionary motive identified in Alfaro et al. (2021). Firms also indicated that they are much less likely to make plans for ten or more years and a little less likely to open new export markets. Another result from the hypotheticals that is not easy to

address in the RCT is the asymmetry of responses to positive or negative changes in uncertainty: along most margins of adjustment, firms reported stronger responses to a decrease in uncertainty than an increase. In our RCT, the possibility of asymmetric effects is difficult to assess for several reasons. First, most firms reduced their uncertainty in light of treatments, so the sample size of firms with rising uncertainty is small. Second, whether firms increased or decreased their uncertainty is not random: firms that increased their uncertainty tended to be firms that were initially very confident whereas those that reduced their uncertainty tended to have much more uncertainty ex-ante. Thus, we cannot separately identify asymmetry in responses from "state-dependence" arising from the level of uncertainty. However, the hypothetical question suggests that there is some asymmetry in the effects on changes in uncertainty and therefore further refines the findings of the RCT experiment.

One notable difference between the RCT results and those from the hypothetical question is that firms reported that they would expect their margins to fall when macroeconomic uncertainty rises while we find in the RCT that margins, if anything, rose with higher uncertainty, although in economic terms the change in margins is very small. The source of this discrepancy is unclear. One possibility is that firms reported different measures of margins in the two questions (e.g. net of overhead costs or not). Another possibility is that firms expected that they would need to reduce their margins in the face of higher uncertainty but, when it occurred in practice, unexpectedly found that they did not need to, which could happen if they tend to e.g. understate demand elasticities or face other uncertainties about their environment. Yet another possibility is that when they answered the hypothetical, they were anticipating general equilibrium outcomes whereas the RCT identifies partial equilibrium responses. In the hypothetical, for example, firms might expect that consumers are also more uncertain about the outlook, which necessitates a reduction in margins to lower prices enough to achieve sales objectives. In the RCT, in contrast, the demand facing the firms is unchanged since only the treated firms are changing their macroeconomic uncertainty. Finally, in the hypothetical, firms anticipated a change in first moments simultaneously with the change in uncertainty, whereas the RCT design identifies the effect of the uncertainty change net of any first moment effects. This example illustrates hypotheticals and RCTs need not identify the exact same responses, and therefore care must be taken in designing hypotheticals that can be compared to RCT or policy experiments. Despite these potential pitfalls, we view the close match between firms' answers to hypotheticals and the RCT experiments as providing a useful reality check on the results emanating from the information treatments.

4.4 Heterogeneity

Do all firms respond equally to changes in uncertainty? In this section, we consider whether firms' responses in terms of prices and employment to changes in uncertainty vary along observable characteristics. To do so, we reproduce results from Table 3 for prices and employment for different subsets of firms, broken down into groups, in Table 8. We focus on prices and employment as two of the main channels through which firms respond to uncertainty but provide more extensive results for other firm choice variables in Appendix Table 8.

We consider a number of different firm and manager characteristics: by industry (manufacturing vs services), by firm size (<10 workers, 10-30 workers, >30 workers), by the number of competitors they face for their main product line (zero, 1-4, or 5 or more), by their capacity utilization (<80%, 80-100%, >100%), by the value they initially assign to macroeconomics forecasts (values of less than $335, $335-$594, and more than $594), by the COVID19 exposure of their industry (highly exposed vs less exposed), and by how many professional associations they are members of. Generally, we find few differences in responses along these splits. There are three notable exceptions. The first is by size: smaller firms (less than 10 workers) responded slightly more in terms of prices than larger firms, but the differences for employment are much starker. The response of firms with less than ten workers is more than four times as large as the employment response of the firms with more than 30 workers. When split by the number of competitors, we find firms who are in more competitive settings did not reduce their employment as much when their uncertainty increased. Finally, we find that firms with low utilization rates changed their employment by more when uncertainty changed than did other firms.

4.5 Implications

Our results speak directly to different models of how uncertainty can affect firm outcomes. One important feature of our approach is that we isolate the ex-ante uncertainty effect from the ex-post volatility effect whereas most empirical analysis can only identify their joint effect (e.g. Vavra 2014, Bachmann et al. 2019). The clear negative effect of higher ex-ante uncertainty on firm employment and investment therefore supports real options channels (Dixit and Pindyck 1994) of uncertainty, which operate independently of ex-post volatility effects. In addition, because we only change the uncertainty of firms without affecting financial markets, our results indicate that uncertainty does not only affect firms through the response of financial markets, as in Gilchrist,

Sim and Zakrajsek (2014). Our estimates also relate to theoretical models of uncertainty in terms of the response of physical versus intangible capital. Consistent with Bloom (2007), we find less sensitivity of intangible capital in the form of R&D to uncertainty than for physical capital.

Our results also speak to models of expectations formation. The fact that firms' expectations respond to the information we provide implies departures from full information rational expectations. The fact that firms' decisions change when provided with this information indicates that the information had value to them. Jointly, this is consistent with models of rational inattention in which firms choose which information and how much information to acquire and process given the costs to doing so (Sims 2003, Mackowiak and Wiederholt 2009). This corroborates other recent evidence for rational inattention. Coibion, Gorodnichenko and Ropele (2020), for example, show that (randomly selected) firms in Italy who were provided every quarter with information about recent aggregate inflation earned more profits on average ex-post than other firms that were not provided with this information, but the size of the profit difference was quite small. This is precisely what one would expect from rational inattention.

5. Conclusion

The uncertainty hypothesis has been a leading contender in macroeconomics as a potential explanation for business cycle fluctuations. Uncertainty spikes can be tied to a wide range of visible events emanating from different sources. If a rise in uncertainty induces a powerful response by households and firms, then changes in uncertainty can provide a potential explanation for the common patterns that we observe across business cycles. This can be true if uncertainty is itself exogenous and the source of the impulse but also if the rise in uncertainty is an endogenous response to other structural shocks. Hence, we need clear causal evidence that changes in uncertainty affect the decisions of economic agents, which can be a challenge since changes in uncertainty are historically highly correlated with changes in first moments.

