Firms' Inflation Expectations and Strategic Complementarities*

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Abstract

This paper relies on a randomized information treatment to analyze the channels that shape firm-level inflation expectations and price-setting decisions: demand complementarities, competitors' strategic complementarities, input costs, and wage bargaining. Using a theoretically founded econometric design I find that information about competitors inflation expectations has a significant impact on firm own product inflation expectations and information about consumers' expectations has a significant impact on firms' overall inflation expectations. Furthermore, I test and find a significant impact of the treatment on price setting behavior (price change and duration) for own product, instrumenting the inflation expectation channels only with variation from the belief update.

Keywords: randomized control trial, information treatment, strategic complementarities, price-frequency distribution.

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1. Introduction

Firms' inflation expectations affect firms' price setting decisions. For this reason there is an increasing interest in understanding firms' inflation expectations (Coibion and Gorodnichenko (2025)), particularly after the recent inflation surge. This paper exploits a randomized information provision experiment to assess the relative role of the main channels that affect firms' inflation expectations and price setting behavior: demand complementarities, competitors' strategic complementarities (see Cooper and John (1988) or Ball and Romer (1990)), input and labor costs. Learning that consumers or competitors expect prices to rise, or that costs increase, can rise firms' inflation expectations and affect their pricing behavior. Results show that the treatment on competitors expectations significantly affects expectations of firms' own product inflation, while the treatment on consumers' expectations significantly affects firms' expectations about economy-wide inflation. The exogenous shift in expectations is then used to study its effect on price setting decisions: I find a significant and positive impact of the instrumented expectations on price setting behavior, both the size and duration of the price change, a likely reflection of the uncertainty faced by firms (see Kumar et al. (2023)).

The randomized control trial was conducted on 2,500 firms in the spring 2022 in Italy, hence during a period of rising inflation. The study solicits firms' expectations of economy-wide inflation, firms' own product inflation and some behavioral variables, such as the frequency and size of price change. The experiment features four treatment arms and one placebo. Firms are treated with information about inflation expectations of consumers, competitors, unions and oil price professional forecasts. If firms learn that consumers or competitors expect high inflation, they have incentives to coordinate their expectations and also to increase prices,[1]. Learning that input or labor costs are rising, for instance through higher unions' indexation,[2] would also increase firms' inflation expectations.

Using an econometric design, which I show to be grounded on a theoretical framework

1 Blinder et al. (1998) asked managers why they did not vary their prices; the most common response was that frequent price changes would antagonize customers. Anderson and Simester (2010) uncovers further evidence with randomized control experiments. Sticky price theories were also devised around this argument: see Rotemberg (2005).

2 Indexation is common in Italy in most collective wage negotiations.

with optimized beliefs, this study examines the impact of the information treatments on both beliefs' update and price setting behavior. First, it relates the belief update on both the economy-wide and the firm' own product inflation, to the treatments, weighted by an exposure measure, consisting in the firms' perception gap, or else the difference between the prior and the signal. This specification allows me to fully exploit firms' heterogenous, and possibly non-linear, update (see Cavallo et al. (2017) or Fuster and Zafar (2022)). To sharpen the understanding of the channels, variants of the baseline specification are estimated, in which the treatment is triple interacted with variables characterizing the market in which the firm operates and that are gathered through the survey questions. The specifications control for firms' demographic and balance sheet variables, which are matched to the survey responses. Second, I estimate the impact of the instrumented posterior on price setting behavior, measured as the size or frequency of the price change.

Before reporting estimates result I highlight some patterns of the survey responses. In line with recent evidence (see Candia et al. (2021)) firms' priors are highly dispersed, bunch at around 10%, posteriors exhibit less bunching suggesting that an update has taken place.[3]

The regression results show that the belief update for economy-wide inflation expectations significantly respond to the treatment on consumers' expectations and the belief update for firms' own product significantly responds to the treatment on competitors expectations. Both updates are toward the signal.[4] Results are robust to the inclusion of controls, time, industry, interviewer and interview date fixed effects and adjustment for omitted variable (see Oster (2019)). By exploiting heterogeneity in the other survey questions we find that the strategic complementarity channel is stronger when firms' mark-ups are below the median, hence when their monopoly power is lower than that of competitors and hence firms act as followers. Furthermore, firms are more responsive to the consumer expectation treatment when their sales to final consumers are above median, indicating that they internalize the response of consumers.

In terms of price setting behavior, we observe a post-treatment shift in the price duration distributions, which is significant to the Kolmogorov test. Finally, I estimate an instrumented

3 The placebo does not respond significantly to the information provision.

4 The treatment about oil price forecasts is significant at times, but exhibit mean reversion, most likely due to the high signals, which firms discounted under high uncertainty.

specification linking the price duration and the size of the price change, declared after the treatment, to the posteriors for either economy-wide or own product inflation expectations instrumented with the baseline specification for the belief update. Hence the instrument relies solely on variation from the randomized information provision, excluding other sources of variation and captures the pass-through from expectations to behavior. The estimated coefficient is positive and significant.[5] Both the price change and the duration increase: through the lens of the model, firms facing higher inflation uncertainty tend to refrain from adjusting prices and do it to a larger extent when they do so.

Related Literature and Contribution. There is an expanding literature on firm expectation and/or information-treatments: see Coibion et al. (2018); Kumar et al. (2015),Coibion et al. (2020),Candia et al. (2021), Link et al. (2021) among others. Most argue that firms' expectations provide a good benchmark for several reasons. As price setters, firms tend to be more attentive to inflation developments, which have a direct impact on their profits. Furthermore, their expectations provide better representation of the population beliefs than those of highly sophisticated professional forecasters. More importantly firms' inflation expectations affect price setting decisions, hence understanding their formation helps predicting the course of inflation. Relative to past literature the experiment puts an emphasis on different channels and solicits also questions on price setting behavior: see Blinder et al. (1998) for early surveys on firms' price setting behavior. The econometric specification follows those deemed best suited for within subjects experiment (Fuster and Zafar (2022)).

Our evidence indicates that demand and competitors strategic complementarities are the main channels affecting firms' inflation expectations and price setting behavior. Early studies on firms' strategic complementarities are Ball and Romer (1990) and Cooper and John (1988). The prior distributions of price duration and size change gathered in our survey is similar to the one gathered in administrative or proprietary datasets (see for instance Eichenbaum et al. (2011), Eichenbaum et al. (2014) or Cavallo and Rigobon (2016) that use scanner or online scrapped data.). The pass-through we uncover from posterior beliefs to a rise in price

5 The F-stat for the instrument are above the value of 10, the threshold for instrument validity, for the own product price adjustment.

duration indicates that firms refrain from taking actions in face of higher inflation uncertainty (see Kumar et al. (2023) for consistent evidence and arguments).

