DO YOU KNOW THAT I KNOW THAT YOU KNOW…? HIGHER-ORDER BELIEFS IN SURVEY DATA

Olivier Coibion
UT Austin and NBER

Yuriy Gorodnichenko
UC Berkeley and NBER

Saten Kumar
Auckland University of Technology

Jane Ryngaert
Wake Forest University

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Abstract: Using novel survey questions on the higher-order expectations of firm managers, we study the formation and evolution of these beliefs. A unique experimental approach allows us to characterize the degree of higher- order thinking of economic agents and how this degree of higher-order thinking affects managers' expectations as well as their economic decisions. We then relate these results to macroeconomic models in which higher-order thinking matters for dynamics.

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I. Introduction

Economists have long understood the importance of higher-order expectations. Keynes (1936) emphasized the beauty contest nature of financial markets, Harsanyi (1967) formalized the role of higher-order beliefs in decision-making, and Morris and Shin (2002) demonstrate how strategic complementarity in actions of agents can make the public provision of information suboptimal when agents also have private sources of information as public information disproportionately affect higher-order beliefs. The role of higher-order beliefs has also become increasingly recognized and studied in the macroeconomic context. For example, Woodford (2003) shows how noisy private information can lead firms to change their prices gradually because of slow-moving higher-order beliefs about the actions of other firms. More recent work has considered how different assumptions about higher-order beliefs can alleviate the "forward guidance" puzzle[1] (e.g. Angeletos and Lian 2018, Gabaix 2016, Fahri and Werning 2017).

One stumbling block to this literature has been the absence of empirical evidence, other than that of the experimental literature, on the higher-order beliefs of economic agents, especially when it comes to their expectations of macroeconomic variables.[2] This paper takes a first step at filling this gap by studying the higher-order macroeconomic expectations of firm managers using a novel survey of firms in New Zealand. This survey asks managers not only about their expectations over macroeconomic variables, but also about what they think other managers expect for these same variables. These responses provide a set of unconditional moments that can be used to discipline models of higher-order thinking. We also provide new evidence on the learning process through a variety of exogenous information treatments that characterize how agents' first-order and higher-order beliefs respond to different kinds of information about the economy. Using a follow-up wave, we can also measure the persistence of changes in beliefs and how changes in beliefs translate into firms' economic decisions.

The survey builds on earlier surveys of firms in New Zealand described in Coibion, Gorodnichenko and Kumar (forthcoming) and Kumar et al. (2015). Relative to this earlier work, we ran two additional waves using a new draw of firms in 2017Q4 and 2018Q2. These firms were

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[1] Standard New Keynesian models that abstract from information frictions imply that announcements about monetary policy in the distant future can have unrealistically larger contemporaneous economic effects.

[2] The experimental literature has documented a number of striking features about higher-order expectations, and we explicitly build on this previous work. The main differences are that we study macroeconomic expectations of actual firm managers, rather than much more narrowly-defined expectations of undergraduates in typical experiments.

asked to assign probabilities to a range of possible outcomes for future inflation, as well as what they believe other firms think future inflation will be, along with a number of other macroeconomic and firm-specific variables. These questions allow us to characterize both mean forecasts and the uncertainty around firms' first-order and higher-order beliefs. We highlight several features of this unique data set. First, the average higher-order forecast of inflation across firms is close to the average first-order forecast of inflation: 3.5% vs 3.4% respectively, a feature which is consistent with most models of noisy information. Second, the cross-sectional standard deviation of higher-order beliefs (disagreement) is smaller (by about 20%) than the dispersion in first-order beliefs about inflation, which is again consistent with typical models of noisy information. Third, firms are on average more uncertain about their own forecast of inflation than they are about what they think other firms are predicting. This result is again consistent with standard models of noisy information. Fourth, we find in the cross-section that firms with larger forecasts of inflation also tend to have larger higher-order inflation forecasts, with a slope coefficient of less than one, which is what would be predicted from typical noisy information models. In short, all four facts are broadly in line with workhorse models of noisy information and provide a novel set of unconditional moments that can be used to discipline these models.

We also study how managers update both their first- and higher-order beliefs in the face of new information. This is done by providing random subsets of managers with different types of information at the end of the initial wave of the survey, after which we immediately present them with new questions about their expectations. To avoid asking identical questions multiple times and to reduce the burden of participating in the survey, we ask firms to provide point estimates for their forecasters instead of answering additional distributional questions. For the control group that receives no information treatment, we observe minimal change between their initial inflation forecasts from distribution questions and the subsequent point forecasts they provide. Other groups of firms are treated with different information. Consistent with Coibion, Gorodnichenko and Kumar (forthcoming), firms that are told about the average forecast of other firms in the survey display relatively small revisions in their inflation forecasts toward the signal provided, indicating that firms treat this information as somewhat uninformative. We find that their higher-order beliefs similarly respond by more relative to those of the control group. In contrast, firms that are told the average *higher-order* belief of other firms adjust both their own inflation forecasts and their higher-order forecasts by much more, effectively putting a weight of 90% on this new signal relative to their prior belief. This is about the same weight that firms place on signals about recent inflation. Hence, firms seem to treat the average higher-order belief of other firms as a strong signal even though the average forecast of other firms is not treated as such.

In a follow-up wave to the survey, we again collect firms' subjective probability distributions over a range of values of inflation, other managers' inflation expectations, and other variables. This allows us to analyze the persistence of treatment effects on expectations as well as the effect of information on subjective uncertainty. We find that these effects are *persistent* over a short time horizon. Three months after the treatment was introduced, firms weighed each type of signal similarly to how they did immediately following treatment. This is true for the updating of both first-order and higher-order inflation expectations. Again, over a longer time horizon, firms treat the average higher-order belief and the past realization of inflation as strong signals but place a lesser weight on the average inflation forecast.

Expectations matter to central banks because macroeconomic models predict that actions will correspond to an economic agent's beliefs. We are interested to see how firms' beliefs translate into actions.[3] In the initial wave of the survey, we ask firms about their planned changes in inputs, prices, and wages. In the follow-up wave, firms were asked about the actual changes they made in these variables. We find that firms receiving any type of information made significant reductions in employment and investment but not in prices or wages.

These results speak directly to a growing body of work in macroeconomics on the expectations formation of economic agents and implications thereof for macroeconomic dynamics. Angeletos and La'O (2009), for example, highlight the importance of considering higher-order beliefs separately from an agent's own beliefs. They argue that in a noisy or imperfect information context, the precision of information does not predict higher-order beliefs the way it does own expectations. Bacchetta and Wincoop (2008) show that the difference between higher-order and own expectations is important for determining the pricing volatility of assets as well as the link between asset pricing and expectations of future asset payoffs. These findings are also informative for the design of policymakers' communication (e.g., Coibion et al. 2018).

More recent work has focused on limits to higher-order reasoning in accounting for the "forward guidance" puzzle. Fahri and Werning (2017), for example, assume that agents form "*k*-level" expectations. While higher-order expectations require that agents solve a problem in which

[3] Armantier et al. (2015) provide some evidence of this type for households.

they iterate over how their actions affect others then how the actions of others affect them etc., models of *k*-level thinking assume that this reasoning process is computationally expensive and difficult, leading agents to stop at some finite "*k*" level of iteration. Level-0 agents will respond to a game non-strategically, possibly even without regard to the rules of the game. A level-1 player will follow the rules of the game, but strategize as if other players are all level-0 players, level-2 players will respond as if all other players are level-1, etc. The experimental literature has documented in laboratory settings that agents generally display very limited "degrees of reasoning", often stopping at 2 or 3 iterations of a problem (Nagel and Duffy 1997, Nagel 1995, Camerer, Ho, and Chong 2004, Stahl and Wilson 1995, Costa-Gomes and Crawford 2006). These results have important macroeconomic implications. For example, Fahri and Werning (2017) show that level-*k* thinking coupled with heterogeneity in market frictions mitigates the effect of monetary policy, addressing the forward guidance puzzle. Garcia-Schmidt and Woodford (2015) use level-*k* reasoning to show that monetary policy commitments to keep the nominal interest rate very low need not be deflationary.

We provide novel evidence on this dimension of higher-order thinking as well by asking respondents questions aimed to measure their degree of *k*-level thinking. Specifically, we follow the experimental literature and ask them to pick a number between 0 and 100, with the winning number being the one that is two-thirds of the average guess across all respondents. While some respondents answer seemingly random numbers, answers for respondents who spent more than 20 seconds answering the question line up squarely on traditional values assigned with different *k*-levels (33 for *k*=1, 22 for *k*=2, etc…) yielding clear metrics of the degree of *k*-level thinking done by these respondents. The resulting distribution is much more heavily tilted toward higher levels of reasoning than is commonly found in the experimental literature, with over twenty-five percent of respondents displaying *k*-levels of thinking of 3 or more, compared to 9% in Nagel (1995) and 13% in Camerer et al. (2004).

Unlike the experimental literature, we also asked respondents to guess about the distribution of other managers' answers (by assigning corresponding weights to ranges of possible answers). This novel question allows us to ascertain what each manager believes the mean answer to be (and whether they therefore pick a number that is two-thirds of that) and whether they think other managers are dispersed in their level of thinking. We document several departures from standard modeling approaches of *k*-level thinking. First, most managers believe other managers will report an answer in the same range as theirs, so they are not picking a value equal to two-thirds of their expected mean. The exception to this is particularly high-level thinkers, those at level 4 and above. Second, managers generally believe that some of the other managers are higher-level thinkers than they are, whereas standard models assume that an agent acts as if all other players are lower-level thinkers relative to them. Third, managers dramatically underestimate the actual dispersion of answers, so they seem largely unaware of the actual distribution of k-level thinking, even among their peers. These facts present a challenge from typical assumptions used when applying k-level thinking to macroeconomic models, e.g. Fahri and Werning (2017).

More problematic for models emphasizing k-level thinking is that we find no systematic relationship between an agent's degree of k-level thinking and either how they revise their beliefs in light of new information or how changes in their information affect their actions. For example, while we see differential responses to information across types of signals, we see no significant difference in responses to information across levels of k. Managers of all reasoning types show similar adjustments in pricing and input decisions between the initial survey and follow-up.

The remainder of the paper is organized as follows. We first explain the nature of the survey as well as the questions designed to target higher-order expectations. Section 3 describes a model of higher-order expectations under strategic complementarities in price and compares the expectations of managers in New Zealand to the predictions of this model. Section 4 describes the results of the experiment and Section 5 describes our results on k-level thinking. Section 6 concludes.

II. Survey

This paper utilizes two additional waves of the survey of firm managers in New Zealand described in Coibion, Gorodnichenko and Kumar (forthcoming). The first wave was implemented in between 2017Q4 and 2018Q1. The follow-up ran from 2018Q1 to 2018Q2, such that each firm manager from the first wave was invited to participate in the second wave three months after his or her initial interview. The first wave included 1,025 firms, with 515 of these participating in the second wave.

2.1 Sampling Frame and Protocol

We obtained information on the population firms in New Zealand from two sources: Kompass New Zealand (KNZ) and Equifax (EQ). Following the Australia and New Zealand Standard

Industrial Classification 2006 (ANZSIC06), firms are classified into one of four broad industries: manufacturing, trade, construction and transportation, and professional and financial services. Following Coibion, Gorodnichenko and Kumar (forthcoming), we focus on firms with six or more employees. We targeted for two thirds of the sample to come from professional and financial services and manufacturing as these industries account for relatively large shares of New Zealand's GDP (New Zealand Treasury, 2016).[4] The remainder of the sample comes from firms in other industries, i.e. trade, construction, communication and transportation. We excluded industries related to the government, community service, agriculture, fishing and mining, and energy, gas and water from the sample. These sectors are often dominated by a few extensively regulated firms or by very small firms. Within each industry, firms are classified as small (6-19 workers), medium (20-49 workers) and large (50 or more workers). To make the survey population more representative, we oversampled firms with 50-99 workers and 100+ workers in each industry. To this end, we contacted all firms that fall into these two employment size groups. We then computed the relative shares of firms in the remaining employment size groups and include enough firms to match the relative share of their size and industry.

To achieve the target of 1,000 firms in the sample, we invited 10,100 firms to participate in the survey. Each firm's general manager received an email containing an information sheet and survey questionnaire about ten days before receiving a phone call to collect responses. Note that the initial questionnaire sent to managers did not include the treatment information and the subsequent related questions. We called each firm three times to elicit responses. After the third round of calls, we examined the response rates for sectors, subsectors and employment size groups. We then targeted groups in which responses rates were low. We continued contacting firms until we hit the target sample size. Appendix B reports response rates by industry and size.

Responses were collected over the phone. A research assistant (RA) called the general manager and recorded answers by hand while also recording the phone call. An independent RA then listened to the recording and confirmed the accuracy of the handwritten responses. For the confidentiality of the participants, the recordings were deleted following data collection. The handwritten questionnaires were then entered into a spreadsheet, with two independent RAs verifying that the handwritten and spreadsheet responses matched. As discussed in Coibion,

[4] New Zealand Treasury (2016), New Zealand: Economic and Financial Overview 2016, Wellington. See https://treasury.govt.nz/sites/default/files/2010-04/nzefo-16.pdf.

Gorodnichenko and Kumar (forthcoming), responses of managers are consistent with information available from other sources and the quality of the survey is reasonably high.[5] Descriptive statistics are provided in Appendix Table 1.

The second wave (follow-up) of the survey was implemented three months after the initial wave. For the follow-up, we contacted all firms that participated in the main wave of the survey. The response rate was approximately 50 percent. We achieved high response rate because we provided respondents with a monetary incentive of $50 gift voucher and dinner and entertainment ticket worth $50. Further, respondents enter into a pool draw to win a cash prize of $5,000. The main reason for non-participation was that the general manager was too busy to respond in a reasonable time frame. Appendix Table 2 examines whether participation in the second wave is correlated with firm/manager characteristics. We find that firms non-participating in the second round are missing at random.

2.2 Survey instrument

After collecting basic demographic information about firms, the survey asks respondents to report their beliefs about future aggregate variables (inflation, unemployment rate, and wages) and about firm-specific outcomes (employment, fixed assets, prices, and wages). The horizon for aggregate variables is one-year ahead. The horizon for firm-specific variables is three-month ahead (which was determined by the timing of the follow-up) and six-month ahead. Firms were also asked to report their perceptions and nowcasts (e.g., their perception of inflation over the previous twelve

[5] We verified our survey data against the publicly available online information in four ways. First, we verified managers' responses about the age of the firm using the information from the Companies Office or their website. We find that the reported age in the survey match exactly with the information available in the Companies Office or their website for 1012 firms. Information about age of 20 firms is not available in any other source. Second, we verified whether the firm exports or not. Firms that indicated in the survey that they export overseas, this information is available in their websites. Third, we asked in the survey about the number of Directors, number of shareholders and the number of shares issued in the business. There are 862 firms classified as Companies in this survey, i.e. public or private companies. We find that more than 98 percent of these firms' responses match with the information available in the Companies Office. Last, we verified survey responses on firm's products and prices. To do this, we randomly selected around 20 percent of the firms (around 206 firms) and asked them about their main product and price of the main product. For 203 firms, details about their main products are available in their websites. 43 out of 203 firms list their prices online in their websites. The reported prices of main products do not match the online information for only 4 firms; this is equivalent to 1 percent. For firms whose prices are not listed online, we made phone enquiries about the price of their main products. These were general customer enquiries about their prices. To this end, we made 163 phone enquiries and 94 percent of the firms' reported price match with the quotes provided.

months). The survey asks a few hypothetical questions to provide us with estimates of parameters that would be difficult to identify otherwise.

Consistent with recommendations in Coibion et al. (2018), expectations were elicited in two ways. First, firms were asked to assign probabilities for possible outcomes. Table 1 provides examples for inflation expectations. These distributional questions are similar to the questions asked in the Survey of Consumer Expectations run by the Federal Reserve Bank of New York. Second, firms were asked to provide point predictions for future inflation and other variables. We do not restrict responses for this type of questions in any way (e.g., we do not censor responses or prompt respondents to reconsider if responses are outside some range). In contrast to previous surveys, we collect information not only about managers' own expectations about future inflation but also about what managers think about other managers' inflation expectations.

The survey has two novel parts. First, after the core part of the survey is complete, respondents are invited to participate in a strategic game to infer their level of thinking. This game is similar to Nagel (1995) and we provide more details in section 5.1. Second, after the game, firms are randomly assigned into control and treatment groups. Firms in a treatment group are provided with a piece of information, while firms in the control group are told nothing. The treatments are described in section 4.2. We use these treatments to study how firms form their expectations and how they use these expectations to set prices, wages, employment, and fixed assets. The questionnaire and other details are provided in Appendix B.

III. Higher-Order Expectations

Strategic complementarities in pricing behavior require that firms think not only of their own expectations of a fundamental, but also of other firms' expectations and actions. Firm A must think about the fundamental and what Firm B thinks of the fundamental. Firm B then anticipates the fundamental, what firm A thinks of the fundamental, and what Firm A thinks that Firm B thinks. Firm A's expectations must respond accordingly, etc. As firms anticipate each other's actions, they form higher-order beliefs that involve iterating a problem to progressively higher levels of reasoning. A similar logic applies to households when they consider how changes in their consumption affects other households' incomes, which in turn affect those households' consumption and therefore the initial households' income. Angeletos and Lian (2017) focus on a similar logic with intertemporal effects. We use the static model of Morris and Shin (2002) to demonstrate how the expectations and higher-order expectations of the firms in our survey compare to the predictions of a model of strategic complementarities where firms perform infinite regress in their expectations.

3.1 Strategic Complementarities in Pricing

Firm $i \in [0,1]$ chooses to set its optimal price, p_i, as a linear combination of its expectations of a fundamental, m, and its expectation of the aggregate price level in the economy, $\overline{p}$:

$$p_i = (1-\alpha)E_i[m] + \alpha E_i[\overline{p}] \tag{1}$$

Parameter $\alpha \in (0,1)$ describes the degree of complementarity in pricing. Because $\overline{p} \equiv \int_0^1 p_j dj$, manager i can iterate the optimal price equation forward by substituting the average optimal price equation for the aggregate price level to obtain:

$$p_i = (1-\alpha)E_i[m] + \alpha E_i\left[\int p_j dj\right] \tag{1'}$$

Define the average expectation in the economy for variable m as $\overline{E}[m] \equiv \left[\int_0^1 E_j(m)dj\right]$ and let $E_i\left[\overline{E}[m]\right]$ be the expectation of manager i about the average expectation in the economy. In a similar spirit, $E_i[\bar{p}]$ is the first-order ("own") expectation about the price level, $E_i\left[\overline{E}[\bar{p}]\right]$ is a higher-order expectation about the price level in the sense that this is an expectation of manager i about what other managers think about the price level. We can iterate these expectations to k^{th} higher orders recursively: $\overline{E}^k[X] \equiv \left[\int_0^1 E_j\left(\overline{E}^{k-1}[X]\right)dj\right]$.

Using the definition of the price level and repeated substitutions in equation (1'), we find that the aggregate price level becomes an average of progressively higher-order expectations of the fundamental, weighted by the complementarities present at each step:

$$\overline{p} = (1-\alpha)\overline{E}[m] + \alpha(1-\alpha)\overline{E}^2[m] + \alpha^2(1-\alpha)\overline{E}^3[m] + \cdots . \tag{2}$$

It follows that the optimal choice of p_i depends on the manager's expectation of each event in equation (2).

$$p_i = (1-\alpha)E_i\left[\overline{E}[m]\right] + \alpha(1-\alpha)E_i\left[\overline{E}^2[m]\right] + \alpha^2(1-\alpha)E_i\left[\overline{E}^3[m]\right] + \cdots. \qquad (3)$$

So far we have not made any assumptions about how expectations are formed. To make progress, we need to impose more structure on how information is received. We do this in the next section.

3.2 Noisy Information

Firms operate under imperfect information. This means that, rather than observing m completely, they see noisy public and private signals that include the true value of m and some noise.[6] Specifically, allow a public signal about the fundamental to take the following form: $y = m + \varepsilon$ where $\varepsilon \sim N(0, \kappa_y^{-1})$. Firm i also receives a private signal about m: $x_i = m + v_i$ with $v_i \sim N(0, \kappa_x^{-1})$ where ε and v_i are uncorrelated. Firms weigh their signals according to the relative noise in each to obtain an individual expectation of m:

$$E_i[m] = \frac{\kappa_y}{\kappa}y + \frac{\kappa_x}{\kappa}x_i = (1-\delta)y + \delta x_i, \qquad (4)$$

where $\kappa = \kappa_x + \kappa_y$ and, for ease of notation, we denote $\frac{\kappa_x}{\kappa}$ and $\frac{\kappa_y}{\kappa}$ as δ and $1-\delta$, respectively, for the remainder of the paper. Aggregating equation (4) across managers gives the average expectation about the fundamental in the economy:

$$\overline{E}\,[m] = (1-\delta)y + \delta m. \qquad (5)$$

Note that manager i's expectation about the average expectation of other managers in the economy is

[6] We treat m as a fixed parameter to simplify algebra. Results are similar when m is stochastic.

$$E_i\left[\overline{E}\ [m]\right] = (1-\delta)y + \delta E_i[m] = (1-\delta^2)y + \delta^2 x_i \tag{5}$$

One can obtain progressively higher-order expectations of m by continuing to substitute $E_i[m]$ for m to find:

$$E_i\left[\overline{E}^k[m]\right] = (1-\delta^{k-1})y + \delta^{k-1}E_i\left[\overline{E}^{k-1}\ [m]\right] = (1-\delta^k)y + \delta^k x_i. \tag{6}$$

Equation (6) shows that higher-orders of reasoning will depend more heavily on the public signal as they rely more on average, rather than idiosyncratic, beliefs.