We provide new causal evidence that exogenous variation in macroeconomic uncertainty, induced by randomly assigned information treatments, has clear and powerful effects on firms' decisions. Higher uncertainty leads firms to reduce their prices, employment and investment as well as makes them less likely to adopt new technologies or open facilities but induces them to engage in more advertising. We interpret these results as providing clear and direct evidence supporting one of the main mechanisms through which uncertainty is supposed to affect economic activity, namely the reaction of firms. In combination with Coibion et al. (2021a) showing that changes in uncertainty

have pronounced effects on household spending, this evidence jointly suggests that two of the main microeconomic channels underlying the uncertainty hypothesis are present and powerful.

By itself, evidence that a mechanism exists and is large does not necessarily mean that it is important. For example, as argued in Bachmann and Bayer (2013), if aggregate uncertainty varied little over time, then it could not be a major source of business cycle fluctuations even if exogenous changes in uncertainty affect firm decisions. Because we do not measure a time series of uncertainty, our paper does not speak directly to the aggregate importance or effects of uncertainty, whether as a shock or as a propagation mechanism for other shocks. However, there already exists ample evidence illustrating that aggregate uncertainty contributes to macroeconomic fluctuations (e.g., Baker et al. 2020, Jurado et al. 2015, Bloom 2009). Our contribution is to provide clear evidence on one of the main mechanisms through which these aggregate effects are likely to materialize: the decisions of firms.

While the uncertainty literature has emphasized the dangers of rising uncertainty as a possible source of downturns, the flip side of our results is that they suggest that policymakers could try to *reduce* uncertainty through communication as a way to stabilize economic activity (see Pedemonte 2020 for an example). Our simple information treatments were surprisingly powerful in reducing the macroeconomic uncertainty perceived by most firms, leading many of them to increase their hiring and investment. Policymakers often try to protect their credibility by being deliberately vague in their statements and forecasts to try and avoid being proven wrong ex-post or having to engage in subsequent policy reversals. The downside of this approach is that it may significantly increase uncertainty among ordinary citizens. Less ambiguity by policymakers and projecting more confidence could potentially achieve the reverse.

References

Alfaro, Ivan, Nicholas Bloom, and Xiaoji Lin, 2021. "The Finance Uncertainty Multiplier." Mimeo.

Altig, David, Jose Barrero, Nicholas Bloom, Steven Davis, Brent Meyer, and Nicholas Parker, 2022. "Surveying Business Uncertainty." *Journal of Econometrics* 231(1): 282-303.

Angeletos, George-Marios, Fabrice Collard, and Harris Dellas, 2020. "Business-Cycle Anatomy," *American Economic Review* 110(10): 3030-3070.

Armantier, Olivier, Scott Nelson, Giorgio Topa, Wilbert van der Klaauw, and Basit Zafar. 2016. "The Price Is Right: Updating Inflation Expectations in a Randomized Price Information Experiment." *Review of Economics and Statistics* 98:503–523.

Aruoba, Boragan, Andres Fernandez, Daniel Guzman, Ernesto Pasten, and Felipe Saffie, 2022. "Pricing under Distress." Mimeo.

Bachmann, Ruediger, Steffen Elstner, and Eric Sims. 2013. "Uncertainty and Economic Activity: Evidence from Business Survey Data." *American Economic Journal: Macroeconomics* 5(2): 217-249.

Bachmann, Ruediger, Kai Cartensen, Stefan Lautenbacher and Martin Schneider. 2021. "Uncertainty and Change: Survey Evidence on Firms' Subjective Beliefs." NBER Working Paper 29430.

Bachmann, Ruediger, Benjamin Born, Steffen Elstner, and Christian Grimme, 2019. "Time-Varying Business Volatility and the Price-Setting of Firms," *Journal of Monetary Economics* 60(6): 704-719.

Bachmann, Ruediger, and Christian Bayer, 2013. "'Wait-and-See' Business Cycles?" *Journal of Monetary Economics* 101: 82-99.

Baker, Scott, Nicholas Bloom, and Stephen Terry. 2020. "Using Disasters to Estimate the Impact of Uncertainty," Forthcoming in *Review of Economic Studies*.

Baker, Scott, Nicholas Bloom, and Steven Davis. 2016 "Measuring Economic Policy Uncertainty," *Quarterly Journal of Economics* 131:1593–1636.

Baley, Isaac, and Anders Blanco. 2019. "Firm Uncertainty Cycles and the Propagation of Nominal Shocks," *American Economic Journal: Macroeconomics* 11(1): 276-337.

Basu, Susanto, John Fernald, and Miles Kimball, 2000. "Are Technology Improvements Contractionary?" *American Economic Review* 96(5): 1418-1448.

Beaudry, Paul, and Franck Portier, 2006. "Stock Prices, News and Economic Fluctuations," *American Economic Review* 96: 1293-1307.

Bloom, Nicholas, Max Floetotto, Nir Jaimovich, Itai Saporta-Eksten, and Stephen Terry. 2018. "Really Uncertain Business Cycles," *Econometrica* 86(3): 1031-1065.

Bloom, Nicholas, Steven Davis, Lucia Foster, Brian Lucking, Scott Ohlmacher and Itai Saporta-Eksten, 2020. "Business-Level Expectations and Uncertainty," NBER Working Paper 28259.

Bloom, Nicholas, Philip Bunn, Scarlet Chen, Paul Mizen, Pawel Smietanka, and Gregory Thwaites, 2019. "The Impact of Brexit on UK Firms," NBER Working Paper 26218.