2. A Conceptual Framework To Motivate Empirical Analysis

I lay down a simply theoretical framework with optimized beliefs and strategic interactions in actions that provides testable implications for the econometric design and the related specifications. I focus on strategic interaction as the econometric evidence provides support for that. The agent, the firm in this case, faces two optimization stages. In the first the firm chooses the optimal beliefs subject to a cost of uncertainty and this leads to a biased Bayesian update[6]. In the second stage, given these optimal beliefs, the firm chooses the actions (prices for instance) taking as given the average action in the economy. The optimal actions will be a function of the higher order beliefs and the competitors actions.

The model features heterogenous firms that, in a first stage, choose beliefs optimally, by maximizing their objective subject to an entropy constraint (see Gilboa et al. (2010) and subsequent extensions of those theories). In a second stage they choose prices conditional on the optimal beliefs and in a strategic interaction with other firms, akin to global games (see Morris and Shin (2001) and subsequent applications). Let us define $p(s \mid \omega)$ as firms' prior beliefs about a state s, on which the firm receives a signal (the information treatment in the experiment) and conditional on the state ω. Firms' objective is $V(a, \omega)$, where a denotes the action, which is chosen in the second stage conditional on the optimal beliefs. The optimal belief, $p(s \mid \omega)$, is chosen to maximize the following value function:

$$V(\pi, a, s) = \max_{p} \sum_{\omega \in \Omega} \frac{p(s \mid \omega)\pi(\omega)}{\sum_{\omega' \in \Omega} p(s \mid \omega')\pi(\omega')} u(a, \omega) + \sigma R(p|\omega) \tag{1}$$

subject to the constraint $\sum_{s'} p(s'|\omega) = 1$ with a multiplier λ. The firm also faces a constraint on the cost of information, which is given by the Kullback-Leibler entropy

6 The optimization problem resembles rational inattention (see **?**) if the entropy measure of uncertainty is the Shannon metrics and the robust control (see **?**) if it is the Kullbach-Leibler.

measure, $R(p|\omega) \equiv \sum_{\omega\in\Omega}\sum_{s\in\S} p(s' \mid \omega) ln\frac{p(s'|\omega)}{\overline{p}(s'|\omega)}$, with a penalty multiplier σ. Heterogeneity in the penalty parameter generates the heterogeneity in the beliefs update observed in the data. When it is positive it implies that the firm suffers a cost from uncertainty and the resulting optimal beliefs are skewed toward the worst case scenario, when negative the firm is uncertainty seeking and the optimal beliefs are skewed toward the best case scenario. Taking the first order condition with respect to $p(s \mid \omega)$ leads to: $\frac{dE_\gamma u(a,\omega)}{dp(s|\omega)} + \sigma ln\frac{p(s|\omega)}{\overline{p}(s|\omega)} - \sigma - \lambda_\omega = 0$, where $E_\gamma u(a,\omega) = \sum_{\omega\in\Omega}\frac{p(s|\omega)\pi(\omega)}{\sum_{\omega'\in\Omega}p(s|\omega')\pi(\omega')}u(a,\omega)$, with γ denoting the Bayesian posterior. Solving for the optimal beliefs from the first order condition leads to: $p(s \mid \omega) = \overline{p}(s \mid \omega)exp\left[-\frac{1}{\sigma}\left(\frac{\pi(\omega)}{E_p\pi(\omega)}\left[u(a,\omega) - E_\gamma u(a,\omega)\right]\right) + 1 + \frac{1}{\sigma}\lambda_\omega\right]$. Note that the bias in the update, namely the terms in the square brackets, depends both on the shadow cost of information, λ_ω, and on the loss (or gains) associated with belief biases $m = u(\omega) - E_\gamma u(\omega)$. Hence the size of the bias in beliefs reflects an optimal trade-off between firms' costs of processing information and the potential losses (or gains) associated with the distorted beliefs. Furthermore, note that this bias corresponds to the perception gap that we define in the data evidence. Given the optimal belief the Bayesian posterior reads as follows:[7]

$$\gamma(\omega_i) = \frac{\overline{p}(s \mid \omega_i)exp(-\frac{m}{\sigma})\cdot\pi(\omega_i)}{\sum_{i=0}^{K}\overline{p}(s \mid \omega_i)exp(-\frac{m}{\sigma})\cdot\pi(\omega_i)}. \tag{2}$$

If $\frac{1}{\sigma}$ approaches 0, equation (2) gives the unbiased Bayesian update, $\gamma(\omega) = \frac{\overline{p}(s|\omega)\pi(\omega)}{\overline{p}(s|\omega)\pi(\omega)+(1-\overline{p}(s|\omega))(1-\pi(\omega))}$. The size and the sign of the $\sigma < 0$ determines the size and sign of the perception bias. Furthermore, since the denominator is the same for the posterior of every state we can approximate $\gamma(\omega_i) \approx \overline{p}(s \mid \omega_i)exp(-\frac{m}{\sigma})$. Log-linearizing the last expression (and skipping the dependence on the state for convenience in notation) leads to the following:

$$ln(\gamma) - ln(\pi(\omega_i)) = ln(\overline{p}\frac{m}{\sigma}) \tag{3}$$

Equation 3 links the belief update to the signal, namely the information treatment in our

7 Consider $s' \in S$ other than s, the first order for $p(s' \mid \omega)$ gives: $p(s \mid \omega) = \overline{p}(s \mid \omega)exp\left[1 + \frac{1}{\sigma}\lambda_\omega\right]$ since $\frac{dE_\gamma u(a,\omega)}{dp(s|\omega)} = 0$. Summing over all s gives: $1 = \sum_{s'\in S}p(s' \mid \omega) = \overline{p}(s \mid \omega)exp\left[-\frac{1}{\sigma}\frac{dE_\gamma u(a,\omega)}{dp(s|\omega)} + 1 + \frac{1}{\sigma}\lambda_\omega\right] + \sum_{s'\in S}\overline{p}(s \mid \omega)exp\left[1 + \frac{1}{\sigma}\lambda_\omega\right]$. We use this in the Bayes formula, $\gamma(\omega) = \frac{p(s|\omega)\pi(\omega)}{\sum_{s'\in S}p(s'|\omega')\pi(\omega')}$, which together with the beliefs first order conditions delivers 2.