Using the firm's optimal price-setting in equation (3), we can substitute for manager i's expectations of m at various orders to obtain the optimal price as a function of received signals:

$$p_i = (1-\alpha)\sum_{k=0}^{\infty}\alpha^k\left[[1-\delta^{k+1}]y + \delta^{k+1}x_i\right]. \tag{7}$$

It follows that every agent sets the optimal price at:

$$p_i \ = \phi_y y \ + \phi_x x_i, \tag{8}$$

where $\phi_y = \frac{1-\delta}{(1-\alpha)\delta+(1-\delta)}$ and $\phi_x = \frac{(1-\alpha)\delta}{(1-\alpha)\delta+(1-\delta)}$. The realization of the aggregate price is the integral of equation (8) across the support of all managers:

$$\overline{p} \ \equiv \int_0^1 p_j dj = \phi_y y \ + \phi_x m. \tag{9}$$

Using these results, we can derive expectations of manager i about the price level:

$$E_i[\overline{p}] = \phi_y y + \phi_x\big((1-\delta)y + \delta x_i\big) = (1-\phi_x\delta)y + \phi_x\delta x_i. \tag{10}$$

Aggregating across agents gives the average expectation about the price level.

$$\overline{E}[\overline{p}] = \phi_y y + \phi_x\big((1-\delta)y + \delta m\big) = (1-\phi_x\delta)y + \phi_x\delta m. \tag{11}$$

The individual expectation of the left-hand side in equation (11) is an individual manager's higher-order expectation:

$$E_i\left[\overline{E}[\overline{p}]\right] = \phi_y y + \phi_x[(1-\delta^2)y + \delta^2 x_i] = (1-\phi_x\delta^2)y + \phi_x\delta^2 x_i. \tag{12}$$

Aggregating equation (12) gives the mean of the higher-order expectation.

$$\overline{E}^2[\overline{p}] = \phi_y y + \phi_x[(1-\delta^2)y + \delta^2 m] = (1-\phi_x\delta^2)y + \phi_x\delta^2 m. \tag{13}$$

These derivations demonstrate that firms in the noisy information model have two sources of uncertainty: noise in the public signal and noise in the private signal. When firms make inferences about fundamental m or when we consider unconditional distributions of $\bar{p}$, both sources of uncertainty appear. However, for a given time period, firms observe y and thus firms do not face uncertainty about what other firms observe. Indeed, equation (9) demonstrates that the price level is a function of public signal y (observed) and fundamental m (unobserved). Because for firm i the expected value of m is a linear combination of y and private signal x_i (see equation (4)), the only source of uncertainty about $\bar{p}$ is the realized private signals of other firms. As a result, uncertainty about $\bar{p}$ is described by distributions conditional on y. Specifically, one can show that the unconditional distribution of these expectations is

$$E_i[\overline{p}] \sim N\big(m, (1-\phi_x\delta)^2\kappa_y^{-1} + (\phi_x\delta)^2\kappa_x^{-1}\big), \tag{14a}$$

$$\overline{E}[\overline{p}] \sim N\big(m, (1-\phi_x\delta)^2\kappa_y^{-1}\big), \tag{14b}$$

$$E_i\left[\overline{E}[\overline{p}]\right] \sim N\big(m, (1-\phi_x\delta^2)^2\kappa_y^{-1} + (\phi_x\delta^2)^2\kappa_x^{-1}\big), \tag{14c}$$

$$\overline{E}^2[\overline{p}] \sim N\big(m, (1-\phi_x\delta^2)^2\kappa_y^{-1}\big), \tag{14d}$$

while the distributions conditional on the public signal (that is, the distributions of beliefs about $\bar{p}$

in a given cross-section of managers for a point in time) are:

$$E_i[\overline{p}]|y \sim N\left(\left[\phi_y + \phi_x(1-\delta)\right]y + \phi_x\delta m, (\phi_x\delta)^2\kappa_x^{-1}\right), \quad (15a)$$

$$\overline{E}[\overline{p}]|y \sim N\left(\left[\phi_y + \phi_x(1-\delta)\right]y + \phi_x\delta m, 0\right), \quad (15b)$$

$$E_i\left[\overline{E}[\overline{p}]\right]|y \sim N\left(\left[\phi_y + \phi_x(1-\delta^2)\right]y + \phi_x\delta^2 m, (\phi_x\delta^2)^2\kappa_x^{-1}\right), \quad (15c)$$

$$\overline{E}^2[\overline{p}]|y \sim N\left(\left[\phi_y + \phi_x(1-\delta^2)\right]y + \phi_x\delta^2 m, 0\right). \quad (15d)$$

3.3 Predictions for Own Expectations and Higher-Order Expectations

Using this model, we derive a set of simple predictions about what one would expect to observe in terms of agents' own expectation of inflation versus their higher-order expectations. We then compare these predictions with the results from the survey. Finally, we use theoretical predictions and empirical moments to quantify various parameters of the model.

3.3.1 Means

Our basic theory predicts that the mean of the distribution of firms' own expectations of the aggregate price level ($E_i[\overline{p}]$) could be similar to that of the firms' higher-order expectation of the aggregate price level $\left(E_i\left[\overline{E}[\overline{p}]\right]\right)$, that is, their expectation of other managers' expectation. Specifically, equations (15a) and (15c) show that for a given realization of public signal y, higher-order expectations assign a larger weight to the public signal and a smaller weight to the private signal (recall that $\delta < 1$). The difference between $E_i[\overline{p}]$ and $E_i\left[\overline{E}[\overline{p}]\right]$ depends on how far y is from m. Indeed,

$$\left(\overline{E}[\overline{p}] - \overline{E}^2[\overline{p}]\right)|y = \phi_x(1-\delta)\delta[m-y]. \quad (16)$$

Thus, even without knowing ϕ_x and δ, we can sign $[m-y]$ using the observed difference in average expectations for high and low orders.

Table 2 shows that, in our sample, $\overline{E}[\pi]|y$ is 3.41 and $\overline{E}^2[\pi]|y$ is 3.50. The negative difference between these two measures is consistent with y being greater than m (that is, the public signal is more "inflationary" than the fundamental). Whether the difference is large or small depends on the magnitudes of ϕ_x and δ, but since $\phi_x, \delta \in (0,1)$ we expect that $m - y < -0.09$. As we show later, $\delta \approx 0.8$ and $\phi_x \approx 0.55$ so that $m - y \approx -1$. Incidentally, the survey responses where collected at the time when oil prices continued to rise thus possibly sending an "inflationary" public signal.[7]

3.3.2 Disagreement

Private signals are the reason why agents disagree about macroeconomic variables in the noisy information model. Equations (15a) and (15c) predict that the cross-sectional variance of higher-order expectations $(\phi_x \delta^2)^2 \kappa_x^{-1}$ will be smaller than the variance of the managers' own expectations $(\phi_x \delta)^2 \kappa_x^{-1}$. This happens as higher-order expectations become more weighted toward the common signal, which is observed by all agents. Note that the ratio of cross-sectional variances for $E_i\left[\overline{E}[\overline{p}]\right]|y$ and $E_i[\overline{p}]|y$ gives us

$$\frac{Var\left(E_i\left[\overline{E}[\overline{p}]\right]|y\right)}{Var(E_i[\overline{p}]|y)} = \frac{\left(\phi_x \delta^2\right)^2 \kappa_x^{-1}}{(\phi_x \delta)^2 \kappa_x^{-1}} = \delta^2 < 1 \qquad (17)$$

and, thus, we can assess the relative importance of private and public signals (recall that $\delta \equiv \frac{\kappa_x}{\kappa_x + \kappa_y}$).

Consistent with the theoretical prediction of $\delta < 1$, we find (Table 2) that disagreement is larger for low-order inflation expectations (standard deviation is 3.06) than for high-order inflation expectations (standard deviation is 2.43). The ratio of these two standard deviations implies $\delta \approx 0.8$, that is, the precision of the private signal is about four times larger than the precision of the public signal.

---

[7] Coibion and Gorodnichenko (2015) document that households' inflation expectations are sensitive to the price of oil, gasoline and similar goods. Kumar et al. (2015) and Coibion, Gorodnichenko and Kumar (forthcoming) present suggestive evidence of high sensitivity of managers' inflation expectations to changes in oil prices and other energy products frequently purchased by consumers.

As we derived above, $\phi_x = \frac{(1-\alpha)\delta}{(1-\alpha)\delta+(1-\delta)}$ and so we can estimate ϕ_x if we have an estimate of strategic complementarity α. While we cannot obtain α from moments of inflation expectations, we can recover this parameter from a series of hypothetical questions:

> **For the next three questions, suppose that neither you nor your competitors face any costs in changing your prices. Also suppose that you get news that the general level of prices went up by 10% in the economy:**
>
> **a.** By what percentage do you think your competitors would raise their prices on average? …………..%
>
> **b.** By what percentage would your firm raise its price on average? …………..%
>
> **c.** By what percentage would your firm raise its price if your competitors did not change their price at all in response to this news? …………..%

Afrouzi (2018) shows that α is the slope in the regression of {the answer in "b" minus the answer in "c"} on {the answer in "a"}. When we implement this regression in our sample, we find $\hat{\alpha} \approx 0.7$ (standard error 0.02). It follows that $\phi_x \approx 0.55$, that is, firms put 55% weight on their private signals and 45% on the public signal when setting prices.

Once we have ϕ_x, we can also estimate the precision of private and public signals. Note that disagreement in low-order inflation expectations is $Var(E_i[\overline{p}]|y) = (\phi_x\delta)^2\kappa_x^{-1}$. Because in the data disagreement is $Var(E_i[\overline{p}]|y) = 3.06^2$, it follows that $\kappa_x \approx 0.02$. Using $\delta \equiv \frac{\kappa_x}{\kappa_x+\kappa_y}$, we find that $\kappa_y = 0.005$. These estimates suggest that both signals could be rather imprecise. However, this imprecision is in agreement with the notion that firms should pay little attention to inflation if inflation is stable and low (e.g., Sims 2003, Mackowiak and Wiederholt 2009), which is the case in New Zealand, an early adopter of inflation targeting.

3.3.3 Uncertainty

We can also use firms' uncertainty about aggregate variables to back out parameters of the model. First, note that, similar to disagreement, the ratio of uncertainty in high-order expectations to uncertainty in low-order expectations satisfies $\frac{(\phi_x\delta^2)^2\kappa_x^{-1}}{(\phi_x\delta)^2\kappa_x^{-1}} = \delta^2 < 1$. Column (4) of Table 2 shows that the ratio of standard deviations implied by the reported distributions for own expectations of inflation (=1.11) and for expectations about other managers (=0.89) is 0.8, which is consistent with the estimate of δ in section 3.3.2.

Second, the model predicts that disagreement (cross-sectional standard deviation of point predictions) and uncertainty (the average standard deviation implied by reported distributions for future inflation) are equal to $(\phi_x \delta)^2 \kappa_x^{-1}$. Indeed, both are determined by the variance of noise in private signals. In the data, uncertainty is about a third of disagreement.[8] Hence, if we use uncertainty to recover κ_x and κ_y, $Var(E_i[\overline{p}]|y) = (\phi_x \delta)^2 \kappa_x^{-1}$. Because in the data uncertainty is $Var(E_i[\overline{p}]|y) = 1.11^2$, it follows that $\kappa_x \approx 0.15$ and $\kappa_y \approx 0.04$ which still imply rather imprecise signals.

3.3.4 Regression Coefficient

Because private signal x_i is the only source of cross-sectional variation in expectations, the model predicts perfect correlation between higher- and lower-order expectations which is unlikely to be borne out in the data given measurement errors and other idiosyncratic variation in survey responses (indeed, $Corr\left(E_i[\overline{p}], E_i\left[\overline{E}[\overline{p}]\right]\right) \approx 0.6$ in our sample). Perhaps a more interesting prediction is that variation in low-order expectations $E_i[\overline{p}]$ should translate in less than one-to-one changes in high-order expectations $E_i\left[\overline{E}[\overline{p}]\right]$. Specifically, the model implies that regressing $E_i\left[\overline{E}[\overline{p}]\right]$ on $E_i[\overline{p}]$ should yield slope equal to

$$\beta = \frac{Cov\left(E_i[\overline{p}], E_i\left[\overline{E}[\overline{p}]\right]\right)}{Var(E_i[\overline{p}])} = \frac{\phi_x^2 \delta^3 \kappa_x^{-1}}{\phi_x^2 \delta^2 \kappa_x^{-1}} = \delta < 1. \qquad (18)$$

Figure 1 shows a scatter plot for $E_i\left[\overline{E}[\overline{p}]\right]$ and $E_i[\overline{p}]$ and the fitted regression line. The estimated slope of the regression is 0.66 (standard error 0.02), which is consistent with the theoretical prediction that the slope should be less than 1. The magnitude is also broadly in line with the

[8] This difference may be rationalized if we allow managers to report beliefs as in Patton and Timmermann (2010). Specifically, suppose that the reported forecast is a weighted average of the signal-based forecast and the individual's belief about the long-run average: $\hat{E}_i[\overline{p}] = \omega_Q \mu_i + (1-\omega_Q) E_i[\overline{p}|x_i, y]$. In this case, the cross-sectional variance of mean predicted price level is $\Omega_{\hat{E}_i[\overline{p}]} = \omega_Q^2 Var(\mu_i) + (1-\omega_Q)^2 Var(E_i[\overline{p}|x_i, y])$ while uncertainty is $(1-\omega_Q)^2 Var(E_i[\overline{p}|x_i, y])$ which is smaller than disagreement.

estimate of δ we obtained in section 3.3.2 (recall that $E_i[\overline{p}]$ is likely measured with error).

In summary, our analysis demonstrates the value of eliciting high-order expectations in surveys of economic agents. Apart from providing moments central for calibration of models with information frictions, these expectations allow policymakers to measure realizations of public signals relative to fundamentals (that is, $m - y$) and the precision of signals received by agents. These estimates are instrumental for assessing the degree of inattention and success of policymakers' communication (e.g., how much precision agents assign to statements by policymakers).

IV. The Effect of Information

In a noisy information environment, firm managers will update their expectations of inflation as well as their expectations of other managers' expectations when they receive new information. However, they will update their expectation only partially, reflecting the fact that they may not believe the information to be fully credible or noiseless. To assess empirically the degree of noise that managers perceive in signals, we introduce signals in an experimental context and gauge the response of managers' expectations to these signals. We then examine how this revision of expectations in light of new information causes firms to change their actions. The results indicate that firms adjust their expectations when presented with new information and that the treatment effects of information are persistent after three months. Furthermore, these changes in expectations lead to changes in input decisions, implying that the introduction of information transmits to the economic decisions of firms.

4.1 Theory of Information Updates

Equations (9) and (10) imply that manager i's own expectation about the price level is a linear combination of public signal y and manager i's expectation about fundamental m, that is, $E_i(m)$. When firms are provided with new private information, they revise their beliefs about m and, correspondingly, about the price level. Specifically, a unit increase in $E_i(m)$ translates into ϕ_x unit increase in $E_i[\overline{p}]$ and $\phi_x\delta$ unit increase in $E_i\left[\overline{E}[\overline{p}]\right]$.

$$E_i \begin{bmatrix} \overline{p} \\ \overline{E}[\overline{p}] \end{bmatrix} = \begin{bmatrix} \phi_y \\ \phi_y + \phi_x(1-\delta) \end{bmatrix} y + \begin{bmatrix} \phi_x \\ \delta\phi_x \end{bmatrix} E_i[m]. \tag{19}$$

We consider three types of signals provided to firms. First, we provide firms with $\overline{E}[\overline{p}]$ (that is, the average of managers' own expectations about inflation), $\overline{E}^2[\overline{p}]$ (that is, the average expectation about other managers' expectation about inflation), and past inflation. Equations (15b) and (15d) indicate that if firms think this information has no noise, firms can infer the value of m. To avoid this extreme (and unrealistic) case, we assume that firms interpret received signals as having some noise. For example, the signal for $\overline{E}[\overline{p}]$ is given by

$$s_B = \overline{E}[\overline{p}] + \xi_B, \tag{20}$$

where $\xi_B \sim N(0, \kappa_B^{-1})$ and ξ_B is uncorrelated with noise ε and ν_i.[9] Note that because $\overline{E}[\overline{p}] = (1 - \phi_x\delta)y + \phi_x\delta m$ and firms observe y directly, signal s_B has the same content as signal $\tilde{s}_B = \phi_x\delta m + \xi_B = H_B m + \xi_B$ with $H_B \equiv \phi_x\delta$. Using the Bayes rule, we can derive beliefs about m after observing $\tilde{s}_B$

$$E_i(m|\tilde{s}_B, x_i, y) = E_i(m|x_i, y) + P\big(\tilde{s}_B - \phi_x\delta E_i(m|x_i, y)\big), \tag{21}$$

where $P_B = \delta\kappa^{-1}\phi_x\delta(\kappa_B^{-1} + (\phi_x\delta)^2\delta\kappa^{-1})^{-1}$ is the gain of the Kalman filter, κ is the precision of the prior $E_i(m|x_i, y)$. We can re-write this equation as:

$$E_i^{post}(m) = (1 - P_B H_B)E_i^{pre}(m) + P_B\tilde{s}_B = \frac{\kappa_B^{-1}}{\kappa_B^{-1} + (\phi_x\delta)^2\delta\kappa^{-1}} E_i^{pre}(m) + P_B\tilde{s}_B, \tag{22}$$

where $E_i^{post}(m)$ denotes expectations after receiving additional information and $E_i^{pre}(m)$ denotes expectations before receiving additional information. The coefficient on the prior belief $E_i^{pre}(m)$ can tell us κ_B, the precision of signal $\tilde{s}_B$, since we can measure $(\phi_x\delta)^2\delta\kappa^{-1}$, the precision of the

[9] Although s_B does not have index i, we interpret s_B as a private signal because we do not tell a firm receiving this signal that other firms receive this signal too.

prior. The uncertainty in the posterior beliefs $E_i^{post}(m)$ is given by $\delta\kappa^{-1}\frac{\kappa_B^{-1}}{\kappa_B^{-1}+(\phi_x\delta)^2\delta\kappa^{-1}}$.

One can derive similar expressions for signal

$$s_C = \overline{E}^2[\overline{p}] + \xi_C = (1-\phi_x\delta^2)y + \phi_x\delta^2 m + \xi_C \tag{23}$$

with $\xi_C \sim N(0,\kappa_C^{-1})$ and an equivalent signal $\tilde{s}_C = \phi_x\delta^2 m + \xi_C = H_C m + \xi_C$ with $H_C \equiv \phi_x\delta^2$ so that

$$E_i^{post}(m) = (1-P_C H_C)E_i^{pre}(m) + P_C\tilde{s}_C = \frac{\kappa_C^{-1}}{\kappa_C^{-1}+(\phi_x\delta^2)^2\delta\kappa^{-1}}E_i^{pre}(m) + P_C\tilde{s}_C \tag{24}$$

which has variance $\delta\kappa^{-1}\frac{\kappa_C^{-1}}{\kappa_C^{-1}+(\phi_x\delta^2)^2\delta\kappa^{-1}}$. Note that if $\kappa_C^{-1} = \kappa_B^{-1}$, we have $P_B > P_C$, that is, signal s_B has a higher weight than signal s_C when firms update their beliefs. Intuitively, as we increase the order of expectations in the signal, the signal contains less information about the unobserved m and gets less attention from managers.

If both signals are provided and noise in the signals is uncorrelated, then

$$E_i^{post}(m) = (1-P_D H_D)E_i^{pre}(m) + P_D\tilde{s}_C, \tag{25}$$

where $H_D = [\phi_x\delta \quad \phi_x\delta^2]'$, $R_D = diag\{\kappa_B^{-1},\kappa_C^{-1}\}$, and $P_D = \delta\kappa^{-1}H_D'(R_D + \delta\kappa^{-1}H_D H_D')^{-1}$. Note that when two signals are provided, the variance of $E_i^{post}(m)$ is smaller than in the case when only one signal is provided.

Finally, we assume that providing firms with past inflation is equivalent to giving them signal $s_E = \phi_m m + \xi_E = H_E m + \xi_E$ where $\xi_E \sim N(0,\kappa_E^{-1})$, $H_E = m$, and ϕ_m measures persistence of fundamental m from one period to another. In this case,

$$E_i^{post}(m) = (1-P_E H_E)E_i^{pre}(m) + P_E\tilde{s}_E = \frac{\kappa_E^{-1}}{\kappa_E^{-1}+(\phi_m)^2\delta\kappa^{-1}}E_i^{pre}(m) + P_E\tilde{s}_E. \tag{26}$$

Note that this signal provides information about the fundamental directly so that, conditional on the prior, the revision of beliefs in response to this signal does not depend on the strategic behavior of firms.

Equations (22), (24), (25) and (26) can be generalized to the form:

$$E_i^{Post}[m] = (1 - PH)E_i^{Pre}[m] + P\tilde{s} \tag{27}$$

Combining equations (19) and (27), one can show that the response of expectations of $\overline{p}$ and $\overline{E}[\overline{p}]$ to information is given by

$$E_i^{Post}\begin{bmatrix}\overline{p}\\ \overline{E}[\overline{p}]\end{bmatrix} = PH\begin{bmatrix}\phi_y\\ \phi_y + \phi_x(1-\delta)\end{bmatrix}y + (1 - PH)E_i^{Pre}\begin{bmatrix}\overline{p}\\ \overline{E}[\overline{p}]\end{bmatrix} + \begin{bmatrix}\phi_x\\ \delta\phi_x\end{bmatrix}P\tilde{s}. \tag{28}$$

Note that weight on the prior $(1 - PH)$ is the same for low- and high-order expectations about the price level. This means that revisions of low- and high-order expectations in response to new information are equal.

4.2 Experiment and Econometric Framework

Following the initial survey where we ask firms about their inflation expectations and higher-order expectations, we perform the following experiment. We divide managers into five groups. Group A is a control group and does not receive any information. Group B receives information about the average beliefs of survey participants about inflation, $\overline{E}[\overline{p}]$. Group C receives information about the average higher-order inflation expectations of survey participants: $\overline{E}^2[\overline{p}]$. Group D's signal consists of both information about average expectations and average higher-order expectations. We utilize Group E to compare the impact of information about other managers' beliefs to information about lagged inflation, as in Coibion, Gorodnichenko, and Kumar (forthcoming).

Immediately after providing firms with information,[10] we ask them to report their point predictions for inflation (one-year ahead) and for their beliefs about what other managers predict

[10] For the control group we simply continue with the questions.

for inflation (one-year head).[11] Measuring revisions in expectations immediately after the treatment allows us to obtain the instantaneous effect of the treatment on firms' beliefs. Note that priors are measured as mean expected inflation implied by the reported distribution of future inflation (see Table 1) while the posteriors are measured as point predictions. In the follow-up wave (three months after the initial wave), we ask firms to report distributions of their beliefs about future inflation (survey questions are identical to those in Table 1). Using responses from the follow-up survey, we construct another measure of posteriors as the mean expected inflation implied by the reported distribution. This set of posteriors provides a sense of the persistence in information on expectations.