Bloom, Nicholas. 2007. "Uncertainty and the Dynamics of R&D," *American Economic Review* 97(2): 250-255.

Bloom, Nicholas. 2009. "The Impact of Uncertainty Shocks," *Econometrica* 77(3): 623-685.

Bloom, Nicholas. 2014. "Fluctuations in Uncertainty." *Journal of Economic Perspectives* 28:153-76.

Bloom, Nicholas, Stephen Bond, and John van Reenen. 2007. "Uncertainty and investment dynamics," *Review of Economic Studies* 74: 391–415.

Caldara, Dario, Cristina Fuentes-Albero, Simon Gilchrist, and Egon Zakrajšek. 2016. "The macroeconomic impact of financial and uncertainty shocks," *European Economic Review* 88(C): 185-207.

Candia, Bernardo, Olivier Coibion, and Yuriy Gorodnichenko, 2022. "The Macroeconomic Expectations of Firms," Forthcoming in the Handbook of Economic Expectations.

Castelnuovo, Efrem, and Giovanno Pellegrino. 2018. "Uncertainty-Dependent Effects of Monetary Policy Shocks: A New-Keynesian Interpretation," *Journal of Economic Dynamics and Control* 93: 277-296.

Cavallo, Alberto, Guillermo Cruces, and Ricardo Perez-Truglia. 2017. "Inflation Expectations, Learning, and Supermarket Prices: Evidence from Survey Experiments." *American Economic Journal: Macroeconomics* 9(3): 1–35.

Coibion, Olivier, Dimitris Georgarakos, Yuriy Gorodnichenko, Geoff Kenny, and Michael. Weber, 2021a. "The Effect of Macroeconomic Uncertainty on Household Spending," forthcoming in *American Economic Review*.

Coibion, Olivier, Dimitris Georgarakos, Yuriy Gorodnichenko, and Maarten van Rooij, 2019. "How Does Consumption Respond to News About Inflation? Field Evidence from a Randomized Control Trial," Forthcoming in *American Economic Journal: Macroeconomics*.

Coibion, Olivier, Yuriy Gorodnichenko, and Tiziano Ropele, 2020. "Inflation Expectations and Firm Decisions: New Causal Evidence," *Quarterly Journal of Economics* 135(1): 165-219.

Coibion, Olivier, Yuriy Gorodnichenko, and Michael Weber. 2022. "Monetary Policy Communications and Their Effects on Household Inflation Expectations." *Journal of Political Economics* 130(6): 1537-1584.

Coibion, Olivier, Yuriy Gorodnichenko, and Saten Kumar. 2018. "How Do Firms Form Their Expectations? New Survey Evidence." *American Economic Review* 108 (9): 2671-2713.

Coibion, Olivier, Yuriy Gorodnichenko, Saten Kumar, and Jane Ryngaert. 2021b. "Do You Know that I Know that You Know…? Higher-Order Beliefs in Survey Data." *Quarterly Journal of Economics* 136(3): 1387-1446.

Dixit, Anivash, and Robert Pindyck, 1994. *Investment under Uncertainty*. Princeton University Press.

Fisher, Jonas. 2006. "The Dynamic Effects of Neutral and Investment-Specific Technology Shocks," *Journal of Political Economics* 114(3): 413-451.

Gali, Jordi, 1999. "Technology, Employment and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations," *American Economic Review* 89(1): 249-271.

Gertler, Mark, and Simon Gilchrist, 1994. "Monetary Policy, Business Cycles, and the Behavior of Small Manufacturing Firms," *Quarterly Journal of Economics* 109(2): 309-340.

Gilchrist, Simon, Jae Sim, and Egon Zakrajsek, 2014. "Uncertainty, Financial Frictions, and Investment Dynamics," NBER Working Paper 20038.

Guiso, Luigi, and Giuseppe Parigi. 1999. "Investment and demand uncertainty," *Quarterly Journal of Economics* 114(1): 185–227.

Gulen, Huseyin, and Mihai Ion. 2016. "Policy Uncertainty and Corporate Investment," *Review of Financial Studies* 29: 523–564.

Handley, Kyle, and Frank Li, 2020. "Measuring the Effects of Firm Uncertainty on Economic Activity: New Evidence from One Million Documents," NBER Working Paper 27896.

Jurado, Kyle, Sydney Ludvigson, and Serena Ng. 2015. "Measuring Uncertainty." *American Economic Review* 105(3): 1177-1216.

Mackowiack, Bartosz, and Mirko Wiederholt, 2009. "Optimal Sticky Prices under Rational Inattention," *American Economic Review* 99(3): 769-803.

Manski, Charles, 2004. "Measuring Expectations," *Econometrica* 72(5): 1329-1376.

Mei, Pierfrancesco, and Stefanie Stantcheva, 2022. "Heterogeneous Spending and Saving Behavior: What can we learn from Survey experiments?" Manuscript.

Pedemonte, Mathieu, 2020. "Fireside Chats: Communication and Consumers' Expectations in the Great Depression," Working Paper 2020-30, Federal Reserve Bank of Cleveland.

Roth, Christopher, and Johannes Wohlfart, 2020. "How Do Expectations about the Macroeconomy Affect Personal Expectations and Behavior?" *Review of Economics and Statistics* 102: 731-48.

Romano, Joseph, and Michael Wolf. 2016. "Efficient computation of adjusted p-values for resampling-based stepdown multiple testing." *Statistics and Probability Letters* 113: 38-40.

Sims, Chritopher. 2003. "Implications of Rational Inattention," *JME* 50: 665-690.

Vavra, Joseph. 2013. "Inflation Dynamics and Time-Varying Volatility: New Evidence and an SS Interpretation," *Quarterly Journal of Economics* 129(1): 215-258.