experiment, weighted by the perception gap. This formalizes the econometric specification used in the empirical analysis and presented in section 6. Upon substituting the optimal beliefs into the firms' objective function, we can derive the optimal actions, such as pricing decisions. Full derivations are shown in Appendix C. Firms' objectives are a weighted average of the distance from the signal and the distance from the average action of the economy: $V(a,\omega) = \frac{(a-s-\alpha A)^2}{2}$. The function captures the cost of strategic complementarities, or else from deviating from the average action, $\frac{(a-A)}{2}$. The first order condition with respect to the action leads to the following linear policy function:

$$\sum_{\omega\in\Omega} \gamma(\omega)\frac{\partial u(a,\omega)}{\partial a} = 0 \qquad or \qquad a = \frac{E_\omega(s \mid \omega)}{2} - \alpha\frac{E_\omega(A)}{2} \tag{4}$$

Following the literature on global games (see Morris and Shin (2001) for instance) we can iteratively substitute the optimal average reaction of the economy, which would take a similar form and this leads to:

$$a^* = \sum_{k=1}^{\infty} \alpha^{k-1}\mathrm{E}^k[s] \tag{5}$$

where $\mathrm{E}^k[s] = E_iE_jE_i...E_i[s]$ is the higher order beliefs, which implies to iteratively apply the biased Bayes update derived in the first stage. The relation in 5 provides a foundation for the econometric specification that links price setting behavior to instrumented inflation beliefs' and shown in equation 8. In this set-up higher risk surrounding the signal, by increasing the cost of information, tilts the distribution of $\gamma(\omega)$ toward worst case scenarios, where the marginal gains from taking an action are lower. Since the optimal beliefs affect the actions through 5, putting more weight on the worst case scenario induces firms to refrain from taking actions. Hence the testable implication of the model is that in an environment with higher uncertainty the price setting decisions results in longer duration, which is the result uncovered by the experiment.

3. Structure of the Survey Experiment and Data

The experiment was conducted during last two weeks of May and the first two weeks in June 2022. It involved interviewing the executive management of 2500 Italian firms. The survey agreement with MBS Consulting stipulated that the survey must be conducted with an employee having an executive role within the company, to ensure that respondents' expectations and intentions are relevant for actual decisions within the company.[8] The full text of the survey is reported in Appendix A.[9] Survey questions and information treatments were filed, through phone interviews, via MBS Consulting S.p.A., a subsidiary company of CERVED, which regularly conducts surveys with firms in Italy and Europe. CERVED also collects, on a regular basis, information about firms' balance sheets and other characteristics, which were linked to the survey responses.

The information experiment is based on a within-subject design.[10]. In the first stage managers' priors beliefs about a number of variables and their price setting behavior are solicited, alongside other information about the firm. Next, firms are randomly assigned one of the four treatment arms described below or to a placebo group. After that, posteriors beliefs and prospective price setting behavior are solicited. The sample of firms is broadly representative of a number of different sectors and include manufacturing and service sector firms, that have at least 10 employees.

Priors, posteriors and treatments. Before the treatment firms are asked expectations about the economy-wide inflation (question 25 in the survey), about inflation on firms' own product (question 26) among other things. The priors were followed by four treatment arms and a placebo treatment, randomly assigned, and then a set of questions on posterior beliefs and price setting behavior.[11] Questions on prior expectations are based on respondents' perceptions of aggregate inflation over the previous 12 months,[12], while posterior expectations

8 The Ethics Committee of Goethe University, Frankfurt, approved on October 21, 2021. The experiment has been pre-registered as AEARCTR-0008831 at the AEA.

9 Questions have been translated to English, but the survey was administered in Italian language.

10 See Fuster and Zafar (2022) for a description of this type of experiments.

11 The multiple treatments have among other things the advantage of alleviating further concerns for demand effects. The questions on the priors and the posteriors are formulated differently for the same reason.

12 This is motivated by the fact that the literature universally finds a strong positive correlation between subjective perceptions of past inflation and subjective expectations about future inflation (see Fuster and Zafar (2022)).

are based on a forward-looking question about inflation in the next 12 months. Respondents in the survey reacted only to salient information: indeed figure 0 in Appendix B shows that there is no response of the control group to the treatment.

The experiment includes four treatment arms and a placebo treatment consisting of 500 firms each.[13] The first treatment provides respondents with professional forecasters' expectations on oil price changes over the next 12 month obtained from Consensus Forecasters. The second provides firms with consumers' inflation expectations over the next 12 months, which is obtained from Confcommercio, the Italian association for consumer protection. The third provides information about past producer price inflation in the sector in which the firm operates: data are compiled from ISTAT (The Italian Statistical Association). The last information treatment provides inflation expectations, over the next 12 months, of the unions operating in the industry in which the firm is located. In all cases the treatment text also highlights how the numbers relate to the median over the last 10 years.

Additional Variables: Firm Heterogeneity and Behavioral Measures. The strength of the channels identified by the information treatments may differ depending on the structure of the markets in which they operate and on the degree of price stickiness before the treatment. To this purpose the survey also solicits information about those aspects. Firms are asked to indicate their main product, the market in which they operate, the percentage that is sold in the local market as opposed to being exported, the percentage sold to final consumers or within the value chain. The survey was conducted at the end of the Covid-19 pandemic period and following the Russian invasion of Ukraine, firms are asked if they expect labor shortages and how they are affected by the war: we use those answers as controls.

Data Preparations. For the regressions and the plots we winsorize the sample at 1% or 5%. For specific variables we apply additional exclusion restrictions replacing, for instance, with missing observations cost shares which are outside of the range 0 to 100 or mark-ups that are above 1. Regressions are run with Huber weights that make the estimates robust to outliers.

13 Firms in the placebo group hear a statement that incorporated firms can enjoy limited liability and that this protects owners' personal wealth.

4. Econometric Specifications

Our econometric analysis is made of two parts. The first examines the impact of the treatment on beliefs updates and the second on the changes in the price setting behavior.

A simple way to test the causal impact of the treatments on firms' beliefs is to estimate a regression linking the posterior beliefs of the variable of interest to the treatments, which may read as follows: $y_{post,i} = \alpha + \sum_{k=1}^{\infty} \beta_k I(x_i = x^k) + \epsilon_i$. Although this regression captures well the average effect, it is not informative about the effects on individual expectations. The descriptive analysis presented in section 5.1 below shows that there is large heterogeneity, both in the priors and in the perception gaps and both determine the extent of the update. The same piece of information has indeed a very different impact if firms' priors are above or below the signal and by how distant they are from the signal. Therefore the extent to which each individual firm updates along the distribution is adequately reflected by the average update: as noted in Fuster and Zafar (2022), if priors were to be perfectly symmetric around the signal, even if agents fully update to the signal the average posterior would be unaffected, as those with priors above the signal revised their beliefs downwards, and vice versa for those with priors below the signal.