Theoretical derivations in equation (28) suggest an econometric specification to assess the influence of various information treatments on managers' beliefs:

$$Posterior_i = constant + b \times Prior_i + error_i \qquad (29)$$

where slope b captures the strength of the prior relative to a signal and the signal is absorbed into the constant term. More informative priors should be associated with high values of b. If the estimated slope $\hat{b}$ is equal to zero, the signal is completely informative which causes managers to discard their priors in favor of the signal. If $0 < \hat{b} < 1$, the signal is partially informative and managers will update their posterior somewhat, but will still rely partially on the prior. If $\hat{b}$ is approximately one, managers see the signal as uninformative and do not update their prior beliefs at all. Note that because we use point predictions for posteriors and implied means for priors, the estimated slope may be biased up or down depending on how well firms respond to probability distribution questions (see e.g. Kleinjans and van Soest 2010, Fischhoff and Bruine de Bruin 1999, Bruine de Bruin et al. 2000). We can capture these effects by examining "revisions" in the control

[11] The questions are:

By how much do you think prices will change overall in the economy over the next 12 months? Please provide an answer in percentage terms.

Answer: ……………… %

What do you think other managers of firms (drawn from the entire New Zealand economy in a representative way) believe will be the growth rate of overall prices in the New Zealand economy over the next 12 months? Please provide an answer in percentage terms.

Answer: ……………… %

group. Because we are interested in how managers respond not only to new information but also to different kinds of information, we estimate specification (29) for each treatment separately.

4.3 Effect of Information Treatments on Expectations

Table 3 reports estimated coefficients on the prior expectation for both own inflation expectations and higher-order inflation expectations in specification (29). We find that when no information is provided, the point estimate of the slope is approximately 0.7 (row 1). This estimate does not mean that firms revise their beliefs in absence of information treatment by large amounts. Instead, this estimate likely highlights differences between expectations elicited as point predictions and expectations elicited as probability distributions. Indeed, when we use point predictions for future inflation before informational treatment we find that the slope is close to one for the control group when measurements of expectations are close to each other in time (see Appendix Table 3).

With this benchmark in mind, we turn to Treatment B (provide firms with $\overline{E}[\pi]$, row 2 in Table 3). When we elicit expectations immediately after the treatment, firms assign 0.50 weight on the prior when they update their first-order inflation expectations (column 1) and 0.43 weight when they update their high-order inflation expectations (column 2).[12] These weights are statistically different from the weights assigned by the control group. If we normalize these weights by the weights in the control group, the adjusted weights are approximately 0.7 and 0.6 for first-order and high-order beliefs respectively. Thus, Treatment B has useful information content that leads firms for revise their beliefs. Specifically, we can use equation (22) to compute the precision of information provided in Treatment B: $\kappa_B = \frac{1-b_B}{b_B}\kappa = \frac{b_B}{1-b_B} \times \frac{1}{Var(E_i[\overline{p}]|y)} \approx \frac{0.5}{1-0.5} \times \frac{1}{3.06^2} \approx 0.1$, that is, the signal is approximately as strong as the prior.

For firms in treatment group C (provide firms with $\overline{E}^2[\pi]$, row 3 in Table 3), the estimated weights on priors are considerably smaller: 0.09 and 0.12 for low- and high-order beliefs. These estimates suggest that firms perceive a much higher precision of the signal in Treatment C than the precision of the signal in Treatment B: $\kappa_C = \frac{1-b_C}{b_C}\kappa \approx 9\kappa$. The weights on the prior are similar in Treatment D (provide firms with $\overline{E}^2[\pi]$ and $\overline{E}[\pi]$, row 4 in Table 3). We interpret this result as

[12] Appendix Figures 1 through 4 shows scatter plots of posteriors against priors.

indicating that information in $\overline{E}[\pi]$ has relatively little new content relative to information in $\overline{E}^2[\pi]$.

For firms receiving information about the past realization of inflation (Treatment E, row 5 in Table 3), the weight on the prior is 0.059 for low-order expectations and 0.062 for high-order expectations. Thus, the precision of the signal about past inflation is $\kappa_E = \frac{1-b_E}{b_E}\kappa \approx 15\kappa$, which is qualitatively similar to the precision of the signal about $\overline{E}^2[\pi]$.

Conducting the same analysis using the posterior belief reported in the follow-up wave produces similar results (see columns (4) and (5) of Table 3). Again, we see mean reversion in the reported responses of the control group. Treatments C, D and E result in low weights on priors while Treatment B yields weights approximately half-way between the control group and other treatment groups. These results indicate that the effect of information is persistent after three months and that the size of treatment effects continue to depend on the type of signal that the firm received. Coibion, Gorodnichenko and Kumar (forthcoming) and Cavallo, Cruces, and Perez-Truglia (2017) find that the difference in beliefs for treatment and control groups largely disappears six months after the treatment. We reconcile these results by using the findings in Coibion, Gorodnichenko and Ropele (2018) who study a long panel of firms to document that informational treatments have significant effects on expectations after three months but vanish after six months.

Our discussion in section 4.1 suggests that high-order expectations and low-order expectations should be updated by the same factor in response to incoming information. Consistent with this prediction, we cannot reject equality of weights in columns (1) and (2) and equality of weights in columns (4) and (5).

4.4 Effect of Information on Actions

Coibion, Gorodnichenko and Kumar (forthcoming) and Coibion, Gorodnichenko and Ropele (2018) document that information treatments lead not only to revisions of inflation expectations but also to changes in firms' behavior. Treatments in these earlier studies provide firms with information about the inflation target of the central bank, professional forecasts, or past inflation. Little is known about how firms react to treatments based on providing firms with information about high-order beliefs. While the previous section finds that revisions of beliefs are similar for low- and high-order inflation expectations, a priori one may observe considerable heterogeneity in employment/investment/etc. responses across these information treatments.

To estimate the effect of changes in inflation expectations on choices of firms, our approach follows Coibion, Gorodnichenko and Kumar (forthcoming). Specifically, before we treat firms, we elicit firms' expectations about their three-month-ahead plans for future employment, investment, wages, and prices. Three months after the initial wave, we survey firms again and ask them to report changes in these four variables. Using this information, we compute forecast error for each variable. The key advantage of using forecast errors is that they effectively difference out firm-fixed effects and thus reduce the size of idiosyncratic variation in the data.

In the next step, we regress forecast errors on changes in inflation expectations:

$$FE_i(X) = constant + b \times \left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right) + error_i \qquad (30)$$

where $FE_i(X)$ is the forecast error for variable X, $E_i^{prior}(\pi)$ is the pre-treatment expected inflation, $E_i^{posterior}(\pi)$ is post-treatment expected inflation. For $E_i^{posterior}(\pi)$, we use beliefs of firms measured immediately after the treatment. Equation (21) shows that $\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$ should be proportional to the difference between the signal and the expected value of the signal, that is, the surprise induced by a treatment. Because we know pre-treatment values of $E_i(\pi)$, $E_i(\bar{E}(\pi))$ and $E_i(\pi_{t-1})$, we calculate the surprise and use it as an instrument for $\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$. Note that for the control group the surprise is zero because firms in this group are not provided with any information. For Group D, which receives both the first- and higher-order expectations, we construct the average surprise in expectations. When we estimate specification (30), we do it on data combining the control group and a given treatment group and estimate the specification for each treatment separately.

Table 4 reports estimates of b for variation treatments where revisions in beliefs on the right-hand side of equation (28) refer to low-order inflation expectations. While treatments vary in their ability to move inflation expectations, results in Table 4 suggest that conditional on moving inflation expectations the reaction of firms is largely similar across treatments. Consistent with Coibion, Gorodnichenko and Kumar (forthcoming), we find that raising inflation expectations by one percentage point generates approximately 0.4 percentage point increase in employment (column 1), approximately 0.2 percentage point increase in fixed assets (column 2), and no effect on firms' prices (column 3) or wages (column 4) over the three months following the treatment.[13] The IV estimates of the effects are approximately double of the OLS estimates (Appendix Table 5). We also find similar results when the regressor in equation (28) is higher-order inflation expectations $\left(E_i^{posterior}\bar{E}(\pi) - E_i^{prior}\bar{E}(\pi)\right)$ instead of low-order inflation expectations $\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$, see Appendix Table 6.

Note that these causal estimates provide "total" effects, that is, the combined influence of a treatment on first- and higher-order inflation expectations. Since Treatments B, C, and E have only one signal, we cannot separately identify the contribution of first- and higher-order beliefs on firms' actions. Treatment D contains two signals (two instruments) and thus offers us an opportunity to run a horserace regression with first- and higher-order expectations included in specification (30). We find (Table 5) that none of the expectations systematically dominates the other and, more generally, few estimates are statistically significantly different from zero. These inconclusive results are consistent with the strong correlation of in revisions of first- and higher-order expectations which limits our ability to identify the independent effects of various orders of expectations.

V. Level-*k* Thinking

Section 3 described a series of predictions that hold if agents undertake infinite degrees of reasoning about the pricing decisions of others. Reasoning of this sort is, however, difficult and computationally intensive. Managers are therefore likely, due to either cognitive constraints or recognizing the costs of such reasoning, to limit their degrees of thinking to levels well below infinity. In this section, we discuss the results of a beauty contest which allows us to categorize the thinking types of firm managers. While this approach to measuring thinking types is common

[13] The survey also collects information about 6-month-ahead plans for firm-specific outcomes in the initial survey and 3-month-ahead plans for the same outcomes in the follow-up survey. This design allows us to also study the response of *revisions* in plans to information treatments (that is, the outcome variable in specification (30) is 3-month-ahead plan in the follow-up wave minus the 6-month-ahead plan in the initial wave). We find that while information treatments tend to increase planned investment, these treatments have no statistically significant effect on plans for employment, prices, and wages (see Appendix Table 4).

in the experimental literature, it has not to our knowledge been included in a survey that also obtains macroeconomic expectations. We further extend the beauty contest question to study the beliefs of firm managers about the guesses of other managers. This allows us to compare the properties of level-k behavior we observe with the predictions of existing models of degrees of reasoning and cognitive hierarchy. We find that the higher-order beliefs in the guessing game *do not* correspond with current models of level-k thinking. We further find that a manager's reasoning type does not influence the manager's reaction to information.

5.1 Categorizing Types

Following Nagel (1995), Nagel and Duffy (1997) and many others, we characterize managers' degree of reasoning by asking the following question:

> *"Please choose a number from zero to 100. We will take your number as well as the numbers chosen by other managers to calculate the average pick. The winning number will be the number that is closest to two-thirds (2/3) of the average. The individual(s) with the winning number will receive (or share with other winners in case of tie) $500."*

A k^{th}-level thinker provides the following guess:

$$g(k) = \left(\frac{2}{3}\right)^k \times 50 \tag{31}$$

The distribution of managers' guesses appears in Figure 2. Guesses appear throughout the entire interval (0-100). However, when we restrict the sample to those managers who spent at least 20 seconds on the question, the guesses pile on integers associated with reasoning types as defined by equation (31) between $k = 1$ and $k = 5$, with the number of managers of each type declining with k. Accordingly, we classify these managers by their guess and assign $k = 0$ to those who answer the question in less than 20 seconds.[14] As a robustness check, we consider an alternative treatment of guesses with short response times: we code responses as level-zero thinking if response times are less than 20 seconds and responses are between 47 and 53; we set level of thinking to missing for other responses with response time less than 20 seconds. We denote this alternative coding with k'.

[14] The guesses associated with $k = 0$ therefore fall throughout the acceptable interval, rather than at 50 as in Nagel 1995.

The average guess in our sample is 33 when we use all responses and 21 when we use guesses with response time of 20 or more seconds. Camerer (1997) reports that average responses for CEOs at Cal Tech's Board of Trustees, for portfolio managers, and for Wharton's MBA students are 38, 24, and 38 respectively. However, Camerer (1997) reports generally lower average scores for subjects participating in experimental settings. Indeed, the thinking types of managers in our survey appear somewhat more dispersed than in experimental studies. We see a greater density of thinkers at $k = 0$, partially due to the way we assign this rating (as anyone who does less than 20 seconds of thinking about the question). In our survey, 36.8 percent of managers are $k = 0$, as opposed to 20 to 27.3 percent in the experimental studies. Our sample is also more heavily weighted towards higher thinking types ($k \geq 3$) than other papers, with roughly a quarter of the sample performing such high degrees of reasoning.

We find that level of thinking is generally uncorrelated with observed characteristics of firms and managers as well as industry fixed effects (Table 6). The only variable that is relatively robustly correlated with level of thinking is the share of domestic sales in total sales. However, even for this variable the quantitative strength of the link is weak: a standard deviation increase in the share is associated with a 0.14-point decrease in the level of thinking.

5.2 Beliefs About Other Managers.

The two primary models of limited reasoning (level-k thinking and cognitive hierarchy) have different approaches to a participant's beliefs about the types of other participants. In the Nagel level-k thinking model, a level-k thinker believes that everyone else in the game performs at level $(k-1)$. Camerer, Ho, and Chong (2004) develop a model of "cognitive hierarchy" that allows agents to form beliefs about the distribution of other reasoning types in the sample. A level-k thinker is assumed to observe the correct frequency of thinkers at his type and types below, but to incorrectly assume that there are no thinkers performing higher degrees of reasoning. As a result, he posits inaccurate relative frequencies of thinkers. As a thinker's reasoning type, k, increases and he observes the true frequencies of a greater number of types, his expectation of the density over the sample becomes "increasingly rational" and closer to the true distribution of types. Both of these models emphasize a particularly important aspect of level-k thinking: individuals cannot conceive of thinkers at levels above their own. To do this would be to engage in the next level of reasoning. Therefore, by definition, a level-k thinker must believe that he is the smartest player (or among the smartest players) in the game.

We introduce a new question designed to elicit beliefs about the distribution of types so that we may compare these beliefs with the modeling assumptions of these two models. Specifically, we ask managers to provide a probability distribution over ranges of other managers' guesses (this question appears in Table 7). Note that we allow managers to choose dominated strategies (e.g., range 60 to 70) to avoid priming of responses.

Table 8 (Figure 3) shows the average believed distribution of guesses for each thinking level, k, as well as the true distribution across guesses (column 8) and the average belief across levels of thinking (column 7). All thinking types believe that the majority of managers share their own type and all managers at levels $k \leq 3$ assign probability to bins associated with players at levels both higher and lower than their own. All managers underestimate the true dispersion of guesses. Accordingly, none of the thinking types correctly conjectures the true density of types, nor do beliefs about the density become closer to the truth with increasing k, as in Camerer, Ho, and Chong (2004). However, the average density across types (column 7) is relatively close to the actual distribution of guesses (column 8), reflecting the fact that *i*) a typical manager believes that other managers have the same level of thinking as the manager and *ii*) as we discuss below, managers appear to not use 2/3 of the average response of other managers.[15]

These results are not fully consistent with either k-level or cognitive hierarchy models. Roughly 80 percent of managers of all reasoning levels assign positive probability to multiple bins a fact that is not consistent with the Nagel model of reasoning. A level-k thinker as defined by the guess in equation (31) should report positive probability on exactly one bin, the one associated with the level $(k - 1)$ guess. This level-k thinker will also not place positive probability on the bin associated with her own guess. For types $k = 1,2,3$, managers place an average probability of 0.72 to 0.77 on this bin, meaning they think that between 72 and 77 percent of other managers are the same type as them. All levels, $k \geq 1$, assign positive probability to bins associated with thinkers beneath their own level, consistent with both Nagel (1995) and Camerer, Ho, and Chong (2004). However, only types $k \geq 4$ report believing that a majority of managers will fall into bins associated with lower level thinkers. Thinkers at types $k \leq 3$ also report positive probability on

[15] Results are similar for k', an alternative coding for level of thinking.

bins associated with levels of k above their own.

These distributions, however, may still be internally consistent in the sense that guesses are equal to two thirds of the average of the conjectured distribution of other managers' guesses. In other words, to win the prize, a manager should submit a guess of two-thirds of his believed average guess of other managers.[16] To test the consistency of a manager's guess in the beauty contest game with his beliefs about the average guess of other managers, we can estimate the following specification:

$$Guess_i^{Own} = b \times E_i[Guess^{HO}] + error_i \qquad (32)$$

where $Guess_i^{Own}$ is the guess submitted by manager i, $E_i[Guess^{HO}]$ is manager i's average guess for other managers' guesses. We find (Table 9) that estimated b is generally close to one for managers with low k and the estimated slope get closer to 2/3 as k decreases. For example, for $k = 4$, we cannot reject the null of $b = 2/3$ (but we can reject this null for $k = 5$). Note that when we compute the implied mean of the reported distribution of other managers' beliefs, we use mid-points of the bins provided in the survey question. Generally, the results for low k are insensitive to using alternative assumptions for picking points within bins, while the results for high ks tend to be more sensitive to how one assigns weights within bins because bins get increasingly coarse for high levels of thinking. With alternative assumptions, one may get estimates of b closer to 2/3 for $k \geq 3$.

In summary, these results propose a puzzle for popular models with agents characterized by varying depths of reasoning. First, managers assign positive probability of other managers having higher levels of thinking. Second, many managers believe that other managers have the same level of thinking. Third, guesses of low-level thinkers appear to be inconsistent with what these thinkers believe about guesses of other managers.

5.3 Expectations with Limited Depth of Reasoning

Our discussion in Section 3 assumes that firms perform infinite iteration of the optimal pricing function. That is, firms are capable of infinite degrees of reasoning, an assumption which models

[16] It may be the case that when asked directly about other managers, survey participants will engage an additional level of reasoning that was not present when they formed their own guess or expectation.

of level-k thinking challenge. To make our model of expectations consistent with level-k thinking, we revise the optimal pricing equation in equation (7) such that firm i will weigh the public and private signals according to

$$p_i(k) = \frac{\sum_{r=0}^{k} \alpha^r \left[[1-\delta^{r+1}] y + \delta^{r+1} x_i \right]}{\sum_{r=0}^{k} \alpha^r}, \tag{33}$$

where k is the firm's type. We allow firms to fall into one of three different thinking types such that $k = 0,1,2$. A level-0 firm will have pricing strategies in equation (8) with $\phi_{x,0} = \delta$ and $\phi_{y,0} = 1 - \delta$. These strategies ignore the strategic complementarity in prices and rely only on the relative precision of the public and private signals. One can show that the strategies for level-1 and level-2 firms will shift weight towards the public signal; that is, $\phi_{x,0} > \phi_{x,1} > \phi_{x,2}$ and $\phi_{y,0} < \phi_{y,1} < \phi_{y,2}$ as $\phi_{x,k} = \delta \frac{1+\alpha\delta+\cdots+(\alpha\delta)^k}{1+\alpha+\cdots+\alpha^k}$ and $\phi_{y,k} = 1 - \phi_{x,k}$.

The aggregate price-level will then be a weighted average of the pricing behavior of each type of firm

$$\overline{p} = \sum_{k=0}^{2} \omega_k \overline{p(k)} \tag{34}$$

where ω_k is the proportion of firms thinking at level-k and $\overline{p(k)} = \phi_{x,k} m + \phi_{y,k} y$.

Heterogeneity in strategies means that firms must consider the distribution of types in forming their expectations. As in Camerer, Ho, and Chong (2004), we allow a firm to correctly observe the frequencies of its own type and types below, but incorrectly assume that no firms think at levels above its own. Accordingly, when the firm normalizes the weights of types, it may posit incorrect relative frequencies of types. In the model with three types, type-0 assumes all other agents are type-0 while type-2 correctly observes the distribution of firms.

Level-0 firms will form expectations of the aggregate price level

$$E_{i,0}[\overline{p}] = \Phi_{x,0} x_i + (1 - \Phi_{x,0}) y = \delta x_i + (1 - \delta) y. \tag{35a}$$

Just as these firms do not iterate expectations in the price-setting equation, they do not iterate on expectations of the price level. Namely, they fail to substitute their expectation of m into equation (32). For this reason and because level-0 firms believe that $\omega_0 = 1$, we obtain $\Phi_{x,0} = \phi_{x,0} = \delta$.

Firms at $k = 1$ will take into account the presence of both level-0 and level-1 firms in forming their expectations. These firms are further capable of iterating their expectation of m one time:

$$E_{i,1}[\overline{p}] = \Phi_{x,1} E_i[m] + \Phi_{y,1} y = \Phi_{x,1}\delta x_i + \left(1 - \Phi_{x,1}\delta\right) y, \tag{35b}$$

where $\Phi_{x,1} = \frac{\omega_0\phi_{x,0}+\omega_1\phi_{x,1}}{\omega_0+\omega_1} = \delta\frac{\left(\omega_0+\omega_1\frac{1+\alpha\delta}{1+\alpha}\right)}{\omega_0+\omega_1}$ and $\Phi_{y,1} = 1 - \Phi_{x,1}$. As $\alpha \in (0,1)$ and $\delta \in (0,1)$, strategy $\Phi_{x,1} \in \left(\phi_{x,1}, \phi_{x,0}\right)$. For samples highly weighted towards level-0 firms (that is, ω_0 large), we would expect to see a $\Phi_{x,1}$ close to the non-strategic $\phi_{x,0}$.

Level-2 firms correctly observe the full distribution of types and can distinguish between the optimal price-setting strategy and the appropriate weight to give the public and private signals in inflation expectations. The first-order expectation for level-2 firms is:

$$E_{i,2}[\overline{p}] = \Phi_{x,2} E_i[m] + \Phi_{y,2} y = \Phi_{x,2}\delta x_i + \left(1 - \Phi_{x,2}\delta\right) y, \tag{35c}$$

where $\Phi_{x,2} = \left(\omega_0\phi_{x,0} + \omega_1\phi_{x,1} + \omega_2\phi_{x,3}\right) = \delta\left(\omega_0 + \omega_1\frac{1+\alpha\delta}{1+\alpha} + \omega_2\frac{1+\alpha\delta+\alpha^2\delta^2}{1+\alpha+\alpha^2}\right)$ and $\Phi_{y,2} = 1 - \Phi_{x,2}$. Because $\phi_{x,0} > \phi_{x,1} > \phi_{x,2}$, $\Phi_{x,2} \in \left(\phi_{x,2}, \phi_{x,0}\right)$.