Table 1. Descriptive statistics

	Mean	Median	St.Dev.
Manager demographics			
Male	0.67	1.00	0.47
Tenure at the firm	10.27	10.00	6.20
Tenure in the industry	26.72	25.00	12.60
Education			
Less than high school	0.01	0.00	0.11
High school diploma	0.15	0.00	0.36
Some college or Associate degree	0.32	0.00	0.47
College Diploma	0.32	0.00	0.47
Graduate Studies (Masters or PhD)	0.20	0.00	0.40
Firm demographics			
Firm age	24.61	22.00	16.13
Employment	30.87	19.00	56.65
Utilization	0.88	0.90	0.17
Sales from New Zealand, %	96.56	100.00	9.50
Number of competitors	11.07	9.00	7.68
Profit slope ($d\pi/dp$)	0.57	0.58	0.21
Invest in advertising	0.68	1.00	0.47
Invest in R&D	0.35	0.00	0.48
Information			
Willingness to pay for a professional forecast, $/year	483.89	444.00	252.58
Value of information from suppliers, customers, peer firms, competitors and professional organizations, $/year	248.30	210.00	176.07
Share of budget allocated to local information	0.27	0.25	0.19
Share of firms that prefer industry magazine over a national newspaper	0.90	1.00	0.30
Talks with a typical customer about economic trends and conditions, per month	13.18	11.00	12.25
Talks with a typical supplier about economic trends and conditions, per month	6.37	4.00	8.08
Talks with a typical peer firm about economic trends and conditions, per month	4.31	4.00	3.32
Planned actions, next 6 months			
Price change	0.36	0.00	1.12
Employment growth	0.48	0.00	2.88
Change in capital stock	0.13	0.00	0.58
Wage growth	0.24	0.00	0.82
Introduce a new product or service	0.12	0.00	0.33
Expand to a new export market	0.01	0.00	0.11
Invest in a new technology/equipment	0.12	0.00	0.33
Open a new production/retail/office facility	0.14	0.00	0.35
Change in the profit margin	-0.00	0.00	1.11
Change in R&D budget	1.11	0.20	1.68
Expectations, priors			
GDP growth, implied mean	3.26	3.16	1.54
GDP growth, implied variance	1.77	1.26	1.67
Inflation, implied mean	4.59	4.60	1.45
Inflation, implied variance	1.37	1.07	1.23
Sales growth, implied mean	1.79	2.00	1.83
Sales growth, implied variance	1.66	1.11	1.84
Expectations, posteriors, control group			
GDP growth, implied mean	3.44	3.24	1.73
GDP growth, implied variance	4.95	3.64	4.64
Inflation, implied mean	4.87	4.82	1.59
Inflation, implied variance	2.74	2.09	2.51
Sales growth, implied mean	2.05	2.17	1.74
Sales growth, implied variance	2.70	1.91	2.76

Table 2. Treatment Effects on Expectations

	GDP growth		Inflation		Sales growth	
	mean	variance	mean	variance	mean	variance
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Revisions in beliefs immediately after treatments						
T1 (mean treatment)	3.80	-0.25	0.84	-1.01	-0.20	0.41
	(0.06)	(0.08)	(0.07)	(0.05)	(0.04)	(0.10)
T2 (uncertainty treatment)	1.40	0.53	1.36	-0.75	-0.14	0.44
	(0.08)	(0.08)	(0.08)	(0.06)	(0.05)	(0.14)
T3 (mean and uncertainty treatment)	3.72	-0.07	1.33	-0.79	-0.11	0.43
	(0.06)	(0.10)	(0.08)	(0.04)	(0.04)	(0.08)
Prior mean	1.09		1.10		0.90	
	(0.01)		(0.01)		(0.01)	
Prior mean × T1	-1.04		-0.44		-0.06	
	(0.02)		(0.01)		(0.02)	
Prior mean × T2	-0.62		-0.50		-0.07	
	(0.03)		(0.02)		(0.02)	
Prior mean × T3	-1.01		-0.52		-0.08	
	(0.02)		(0.02)		(0.02)	
Prior variance		2.60		1.54		1.56
		(0.04)		(0.05)		(0.05)
Prior variance × T1		-2.34		-0.18		-0.68
		(0.07)		(0.02)		(0.08)
Prior variance × T2		-2.18		-0.18		-0.65
		(0.07)		(0.02)		(0.10)
Prior variance × T3		-2.07		-0.21		-0.71
		(0.09)		(0.01)		(0.07)
Observations	4,137	4,137	4,145	4,145	4,145	4,145
R-squared	0.75	0.75	0.78	0.68	0.91	0.69
Panel B. Revisions in beliefs in the follow-up wave						
T1 (mean treatment)	1.92	0.25	2.39	0.28	-0.42	0.07
	(0.10)	(0.12)	(0.17)	(0.12)	(0.07)	(0.18)
T2 (uncertainty treatment)	1.03	0.70	2.37	0.76	-0.15	-0.09
	(0.11)	(0.14)	(0.14)	(0.11)	(0.08)	(0.22)
T3 (mean and uncertainty treatment)	2.09	1.03	2.46	0.34	-0.18	0.33
	(0.09)	(0.13)	(0.14)	(0.10)	(0.07)	(0.16)
Prior mean	1.08		1.11		0.87	
	(0.02)		(0.01)		(0.02)	
Prior mean × T1	-0.54		-0.54		0.04	
	(0.03)		(0.04)		(0.03)	
Prior mean × T2	-0.35		-0.57		-0.01	
	(0.04)		(0.03)		(0.03)	
Prior mean × T3	-0.62		-0.61		0.00	
	(0.03)		(0.03)		(0.03)	
Prior variance		2.40		1.92		1.85
		(0.07)		(0.07)		(0.10)
Prior variance × T1		-1.70		-0.18		-0.18
		(0.10)		(0.04)		(0.15)
Prior variance × T2		-1.45		-0.19		-0.44
		(0.10)		(0.03)		(0.16)
Prior variance × T3		-1.96		-0.20		-0.68
		(0.10)		(0.03)		(0.12)
Observations	2,025	2,025	2,025	2,025	2,025	2,025
R-squared	0.71	0.71	0.61	0.48	0.90	0.82

Notes: The table reports estimates of specification (2) for posterior beliefs measured immediately after the treatment (Panel A) and six months after the treatment (Panel B). Robust standard errors are reported in parentheses.