To capture this heterogeneity the econometric specification links the belief update, for either of the solicited inflation expectations, to the treatment interacted with the perception gap, namely the distance between the prior and the signal. The latter captures the exposure to the treatment. The econometric specification reads as follows:

$$\begin{aligned} y_{i,post} - y_{i,prior} = \alpha + \sum_{k=1}^{K} \beta_k \underset{Treatment}{I(x_i = x^k)} \underset{Indicator}{} \underset{Perception\ Gap}{(x^k - \hat{x}^k_{i,prior})} + \\ + \sum_{k=1}^{K} \gamma_{1,k} I(x_i = x^k) + \sum_{k=1}^{K} \gamma_{2,k} (x^k - \hat{x}^k_{i,prior}) + Z_t + \epsilon_i \end{aligned} \tag{6}$$

where $y_{i,post}$ is the posterior expectation reported after the treatment, while $y_{i,post} - y_{i,prior}$ is the belief update. The variable $I(x_i = x^k)$ is the treatment indicator dummy. The perception gap, $(x^k - \hat{x}^k_{i,prior})$, is the difference between the respondent's prior and the signal. Furthermore, the specification includes not only the interaction between the treatment and

the exposure given by the perception gap, but also its components separately, hence it controls for heterogeneity in the priors. It has been shown that this specification is generally in line with models of Bayesian updating with Gaussian distributions, where the posterior is the weighted average of a person's prior and a signal received. The weight on the signal would correspond to the coefficient β_k (see Cavallo et al. (2017)). Given this the above specification is also in line with the theoretical benchmark, presented in section 2, which derives the optimal beliefs under a Bayesian update with signal extraction. In that model too the optimal belief update, equation 3, depends on the signals, weighted by the perception gaps, and the priors, likewise equation 6. The model additionally highlights that the elasticity of the belief's update, β_k, also depends on the uncertainty surrounding the signal.

The dependent variable, $y_{i,post}$, is either the posterior for economy-wide inflation (question 25) or for firms' own product inflation (question 22). Their differential response is also informative. It is to be expected for instance that the beliefs on the firm's product inflation are more responsive to the signal on competitors' expectations, while the beliefs on economy-wide inflation may respond more to consumers' inflation expectations. The specification is estimated for each group, including the control and it includes alternatively firms' demographic and balance sheet controls, sector, time and interviewer fixed effects. The balance sheet controls include sales, sales trends, value added, revenues, expenditures, general expenditures, operating costs, income, profits, cash flow, total asset, net asset, EBITDA, ROE, ROI, ROS, employees. The demographics controls include age, sex, education, work experience and experience in the firm. Estimates are also done with the Oster (2019) adjustment to account for possible omitted variables. At last, note that in all regressions data have been Huber weighted, an adjustment which make estimates robust to outliers.

The survey included other questions on the characteristics of the market in which the firm operate. We exploit the heterogeneity in the responses to those questions to further qualify

and characterize the strength of the channels in a triple interacted specification that reads as follows:

$$y_{i,post} - y_{i,prior} = \alpha + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) I(z_i < \overline{z}) + \\ + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) I(z_i > \overline{z}) + \\ + \sum_{k=1}^{K} \gamma_{1,k} I(x_i = x^k) + \sum_{k=1}^{K} \gamma_{2,k}(x^k - \hat{x}^k_{i,prior}) + Z_t + \epsilon_i \tag{7}$$

where the variable z captures the dimension along which firms are ranked, as being above or below the variable median value, $\overline{z}$. The variables considered to rank firms are the percentage sale to end consumer (question 5 of the survey) or the mark-up given by the difference between the sale price and the unitary cost. The first measures the salience of the consumer demand channel, the second the importance of competition and market concentration. In a further specification we interact the treatment dummy with the price duration stated by firms before the treatment, which we take as a predetermined measure of price stickiness.

To the extent that the randomized information affected firms' expectations, the exogenous shift in expectations can also be used to study the impact of the treatment on behavior, price setting in this case. To capture this one can estimate the following model:

$$p_i = \delta + \kappa \hat{y}_{i,post} + \Gamma Z_i + \nu_i \tag{8}$$

where where the posterior expectation $\hat{y}_{i,post}$ is instrumented using the variation stemming from equation 6.[14] The variable p_i is given by the replies to the post-treatment questions 22, which asks in how many months the firm will be changing prices and by question 23, which asks about the size of the price change. Finally, the variable Z_i is a vector of other individual characteristics that could also influence the action a_i. Equation 8 has a parallel in the model, where the equilibrium condition 4 links the optimal action to the optimal belief update.

14 Since equation 6 includes also the constituents of the interaction term, the variation embedded in the posteriors estimated with this specification capture solely the randomized variation and no other, thereby satisfying the exclusion restriction of the instrument.

5. Results

5.1. Survey Validation and Facts about Distributions

Before presenting the results of the econometric specification it is useful to examine and discuss a number of statistics that serve to assess the validity of the survey experiment and to disentangle the sources of variation in the experiment data.

Balance Checks among Treated and Control Groups. We start by examining if the control and the treated groups (jointly or separately) are balanced, hence randomly assigned, both in terms of firms' characteristics and priors distributions. Table 5 and table 6 in Appendix B present means and standard deviations for the demographic and balance sheets variables across the control and each treatment group, as well as the test for significant differences. There no significant difference. Furthermore, table 7 in appendix B reports tests to detect whether there is any significant difference in the means of a multinominal distribution of all balance sheet or demographic variables across the control and the treated groups. No significant difference is detected. The mean of the prior inflation expectation for the group treated with consumers' expectations is different than that of the other groups. I therefore run a Kolmogorov-Smirnov test across distributions of the priors for all treated and control samples: no significant difference is detected on the winsorized distributions across all groups (see Appendix B). This is compelling since the identification strategy in the econometric specification exploits the heterogeneity in individual perception gaps and updating, hence what matters the most is that the whole prior distributions for the control and the treated groups exhibit no significant difference.[15] At last, figure 0 in Appendix B shows that the control group did not update significantly following the information treatment.