The aggregate expectation for each type is therefore:

$$\overline{E}_0[\overline{p}] = \Phi_{x,0} m + \left(1 - \Phi_{x,0}\right) y \tag{36a}$$

$$\overline{E}_1[\overline{p}] = \Phi_{x,1}\delta m + \left(1 - \Phi_{x,1}\delta\right) y \tag{36b}$$

$$\overline{E}_2[\overline{p}] = \Phi_{x,2}\delta m + \left(1 - \Phi_{x,2}\delta\right) y \tag{36c}$$

Aggregating across types and firms gives:

$$\overline{E}[\overline{p}] = \textstyle\sum_{k=0}^{2} \omega_k \overline{E}_k[\overline{p}] = (\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x\delta)m + \left(1 - (\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x\delta)\right)y, \tag{37}$$

where $\overline{\Phi}_x = \sum_{k=0}^{2} \omega_k \Phi_{x,k}$. Because by definition level-0 and level-1 firms are unable to iterate expectations past their first order expectation, their higher-order expectation is the same as their first-order expectation:

$$E_{i,0}\left[\overline{E}[\overline{p}]\right] = \Phi_{x,0} x_i + \left(1 - \Phi_{x,0}\right) y = \delta x_i + (1 - \delta) y, \tag{38a}$$

$$E_{i,1}\left[\overline{E}[\overline{p}]\right] = \Phi_{x,1} E_i[m] + \Phi_{y,1} y = \Phi_{x,1} \delta x_i + \left(1 - \Phi_{x,1}\delta\right) y. \tag{38b}$$

In contrast, level-2 thinkers use the weights in forming higher-order expectations:

$$E_{i,2}\left[\overline{E}[\overline{p}]\right] = (\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x \delta)[m] + \left(1 - (\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x \delta)\right) y.$$

Unlike level-0 and level-1 firms, level-2 firms will be able to iterate their expectations for a second time, substituting $E_i[m] = \delta x_i + (1-\delta) y$:

$$E_{i,2}\left[\overline{E}[\overline{p}]\right] = \delta\left(\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x \delta\right) x_i + \left(1 - \delta(\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x \delta)\right) y. \tag{38c}$$

Note that as ω_0 increases, the weight on the private signal in equation (36c) increases because of a "mechanical" effect (more weight is assigned to $\Phi_{x,0}$) and a strategic effect (given strategic complementarity, high-level thinkers want to be closer to what is done by level-0 thinkers if there are many level-0 thinkers).

The aggregate higher-order expectations for each type are:

$$\overline{E}_0^2[\overline{p}] = \Phi_{x,0} m + \left(1 - \Phi_{x,0}\right) y \tag{39a}$$

$$\overline{E}_1^2[\overline{p}] = \delta \Phi_{x,1} m + \left(1 - \delta \Phi_{x,1}\right) y \tag{39b}$$

$$\overline{E}_2^2[\overline{p}] = \delta\left(\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x \delta\right) m + \left(1 - \delta(\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x \delta)\right) y \tag{39c}$$

The average higher order expectation is then:

$$\overline{E}^2[\overline{p}] = \sum_{k=0}^{2} \omega_k \overline{E}_k^2[\overline{p}]. \tag{20}$$

As Section 4.1 outlines, managers can transform signals about the average first-order and higher-order inflation expectation (signals B and C) into signals about m. Signal B, in Equation (21), will be differently perceived by managers at different k levels.[17]

$$\tilde{s}_{B,0} = H_{B,0}m + \xi_B = \Phi_{x,0}m + \xi_B \tag{41a}$$

$$\tilde{s}_{B,1} = H_{B,1}m + \xi_B = \Phi_{x,1}\delta m + \xi_B \tag{41b}$$

$$\tilde{s}_{B,2} = H_{B,2}m + \xi_B = \Phi_{x,2}\delta m + \xi_B \tag{41c}$$

Note that the interpretation of signals may be incorrect because agents' perception of the data generating process (DGP) may deviate from the actual DGP. For example, for level-0 firms perception of DGP is given by equation (34a) while actual DGP is given by equation (35). Indeed, only agents with the highest k have the correct perception. As a result, although agents believe they should interpret signals as in equation (39), the effective signals are different. For level-0 firms:

$$\begin{aligned}\tilde{s}_{B,0} &= (\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x\delta)m + \left(1 - (\omega_0(1-\delta)\Phi_{x,0} + \overline{\Phi}_x\delta)\right)y + \xi_B - \left(1 - \Phi_{x,0}\right)y \\ &= \Phi_{x,0}m + \left((\omega_0 - 1)\Phi_{x,0} + \delta\left(\omega_1\Phi_{x,1} + \omega_2\Phi_{x,2}\right)\right)(m - y) + \xi_B \\ &= \Phi_{x,0}m + \tilde{\xi}_{B,0}\end{aligned} \tag{41a'}$$

where $\tilde{\xi}_{B,0} \equiv \left((\omega_0 - 1)\Phi_{x,0} + \delta\left(\omega_1\Phi_{x,1} + \omega_2\Phi_{x,2}\right)\right)(m - y) + \xi_B$. Thus, level-0 firms interpret $\tilde{\xi}_{B,0}$ as uncorrelated noise, in fact the "noise" is correlated with fundamental m and public signal y. This interpretation of the signal means that, in the long run, level-0 firms may be overconfident in their certainty because $Var(\tilde{\xi}_{B,0}) > Var(\xi_B)$ and, relatedly, these firms may have more disagreement because they may overreact to the perceived noise.

Likewise, for level-1 firms:

$$\tilde{s}_{B,1} = \Phi_{x,1}\delta m + \tilde{\xi}_{B,1} \tag{41b'}$$

[17] Only level-2 will correctly interpret this signal.

where $\tilde{\xi}_{B,1} \equiv \left(\omega_0 \Phi_{x,0} + \left(\bar{\Phi}_x - \Phi_{x,1}\right)\delta\right)(m - y) + \xi_B$. Because level-2 thinkers correctly perceive the signal, Equation (39c) accurately describes the signal and does not require any adjustment.

For each group, we can then show:

$$E_{i,0}^{Post}[m] = \left(\frac{\kappa_B^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,0}\right)^2 \delta \kappa^{-1}}\right) E_i^{Pre}[m] + P_{B,0}\tilde{s}_{B,0} \tag{42a}$$

$$E_{i,1}^{Post}[m] = \left(\frac{\kappa_B^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,1}\delta\right)^2 \delta \kappa^{-1}}\right) E_i^{Pre}[m] + P_{B,1}\tilde{s}_{B,1} \tag{42b}$$

$$E_{i,2}^{Post}[m] = \left(\frac{\kappa_B^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,2}\delta\right)^2 \delta \kappa^{-1}}\right) E_i^{Pre}[m] + P_{B,2}\tilde{s}_{B,2} \tag{42c}$$

where the coefficient on the prior corresponds to $(1 - PH)$ in equation (27). Because $\Phi_{x,2} < \Phi_{x,1} < \Phi_{x,0}$, we can predict that the weight on the prior increases in level of thinking k.

Combining equation (28) with equations (42) gives:

$$E_{i,0}^{Post}\begin{bmatrix} \bar{p} \\ \bar{E}[\bar{p}] \end{bmatrix} = \left(\frac{\left(\Phi_{x,0}\right)^2 \delta \kappa^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,0}\right)^2 \delta \kappa^{-1}}\right) \begin{bmatrix} 1 - \Phi_{x,0} \\ 1 - \Phi_{x,0} \end{bmatrix} y + \left(\frac{\kappa_B^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,0}\right)^2 \delta \kappa^{-1}}\right) E_{i,0}^{Pre}\begin{bmatrix} \bar{p} \\ \bar{E}[\bar{p}] \end{bmatrix} + \begin{bmatrix} \Phi_{x,0} \\ \Phi_{x,0} \end{bmatrix} P_{B,0}\tilde{s}_{B,0}$$

$$E_{i,1}^{Post}\begin{bmatrix} \bar{p} \\ \bar{E}[\bar{p}] \end{bmatrix} = \left(\frac{\left(\Phi_{x,1}\delta\right)^2 \delta \kappa^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,1}\delta\right)^2 \delta \kappa^{-1}}\right) \begin{bmatrix} 1 - \Phi_{x,1}\delta \\ 1 - \Phi_{x,1}\delta \end{bmatrix} y + \left(\frac{\kappa_B^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,1}\delta\right)^2 \delta \kappa^{-1}}\right) E_{i,1}^{Pre}\begin{bmatrix} \bar{p} \\ \bar{E}[\bar{p}] \end{bmatrix} + \begin{bmatrix} \Phi_{x,1}\delta \\ \Phi_{x,1}\delta \end{bmatrix} P_{B,1}\tilde{s}_{B,1}$$

$$E_{i,2}^{Post}\begin{bmatrix} \bar{p} \\ \bar{E}[\bar{p}] \end{bmatrix} = \left(\frac{\left(\Phi_{x,2}\delta\right)^2 \delta \kappa^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,2}\delta\right)^2 \delta \kappa^{-1}}\right) \begin{bmatrix} 1 - \Phi_{x,1}\delta \\ \left(1 - \delta\left(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta\right)\right) \end{bmatrix} y +$$
$$\left(\frac{\kappa_B^{-1}}{\kappa_B^{-1} + \left(\Phi_{x,2}\delta\right)^2 \delta \kappa^{-1}}\right) E_{i,1}^{Pre}\begin{bmatrix} \bar{p} \\ \bar{E}[\bar{p}] \end{bmatrix} + \begin{bmatrix} \delta\Phi_{x,2} \\ \delta\left(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta\right) \end{bmatrix} P_{B,2}\tilde{s}_{B,2}$$

Note that the difference in weight on priors across k is largely governed by variation in $H_{B,k}$ across k. Given our parameter estimates for α and δ as well as the distribution of types, we find that $\Phi_{x,0} \approx 0.80$, $\Phi_{x,1}\delta \approx 0.61$, $\Phi_{x,2}\delta \approx 0.59$. Thus, while the model predicts differentiated responses to signals across k, the differences could be rather small.

We can derive similar expressions for signal C, which gives firms the average higher-order expectations. Firms perceive:

$$\tilde{s}_{C,0} = H_{C,0}m + \xi_C = \Phi_{x,0}m + \xi_C \tag{43a}$$

$$\tilde{s}_{C,1} = H_{C,1}m + \xi_C = \Phi_{x,1}\delta m + \xi_C \tag{43b}$$

$$\tilde{s}_{C,2} = H_{C,2}m + \xi_C = \delta\big(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta\big)m + \xi_C \tag{43c}$$

Because level-0 and level-1 firms incorrectly perceive the DGP, equations (43a) and (43b) must be translated into the effective signals:

$$\tilde{s}_{C,0} = \Phi_{x,0}m + \tilde{\tilde{\xi}}_{C,0} \tag{43a'}$$

$$\tilde{s}_{C,1} = \Phi_{x,1}\delta m + \tilde{\tilde{\xi}}_{C,1} \tag{43b'}$$

where $\tilde{\tilde{\xi}}_{C,0} \equiv \big[(1-\omega_0)\Phi_{x,0} + \omega_1\Phi_{x,1}\delta + \omega_2\delta\big(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta\big)\big](y-m) + \xi_C$ and $\tilde{\tilde{\xi}}_{C,1} \equiv \big[\omega_0\Phi_{x,0} + (1-\omega_1)\Phi_{x,1}\delta + \omega_2\delta\big(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta\big)\big](y-m) + \xi_C$.

Firms then update their expectations of the fundamental according to:

$$E_{i,0}^{Post}[m] = \left(\frac{\kappa_C^{-1}}{\kappa_C^{-1} + (\Phi_{x,0})^2\delta\kappa^{-1}}\right)E_i^{Pre}[m] + P_{C,0}\tilde{s}_{C,0} \tag{44a}$$

$$E_{i,1}^{Post}[m] = \left(\frac{\kappa_C^{-1}}{\kappa_C^{-1} + (\Phi_{x,1}\delta)^2\delta\kappa^{-1}}\right)E_i^{Pre}[m] + P_{C,1}\tilde{s}_{C,1} \tag{44b}$$

$$E_{i,2}^{Post}[m] = \left(\frac{\kappa_C^{-1}}{\kappa_C^{-1} + \big(\delta(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta)\big)^2\delta\kappa^{-1}}\right)E_i^{Pre}[m] + P_{C,2}\tilde{s}_{C,2} \tag{44c}$$

Equations (44a) and (44b) imply that, provided $\kappa_B = \kappa_C$, the weight on priors for level-0 and level-1 firms is the same when firms are presented with signals B and C because these firms cannot perform a second iteration on expectations.

Combining equation (28) with equations (44) gives:

$$E_{i,0}^{Post}\begin{bmatrix}\bar{p}\\ \bar{E}[\bar{p}]\end{bmatrix} = \left(\frac{(\Phi_{x,0})^2\delta\kappa^{-1}}{\kappa_C^{-1} + (\Phi_{x,0})^2\delta\kappa^{-1}}\right)\begin{bmatrix}1-\Phi_{x,0}\\ 1-\Phi_{x,0}\end{bmatrix}y + \left(\frac{\kappa_C^{-1}}{\kappa_C^{-1} + (\Phi_{x,0})^2\delta\kappa^{-1}}\right)E_{i,0}^{Pre}\begin{bmatrix}\bar{p}\\ \bar{E}[\bar{p}]\end{bmatrix} + \begin{bmatrix}\Phi_{x,0}\\ \Phi_{x,0}\end{bmatrix}P_{C,0}\tilde{s}_{C,0}$$

$$E_{i,1}^{Post}\begin{bmatrix}\bar{p}\\ \bar{E}[\bar{p}]\end{bmatrix} = \left(\frac{(\Phi_{x,1}\delta)^2\delta\kappa^{-1}}{\kappa_C^{-1} + (\Phi_{x,1}\delta)^2\delta\kappa^{-1}}\right)\begin{bmatrix}1-\Phi_{x,1}\delta\\ 1-\Phi_{x,1}\delta\end{bmatrix}y + \left(\frac{\kappa_C^{-1}}{\kappa_C^{-1} + (\Phi_{x,1}\delta)^2\delta\kappa^{-1}}\right)E_{i,1}^{Pre}\begin{bmatrix}\bar{p}\\ \bar{E}[\bar{p}]\end{bmatrix} + \begin{bmatrix}\Phi_{x,1}\delta\\ \Phi_{x,1}\delta\end{bmatrix}P_{C,1}\tilde{s}_{C,1}$$

$$E_{i,2}^{Post}\begin{bmatrix}\bar{p}\\ \bar{E}[\bar{p}]\end{bmatrix} = \left(\frac{\big(\delta(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta)\big)^2\delta\kappa^{-1}}{\kappa_C^{-1} + \big(\delta(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta)\big)^2\delta\kappa^{-1}}\right)\begin{bmatrix}1-\Phi_{x,2}\delta\\ \big(1-\delta(\omega_0(1-\delta)\Phi_{x,0} + \bar{\Phi}_x\delta)\big)\end{bmatrix}y +$$

$$\left(\frac{\kappa_C^{-1}}{\kappa_C^{-1}+\left(\delta\left(\omega_0(1-\delta)\Phi_{x,0}+\bar{\Phi}_x\delta\right)\right)^2\delta\kappa^{-1}}\right)E_{i,1}^{Pre}\begin{bmatrix}\bar{p}\\ \bar{E}[\bar{p}]\end{bmatrix}+\begin{bmatrix}\Phi_{x,2}\delta\\ \delta\left(\omega_0(1-\delta)\Phi_{x,0}+\bar{\Phi}_x\delta\right)\end{bmatrix}P_{C,2}\tilde{s}_{C,2}$$

Given our parameter estimates for α and δ as well as the distribution of types, we find that $\Phi_{x,0}\approx 0.80$, $\Phi_{x,1}\delta\approx 0.61$, $\delta\left(\omega_0(1-\delta)\Phi_{x,0}+\bar{\Phi}_x\delta\right)\approx 0.53$. These estimates determine the difference in the weight given to priors across k.

Firms in Group D receive both signals. If the noise terms in both signals are uncorrelated

$$E_{i,k}^{post}(m)=\left(1-P_{D,k}H_{D,k}\right)E_i^{pre}(m)+P_{D,k}\tilde{s}_{D,k}, \tag{45}$$

where $H_{D,0}=[\Phi_{x,0}\quad \Phi_{x,0}]'$, $H_{D,1}=[\Phi_{x,1}\delta\quad \Phi_{x,1}\delta]'$, $H_{D,2}=\left[\Phi_{x,2}\delta\quad \delta\left(\omega_0(1-\delta)\Phi_{x,0}+\bar{\Phi}_x\delta\right)\right]'$, $R_D=diag\{\kappa_B^{-1},\kappa_C^{-1}\}$, and $P_{D,k}=\delta\kappa^{-1}H_{D,k}'\left(R_D+\delta\kappa^{-1}H_{D,k}H_{D,k}'\right)^{-1}$.

All thinking types are able to correctly process Signal E, which contains an estimate of past inflation. Intuitively, signal E provides direct information about the fundamental and updating beliefs does not require thinking about the behavior of other agents in the economy. We therefore do not expect to see any difference between responses to this signal across k.

5.4 Expectations and Actions by Level of Thinking

In this section, we test predictions of the framework developed in the previous section. Table 10 shows that mean expected inflation and disagreement about future inflation decrease in k, while uncertainty is approximately constant across k. This pattern holds for low- and high-order inflation expectations. This pattern is broadly consistent with theoretical predictions: low-k firms should disagree more and should be more likely to have expectations with larger departures from fundamentals. We also observe that as k increases the degree of complementarity in pricing α tends to increase as well. Note that $\alpha\neq 0$ for $k=0$ firms and thus the assumption of no strategic complementarity typically assigned level-0 firms may be too extreme. The precision of signals (κ_x,κ_y), the relative precision of the private signal (δ), and the weight on the private signal (ϕ_x) exhibit an inverted-U shape in k. In contrast our theory predicts that $\phi_{x,k}$ should decrease in k

monotonically. While in our theoretical setting the cross-sectional correlation between low- and high-order inflation expectations is perfect (recall that private signals x_i is the only source of variation in the cross-section), one may expect the correlation to be stronger for low-level thinkers because these thinkers do not distinguish between low- and high-level expectations. Correlation between low- and high-order inflation expectations is weakly increasing in k.

Our theoretical analysis suggests that the response of managers to new information should vary in the level of thinking, k, although the differences may be small given the observed strategic complementarity in pricing (α), a high weight on private signals (δ), and a large share of level-0 managers (ω_0). To assess the degree of heterogeneity in the weight assigned to priors across k, we estimate specification (29) for k equal to 0, 1, and 2+ and report results in Table 11. Our estimates are inconsistent with several predictions. First, our theory predicts that level-0 firms should not make a distinction between signals B and C because giving information about low-order expectations or high-order expectations does not make a difference for this type of agents (recall, these agents iterate forward neither "prices" nor "expectations"). Inconsistent with this prediction, we observe that the weight on the prior is systematically smaller for Treatment C than for Treatment B and the magnitudes are similar to what is observed for $k = 1$ and $k \geq 2$. Furthermore, level-0 firms should not make a distinction between signals B and D because they do not differentiate between information contained in expectations and information contained in fundamentals. Again, this prediction is not borne out in the data. Second, level-1 firms should respond differently to signal E and signals B, C, D and should respond similarly to signals B and C (firms in this group understand the difference between fundamentals and expectations but do not distinguish among orders of expectations). We fail to find support evidence consistent this prediction. Finally, our theory predicts that, *ceteris paribus*, the weight on the prior increases in the level of thinking. In contrast, we find little variation in the weight across k.

We find similar patterns for the responses of employment, investment, prices, and wages (Table 12). Specifically, when we estimate equation (30) for each level k separately, we typically cannot reject equality of responses for each outcome variable across different levels of k. Given that firms appear to revise their beliefs similarly for all k, this finding suggests that conditional on moving inflation expectations firms react to the revision in expectations in largely the same way.

This evidence should be interpreted with caution: *i*) given our estimates of parameters, the amount of variation is relatively small; *ii*) sample sizes are relatively small so that sampling uncertainty in the estimates (standard errors) is relatively large. Obviously, the latter point can be resolved in future work that will utilize much larger samples to obtain sharper inference. The former point may suggest that we may need to contemplate using other values for key parameters that would generate patterns observed in the data. For example, instead of using our estimate of strategic complementarity $\alpha \approx 0.7$, one may perhaps consider values of α closer to zero which would reduce predicted differences in reactions across k. Finally, it is possible that the level of thinking elicited in the beauty contest game is specific to the game and it has little bearing for levels of thinking managers have when they revise their inflation expectations as well as set employment, investment, etc. If so, we fail to find meaningful variation across k because our identification of k does not capture the relevant level of thinking.

VI. Concluding remarks

This paper presents novel survey evidence on higher-order expectations, the response of actions (employment, investment, prices, and wages) and low/high-order inflation expectations to information, and importance of level-*k* thinking for beliefs and choices. We find evidence broadly in line with noisy information models where firm managers face strategic complementarities in pricing, requiring them to form higher-order beliefs about other managers. Using randomized controlled variation in information received by managers, we estimate the treatment effects of information on firm expectations and actions. These results provide rationale for utilizing survey measures of inflation expectations in policymaking (that is, firms act on their inflation expectations reported in surveys) and provide a foundation for policies operating via information treatments.

We also find evidence consistent with managers being unable to reason to an infinite degree. Accordingly, we categorize managers by their thinking types by introducing a commonly used experimental technique to a survey including macroeconomic expectations. We further show that levels of thinking conform to some aspects of different models of level-*k* thinking, but do not line up with other aspects (e.g., our analysis suggests that depths of reasoning do not materially impact manager responses to treatments). Future work may focus on modeling and defining the behavior of a level-*k* thinker, using our empirical results to discipline such models.