Table 3. Effects of Uncertainty on Firm Decisions relative to Plans.

	Dependent variable: Change relative to plan						
	Price	Employment	Capital stock	Wages	Advert. budget	R&D budget	Profit margin
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Posterior mean	-0.057	-0.077	-0.024	-0.008	0.036	0.016	-0.060
	(0.017)	(0.105)	(0.015)	(0.009)	(0.023)	(0.008)	(0.016)
Posterior uncertainty	-0.106	-0.618	-0.075	0.003	0.110	0.000	0.009
	(0.006)	(0.045)	(0.007)	(0.003)	(0.009)	(0.003)	(0.004)
Observations	2,020	2,020	2,020	2,020	2,020	2,020	2,020
1st stage F stat: post. mean	438.2	438.2	438.2	438.2	438.2	438.2	438.2
1st stage F stat: post. var	437.8	437.8	437.8	437.8	437.8	437.8	437.8

Notes: The table reports instrumental variable estimates of specification (3) for outcome variables indicated in column headers. Prior beliefs (1st and 2nd moments) are included but not reported. The first stage regressions are given by specifications (4') and (4''). Robust standard errors are reported in parentheses.

Table 4. Effects of Uncertainty on Introduction of New Products, New Technologies and New Facilities.

	New product	New technology	New facility
	(1)	(2)	(3)
Posterior mean	-0.256	-1.718	-4.248
	(0.678)	(0.760)	(0.793)
Posterior uncertainty (var)	-0.087	-2.464	-2.136
	(0.125)	(0.249)	(0.246)
Plan	0.473	0.533	0.518
	(0.031)	(0.029)	(0.028)
Observations	2,020	2,020	2,020
1st stage F stat: post. mean	440.8	438.8	439.0
1st stage F stat: post. var	436.1	438.0	438.6

Notes: The table reports instrumental variable estimates for specification (5) for outcome variables indicated in column headers. Prior beliefs (1st and 2nd moments) are included but not reported. The first stage regressions are given by specifications (4') and (4''). Robust standard errors are reported in parentheses.

Table 5. Effects of Uncertainty on Additional Firm Decisions relative to Initial Levels.

	Dependent variable: Change relative to initial level				
			Value of information		
	Employment	Sales	Macro forecast	Info from customers, suppliers, peers, etc.	Dollars allocated to info. about own industry
	(1)	(2)	(3)	(4)	(5)
Posterior mean	0.013	3.716	-2.395	-1.575	0.495
	(0.126)	(0.668)	(3.361)	(1.322)	(0.369)
Posterior uncertainty (var)	-0.616	-0.849	4.315	4.305	-0.383
	(0.045)	(0.192)	(0.908)	(0.423)	(0.107)
Observations	2,020	1,182	2,020	2,020	2,020
1st stage F stat: post. mean	438.1	215.8	438.2	438.2	438.2
1st stage F stat: post. var	436.7	222.2	437.8	437.8	437.8

Notes: The table reports instrumental variable estimates of specification (6) for outcome variables indicated in column headers. Prior beliefs (1st and 2nd moments) are included but not reported. The first stage regressions are given by specifications (4') and (4''). Robust standard errors are reported in parentheses.

Table 6. Effects of Uncertainty on Firm Decisions relative to Plans, control for other expectation.

	Change relative to plan						
	Price	Employment	Capital stock	Wages	Advert. budget	R&D budget	Profit margin
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Posterior mean (GDP)	-0.052	-0.080	-0.024	-0.007	0.050	0.019	-0.064
	(0.018)	(0.107)	(0.016)	(0.008)	(0.023)	(0.009)	(0.018)
Posterior uncertainty (GDP)	-0.109	-0.628	-0.084	0.002	0.078	0.000	0.016
	(0.011)	(0.066)	(0.010)	(0.004)	(0.015)	(0.004)	(0.007)
Posterior mean (Sales)	0.015	-0.301	0.036	-0.005	-0.040	0.018	0.005
	(0.034)	(0.212)	(0.027)	(0.010)	(0.045)	(0.018)	(0.024)
Posterior uncertainty (Sales)	0.004	0.050	0.014	-0.009	-0.001	-0.004	-0.008
	(0.014)	(0.079)	(0.009)	(0.006)	(0.019)	(0.006)	(0.017)
Posterior mean (Inflation)	0.010	-0.008	-0.009	0.020	0.165	0.013	-0.027
	(0.030)	(0.158)	(0.024)	(0.015)	(0.047)	(0.012)	(0.019)
Posterior uncertainty (Inflation)	-0.001	0.099	0.021	-0.006	-0.020	-0.012	0.002
	(0.014)	(0.081)	(0.012)	(0.005)	(0.025)	(0.007)	(0.010)
Observations	2,020	2,020	2,020	2,020	2,020	2,020	2,020
1st stage F stat: post. mean	375.8	375.8	375.8	375.8	375.8	375.8	375.8
1st stage F stat: post. var	70.29	70.29	70.29	70.29	70.29	70.29	70.29

Notes: The table reports instrumental variable estimates of specification (7) for outcome variables indicated in column headers. Prior beliefs (1st and 2nd moments) are included but not reported. The first stage regressions are given by specifications (8') and (8''). Robust standard errors are reported in parentheses.