Distributions of Priors, Posteriors, Perception Gaps, Price Duration and Firms' Exposure Measures. Next, we examine the distributions of the main variables of interest for the experimental evidence. Those include the priors and posteriors, the perception gap, which is the main exposure variable used in 6, the price duration which is our post-treatment

15 Despite the validation of the balance checks, the regression is nevertheless going to include controls from all the demographics and balance sheet variables at disposal, as well as industry fixed effects to address any remaining concern of group selection.

behavioural variable and other firms' characteristics that capture firms' exposure to specific channels. All are shown in figure 1. Both prior and posteriors (bottom panels) exhibit a bunching at 10% and are skewed. This is in line with the facts documented in other survey from Coibion et al. (2018). There is large variation in the priors, a reflection of firms' heterogeneity in information processing. Variation in the priors also implies variation in the perception gap (second panel, second row). Since this is our exposure measure in equation 6, its variation increases the likelihood of precisely identifying the information processing capacity as the mediator channel of our treatment. The two panels on the right of figure 1 show that distributions of the posterior conditional on the prior being above (pink bars) or below (blue bars) the median.[16] The bunching at 10% is now smaller, an indication that firms have updated their expectations after the treatment, posteriors correlate with priors, a general feature of Bayesian updating, and updating appears asymmetric with infra-marginal updating more when priors lies below the signal.

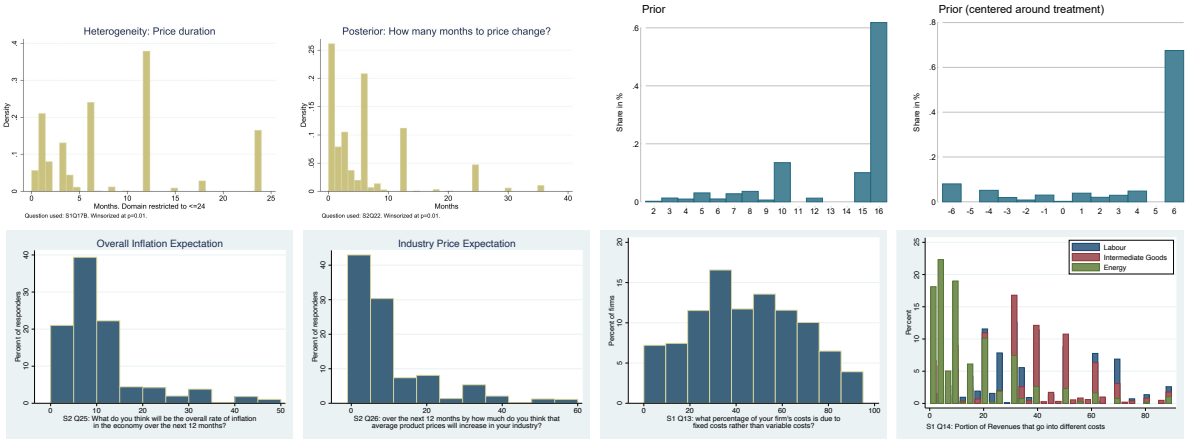
The right two panels in figure 1 report the distribution of the price duration before (left panel) and after (right panel) the treatment. First, this too exhibits large variation: for a large mass of firms the average price duration is within two quarters, but many firms also change prices every other year. Second, the post treatment distribution is clearly different than the first, an indication that the signal has had an effect on firms' behaviour as well. We will discuss the statistical significance of those, for each treatment group, in section 6.

Furthermore, the two panels on the right of the second row show the distribution for the main components of firms' cost shares. Those capture the extent to which firms' beliefs and actions are exposed to the channels considered in the treatments. For instance the share of labour costs captures the extent to which firms were exposed to the unions' treatment. The distribution exhibits significant variation, an indication that randomly chosen firms were likely to perceive the treatment as salient.

At last, figure 1 in Appendix B presents the beliefs updates, posterior minus priors, for each treated groups separately and broken on above and below the signal. Data are winsoried at 5%. Group 2 is the one treated with information on oil price forecast, group 3 is the one

16 The bars are estimates from a regression linking beliefs revisions to priors interacted with a dummy for the prior being above or below the treatment.

Figure 1: Distribution of priors, posteriors, perception gap, price duration and firms' exposure variables. First two panels show the distribution of firms according to their share of fixed and variable costs (left panel), whose structure is solicited in question 13 of the survey experiment, and of costs components (right panel), namely energy, intermediate inputs and labor, which is solicited in question 14. Panels in the second row show the distribution of price durations: in the left panel, second row, there is the distribution of the price duration pre treatment (question 17) and in the right panel, second row, there is the price duration post-treatment. Third row shows the distribution of the priors on the left panel and the distribution of the perception gap (prior minus signal) on the right. Fourth row shows the distribution of the posteriors for both overall inflation and industry product inflation. Data are winsorized at 1%.



with consumers' inflation expectation, group 4 is the one treated with information on sectoral inflation expectations, group 5 is the one treated with unions' inflation expectations. For groups 2, 3 and 5 the plots show the perception gap for economy-wide inflation, fro group 4 we focus on perception gap of own-product inflation. Visually firms are more likely to upward when the prior was below the signal and viceversa, implying that there is updated in the direction of the signals consistent with any model of Bayesian update. For group 2 the update there is a large share of firms that update downward and this maybe due to some mean reversion: we will go back to this point later on.

5.2. Baseline Results for Individual Belief Update

The baseline regression in 6 is estimated using either economy-wide inflation or inflation of firms' own products. We expect the two also to be related to different channels: the first is more likely to capture effects through consumers' demand and the second is more likely to be related to competition. Results are shown in table 1, which focuses on the coefficient of interest on the interaction term, β_k. The coefficients reported are standardized, data are winsorized at 5% and estimates are Huber weighted. The table also reports the Oster

(2019) adjustment for potential omitted variable. The threshold for this statistics is passed successfully for all estimated coefficients.

First, the coefficient on competitors' expectations is positive, indicating an update toward the signal, and significant for the firms' beliefs on own product inflation, but not for overall inflation. This is consistent with the role of strategic complementarities as affecting sector, but not necessarily economy-wide, inflation. The update toward the signal is consistent with the coordination externalities highlighted in the model presented in section 2. The coefficient remains significant when we include, or not, controls or industry fixed effects. The coefficient on the consumers' inflation expectations significantly and positively affects economy-wide inflation, but not their firms' product inflation. This suggests that firms take this as a signal of economy excess demand affecting overall inflation. Similar considerations hold for the coefficient on the unions' inflation expectations, which positively and significantly impact economy-wide inflation. In Italy collective bargaining is conducted at sector level and unions' inflation expectations have to be taken into consideration when indexing wages. Hence their impact on sector inflation is intuitive. The estimated coefficient on oil price is significant but negative, indicating a mean reversion most likely due to the high level of the signal and the high volatility surrounding oil prices. Firms would indeed tend to discount such signals.