Jointly, these results contribute to a broader research agenda explaining the expectations formation of agents and utilizing these expectations in policymaking. Central banks may find this work particularly interesting as our results challenge certain model-based predictions of how expectations are formed and how decision-makers reason through information problems. For example, our approach allows us to quantify how much attention managers allocate to aggregate inflation. We find that managers exhibit considerable inattention to aggregate inflation so that their priors about inflation are rather diffuse. This inattention presents challenges and opportunities for managing inflation expectations. For example, although central banks may have hard time attracting attention of managers, conditional on having their attention central banks can move inflation expectation strongly. Our results also contribute to understanding what information is most effective in influencing inflation expectations. To this end, we find that providing managers with actual past inflation or with higher-order expectations has the strongest effect on inflation expectations.

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Table 1. Distribution of probability bins

Panel A. Own expectations

Please assign probabilities (from 0-100) to the following ranges of possible overall price changes for the New Zealand economy over the next 12 months: (Note that the probabilities in the column should sum to 100)

Percentage Price Changes PER YEAR over the next 12 months.	**Probabilities**	
More than 25%:	………………	**%**
From 15 to 25%:	………………	**%**
From 10 to 15%:	………………	**%**
From 8 to 10%:	………………	**%**
From 6 to 8%:	………………	**%**
From 4 to 6%:	………………	**%**
From 2 to 4%:	………………	**%**
From 0 to 2%:	………………	**%**
From -2 to 0%:	………………	**%**
From -4 to -2%:	……………..	**%**
From -6 to -4%:	……………..	**%**
From -6 to -8%:	………………	**%**
From -8 to -10%:	………………	**%**
From -10 to -15%:	………………	**%**
From -15 to -25%:	………………	**%**
Less than -25%:	………………	**%**
Total (the column should sum to 100%):	**100**	**%**

Panel B. Expectations of Other Managers' Beliefs

We would like to know what your opinion is about what *other* managers (drawn from all sectors of the New Zealand economy in a representative way) think will happen to overall prices in the economy. Please assign probabilities (from 0-100) **to the following ranges of beliefs that other managers might hold about overall price changes in the economy over the next 12 months for New Zealand:** (Note that the probabilities in the column should sum to 100)

Percentage Price Changes PER YEAR over the next 12 months.	**Probabilities**	
More than 25%:	………………	**%**
From 15 to 25%:	………………	**%**
From 10 to 15%:	………………	**%**
From 8 to 10%:	………………	**%**
From 6 to 8%:	………………	**%**
From 4 to 6%:	………………	**%**
From 2 to 4%:	………………	**%**
From 0 to 2%:	………………	**%**
From -2 to 0%:	………………	**%**
From -4 to -2%:	……………..	**%**
From -6 to -4%:	……………..	**%**
From -6 to -8%:	………………	**%**
From -8 to -10%:	………………	**%**
From -10 to -15%:	………………	**%**
From -15 to -25%:	………………	**%**
Less than -25%:	………………	**%**
Total (the column should sum to 100%):	**100**	**%**

Table 2. Expectations of future inflation and other managers' inflation expectations.

	# obs.	Mean	St.dev. (disagreement)	Uncertainty	Correlation with expected inflation
	(1)	(2)	(3)	(4)	(5)
Initial wave (pre experiment)					
Expected inflation, 12-month ahead	1,032	3.41	3.06	1.11	1.00
Expected inflation expectation of other managers, 12-month ahead	1,032	3.50	2.43	0.89	0.68
p-value for equality of moment		0.18	0.00	0.00	
Initial wave (post experiment)					
Expected inflation, 12-month ahead	1,032	3.25	1.76	-	1.00
Expected inflation expectation of other managers, 12-month ahead	1,032	3.23	1.42	-	0.62
p-value for equality of moment		0.79	0.00	-	
Follow-up wave					
Expected inflation, 12-month ahead	515	3.03	2.11	0.89	1.00
Expected inflation expectation of other managers, 12-month ahead	515	3.49	1.74	1.14	0.70
p-value for equality of moment		0.00	0.00	0.00	
Memorandum					
Expected inflation, 12-month ahead, point prediction, initial wave	1,032	3.76	2.52	-	0.63
Perceived inflation, previous 12 months, point prediction, initial wave	1,032	4.11	2.55	-	0.93

Notes: The table reports basic moments of expected inflation and higher-order expectations. Column (3) reports the cross-sectional standard deviation of mean inflation forecasts. Column (4) report the average (across managers) of standard deviation of the reported distribution for future inflation.

Table 3. Effect of Information Treatment on Expectations. .

Row	Treatment	Initial wave			Follow-up wave		
		Own Expectations	Higher-order Expectations	p-value equality	Own Expectations	Higher-order Expectations	p-value equality
		(1)	(2)	(3)	(4)	(5)	(6)
(1)	Group A, Control	0.727***	0.699***	0.35	0.744***	0.708***	0.45
		(0.020)	(0.021)		(0.038)	(0.038)	
(2)	Group B, $\overline{E}[\pi_t]$	0.502***	0.430***	0.21	0.461***	0.513***	0.45
		(0.041)	(0.039)		(0.065)	(0.049)	
(3)	Group C, $\overline{E}^2[\pi_t]$	0.090***	0.118***	0.36	0.116***	0.146***	0.61
		(0.018)	(0.024)		(0.043)	(0.047)	
(4)	Group D, $\overline{E}[\pi_t]$ and $\overline{E}^2[\pi_t]$	0.096***	0.071***	0.37	0.155***	0.097**	0.18
		(0.022)	(0.019)		(0.038)	(0.042)	
(5)	Group E, π_{t-1}	0.059***	0.062***	0.90	0.088**	-0.006	0.14
		(0.015)	(0.021)		(0.043)	(0.040)	
	Observations	1,032	1,032		515	515	
	R^2	0.757	0.759		0.653	0.602	

Notes: The table reports the coefficient on managers' pre-treatment inflation expectations in specification (29). The dependent variable in each column is the post-treatment inflation expectation. All inflation expectations are measured at the one-year-ahead horizon. Columns (1) and (2) present results for post-treatment inflation expectations measured immediately after treatment. Columns (4) and (5) present results for post-treatment inflation expectations measured three months after treatment. Columns (1) and (4) are for firms' own inflation expectations Columns (2) and (5) present the same results for the expectation of other firms' inflation expectations. Column (3) reports p-values of the null hypothesis that columns (1) and (2) are equal. Column (6) reports p-values of the null hypothesis that columns (4) and (5) are equal. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Table 4. Effect of Information Treatment on Actions.

Treatment effect (relative to control group)	Percent change in:			
	Workers	Fixed Assets	Price of Main Product	Wages
	(1)	(2)	(3)	(4)
Treatment B ($\overline{E}[\pi]$)				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.407***	0.342***	0.141	0.003
	(0.152)	(0.125)	(0.132)	(0.015)
R^2	245	245	245	245
Observations	-0.038	-0.050	0.028	0.001
1st stage F-stat	149.6	149.6	149.6	149.6
Treatment C ($\overline{E}^2[\pi]]$)				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.493*	0.141**	-0.078	0.043*
	(0.260)	(0.063)	(0.072)	(0.024)
R^2	252	252	252	252
Observations	-0.097	0.103	-0.043	-0.198
1st stage F-stat	15.47	15.47	15.47	15.47
Treatment D ($\overline{E}[\pi]$ and $\overline{E}^2[\pi]]$))				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	-0.264	0.214***	0.019	0.016
	(0.184)	(0.060)	(0.062)	(0.018)
R^2	253	253	253	253
Observations	0.004	0.066	0.002	0.010
1st stage F-stat	318.8	318.8	318.8	318.8
Treatment E: (π_{t-1})				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.352***	0.251***	0.096	0.021
	(0.095)	(0.096)	(0.094)	(0.013)
R^2	251	251	251	251
Observations	0.049	-0.028	-0.005	-0.000
1st stage F-stat	49.19	49.19	49.19	49.19

Notes: The table reports the coefficient on revision of own inflation expectations in specification (30). The regressand in each column is forecast error for a given firm-specific outcome indicated in the second row of the table. The regressor is instrumented with surprise component in the provided signal, that is, the difference between information provided in a treatment and pre-treatment expectation for the variable provided in the treatment. *1st stage F-stat* reports the first-stage F-statistic. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Table 5. Horserace regressions.

Panel A. Second-stage regression

Regressors	Workers	Fixed Assets	Price of Main Product	Wages
	Dependent variable: percent change in:			
	(1)	(2)	(3)	(4)
$E_i^{posterior}\pi - E_i^{prior}\pi$	-0.086	0.168**	0.036	0.028
	(0.222)	(0.083)	(0.053)	(0.021)
$E_i^{posterior}[\bar{E}(\pi)] - E_i^{prior}[\bar{E}(\pi)]$	-0.239	0.062	-0.023	-0.016
	(0.206)	(0.071)	(0.077)	(0.016)
Observations	253	253	253	253
R-squared	0.002	0.100	-0.001	0.005

Panel B. First-stage regression

	Dependent variable:	
	$E_i^{posterior}\pi - E_i^{prior}\pi$	$E_i^{posterior}[\bar{E}(\pi)] - E_i^{prior}[\bar{E}(\pi)]$
	(1)	(2)
$s_B - E_i^{prior}\pi$	0.906***	-0.044**
	(0.037)	(0.019)
$s_C - E_i^{prior}[\bar{E}(\pi)]$	-0.034	0.953***
	(0.030)	(0.027)
Observations	253	253
R^2	0.656	0.679
1st stage F-stat	501.9	655.4

Notes: Panel A of the table reports the coefficient on revision of own inflation expectations and revision of higher-order inflation expectation in specification (30). The regressand in each column is forecast error for a given firm-specific outcome indicated in the second row of the table. The regressors are instrumented with surprise component in the provided signals, that is, the difference between information provided in a treatment and pre-treatment expectation for the variable provided in the treatment. The first-stage regression is reported in Panel B. *1st stage F-stat* reports the first-stage F-statistic. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Table 6. Predictors of level of thinking.

Dependent variable: k, level of thinking	Sample					
	All responses		Responses with $k > 0$		Responses with non-missing k'	
	(1)	(2)	(3)	(4)	(5)	(6)
Firm characteristics						
Ln(Employment)	-0.314***	-0.315***	-0.023	-0.021	-0.131	-0.140
	(0.066)	(0.068)	(0.088)	(0.090)	(0.093)	(0.095)
Ln(Age)	-0.038	-0.035	0.022	0.023	-0.023	-0.017
	(0.048)	(0.048)	(0.055)	(0.055)	(0.057)	(0.057)
Share of domestic sales	-0.013**	-0.011	-0.012*	-0.013*	-0.017**	-0.019**
	(0.006)	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)
Number of competitors	0.044***	0.043***	0.002	0.002	0.008	0.007
	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)	(0.012)
Manager characteristics						
Manager's tenure at the firm	-0.011*	-0.012*	-0.007	-0.006	-0.002	-0.003
	(0.007)	(0.006)	(0.009)	(0.009)	(0.009)	(0.009)
Manager's gender (female = 1)	0.006	-0.005	0.093	0.084	0.007	-0.031
	(0.110)	(0.111)	(0.126)	(0.129)	(0.133)	(0.137)
Manager's years of schooling	0.008	0.010	0.024	0.024	0.021	0.021
	(0.023)	(0.023)	(0.026)	(0.026)	(0.027)	(0.027)
Observations	1,032	1,032	654	654	726	726
R^2	0.144	0.148	0.009	0.011	0.019	0.022
Industry FE	No	Yes	No	Yes	No	Yes

Notes: The table report results of regressing level of thinking k on firm and manager characteristics. Industry fixed effects at the one-digit level. Coding k' for level of thinking sets $k' = 0$ for responses with response time of 20 seconds or more and responses close to 50 and response time less than 20 seconds. The coding of k and k' are identical for $k > 0$. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Table 7. Distribution of beliefs about other managers' guesses in the beauty contest game.

Other managers are asked to guess a number from zero to 100, with the goal of making their guess as close as possible to two-thirds of the average guess of all those participating in the contest. What percentage of other managers' guesses do you think will fall in each of the following ranges?

Range of Guesses	Percentage of Other Managers
From 0 to 9.99	……………… %
From 10 to 19.99	……………… %
From 20 to 29.99	……………… %
From 30 to 39.99	……………… %
From 40 to 49.99	……………… %
From 50 to 59.99	……………… %
From 60 to 69.99	……………… %
From 70 to 79.99	……………… %
From 80 to 89.99	……………… %
From 90 to 100	……………… %

Note: table reports the survey question to elicit manager beliefs about the distribution of guess submitted by other managers.

Table 8. Beliefs about distribution of other managers' guesses.

Range of Guesses	Level of thinking						Average expected distribution	Actual distribution	memorandum $k' = 0$
	$k = 0$	$k = 1$	$k = 2$	$k = 3$	$k = 4$	$k = 5$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
From 0 to 9.99	5.9	0.0	1.0	9.8	25.0	79.0	8.9	8.9	1.0
From 10 to 19.99	7.1	1.6	11.9	74.5	68.7	18.8	22.4	22.4	2.2
From 20 to 29.99	7.8	12.1	76.3	14.6	4.9	2.0	19.7	19.7	6.8
From 30 to 39.99	7.4	72.3	10.1	1.1	1.1	0.1	19.7	19.7	11.0
From 40 to 49.99	12.7	13.2	0.7	0.0	0.2	0.0	7.5	7.5	26.3
From 50 to 59.99	19.4	0.8	0.0	0.0	0.0	0.0	7.3	7.3	21.5
From 60 to 69.99	13.2	0.0	0.0	0.0	0.0	0.0	4.8	4.8	14.8
From 70 to 79.99	11.3	0.0	0.0	0.0	0.0	0.0	4.2	4.2	9.0
From 80 to 89.99	9.0	0.0	0.0	0.0	0.0	0.0	3.3	3.3	4.6
From 90 to 100	6.0	0.0	0.0	0.0	0.0	0.0	2.2	2.2	2.8

Notes: The table reports average probabilities assigned to the beliefs of other managers' guesses. Column (7) is the average of columns (1)-(6) weighted by the share of managers with level k thinking. Column (8) shows the actual distribution of guesses. Classification of managers into various level of k is described in section 5.1. Coding k' for level of thinking sets $k' = 0$ for guesses in the beauty contest with response time of 20 seconds or more and responses close to 50 and response time less than 20 seconds. The coding of k and k' are identical for $k > 0$. Column (9) reports the average probabilities for $k' = 0$.

Table 9. Test of internal consistency of reported guesses in the beauty contest game.

Dependent variable: $Guess_i^{Own}$	Estimation sample:							
	All responses	$k > 0$	$k = 0$	$k = 1$	$k = 2$	$k = 3$	$k = 4$	$k = 5$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$E_i[Guess^{HO}]$	0.982***	0.912***	1.005***	0.937***	0.881***	0.932***	0.707***	0.814***
	(0.010)	(0.005)	(0.014)	(0.005)	(0.007)	(0.012)	(0.031)	(0.054)
Observations	1,032	654	378	216	160	134	110	34
R^2	0.950	0.985	0.943	0.992	0.989	0.979	0.938	0.887
p-value(slope=2/3)	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.01

Note: The table reports the estimated slope in specification (32) by level of thinking k. Classification of managers into various level of k is described in section 5.1. p-value(slope=2/3) reports the p-value for the null that the estimate is equal to 2/3. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Table 10. Moments of inflation expectations and implied parameter values by level of thinking.

	Level of thinking						
	$k=0$	$k=1$	$k=2$	$k=3$	$k=4$	$k=5$	memorandum $k'=0$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Moment of own inflation expectations							
Mean	5.16	2.60	2.24	2.40	2.46	1.54	3.53
Disagreement	2.83	2.91	2.50	2.71	2.60	2.49	2.87
Uncertainty	1.29	1.06	0.95	0.92	1.02	1.03	1.10
Moment of high-order inflation expectations							
Mean	4.87	2.83	2.74	2.69	2.62	2.13	3.87
Disagreement	2.09	2.40	2.17	2.32	2.20	1.58	2.54
Uncertainty	0.88	0.95	0.80	0.92	0.93	0.86	0.90
Correlation between low- and high-order inflation expectations	0.48	0.66	0.68	0.70	0.71	0.79	0.65
Strategic complementarity in pricing, α	0.68	0.69	0.75	0.56	0.84	0.82	0.82
Implied parameters							
δ	0.74	0.82	0.87	0.86	0.85	0.63	0.89
ϕ_x	0.47	0.59	0.62	0.72	0.47	0.24	0.58
κ_x	0.015	0.028	0.047	0.052	0.023	0.004	0.032
κ_y	0.004	0.007	0.012	0.013	0.006	0.001	0.008
Observations	378	216	160	134	110	34	72

Notes: The table reports moments of inflation expectations by level of thinking k. Classification of managers into various level of k is described in section 5.1. Coding k' for level of thinking sets $k'=0$ for guesses in the beauty contest with response time of 20 seconds or more and responses close to 50 and response time less than 20 seconds. The coding of k and k' are identical for $k>0$. Disagreement is the cross-sectional standard deviation of mean inflation forecasts. Uncertainty is the average (across managers) of standard deviation of the reported distribution for future inflation. Parameters $\alpha, \delta, \phi_x, \kappa_x, \kappa_y$ implied by these moments are calculated as in section 3. Precision of signals κ_x, κ_y is calculated using disagreement in low- and high-order inflation expectations.

Table 11. Revisions of beliefs by level of thinking

	$k = 0$		$k = 1$		$k \geq 2$	
	Own Expectations	Higher-order Expectations	Own Expectations	Higher-order Expectations	Own Expectations	Higher-order Expectations
	(1)	(2)	(3)	(4)	(5)	(6)
Group A, Control	0.704***	0.715***	0.722***	0.634***	0.732***	0.726***
	(0.042)	(0.028)	(0.033)	(0.058)	(0.035)	(0.028)
Group B, $\overline{E}[\pi_t]$	0.554***	0.284***	0.522***	0.521***	0.446***	0.500***
	(0.109)	(0.058)	(0.068)	(0.127)	(0.061)	(0.054)
Group C, $\overline{E}^2[\pi_t]$	0.100***	0.141**	0.029	0.053	0.098**	0.127***
	(0.031)	(0.056)	(0.021)	(0.035)	(0.038)	(0.038)
Group D, $\overline{E}[\pi_t]$ and $\overline{E}^2[\pi_t]$	0.082**	0.079	0.107***	0.028*	0.090**	0.066**
	(0.035)	(0.049)	(0.039)	(0.014)	(0.035)	(0.028)
Group E, π_{t-1}	0.033*	0.065	0.103**	0.036	0.071**	0.102**
	(0.019)	(0.048)	(0.046)	(0.031)	(0.032)	(0.044)
Observations	378	378	216	216	438	438
R^2	0.753	0.785	0.777	0.755	0.719	0.723

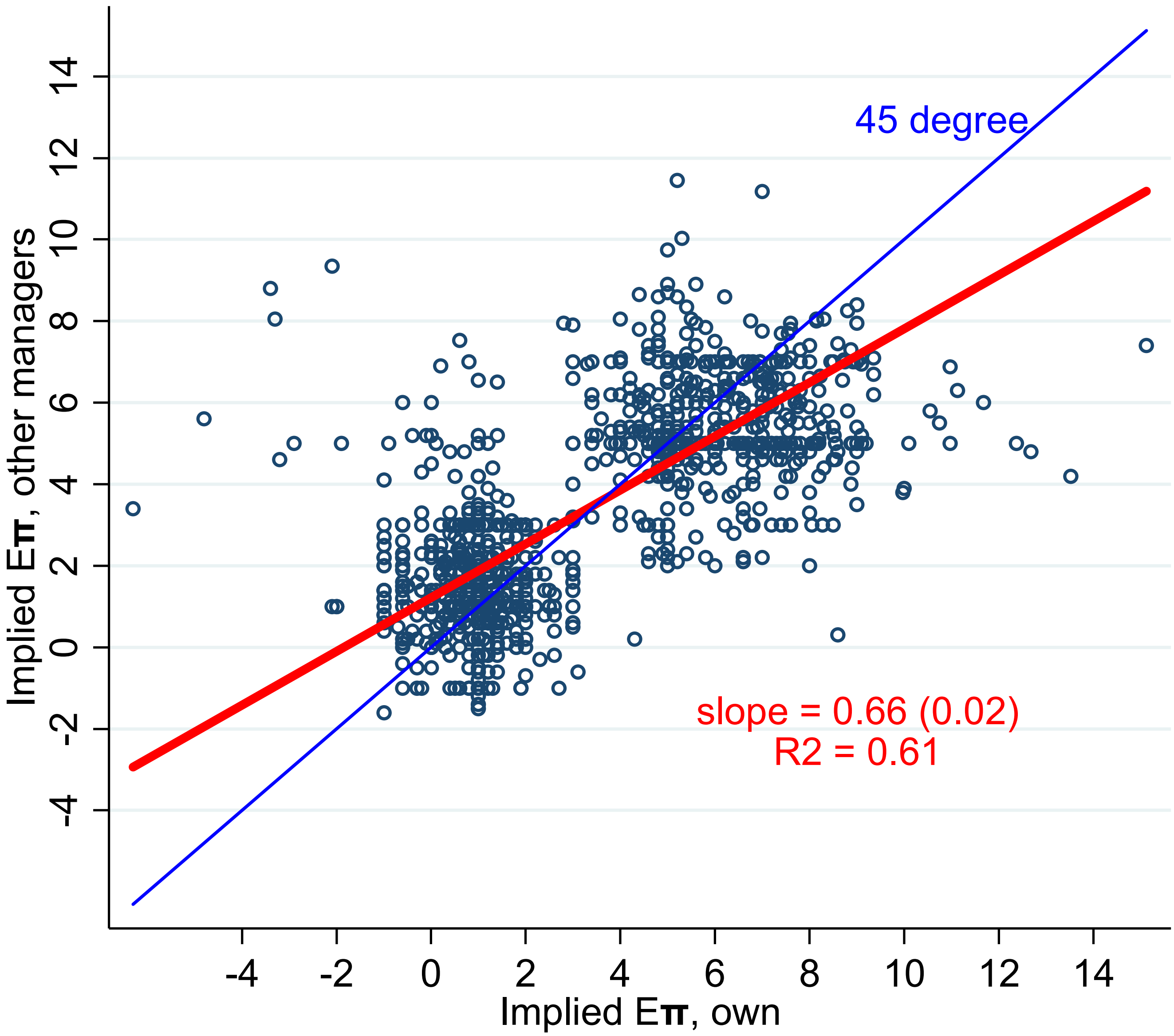
Notes: The table reports the coefficient on managers' pre-treatment inflation expectations in specification (29) by level of thinking k. Classification of managers into various level of k is described in section 5.1. The dependent variable in each column is the post-treatment inflation expectation. Post-treatment inflation expectations measured immediately after treatment. All inflation expectations are measured at the one-year-ahead horizon. Columns (1), (3), and (5) are for firms' own inflation expectations. Columns (2), (4), and (6) present the same results for the expectation of other firms' inflation expectations. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Table 12. Effect of Information Treatment on Actions.