Table 7. The Hypothetical Effects of Uncertainty on Firms' Decisions.

Outcome	increase	decrease	p-val(equality)
	(1)	(2)	(3)
To hire more employees	-1.29	1.71	0.00
	(0.02)	(0.01)	
To raise my price(s)	-1.23	1.67	0.00
	(0.02)	(0.01)	
To purchase more machinery/physical equipment	-1.32	1.64	0.00
	(0.03)	(0.02)	
To open/invest in new facilities	-1.28	1.70	0.00
	(0.02)	(0.01)	
To increase average wages	-0.59	0.62	0.25
	(0.02)	(0.02)	
To open new export markets	-0.30	0.24	0.12
	(0.03)	(0.03)	
To apply for new loans	-0.62	0.62	0.93
	(0.02)	(0.02)	
To increase cash reserves	1.23	-1.66	0.00
	(0.02)	(0.02)	
To introduce new products/services	-1.11	1.62	0.00
	(0.02)	(0.02)	
To make plans for ten or more years from now	-1.69	1.67	0.57
	(0.02)	(0.01)	
To do more advertising	1.60	-1.64	0.09
	(0.02)	(0.02)	
To engage in more R&D	-1.48	1.47	0.65
	(0.02)	(0.02)	
To see my operating margins increase	-1.73	1.67	0.00
	(0.01)	(0.01)	

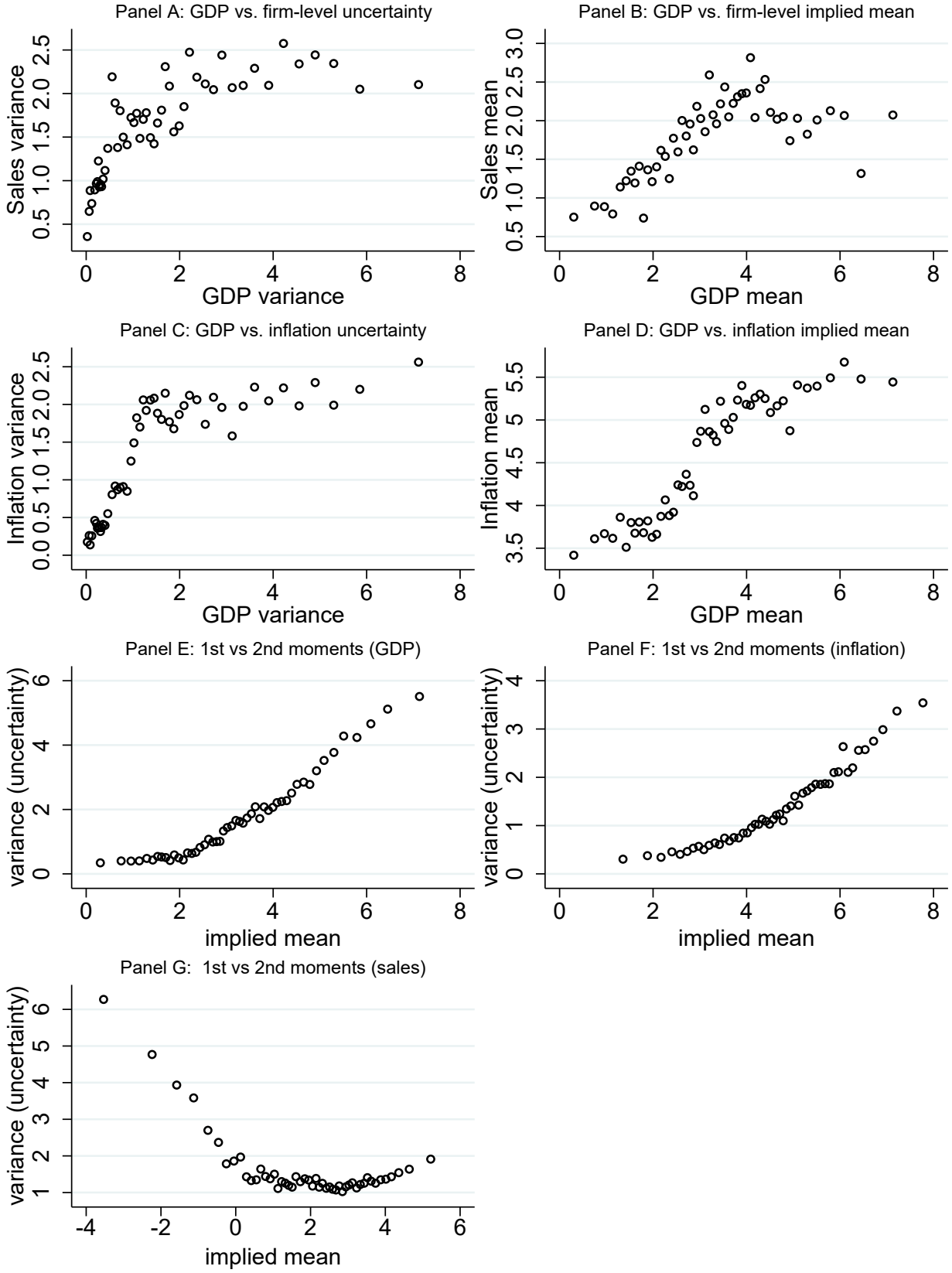
Notes: The table reports average changes in self-reported changes in probability of a given action in response to a hypothetical change in uncertainty. Firms' answers to each category are on a scale of -2 to 2, with -2 corresponding to "much less likely", -1 to "somewhat less likely", 0 to "neither more nor less likely", 1 to "somewhat more likely", and 2 to "much more likely" with increments of 1 in between for each categorical answer. Robust standard errors are reported in parentheses. Column (3) report p-value for the equality of average responses reported in columns (1) and (2).