Table 1: Baseline regressions with 4 treatment groups and one control. The dependent variable is an update equal to the difference of the posterior and the prior, or else the belief update. Regression specification is given by $y_{i,post} - y_{i,prior} = \alpha + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) + \sum_{k=1}^{K} \gamma_{1,k} I(x_i = x^k) + \sum_{k=1}^{K} \gamma_{2,k}(x^k - \hat{x}^k_{i,prior}) + Z_t + \epsilon_i$. Belief update relates to overall inflation in the economy (question 25), their own product inflation (question 26).

	Own Product Inflation					Overall Inflation				
Perception gap interactions										
Oil price	-14.69***	-9.667***	-13.56***	-10.27***	-15.18***	-13.22***	-14.98***	-12.29***	-14.31***	-13.34***
	(1.217)	(0.965)	(1.290)	(1.029)	(1.183)	(1.176)	(0.902)	(1.195)	(0.963)	(1.182)
δ for $\beta = 0$	4.761		14.571			1.325		1.436		
Consumer Price	-0.744	3.253**	0.0614	3.087*	-1.001	7.306***	6.183***	8.590***	6.954***	7.266***
Expectations	(1.380)	(1.133)	(1.573)	(1.264)	(1.327)	(1.191)	(1.035)	(1.194)	(0.982)	(1.189)
δ for $\beta = 0$	-.560		.1211964			.961		2.503		
Sector Price	5.176***	10.06***	5.622***	9.468***	4.389***	1.198	-0.651	0.254	-0.745	1.179
Expectations	(1.338)	(1.174)	(1.430)	(1.229)	(1.285)	(1.317)	(1.114)	(1.406)	(1.125)	(1.335)
δ for $\beta = 0$	2.165		1.810			2.299		2.873		
Unions Price	-1.501	3.328*	-1.658	3.164*	-1.869	8.949***	7.054***	9.568***	7.789***	8.821***
Expectations	(1.670)	(1.341)	(1.784)	(1.400)	(1.652)	(1.251)	(0.916)	(1.225)	(0.953)	(1.257)
δ for $\beta = 0$	-2.395		-107.995			1.398		4.878		
Controls and FE										
Demographic	X		X		X	X		X		X
Balance Sheet Controls	X		X		X	X		X		X
Industry FE	X	X			X	X	X			X
War Dummy heightObs.	1452	2383	1537	2472	1444	1433	2329	1520	2423	1435
R^2	0.628	0.542	0.482	0.429	0.788	0.742	0.698	0.671	0.789	0.640

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 2: Firms' Heterogeneity. Estimated values for the specification: $y_{i,post} - y_{i,prior} = \alpha + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) I(z_i < \overline{z}) + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) I(z_i > \overline{z}) + \sum_{k=1}^{K} \gamma_{1,k} I(x_i = x^k) + \sum_{k=1}^{K} \gamma_{2,k}(x^k - \hat{x}^k_{i,prior}) + Z_t + \epsilon_i$, where the dependent variable is the belief update, either of overall inflation in the economy (question 25) and their own product inflation (question 26). Heterogeneity dummy is defined based on the median value of the variable. They are the share sold to end consumers (question 5 of the survey) and the mark-up given by difference of sale price and cost of main product (question 16A).

	Sales to consumers		Markup			
	Overall inflation		Overall inflation		Own Price	
Perception gap interactions						
Consumer Expectations × <= median	5.152***	5.324***	3.540*	4.054***	-1.913	0.136
	(1.283)	(1.057)	(1.372)	(1.079)	(1.787)	(1.581)
Consumer Expectations × > median	7.659***	7.603***	6.119***	5.060***	-5.507**	-2.676
	(1.959)	(1.482)	(1.510)	(1.124)	(1.947)	(1.498)
Competitor Expectations × <= median	-0.310	-1.259	-0.459	-2.926*	2.934	5.650***
	(1.542)	(1.154)	(1.667)	(1.359)	(1.871)	(1.321)
Competitor Expectations × > median	-0.312	0.452	-1.973	-1.572	2.583	5.681***
	(1.868)	(1.633)	(1.751)	(1.271)	(1.623)	(1.473)
Observations	1431	2320	1433	2324	1451	2379
R^2	0.790	0.751	0.797	0.746	0.620	0.554
Demographic and Balance Sheet Controls	X		X		X	

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Heterogeneity. Next we exploit other questions in the survey that solicited information about the characteristics of the markets in which firms' operate. This allows us to refine further the demand and competition channels. We use them to create a dummy for whether the variable of interest is above or below median and interact it with the treatment dummy in equation 7. To construct the dummy firms are ranked according to the share of product sold to end consumers (question 5) or the net mark-up, the difference between sale price and production costs per unit of goods (question 16A), are above median. We also construct a dummy using the price duration stated before the treatment, as measure of price stickiness. Results are shown for the coefficient of interest in table 2 for the interactions with market structure variables and in table 3 for the interaction with the proxy of price stickiness. The specifications include those with sector, time and interviewer fixed effects.

First, firm expectations about economy-wide inflation are more responsive to the treatment on consumers' expectations when the sales to final consumers is above the median, relatively to sales within the value chain, or when mark-ups are above the median. Those firms are more likely to respond to signals of exogenous changes in demand elasticity. Second, own product inflation are more responsive to signals about competitors' expectations when they have lower (the median) mark-ups. Firms with low mark-ups are likely to be market followers

Table 3: Heterogeneity by Price Stickiness. Baseline regressions with 4 treated groups and one control, dependent variable is the belief update, that is the difference of the posterior and the prior. Regression specification is given by $y_{i,post} - y_{i,prior} = \alpha + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) I(z_i < \overline{z}) + \sum_{k=1}^{K} \beta_k I(x_i = x^k)(x^k - \hat{x}^k_{i,prior}) I(z_i > \overline{z}) + \sum_{k=1}^{K} \gamma_{1,k} I(x_i = x^k) + \sum_{k=1}^{K} \gamma_{2,k}(x^k - \hat{x}^k_{i,prior}) + Z_t + \epsilon_i$. Belief update relates to overall inflation in the economy (question 25) and their own product inflation (question 26). The treatment is interacted with a dummy for the pre-treatment stated price duration (question 17 of the survey) being above or below the median.