Treatment effect (relative to control group)	k-level	Percent change in: Workers	Fixed Assets	Price of Main Product	Wages
		(1)	(2)	(3)	(4)
Treatment B ($\overline{E}[\pi]$)					
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	$k = 0$	0.597*	0.534**	0.178	0.034
		(0.311)	(0.252)	(0.209)	(0.035)
	$k = 1$	0.264	0.361	-0.058	0.000
		(0.188)	(0.240)	(0.102)	(0.000)
	$k \geq 2$	0.365	0.259	0.211	-0.027
		(0.270)	(0.201)	(0.234)	(0.021)
Treatment C ($\overline{E}^2[\pi]]$)					
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	$k = 0$	0.222	0.160	-0.145	0.014
		(0.302)	(0.100)	(0.133)	(0.020)
	$k = 1$	1.511	-0.724	2.182	1.252
		(16.412)	(8.896)	(24.137)	(14.267)
	$k \geq 2$	1.203	0.170*	-0.132	0.071
		(0.780)	(0.088)	(0.127)	(0.052)
Treatment D ($\overline{E}[\pi]$ and $\overline{E}^2[\pi]]$))					
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	$k = 0$	-0.219	0.239**	0.187*	0.031
		(0.390)	(0.114)	(0.113)	(0.042)
	$k = 1$	-0.407	0.214**	-0.290	0.000
		(0.425)	(0.089)	(0.192)	(0.000)
	$k \geq 2$	-0.425	0.242***	-0.034	-0.014
		(0.355)	(0.092)	(0.040)	(0.009)
Treatment E: (π_{t-1})					
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	$k = 0$	0.224*	0.135*	0.006	0.005
		(0.123)	(0.072)	(0.073)	(0.017)
	$k = 1$	0.791**	0.525**	0.665	0.004
		(0.319)	(0.232)	(0.605)	(0.004)
	$k \geq 2$	0.390***	0.352	-0.002	0.043
		(0.119)	(0.223)	(0.084)	(0.030)

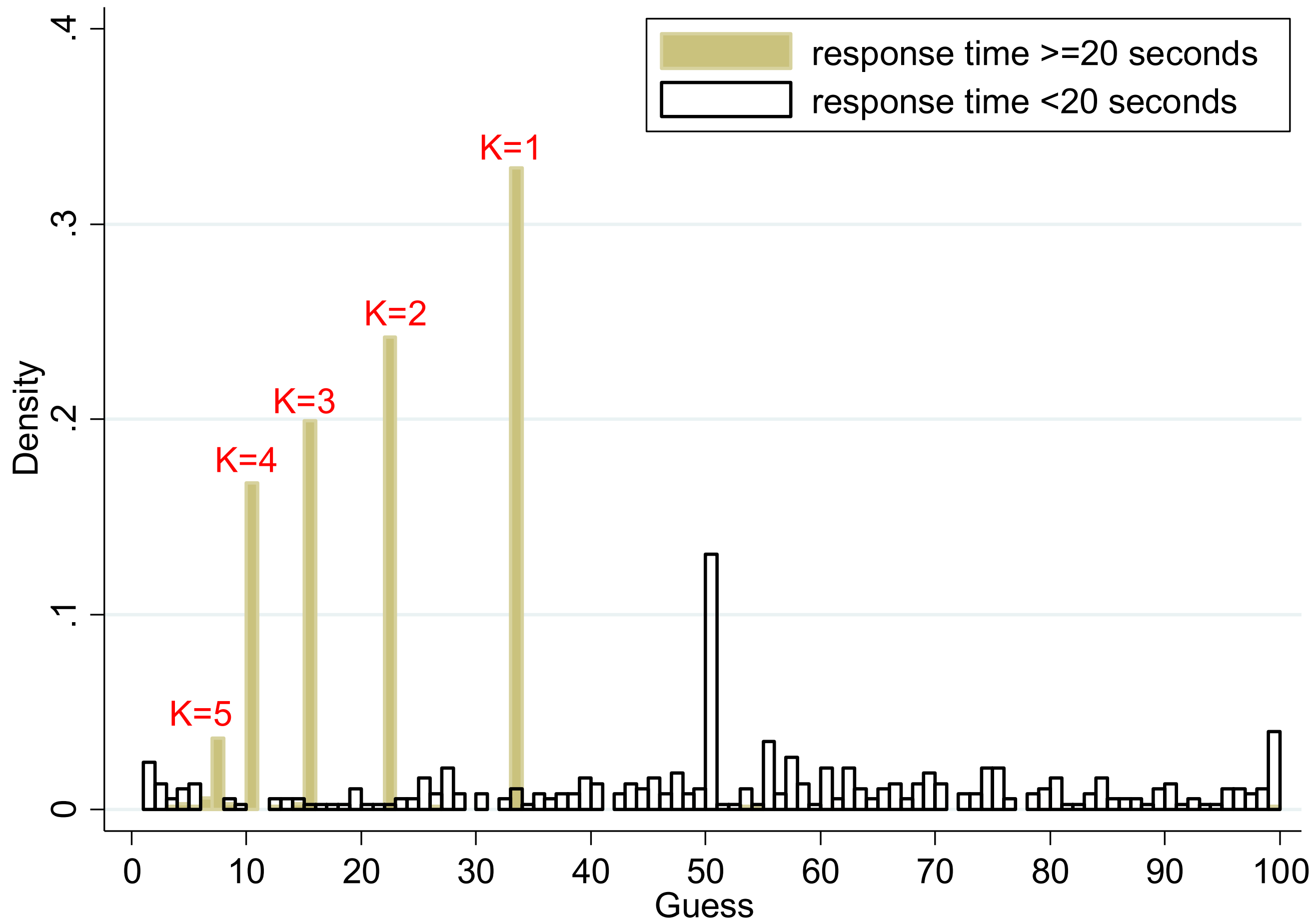
Notes: The table reports the coefficient on revision of own inflation expectations in specification (30) by level of thinking k. Classification of managers into various level of k is described in section 5.1. The regressand in each column is forecast error for a given firm-specific outcome indicated in the second row of the table. The regressor is instrumented with surprise component in the provided signal, that is, the difference between information provided in a treatment and pre-treatment expectation for the variable provided in the treatment. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Figure 1. Own Expectations and Higher-order Expectations.



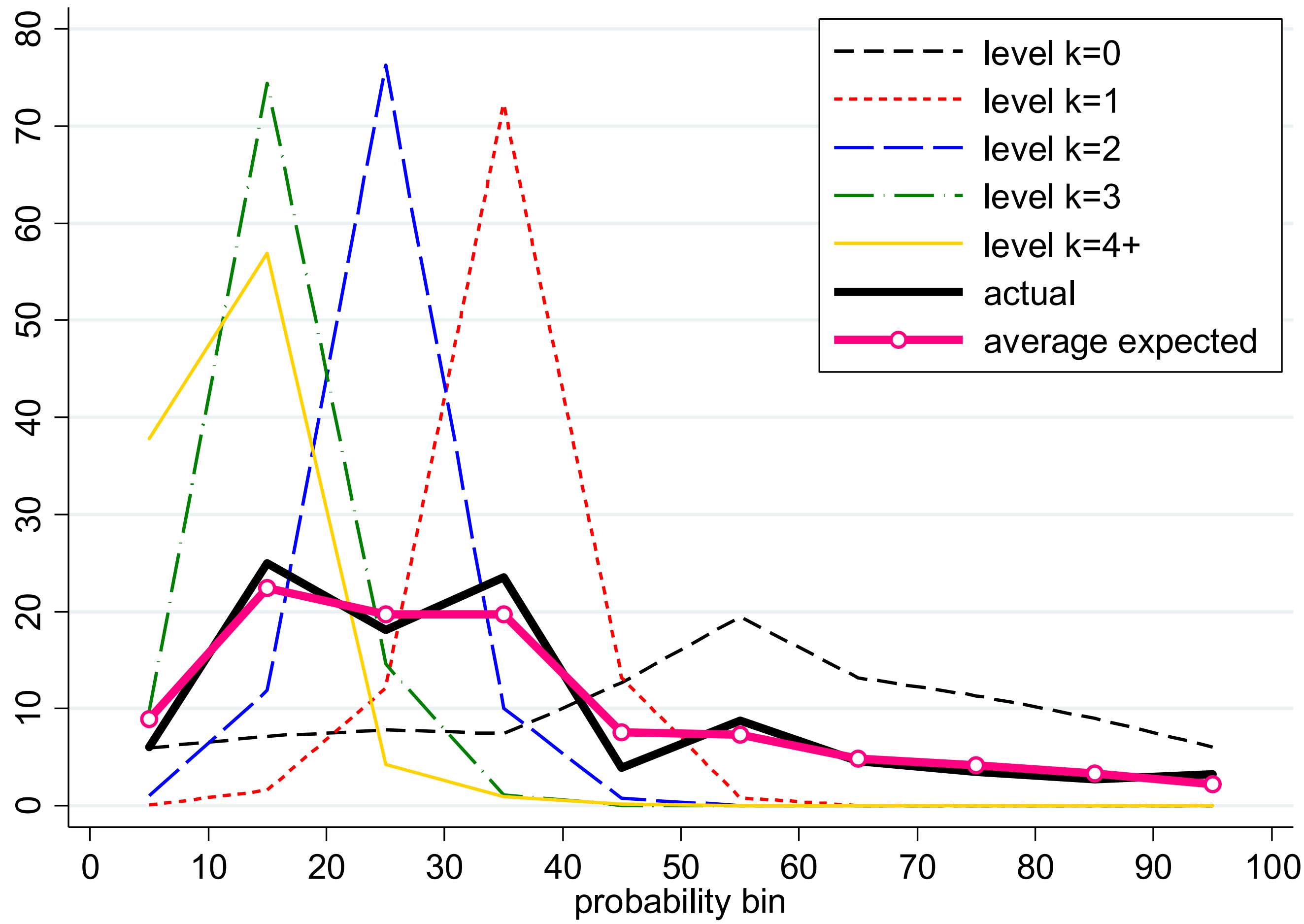
Notes: The figure reports the relationship between a managers' own expectation of inflation and his higher-order expectation of inflation. Expectations are measured as mean expectations implied by the reported probability distributions for future inflation (see Table 1 for the wording of the questions). Expectations are for the one-year-ahead horizon.

Figure 2. Responses to Beauty Contest Question.



Notes: This figure shows the distribution of guesses from the beauty contest game. We asked managers to provide a guess between zero and 100 with the guess closest to 2 of the average guess receiving a prize. For managers who spent at least 20 seconds in considering their guess, we see clumping of guesses at those points which correspond neatly with level-*k* types as defined in Nagel (1995). Those managers who answered the question in less than 20 seconds made guesses dispersed across the full interval.

Figure 3. Beliefs about distribution of other managers' guesses.



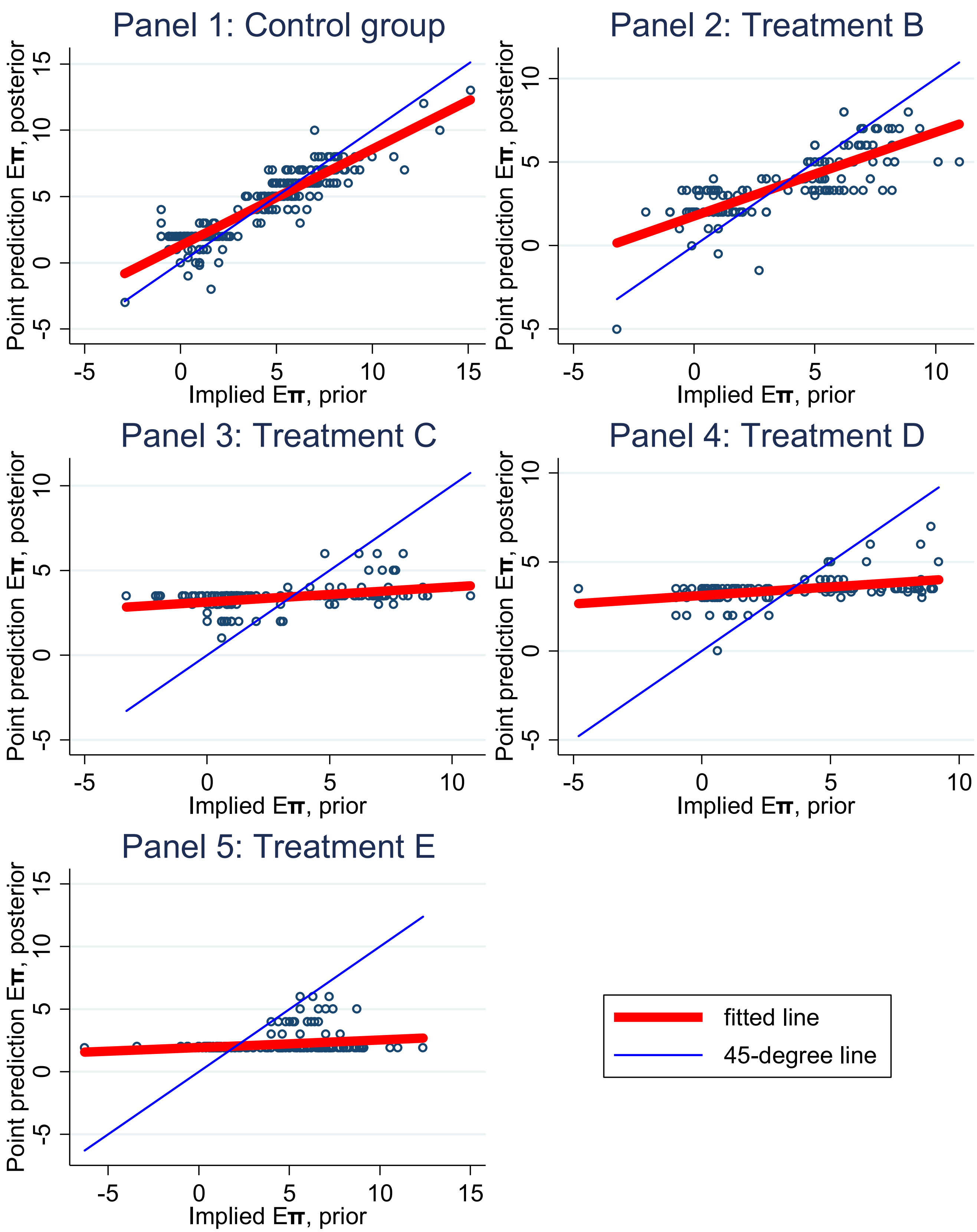
Notes: This figure shows the average belief of each reasoning type ($k = 0, 1, 2, \ldots$), about other managers' guesses in the beauty contest game. Individuals of each type believe that the majority of other managers provide guesses similar to their own. All thinking types underestimate the true dispersion of guesses.

Online Appendix

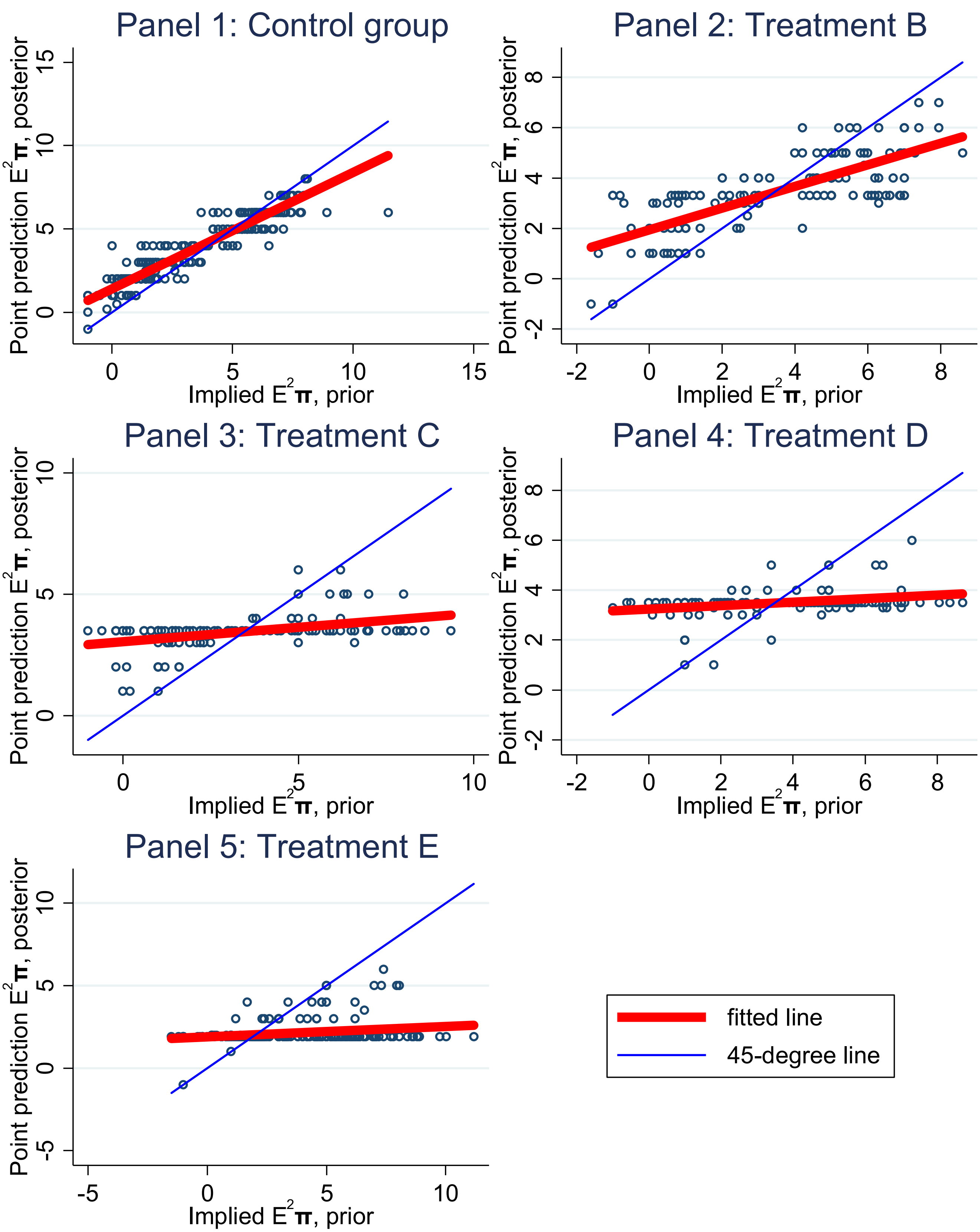
Appendix A.

Additional Tables and Figures

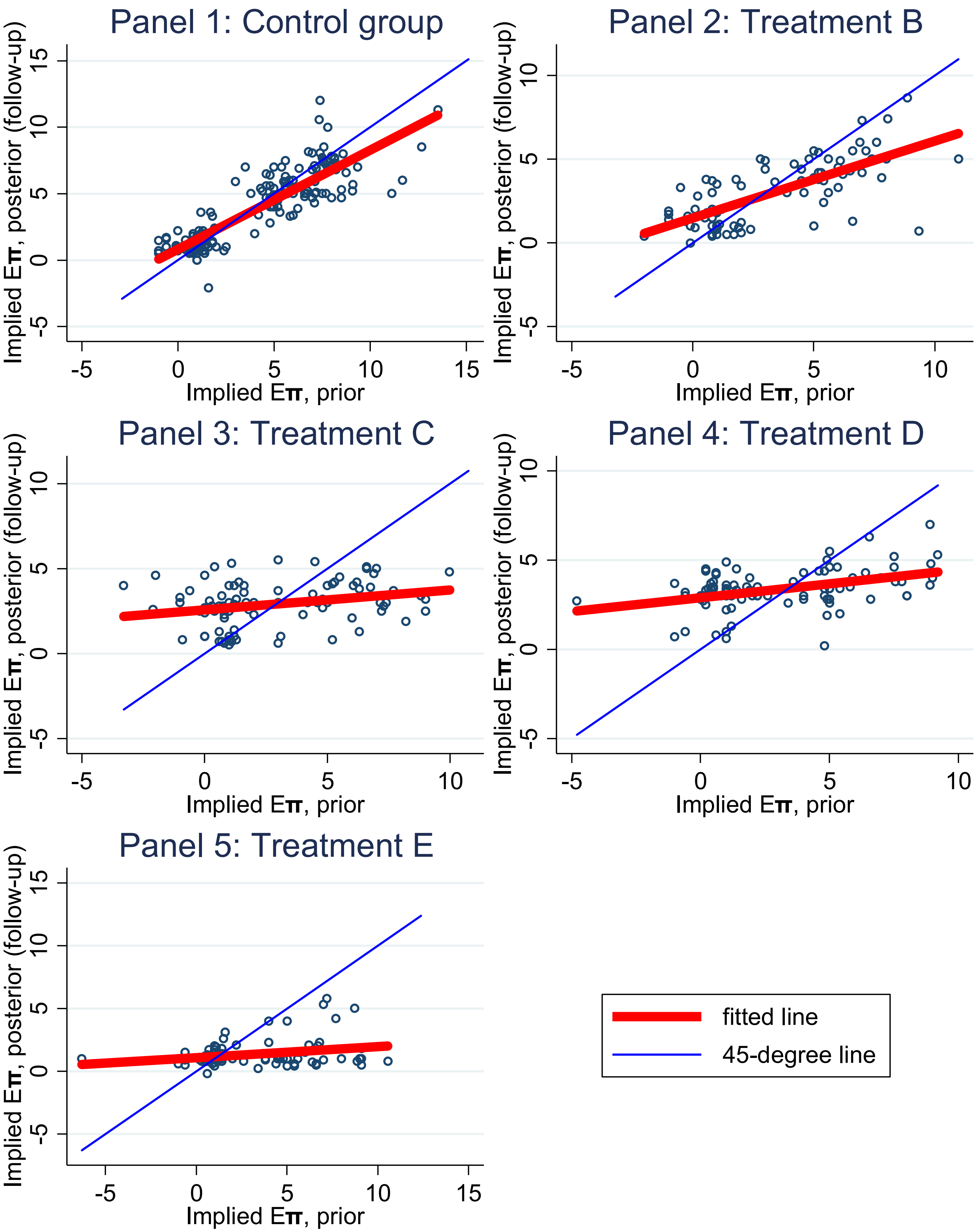
Appendix Figure 1. Revision of beliefs immediately after treatment: low-order beliefs.