Table 8. Heterogeneous Effects of Uncertainty on Prices and Employment.

Decomposition	Effect on Prices	N. of obs.	Effect on Employment	N. of obs.
By industry:				
Manufacturing	-0.09	689	-0.60	689
	(0.01)		(0.07)	
Services	-0.12	1231	-0.65	1231
	(0.01)		(0.06)	
By firm size:				
# of workers<10	-0.14	519	-1.34	519
	(0.02)		(0.13)	
# of workers>=10 & workers<30	-0.10	890	-0.71	890
	(0.01)		(0.06)	
# of workers>=30	-0.10	610	-0.31	611
	(0.01)		(0.03)	
By competition:				
Number of competitors = 0	-0.11	408	-0.80	408
	(0.01)		(0.13)	
Number of competitors >0 & <5	-0.10	669	-0.71	670
	(0.01)		(0.07)	
Number of competitors >=5	-0.11	942	-0.48	942
	(0.01)		(0.05)	
By utilization:				
Utilization <0.8	-0.11	237	-0.80	238
	(0.03)		(0.17)	
Utilization >=0.8 & <=1	-0.10	646	-0.67	646
	(0.01)		(0.09)	
Utilization >1	-0.08	165	-0.58	165
	(0.02)		(0.14)	
By total valuation of macroeconomic information:				
Value of macro forecasts <$335	-0.12	671	-0.57	671
	(0.01)		(0.07)	
Value of macro forecasts >=$335 & <$594	-0.08	674	-0.66	674
	(0.01)		(0.07)	
Value of macro forecasts >=$594	-0.11	674	-0.61	675
	(0.01)		(0.08)	
By COVID19 exposure				
Industries more exposed to Covid	-0.10	1085	-0.65	1085
	(0.01)		(0.07)	
Industries less exposed to Covid	-0.10	935	-0.57	935
	(0.01)		(0.08)	
By membership in professional associations:				
Prof. assoc. member: many	-0.11	817	-0.56	817
	(0.01)		(0.07)	
Prof. assoc. member: one	-0.10	969	-0.65	970
	(0.01)		(0.06)	
Prof. assoc. member: none	-0.12	233	-0.64	233
	(0.02)		(0.15)	

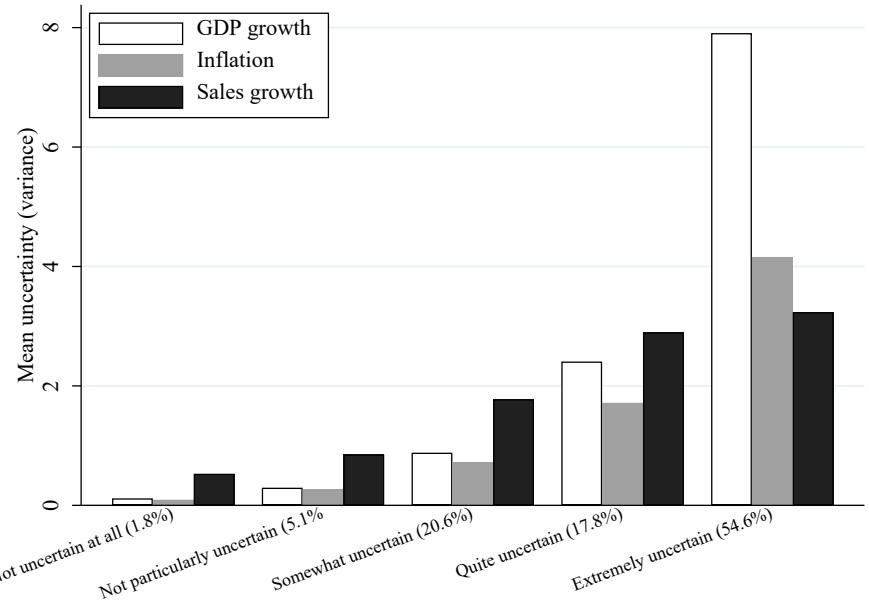
Notes: The table reports instrumental variable estimates of specification (3) for outcome variables indicated in column headers for various subsamples. Prior beliefs (1st and 2nd moments) are included but not reported. The first stage regressions are given by specifications (4') and (4''). Robust standard errors are reported in parentheses.

Figure 1. First and Second Moments of Expectations.



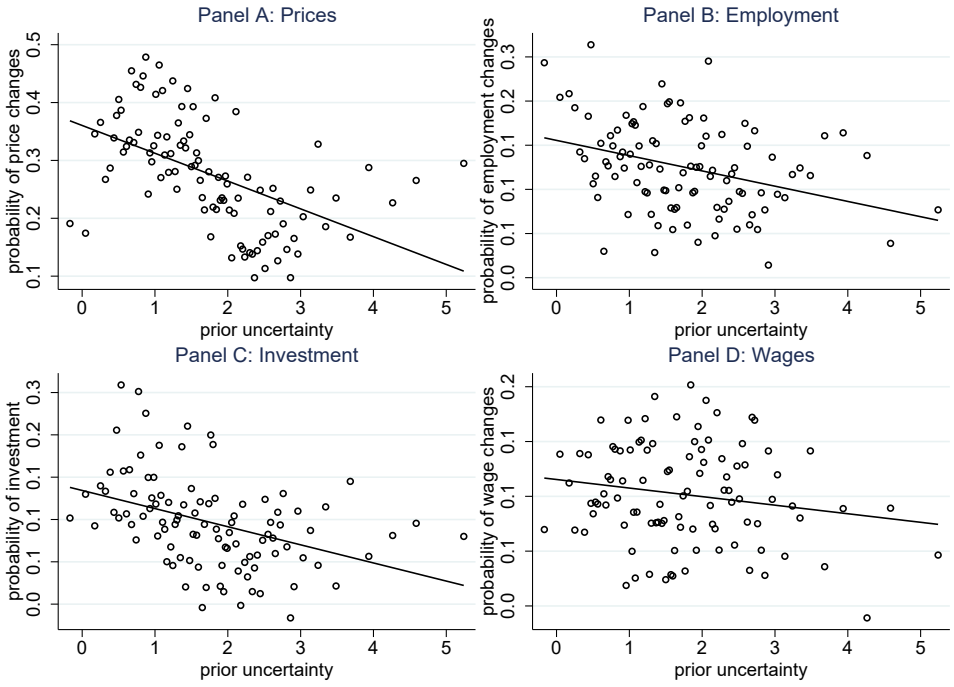
Notes: the figure presents binscatter plots for the 1st and 2nd moments of pre-treatment expectations.