	Price duration			
	Overall inflation		Own Price	
Perception gap interactions				
Consumer Expectations × <= median	10.40***	9.636***	-9.931***	1.453
	(1.448)	(1.403)	(2.117)	(1.585)
Consumer Expectations × > median	9.570***	8.949***	-1.340	7.073***
	(1.483)	(1.503)	(1.889)	(1.705)
Competitor Expectations × <= median	4.308**	2.654	1.336	10.06***
	(1.585)	(1.531)	(1.692)	(1.684)
Competitor Expectations × > median	2.686	2.250	2.358	11.15***
	(1.790)	(1.668)	(1.927)	(1.648)
Observations	1423	2325	1440	2374
R^2	0.799	0.748	0.639	0.548
Demographic and Balance Sheet Controls	X		X	

Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

and as such they tend to align more to competitors' expectations. Differences in mark-ups do not seem to affect the responsiveness to other treatments. We also find, but do not report for brevity, that firms whose share of labor costs above the median are more sensitive to the treatment related to labor union expectations. The same ranking however does not affect the responsiveness of all other treatments.

6. Impact of Treatment on Price Setting Behavior

We now examine the impact of the treatment on price setting behavior. We start by examining the distribution of the variables related to price setting behavior before and after the treatment. Figure 0 shows in the top panels distribution of price setting frequency before and after the treatment. The first is obtained from responses to question 17 and the second is obtained from responses to question 22, asking about price frequency.[17] Questions on price duration are 23 and 24A. The distributions are shown for the four sample of firms treated with different information signals. The prior distributions all look very similar among

17 Priors and posteriors are winsorized as usual.

each other. They are also left skewed and exhibit a bunch at around 10 months like those presented in Nakamura and Steinsson (2008) using administrative data.

The bottom part of Figure 0 shows the distribution for the size of the price change after the treatment, question 23. The distribution is again skewed to the left and the median size of the price change is around 10%, something which aligns with evidence from scanner data (see for instance Eichenbaum et al. (2014)). Interestingly the size of the price change is smaller in absence of menu costs.

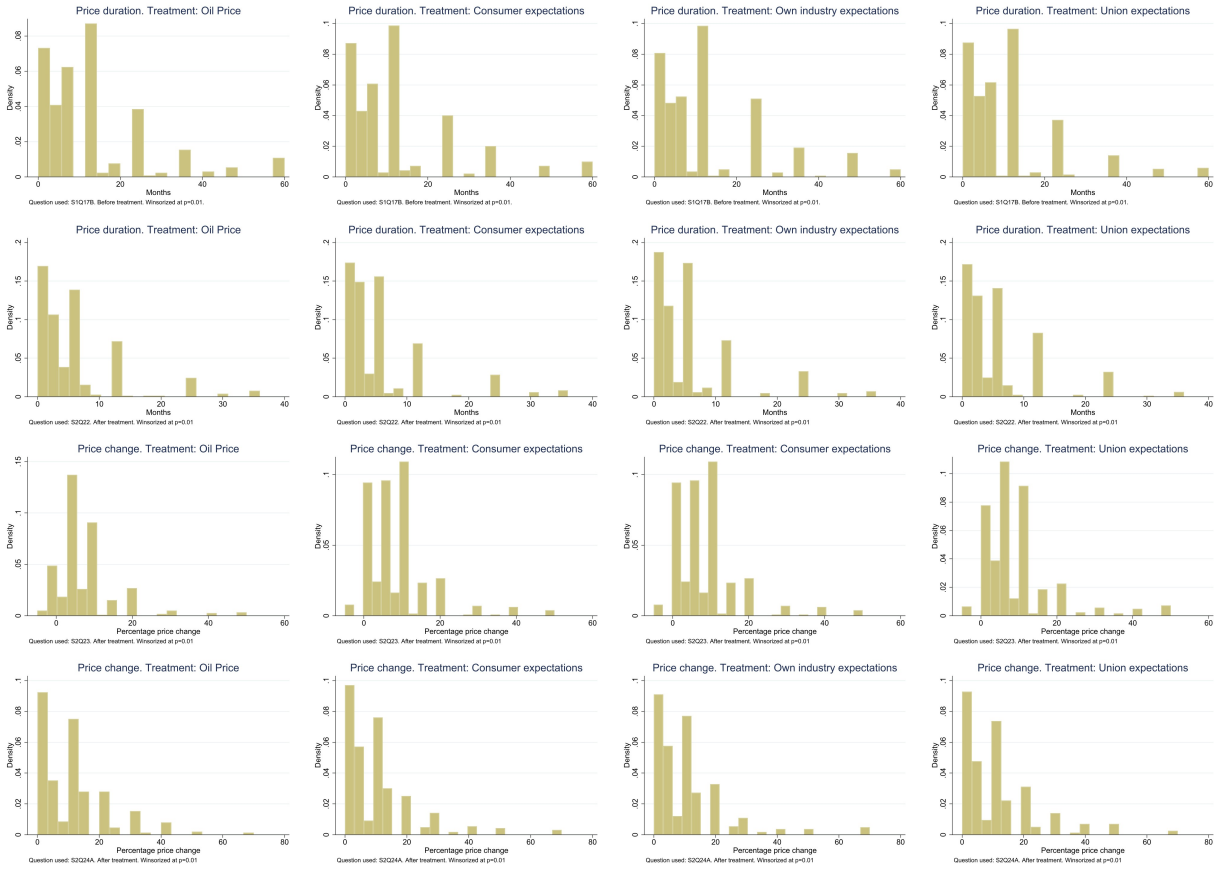
All distribution after the treatment exhibit a shift forward, which is significant based on Kolomgorov tests. This suggests that the treatment has affected behavior, an hypothesis that we test next with an instrumented specification.

Table 4: Behavioral regressions. Specifications regress expected price duration (post treatment question 22) and the size of the price change (post treatment question 23) on instrumented posterior beliefs about own industry and overall price inflation using 2SLS. We consider 2 specifications of the first stage: with/without fixed effects. Specification includes fixed effects.

Price duration		
	Own Industry Price	Overall Inflation
Predicted posterior	0.206**	0.143
	(0.0744)	(0.124)
Observations	979	1011
R^2	0.634	0.675
First Stage F-Statistic	12.27	9.06
First Stage Fixed Effects	X	X
Size Price Change		
	Own Industry Price	Overall Inflation
Predicted posterior	0.278**	0.452*
	(0.103)	(0.181)
Observations	1009	1058
R^2	0.398	0.371
First Stage F-Statistic	12.27	9.06
First Stage Fixed Effects	X	X
Standard errors in parentheses	, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$	

Estimates of the Impact of the Treatment on Price Setting Behavior. Next, we test the impact of the treatment on price setting behavior more formally, by estimating the specification 8. To tackle the pass-through from expectations to price setting behavior we

Figure 0: Distribution of price change duration and price change frequency before and after the treatment. Changes in price duration are obtained from responses to question 17 and the second is obtained from responses to question 22 (asking about price frequency). For size of the price changes those are obtained from question 23 and questions 24A. The distributions are shown for the four groups of treated firms. Priors and posteriors are winsorized at 5%.



estimate the instrumented specification in 8, as linking price duration and the size of the price change solicited after the treatment (question 22 and 23) onto instrumented posterior of either the economy-wide inflation rate or the firm own product inflation rate, as estimated from 6.[18] Table 4 shows results. The estimated coefficients are significant and positive, except for the specification linking price duration to instrumented expectation of economy-wide inflation. The F-Stat is generally above 10, the value typically suggested for validation of a non-weak instrument (see Stock and Yogo (2005), Andrews et al. (2019)).