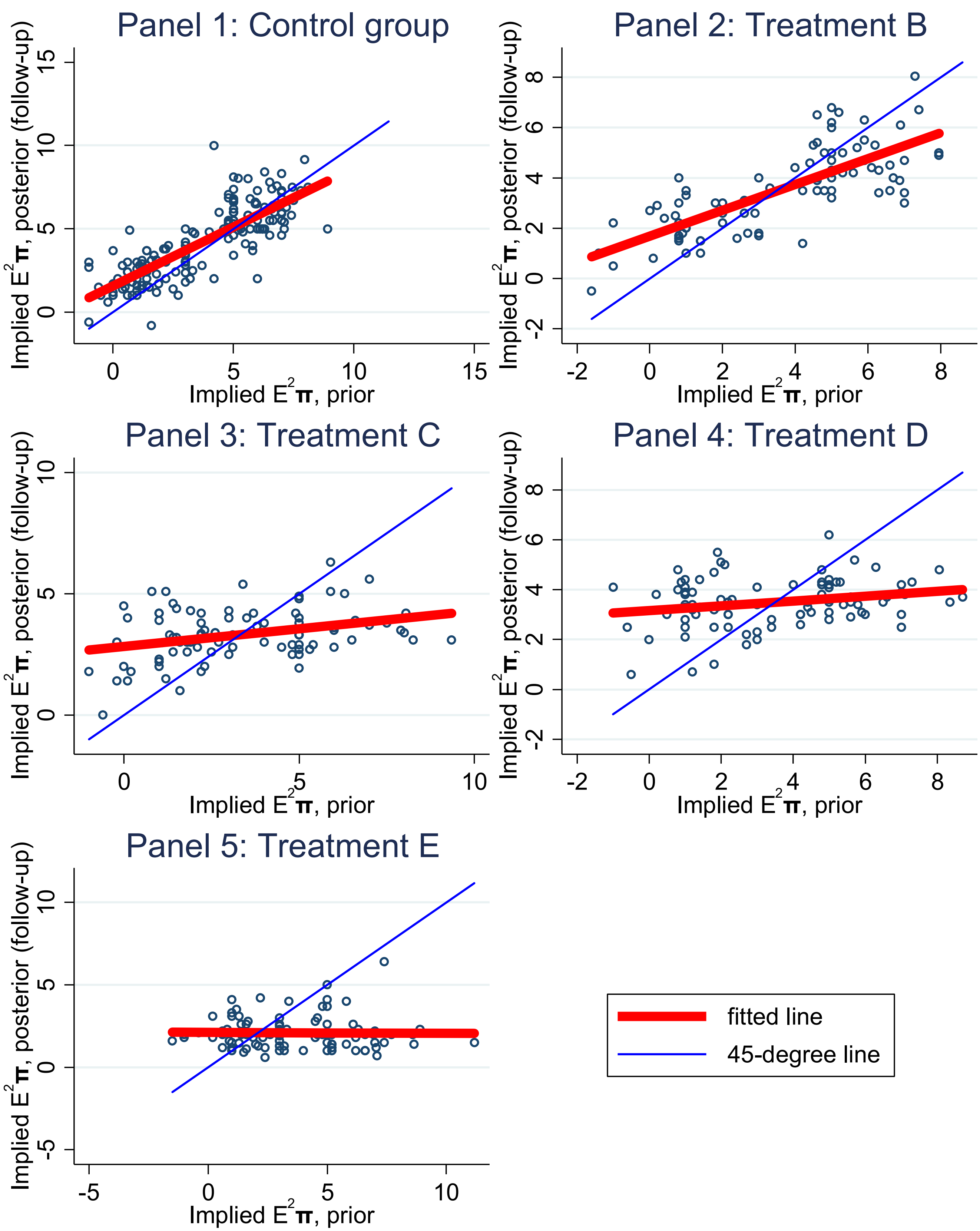
Appendix Figure 2. Revision of beliefs immediately after treatment: high-order beliefs.



Appendix Figure 3. Revision of beliefs in the follow-up survey: low-order beliefs.



Appendix Figure 4. Revision of beliefs in the follow-up survey: high-order beliefs.



Appendix Table 1. Descriptive statistics for the initial wave of the survey.

	Mean (1)	St.dev. (2)
Firm characteristics		
Employment	37.70	67.98
Age	25.97	19.23
Share of domestic sales in total sales	97.19	7.69
Number of competitors	8.78	6.26
Manager characteristics		
Tenure at the firm	11.48	7.32
Gender (female=1)	0.19	0.39
Years of schooling	16.71	1.92
Level of thinking		
k	1.50	1.51
k'	2.13	1.38
$k \vert k > 0$	2.37	1.24

Notes: the number of observations is 1,032.

Appendix Table 2. Predictors of selection into the follow-up wave of the survey.

	Dependent variable: Participation in the follow-up wave of the survey			
	(1)	(2)	(3)	(4)
Ln(Employment)	-0.026	-0.022	-0.020	-0.023
	(0.023)	(0.023)	(0.024)	(0.024)
Ln(Age)	-0.028	-0.029	-0.029	-0.027
	(0.018)	(0.018)	(0.018)	(0.018)
Share of domestic sales	-0.002	-0.002	-0.002	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Number of competitors	-0.004	-0.005	-0.005	-0.005
	(0.003)	(0.004)	(0.004)	(0.004)
Manager's tenure at the firm		-0.004	-0.004	-0.004
		(0.002)	(0.002)	(0.002)
Manager's gender (male = 1)		-0.015	-0.015	-0.023
		(0.039)	(0.039)	(0.040)
Manager's years of schooling		0.001	0.001	0.001
		(0.008)	(0.008)	(0.008)
Level of thinking, k			0.004	0.004
			(0.011)	(0.011)
Constant	0.892***	0.926***	0.913***	1.000***
	(0.222)	(0.259)	(0.262)	(0.268)
Observations	1,032	1,032	1,032	1,032
R-squared	0.005	0.007	0.007	0.011
Industry FE	No	No	No	Yes

Notes: the table reports estimates of the linear probability model to check selection on observable characteristics of firms and managers. Participation is the dummy variable equal to one if a firm participates in the follow-up and zero otherwise. Industry fixed effects are at the one-digit level. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Appendix Table 3. Effect of Information Treatment on Expectations.

Row	Treatment	Initial wave	Follow-up wave
		Own Expectations	Own Expectations
		(1)	(4)
(1)	Group A, Control	0.968***	0.973***
		(0.014)	(0.045)
(2)	Group B, $\overline{E}[\pi_t]$	0.625***	0.574***
		(0.051)	(0.076)
(3)	Group C, $\overline{E}^2[\pi_t]$	0.122***	0.157**
		(0.026)	(0.061)
(4)	Group D, $\overline{E}[\pi_t]$ and $\overline{E}^2[\pi_t]$	0.115***	0.175***
		(0.031)	(0.049)
(5)	Group E, π_{t-1}	0.073***	0.096*
		(0.020)	(0.054)
	Observations	1,032	515
	R^2	0.840	0.672

Notes: the table replicates analysis in Table 3 with the regressor being the point prediction for inflation rather than implied mean. See note to Table 3 for more details.

Appendix Table 4. Effect of Information Treatment on Future Plans.

Treatment effect (relative to control group)	Percent change in: Workers	Fixed Assets	Price of Main Product	Wages
	(1)	(2)	(3)	(4)
Treatment B ($\overline{E}[\pi]$)				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.004	0.491**	0.396*	-0.015
	(0.338)	(0.250)	(0.218)	(0.036)
R^2	245	245	245	245
Observations	-0.000	-0.011	0.016	-0.001
1st stage F-stat	149.6	149.6	149.6	149.6
Treatment C ($\overline{E}^2[\pi]]$)				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.017	0.027	-0.140	0.098
	(0.367)	(0.138)	(0.231)	(0.083)
R^2	252	252	252	252
Observations	-0.000	0.005	-0.033	-0.021
1st stage F-stat	15.47	15.47	15.47	15.47
Treatment D ($\overline{E}[\pi]$ and $\overline{E}^2[\pi]]$))				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	-0.220	0.219**	0.106	0.036
	(0.187)	(0.093)	(0.125)	(0.055)
R^2	253	253	253	253
Observations	0.008	0.006	0.002	0.009
1st stage F-stat	318.8	318.8	318.8	318.8
Treatment E: (π_{t-1})				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.109	0.098	-0.202	-0.012
	(0.204)	(0.121)	(0.148)	(0.030)
R^2	251	251	251	251
Observations	0.001	0.007	-0.024	-0.004
1st stage F-stat	49.19	49.19	49.19	49.19

Notes: The table reports the coefficient on revision of own inflation expectations in specification (30). The regressand in each column is revision in plans for a given firm-specific outcome indicated in the second row of the table; that is, the outcome variable in specification (30) is 3-month-ahead plan in the follow-up wave minus the 6-month-ahead plan in the initial wave. The regressor is instrumented with surprise component in the provided signal, that is, the difference between information provided in a treatment and pre-treatment expectation for the variable provided in the treatment. *1st stage F-stat* reports the first-stage F-statistic. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Appendix Table 5. Effect of Information Treatment on Actions, OLS.

Treatment effect (relative to control group)	Percent change in: Workers	Fixed Assets	Price of Main Product	Wages
	(1)	(2)	(3)	(4)
Treatment B ($\overline{E}[\pi]$)				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.169**	0.145**	0.146**	0.003
	(0.072)	(0.057)	(0.074)	(0.005)
R^2	245	245	245	245
Observations	0.038	0.061	0.028	0.001
Treatment C ($\overline{E}^2[\pi]]$)				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.155*	0.127***	0.010	0.008
	(0.089)	(0.046)	(0.029)	(0.005)
R^2	252	252	252	252
Observations	0.025	0.105	0.001	0.013
Treatment D ($\overline{E}[\pi]$ and $\overline{E}^2[\pi]]$))				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	-0.149	0.134***	0.023	0.013
	(0.129)	(0.047)	(0.036)	(0.011)
R^2	253	253	253	253
Observations	0.010	0.103	0.002	0.010
Treatment E: (π_{t-1})				
$\left(E_i^{posterior}(\pi) - E_i^{prior}(\pi)\right)$	0.207***	0.117***	0.042	0.010**
	(0.066)	(0.036)	(0.030)	(0.005)
R^2	251	251	251	251
Observations	0.096	0.093	0.009	0.024

Notes: The table reports the OLS coefficient on revision of own inflation expectations in specification (30). The regressand in each column is forecast error for a given firm-specific outcome indicated in the second row of the table. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Appendix Table 6. Effect of Information Treatment on Actions, higher order expectations on the RHS.

Treatment effect (relative to control group)	Percent change in: Workers	Fixed Assets	Price of Main Product	Wages
	(1)	(2)	(3)	(4)
Treatment B ($\overline{E}[\pi]$)				
$E_i^{posterior}[\bar{E}(\pi)] - E_i^{prior}[\bar{E}(\pi)]$	0.644***	0.540***	0.223	0.005
	(0.245)	(0.205)	(0.215)	(0.023)
R^2	245	245	245	245
Observations	-0.144	-0.294	-0.028	-0.003
1st stage F-stat	60.64	60.64	60.64	60.64
Treatment C ($\overline{E}^2[\pi]]$)				
$E_i^{posterior}[\bar{E}(\pi)] - E_i^{prior}[\bar{E}(\pi)]$	0.326**	0.093**	-0.052	0.028**
	(0.162)	(0.043)	(0.046)	(0.014)
R^2	252	252	252	252
Observations	0.039	0.022	-0.009	0.047
1st stage F-stat	561.8	561.8	561.8	561.8
Treatment D ($\overline{E}[\pi]$ and $\overline{E}^2[\pi]]$))				
$E_i^{posterior}[\bar{E}(\pi)] - E_i^{prior}[\bar{E}(\pi)]$	-0.355	0.288***	0.026	0.021
	(0.244)	(0.084)	(0.084)	(0.024)
R^2	253	253	253	253
Observations	-0.010	-0.010	0.003	-0.016
1st stage F-stat	182.9	182.9	182.9	182.9
Treatment E: (π_{t-1})				
$E_i^{posterior}[\bar{E}(\pi)] - E_i^{prior}[\bar{E}(\pi)]$	0.311***	0.222**	0.085	0.018
	(0.095)	(0.089)	(0.085)	(0.012)
R^2	251	251	251	251
Observations	0.035	0.033	-0.012	0.000
1st stage F-stat	83.65	83.65	83.65	83.65

Notes: The table reports the coefficient on revision of higher-order inflation expectations in specification (30). The regressand in each column is forecast error for a given firm-specific outcome indicated in the second row of the table. The regressor is instrumented with surprise component in the provided signal, that is, the difference between information provided in a treatment and pre-treatment expectation for the variable provided in the treatment. *1st stage F-stat* reports the first-stage F-statistic. Robust standard errors are reported in parentheses. ***, **, and * indicate significance at the 0.01, 0.05 and 0.10 percent levels, respectively.

Appendix B. Survey Questionnaire, Sampling Frame, and Response Rate

FIRMS IN NEW ZEALAND
2017 SURVEY (INITIAL WAVE)

AUT UNIVERSITY Faculty of Business and Law

This questionnaire asks about the firms' prices, output and expectations. Please be assured all replies are confidential. Your responses will remain 100% anonymous. Participation is voluntary. Participation or non-participation will neither advantage nor disadvantage the participant. By completing this questionnaire you indicate your consent to participate. This questionnaire must be completed by a senior management official (Director or Manager).

Dr Saten Kumar. Phone: (09) 921 9999 ext. XXXX. Email: xxxxx@aut.ac.nz

SECTION A. BASIC CHARACTERISTICS OF THIS FIRM

1. **What is the total number of employees working at this firm? How many are used for the main product or product line?**

	Employment for firm:	Employment for main product:
Number:	....	....

2. **How many years old is the firm?**

Answer:	**………………**	**year(s) old**

3. **What percentage of the firm's revenues in the last 12 months came from sales in New Zealand** (vs. other countries)**?**

Answer:	**………………**	**% of sales originating in New Zealand**

4. **How many direct competitors does the firm face in its main product line?**

Answer:	**………………**	**firms.**

5. **If your firm were free to change its price** (i.e. suppose there was no cost to renegotiating contracts with clients, no costs of reprinting catalogues, etc.) **right now, by how much would it change its price?** Please provide a percentage answer (e.g. "+10%" for a 10% increase in price). **By how much do you think profits would change as a share of revenues?** Please provide a numerical answer in percent (e.g. "+10%" if profits are expected to rise by 10% of revenues).

Change in price:	**………………**	**%**
Expected change in profits:	**………………**	**% of revenues**

SECTION B: CHARACTERISTICS OF THE FIRM MANAGER

6. **How many years of work experience do you have:**

At this firm:	**………………**	**year(s)**	**In this industry:**	**………………**	**year(s)**

7. **What is your gender?**
   a. Male
   b. Female

8. **What is your highest educational qualification?**
   a. Less than high school
   b. High school diploma
   c. Some college or Associate degree
   d. College Diploma
   e. Graduate Studies (Masters or PhD)

9. **Who makes decisions in the business regarding price of the main product, assets, new capital investment and employment of new workers?** Please tick the relevant option.

	Pricing	Assets	Investment	Employment
Myself only	…………	…………	…………	…………
Myself and other staff member(s)	…………	…………	…………	…………
Other staff member(s)	…………	…………	…………	…………
Someone outside of this business	…………	…………	…………	…………

10. **How much do you contribute in the decisions related to price setting of the main product, assets, new capital investment, and employment of new workers?** Please tick the relevant option.

	Pricing	Assets	Investment	Employment
Very Strongly	…………….	…………….	…………….	…………….
Strongly	…………….	…………….	…………….	…………….
Moderately	…………….	…………….	…………….	…………….
Weakly	…………….	…………….	…………….	…………….
Very Weakly	…………….	…………….	…………….	…………….

SECTION C: ECONOMIC EXPECTATIONS

11. **During the *next twelve* months, do you expect prices overall in the economy to go up, go down, or stay the same?**
Go up ☐ **Go down** ☐ **Stay the same** ☐

[If the answer is "Stay the same" proceed to next question below. Otherwise, ask **"By how much, in % terms?"**
Answer: ………….. %

12. **By how much do you think prices will change overall in the economy over the following periods?** Please provide an answer in percentage terms.

2018Q1:	**………………**	**% relative to 2017Q4**
2018Q2:	**………………**	**% relative to 2017Q4**
2018Q3:	**………………**	**% relative to 2017Q4**
2018Q4:	**………………**	**% relative to 2017Q4**

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

13. **Please assign probabilities (from 0-100) to the following ranges of possible overall price changes for the New Zealand economy over the next 12 months:** (Note that the probabilities in the column should sum to 100)

Percentage Price Changes in 12 Months	**Probabilities**	
More than 25%:	**………………**	**%**
From 15 to 25%:	**………………**	**%**
From 10 to 15%:	**………………**	**%**
From 8 to 10%:	**………………**	**%**
From 6 to 8%:	**………………**	**%**
From 4 to 6%:	**………………**	**%**
From 2 to 4%:	**………………**	**%**
From 0 to 2%:	**………………**	**%**
From 0 to -2%:	**………………**	**%**
From -2 to -4%:	**………………**	**%**
From -4 to -6%:	**………………**	**%**
From -6 to -8%:	**………………**	**%**
From -8 to -10%:	**………………**	**%**
From -10 to -15%:	**………………**	**%**
From -15 to -25%:	**………………**	**%**
Less than -25%:	**………………**	**%**
Total (the column should sum to 100%):	**100**	**%**

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

14. **We would like to know what your opinion is about what *other* managers (drawn from all sectors of the New Zealand economy in a representative way) think will happen to overall prices in the economy. Please assign probabilities** (from 0-100) **to the following ranges of beliefs that other managers might hold about overall price changes in the economy over the next 12 months for New Zealand:** (Note that the probabilities in the column should sum to 100)

Percentage Price Changes in 12 Months	% of managers	
More than 25%:	………………	%
From 15 to 25%:	………………	%
From 10 to 15%:	………………	%
From 8 to 10%:	………………	%
From 6 to 8%:	………………	%
From 4 to 6%:	………………	%
From 2 to 4%:	………………	%
From 0 to 2%:	………………	%
From -2 to 0%:	………………	%
From -4 to -2%:	……………..	%
From -6 to -4%:	……………..	%
From -6 to -8%:	………………	%
From -8 to -10%:	………………	%
From -10 to -15%:	………………	%
From -15 to -25%:	………………	%
Less than -25%:	………………	%
Total (the column should sum to 100%):	**100**	%

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

15. **If your firm was free to change its price** (i.e. suppose there was no cost to renegotiating contracts with clients, no costs of reprinting catalogues, etc.) ***in three months*, what probability would you assign to each of the following categories of possible price changes the firm would make?** Please provide a percentage answer.

Range of "Costless" Price Change in 3 Months	Probability (in %)	
More than 25%:	………………	%
From 15 to 25%:	………………	%
From 10 to 15%:	………………	%
From 8 to 10%:	………………	%
From 6 to 8%:	………………	%
From 4 to 6%:	………………	%
From 2 to 4%:	………………	%
From 0 to 2%:	………………	%
From -2 to 0%:	………………	%
From -4 to -2%:	……………..	%
From -6 to -4%:	……………..	%
From -6 to -8%:	………………	%
From -8 to -10%:	………………	%
From -10 to -15%:	………………	%
From -15 to -25%:	………………	%
Less than -25%:	………………	%
Total (the column should sum to 100%):	**100**	%

16. **For the next three questions, suppose that neither you nor your competitors face any costs in changing your prices. Also suppose that you get news that the general level of prices went up by 10% in the economy:**
    d. By what percentage do you think your competitors would raise their prices on average? ………….. %
    e. By what percentage would your firm raise its price on average? ………….. %
    f. By what percentage would your firm raise its price if your competitors did not change their price at all in response to this news? ………….. %

17. **When is your firm going to change its price next (**in months**) and by how much (**in % change**)?**
    Time until next price change: …………….. months
    Size of next price change: …………….. %

18. **By how much do you think overall prices in the economy have changed over the last 12 months?** Please provide an answer in % change. *Answer*: ……………….. %

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

19. **Please assign probabilities** (from 0-100) **to the following ranges for what the unemployment rate might be in 12 months in New Zealand:** (Note that the probabilities in the column should sum to 100)

Possible Unemployment Rates in 12 Months	**Probabilities**	
10% or more:	**………………**	**%**
From 9 to 9.9%:	**………………**	**%**
From 8 to 8.9%:	**………………**	**%**
From 7 to 7.9%:	**………………**	**%**
From 6 to 6.9%:	**………………**	**%**
From 5 to 5.9%:	**………………**	**%**
From 4 to 4.9%:	**………………**	**%**
From 3 to 3.9%	**………………**	**%**
Less than 3%:	**………………**	**%**
Total (the column should sum to 100%):	**100**	**%**

Instructions: for each bin of the unemployment question, ask the question about expected wage changes. For example, if a respondent assigned positive probability to 7-7.9% and 6-6.9%, Q9 should be asked twice. You indicated that unemployment rate could be 6-6.9%, if this prediction materialized, what do you think will happen with wages? You also indicated that unemployment rate could be 7-7.9%, if this prediction materialized, what do you think will happen with wages? By taking a product of responses in Q20 and Q21, we can construct the matrix of joint distribution of probabilities.