Figure 2. Qualitative vs Quantitative Uncertainty.



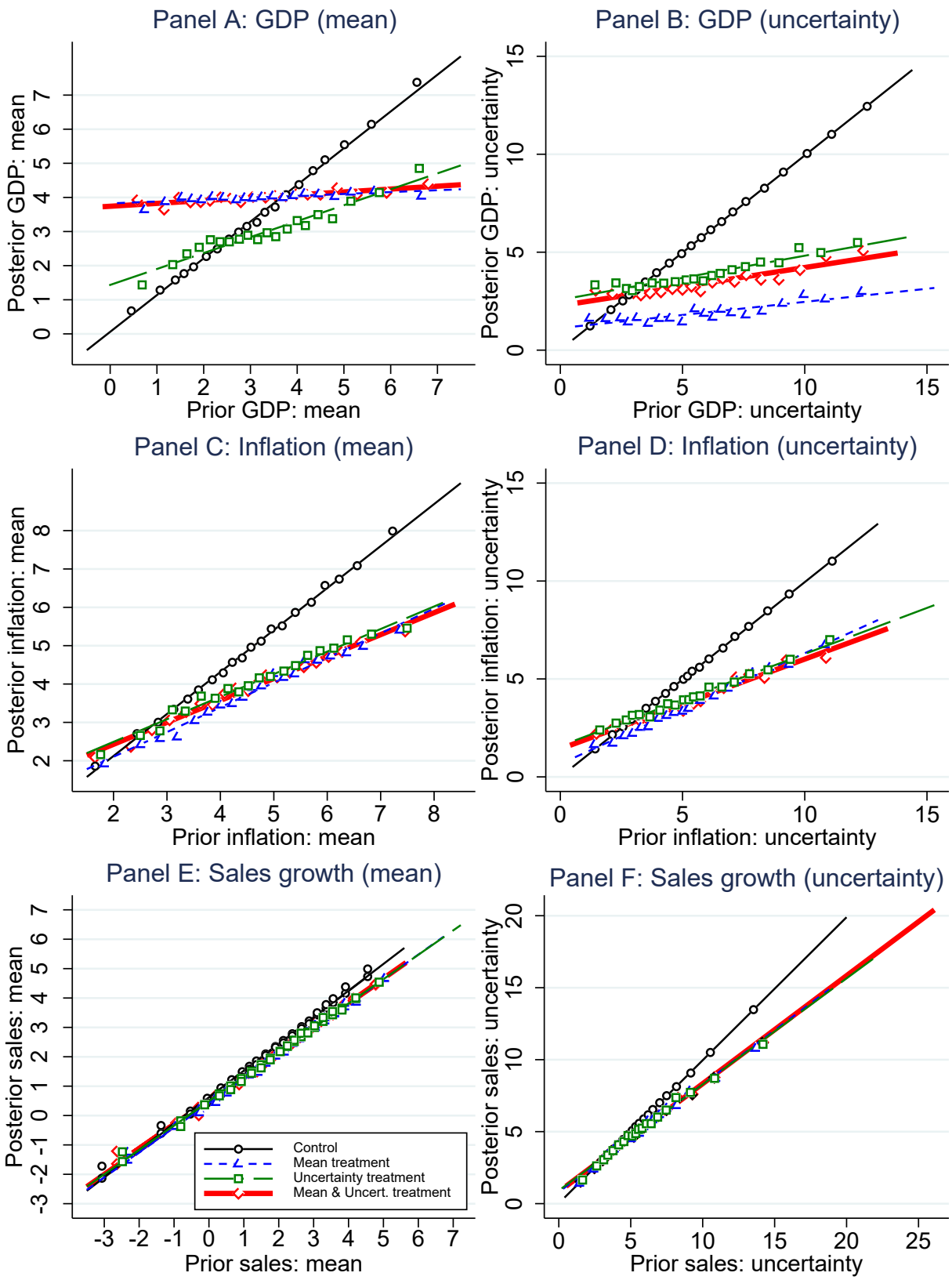
Notes: the figure shows average uncertainty in expectations by qualitative response. All results are for the control group. Uncertainty is measured using the question as in Altig et al. (2022). The shares of responses for each qualitative response are reported in parentheses.

Figure 3. Uncertainty and Bands of Inaction.



Notes: Each panel plots binscatters of firms' macroeconomic uncertainty (x-axis) versus the fraction of firms in each bin reporting that they expect to change prices (Panel A), employment (Panel B), investment (Panel C) or wages (panel D) over the next 6 months after orthogonalizing with respect to firm demographics and their expectations for the level of GDP growth.

Figure 4. Effects of Information Treatments on Expectations.



Notes: the figures show binscatter plots for posterior and prior beliefs by treatment group. The second moment is measured as a range (max-min). Posterior beliefs are measured immediately after the treatment.