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

20. **Please assign probabilities (from 0-100) to the following ranges of possible changes in overall wages and compensation for the New Zealand economy over the next 12 months for a given level of unemployment you reported in the previous question:** (Note that the probabilities in the column should sum to 100)

Percentage Wage and Compensation Changes in 12 Months	**Probabilities**	
More than 25%:	**………………**	**%**
From 15 to 25%:	**………………**	**%**
From 10 to 15%:	**………………**	**%**
From 8 to 10%:	**………………**	**%**
From 6 to 8%:	**………………**	**%**
From 4 to 6%:	**………………**	**%**
From 2 to 4%:	**………………**	**%**
From 0 to 2%:	**………………**	**%**
From 0 to -2%:	**………………**	**%**
From -2 to -4%:	**………………**	**%**
From -4 to -6%:	**………………**	**%**
From -6 to -8%:	**………………**	**%**
From -8 to -10%:	**………………**	**%**
From -10 to -15%:	**………………**	**%**
From -15 to -25%:	**………………**	**%**
Less than -25%:	**………………**	**%**
Total (the column should sum to 100%):	**100**	**%**

SECTION D: Anticipated Actions

21. **Over the next 3 and 6 months, by how much do you anticipate to change relative to the current levels:**

	Over next 3 months from now	Over next 6 months from now
a) The price of your main product:	………………. %	………………. %
b) Total employment at your firm:	………………. %	………………. %
c) Total fixed assets at your firm:	………………. %	………………. %
d) Average wages and compensation at your firm:	………………. %	………………. %

SECTION E: Measuring k-level thinking

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

22. **This question is being asked of all managers in the survey, drawn from all sectors of the New Zealand economy in a representative way.**

    Please choose a number from zero to 100. We will take your number as well as the numbers chosen by other managers to calculate the average pick. The winning number will be the number that is closest to two-thirds (2/3) of the average.

    The individual(s) with the winning number will receive (or share with other winners in case of tie) $500.

    Please take your time to answer this question.

Your chosen number is: ………………

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

23. **Other managers are asked to guess a number from zero to 100, with the goal of making their guess as close as possible to two-thirds of the average guess of all those participating in the contest. What percentage of other managers' guesses do you think will fall in each of the following ranges?**

Range of Guesses	Percentage of Other Managers
From 0 to 9.99	……………… %
From 10 to 19.99	……………… %
From 20 to 29.99	……………… %
From 30 to 39.99	……………… %
From 40 to 49.99	……………… %
From 50 to 59.99	……………… %
From 60 to 69.99	……………… %
From 70 to 79.99	……………… %
From 80 to 89.99	……………… %
From 90 to 100	……………… %

SECTION F: EXPERIMENT & Follow-up [TO BE ASKED ONLY ON THE PHONE]

Instructions:
This part is not mailed to firms before the interview. 5 groups of firms (~200 each, randomly selected): We must interview firms for Group A FIRST. From this group, we use their answers to questions 1&2 in section C to provide information to other groups. Specifically,

Using survey responses from Group A, construct using question X of section C the average expectation of inflation over the next 12 months. Call this **EPI**.
Using survey responses from Group A, construct using question X of section C the average belief about what other managers expect inflation to be over the next 12 months. Call this **EPI_HO**.

a) [300 firms] Group A is the control group. Skip straight to "Follow-up questions" below.
b) [150+ firms] Group B is first treatment group. They are read INFORMATION 1 below, then are asked follow-up questions below.
c) [150+ firms] Group C is second treatment group. They are read INFORMATION 2 below, then are asked follow-up questions below.
d) [150+ firms] Group D is second treatment group. They are read INFORMATION 3 below, then are asked follow-up questions below.
e) [250 firms] Group E is third treatment group. They are read INFORMATION 4 below, then are asked follow-up questions below.

INFORMATION 1 (for firms in Group B): "The average respondent in this survey predicts that inflation over the next 12 months will be **[EPI]**".
INFORMATION 2 (for firms in Group C): "The average respondent in this survey believes that other New Zealand managers would predict inflation over the next 12 months to be **[EPI_HO]**".
INFORMATION 3 (for firms in Group D): "The average respondent in this survey predicts that inflation over the next 12 months will be **[EPI].** In addition, the average respondent believes that other New Zealand managers would predict inflation over the next 12 months to be **[EPI_HO]**".
INFORMATION 4 (for firms in Group E): "The most recent value for the annual rate of change of overall prices in the New Zealand economy was reported in September 2017 to be X.X% over the previous twelve months".

Follow-up Questions:

24. **By how much do you think prices will change overall in the economy over the next 12 months?** Please provide an answer in percentage terms.

Answer: ……………… %

25. **What do you think other managers of firms (drawn from the entire New Zealand economy in a representative way) believe will be the growth rate of overall prices in the New Zealand economy over the next 12 months?** Please provide an answer in percentage terms.

Answer: ……………… %

26. **If your firm was free to change its price** (i.e. suppose there was no cost to renegotiating contracts with clients, no costs of reprinting catalogues, etc.) ***in three months*, by how much would it change its price?** Please provide an answer in percentage terms.

Answer: ……………… %

27. **By how much do you think wages and compensation will change overall in the economy over the next 12 months?** Please provide an answer in percentage terms.

Answer: ……………… %

28. **What do you think the unemployment rate in New Zealand will be in twelve months?** Please provide a quantitative answer in percentage terms.

Answer: ……………… %

FIRMS IN NEW ZEALAND
2018 SURVEY (FOLLOW-UP WAVE)

AUT UNIVERSITY
Faculty of Business and Law

This questionnaire asks about the firms' prices, output and expectations. Please be assured all replies are confidential. Your responses will remain 100% anonymous. Participation is voluntary. Participation or non-participation will neither advantage nor disadvantage the participant. By completing this questionnaire you indicate your consent to participate. This questionnaire must be completed by a senior management official (Director or Manager).

Dr Saten Kumar. Phone: (09) 921 9999 ext. XXXX. Email: xxxxx@aut.ac.nz

SECTION A. BASIC CHARACTERISTICS OF THIS FIRM

29. **What is the total number of employees working at this firm? How many are used for the main product or product line?**

	Employment for firm:	Employment for main product:
Number:	....	....

SECTION B: CHARACTERISTICS OF THE FIRM MANAGER

30. **How many years of work experience do you have:**

At this firm:	………………	**year(s)**	**In this industry:**	………………	**year(s)**

SECTION C: ECONOMIC EXPECTATIONS

31. **During the *next twelve* months, do you expect prices overall in the economy to go up, go down, or stay the same?**
Go up ☐ **Go down** ☐ **Stay the same** ☐

[If the answer is "Stay the same" proceed to next question below. Otherwise, ask **"By how much, in % terms?"**
Answer: ………….. %

32. **By how much do you think prices have changed or will change overall in the economy over the following periods?** Please provide an answer in percentage terms.

2018Q1:	………………	**% relative to 2017Q4**
2018Q2:	………………	**% relative to 2017Q4**
2018Q3:	………………	**% relative to 2017Q4**
2018Q4:	………………	**% relative to 2017Q4**

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

33. **Please assign probabilities (from 0-100) to the following ranges of possible overall price changes for the New Zealand economy over the next 12 months:** (Note that the probabilities in the column should sum to 100)

Percentage Price Changes in 12 Months	Probabilities	
More than 25%:	………………	**%**
From 15 to 25%:	………………	**%**
From 10 to 15%:	………………	**%**
From 8 to 10%:	………………	**%**
From 6 to 8%:	………………	**%**
From 4 to 6%:	………………	**%**
From 2 to 4%:	………………	**%**
From 0 to 2%:	………………	**%**
From 0 to -2%:	………………	**%**
From -2 to -4%:	………………	**%**
From -4 to -6%:	………………	**%**
From -6 to -8%:	………………	**%**
From -8 to -10%:	………………	**%**
From -10 to -15%:	………………	**%**
From -15 to -25%:	………………	**%**
Less than -25%:	………………	**%**
Total (the column should sum to 100%):	**100**	**%**

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

34. **We would like to know what your opinion is about what *other* managers (drawn from all sectors of the New Zealand economy in a representative way) think will happen to overall prices in the economy. Please assign probabilities** (from 0-100) **to the following ranges of beliefs that other managers might hold about overall price changes in the economy over the next 12 months for New Zealand:** (Note that the probabilities in the column should sum to 100)

Percentage Price Changes in 12 Months	% of managers	
More than 25%:	………………	%
From 15 to 25%:	………………	%
From 10 to 15%:	………………	%
From 8 to 10%:	………………	%
From 6 to 8%:	………………	%
From 4 to 6%:	………………	%
From 2 to 4%:	………………	%
From 0 to 2%:	………………	%
From -2 to 0%:	………………	%
From -4 to -2%:	……………..	%
From -6 to -4%:	……………..	%
From -6 to -8%:	………………	%
From -8 to -10%:	………………	%
From -10 to -15%:	………………	%
From -15 to -25%:	………………	%
Less than -25%:	………………	%
Total (the column should sum to 100%):	**100**	%

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

35. **If your firm was free to change its price** (i.e. suppose there was no cost to renegotiating contracts with clients, no costs of reprinting catalogues, etc.) ***today*, what probability would you assign to each of the following categories of possible price changes the firm would make?** Please provide a percentage answer.

Range of "Costless" Price Changes today	Probability (in %)	
More than 25%:	………………	%
From 15 to 25%:	………………	%
From 10 to 15%:	………………	%
From 8 to 10%:	………………	%
From 6 to 8%:	………………	%
From 4 to 6%:	………………	%
From 2 to 4%:	………………	%
From 0 to 2%:	………………	%
From -2 to 0%:	………………	%
From -4 to -2%:	……………..	%
From -6 to -4%:	……………..	%
From -6 to -8%:	………………	%
From -8 to -10%:	………………	%
From -10 to -15%:	………………	%
From -15 to -25%:	………………	%
Less than -25%:	………………	%
Total (the column should sum to 100%):	**100**	%

36. **When did your firm last change its price (**in months**) and by how much (**in % change**)?**

    Time since last price change: …………….. months

    Size of last price change: …………….. %

37. **By how much do you think overall prices in the economy have changed over the last 12 months?** Please provide an answer in % change. *Answer*: ……………….. %

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

38. **Please assign probabilities** (from 0-100) **to the following ranges for what the unemployment rate might be in 12 months in New Zealand:** (Note that the probabilities in the column should sum to 100)

Possible Unemployment Rates in 12 Months	**Probabilities**	
10% or more:	………………	**%**
From 9 to 9.9%:	………………	**%**
From 8 to 8.9%:	………………	**%**
From 7 to 7.9%:	………………	**%**
From 6 to 6.9%:	………………	**%**
From 5 to 5.9%:	………………	**%**
From 4 to 4.9%:	………………	**%**
From 3 to 3.9%	………………	**%**
Less than 3%:	………………	**%**
Total (the column should sum to 100%):	**100**	**%**

Instructions: for each bin of the unemployment question, ask the question about expected wage changes. For example, if a respondent assigned positive probability to 7-7.9% and 6-6.9%, Q9 should be asked twice. You indicated that unemployment rate could be 6-6.9%, if this prediction materialized, what do you think will happen with wages? You also indicated that unemployment rate could be 7-7.9%, if this prediction materialized, what do you think will happen with wages? By taking a product of responses in Q20 and Q21, we can construct the matrix of joint distribution of probabilities.

Instructions: Time this question (that is, how much time a respondent takes to answer the question)

39. **Please assign probabilities (from 0-100) to the following ranges of possible changes in overall wages and compensation for the New Zealand economy over the next 12 months for a given level of unemployment you reported in the previous question:** (Note that the probabilities in the column should sum to 100)

Percentage Wage and Compensation Changes in 12 Months	**Probabilities**	
More than 25%:	………………	**%**
From 15 to 25%:	………………	**%**
From 10 to 15%:	………………	**%**
From 8 to 10%:	………………	**%**
From 6 to 8%:	………………	**%**
From 4 to 6%:	………………	**%**
From 2 to 4%:	………………	**%**
From 0 to 2%:	………………	**%**
From 0 to -2%:	………………	**%**
From -2 to -4%:	………………	**%**
From -4 to -6%:	………………	**%**
From -6 to -8%:	………………	**%**
From -8 to -10%:	………………	**%**
From -10 to -15%:	………………	**%**
From -15 to -25%:	………………	**%**
Less than -25%:	………………	**%**
Total (the column should sum to 100%):	**100**	**%**

SECTION D: Recent and Anticipated Actions

40. **Over the last 3 months, by how much have each of the following changed and by how much do you anticipate them to change relative to the current levels over the next 3 months:**

	Over the last 3 months	Over next 3 months from now
e) The price of your main product:	………………. %	………………. %
f) Total employment at your firm:	………………. %	………………. %
g) Total fixed assets at your firm:	………………. %	………………. %
h) Average wages and compensation at your firm:	………………. %	………………. %

FOLLOW-UP QUESTIONS TO BE ASKED ONLY ON THE PHONE

41. How often do you follow news about the Reserve Bank of New Zealand?
    a. Daily
    b. Weekly
    c. Monthly
    d. Quarterly
    e. Yearly
    f. I don't follow news about the RBNZ

42. In the last three months, have you heard any news about a change of leadership at the RBNZ?
    a. Yes
    b. No

43. Who is the current governor of the RBNZ?
    a. Graeme Wheeler
    b. Grant Spencer
    c. Adrian Orr
    d. Bill English
    e. Other

END OF SURVEY
Thank you for your participation!

Appendix Table B.1: Number of Firms by Sector and Size in NZ, 2016

	Number of Firms 6-9 Workers	10-19 Workers	20-49 Workers	50-99 Workers	100+ Workers	> 6 Workers
Manufacturing	1737	1791	1248	420	312	5508
Rental, Hiring and Real Estate	528	330	153	15	36	1062
Professional, Technical, Scientific Services & Administrative Support Services	2595	2016	1188	357	336	6492
Financial and Insurance Services	267	159	96	42	69	633
Construction	2487	1821	837	204	93	5442
Wholesale Trade	1284	1107	657	222	120	3390
Retail Trade	2172	1704	678	258	315	5127
Accommodation and Food Services	2601	2511	1230	201	108	6651
Transport, Postal, Warehousing & Information Media	744	681	438	171	156	2190
Total	14415	12120	6525	1890	1545	36495

Source: Statistics New Zealand

Appendix Table B.2: Percentage of Firms by Sector and Size in NZ, 2016

	Percentage of Firms 6-9 Workers (%)	10-19 Workers (%)	20-49 Workers (%)	50-99 Workers (%)	100+ Workers (%)	> 6 Workers (%)
Manufacturing	31.54	32.52	22.66	7.63	5.66	100
Rental, Hiring and Real Estate	49.72	31.07	14.41	1.41	3.39	100
Professional, Technical, Scientific Services & Administrative Support Services	39.97	31.05	18.30	5.50	5.18	100
Financial and Insurance Services	42.18	25.12	15.17	6.64	10.90	100
Construction	45.70	33.46	15.38	3.75	1.71	100
Wholesale Trade	37.88	32.65	19.38	6.55	3.54	100
Retail Trade	42.36	33.24	13.22	5.03	6.14	100
Accommodation and Food Services	39.11	37.75	18.49	3.02	1.62	100
Transport, Postal, Warehousing & Information Media	33.97	31.10	20.00	7.81	7.12	100

Source: Statistics New Zealand

Appendix Table B.3: Number of Firms by Sector and Size in the Population of our Survey, 2017

	Number of Firms 6-9 Workers	10-19 Workers	20-49 Workers	50-99 Workers	100+ Workers	> 6 Workers
Manufacturing	946	975	680	420	312	3333
Rental, Hiring and Real Estate	200	125	58	15	36	433
Professional, Technical, Scientific Services & Administrative Support Services	868	674	397	357	336	2633
Financial and Insurance Services	80	47	29	42	69	267
Construction	241	177	81	204	93	796
Wholesale Trade	65	56	33	222	120	496
Retail Trade	84	66	26	258	315	750
Accommodation and Food Services	272	263	129	201	108	973
Transport, Postal, Warehousing & Information Media	20	32	48	164	156	420
Total	2776	2415	1481	1883	1545	10100

Appendix Table B.4: Percentage of Firms by Sector and Size in the Population of our Survey, 2017

	Percentage of Firms 6-9 Workers (%)	10-19 Workers (%)	20-49 Workers (%)	50-99 Workers (%)	100+ Workers (%)	> 6 Workers (%)
Manufacturing	28	29	20	13	9	100
Rental, Hiring and Real Estate	46	29	13	3	8	100
Professional, Technical, Scientific Services & Administrative Support Services	33	26	15	14	13	100
Financial and Insurance Services	30	18	11	16	26	100
Construction	30	22	10	26	12	100
Wholesale Trade	13	11	7	45	24	100
Retail Trade	11	9	4	34	42	100
Accommodation and Food Services	28	27	13	21	11	100
Transport, Postal, Warehousing & Information Media	5	8	11	39	37	100

Appendix Table B.5: Survey Framework of Main Wave, Number of Firms According to Employment Size Group

	6-9 Workers			10-19 Workers			20-49 Workers			50-99 Workers			100+ Workers		
	Stats NZ Records	Firms Approached	Response	Stats NZ Records	Firms Approached	Response	Stats NZ Records	Firms Approached	Response	Stats NZ Records	Firms Approached	Response	Stats NZ Records	Firms Approached	Response
Manufacturing	1737	946	73	1791	975	94	1248	680	83	420	420	44	312	312	25
Rental, Hiring and Real Estate	528	200	14	330	125	13	153	58	13	15	15	9	36	36	0
Professional, Technical, Scientific Services & Administrative Support Services	2595	868	41	2016	674	46	1188	397	66	357	357	36	336	336	5
Financial and Insurance Services	267	80	21	159	47	17	96	29	29	42	42	10	69	69	4
Construction	2487	241	18	1821	177	19	837	81	24	204	204	16	93	93	3
Wholesale Trade	1284	65	12	1107	56	14	657	33	17	222	222	11	120	120	2
Retail Trade	2172	84	32	1704	66	27	678	26	35	258	258	14	315	315	15
Accommodation and Food Services	2601	272	9	2511	263	12	1230	129	14	201	201	5	108	108	1
Transport, Postal, Warehousing & Information Media	744	20	13	681	32	23	438	48	33	171	164	12	156	156	8

Appendix Table B.6: Survey Framework of Main Wave, Percentage of Firms According to Employment Size Group

	6-9 Workers			10-19 Workers			20-49 Workers			50-99 Workers			100+ Workers		
	Stats NZ Records (%)	Firms Approached (%)	Response (%)	Stats NZ Records (%)	Firms Approached (%)	Response (%)	Stats NZ Records (%)	Firms Approached (%)	Response (%)	Stats NZ Records (%)	Firms Approached (%)	Response (%)	Stats NZ Records (%)	Firms Approached (%)	Response (%)
Manufacturing	32	28	23	33	29	29	23	20	26	8	13	14	6	9	8
Rental, Hiring and Real Estate	50	46	29	31	29	27	14	13	27	1	3	18	3	8	0
Professional, Technical, Scientific Services & Administrative Support Services	40	33	21	31	26	24	18	15	34	5	14	19	5	13	3
Financial and Insurance Services	42	30	26	25	18	21	15	11	36	7	16	12	11	26	5
Construction	46	30	23	33	22	24	15	10	30	4	26	20	2	12	4
Wholesale Trade	38	13	21	33	11	25	19	7	30	7	45	20	4	24	4
Retail Trade	42	11	26	33	9	22	13	4	28	5	34	11	6	42	12
Accommodation and Food Services	39	28	22	38	27	29	18	13	34	3	21	12	2	11	2
Transport, Postal, Warehousing & Information Media	34	5	15	31	8	26	20	11	37	8	39	13	7	37	9

Appendix Table B.7: Survey Framework of Main Wave, Total Firms

	Number of Firms			Percentage of Firms		
	Stats NZ Records (#)	Firms Approached (#)	Response (#)	Stats NZ Records (%)	Firms Approached (%)	Response (%)
Manufacturing	5508	3333	319	100	61	10
Rental, Hiring and Real Estate	1062	433	49	100	41	11
Professional, Technical, Scientific Services & Administrative Support Services	6492	2633	194	100	41	7
Financial and Insurance Services	633	267	81	100	42	30
Construction	5442	796	80	100	15	10
Wholesale Trade	3390	496	56	100	15	11
Retail Trade	5127	750	123	100	15	16
Accommodation and Food Services	6651	973	41	100	15	4
Transport, Postal, Warehousing & Information Media	2190	420	89	100	19	21
Total	36495	10100	1032	100	27.64	10.22

Appendix Table B.8: Survey Framework of Follow-up Wave, Number of Firms

	6-9 Workers		10-19 Workers		20-49 Workers		50-99 Workers		100+ Workers		Totals	
	Firms Approached	Response	Firms Approached	Response	Firms Approached	Response	Firms Approached	Response	Firms Approached	Response	Firms Approached	Response
Manufacturing	73	36	94	43	83	42	44	26	25	10	319	157
Rental, Hiring and Real Estate	14	6	13	8	13	4	9	2	0	0	49	20
Professional, Technical, Scientific Services & Administrative Support Services	41	22	46	22	66	38	36	17	5	0	194	99
Financial and Insurance Services	21	10	17	10	29	15	10	4	4	2	81	41
Construction	18	6	19	11	24	13	16	7	3	2	80	39
Wholesale Trade	12	7	14	6	17	9	11	3	2	1	56	26
Retail Trade	32	15	27	14	35	14	14	11	15	10	123	64
Accommodation and Food Services	9	5	12	6	14	8	5	2	1	0	41	21
Transport, Postal, Warehousing & Information Media	13	6	23	13	33	18	12	6	8	5	89	48
Total	233	113	265	133	314	161	157	78	63	30	1032	515

Appendix Table B.9: Survey Framework of Follow-up Wave, Response Rates

	6-9 Workers Response Rates	**10-19 Workers** Response Rates	**20-49 Workers** Response Rates	**50-99 Workers** Response Rates	**100+ Workers** Response Rates
Manufacturing	49	46	51	59	40
Rental, Hiring and Real Estate	43	62	31	22	0
Professional, Technical, Scientific Services & Administrative Support Services	54	48	58	47	0
Financial and Insurance Services	48	59	52	40	50
Construction	33	58	54	44	67
Wholesale Trade	58	43	53	27	50
Retail Trade	47	52	40	79	67
Accommodation and Food Services	56	50	57	40	0
Transport, Postal, Warehousing & Information Media	46	57	55	50	63