7. Conclusions

This study exploits a randomized control trial to examine the impact of an exogenous shock about inflation on firms inflation expectations and price setting behaviour. The study focuses on comparing different channels and examining the impact on price setting behavior through different variables, price change and duration. Channels related to demand and strategic complementarities appear the most relevant. Our treatments, which proxies well an inflation shock, significantly modifies both the distributions of the price duration and the size of the price change, thereby providing causal evidence of the state dependent pricing behavior.

18 Following Balla-Elliott (2023) all posteriors for which there is a negative learning rate, defined as the ratio of the update over the difference between the signal and the prior. Balla-Elliott (2023) shows that in experiments with multiple treatments negative learning rates induce an attenuation bias.

A. Appendix: Survey Design on Firm's Inflation Expectations and Price Setting Behavior

Section 1: Firm-level Pricing.

1. Some of the following questions will focus on an individual product or product group of your firm. Can you tell us what is the product or product group about which you feel most comfortable talking to us?

Thanks. Going forward, please keep this product or product group in mind when we will ask you about the "main product" of your firm.

2. What is the current average selling price of your firm's main product?

3. 3A. As far as you recall, what was the average selling price of your firm's main product a month ago?

3B. And six months ago?

3C. And one year ago?

4. Approximately what percentage of your firm's total revenues is due to products you will sell in foreign markets?

5. And approximately what percentage of your firm's total revenues is due to sales to end consumers rather than to other firms?

6. Approximately by what percentage do you think the demand for your main product would fall if you increased its current price by 10

7. And approximately how many direct competitors does your firm face in its main product?

8. Now suppose that you faced no competitors. By what percentage do you think you might increase the price of your main product without losing any customers?

9. 9A. Please give us an approximate estimate of the value of the total amount produced by your firm over the last 12 months.

9B. Now suppose that over the last 12 months you could have operated at full capacity (i.e. given all the equipment, machinery, and labor force available and for as many hours as possible). What's your estimate of the value of the total amount you could have produced under this scenario?

10. In some firms, sales rise and fall strongly with the ups and downs of the economy, whereas in other firms they are much less sensitive to the state of the economy. On a scale between 1 and 10, how sensitive do you think your sales are sensitive to the ups and downs of the economy?

11. When you set the price of your main product, on a scale from 1 to 10 to what extent do you consider your or experts' forecasts about future economic activity?

12. And on a scale from 1 to 10, to what extent do you consider forecasts about future general inflation, whether your own or those from contract negotiations with labor unions?

13. Approximately what percentage of the costs your firm faces is due to fixed costs rather than variable costs?

14. 14A. Please assume that your revenues are worth 100. What part of this goes to pay labor costs?

14B. And to pay intermediate goods?

14C. And to pay energy costs?

15. 15A. Has your firm invested in new fixed assets over the last 12 months? For instance, think of machinery or buildings.

15B. If yes, what is the size of these investments as a percentage of your total revenues?

16. 16A. As far as you know, what is the difference between the sale price of your main product and the costs you face to produce it, in Euros?

16B. Was this wedge between the sales price and production costs for your main product different 12 months ago? If so, by how much? [NOTE for recording of answer: if the answer is NO, please write "0". If the answer is YES, please report the value, e.g., 5 for +5 Euros and -2 for -2 Euros.]

17. 17A. Normally do you change the price of your main product in response to specific events such as increases in costs or periodically? 17B. As far as you know, how often do you typically change the price of your main product? 1 = daily 2 = weekly 3 = monthly 4 = quarterly 5 = half-annually 6 = annually 7 = less frequently than annually

18. The COVID-19 pandemic has induced some workers to stay unemployed. Do you think that this absenteeism might have a relevant effect on your ability to produce going forward? Yes or No?

Section 2. Economic Expectations.

In this section, we will ask your opinion about future economic conditions. There is no right or wrong answer here. It is extremely important for us that you provide your own opinion rather than asking somebody else or looking up any information on the internet.

19. Please think about inflation, i.e. the general average rise of all prices of goods and services in the economy. For instance, think of the prices of products, services, and energy. Over the last 12 months, by how much do you think prices have increased, on average, in percentage terms?

20. And over the last 12 months, by how much do you think the prices of products sold in your industry have increased?

21. And over the last 12 months, by how much do you think energy prices have increased?

Randomized Information Treatments.

[Internal Note: Please split sample into 5 groups randomly. Please display for each group the text indicated before letting the respondent move to the subsequent questions]

Group 1 (Control):

Please read the following information:

"Firms can enjoy limited liability if they are established as corporation. In this case, firm owners do not have to respond of the firm's obligations with their own personal wealth."

Group 2 (Production Costs):

"Oil price, which is an important part of energy costs, has increased by 52% over the last 12 months. This increase is much higher than the historical average changes of energy costs over the last 10 years. Professional forecasters expect these prices will rise more over the next 12 months."

Group 3 (Consumers' expectations):

Consumer prices in Italy have increased by 6.8% over the last 12 months. This increase is much higher than the historical average changes in consumer prices over the last 10 years. Italian consumers on average expect prices to increase more over the next 12 months.

Group 4 (Competitors' expectations):

Producer prices in your industry have increased by XX% over the last 12 months. This increase is much higher than the historical average changes in producer prices over the last 10 years. Firms in your industry on average expect prices to rise more over the next 12 months.

[NOTE: sector-specific values of inflation inserted here]

Group 5 (Labor Unions'/Workers' expectations): Please read the following information:

Inflation in Italy has increased by 6.8% over the last 12 months. This increase is much higher than the historical average change over the last 10 years. Labor Unions in your industry on average expect prices to rise more over the next 12 months.

The Randomized Information Treatments End Here.

[Internal Note: Please ask the following questions to everybody]

22. In how many months do you think your firm will change the price of its main product?

23. And by how much do you think the change will be, in percentage terms?

24. 24A. Now suppose that your firms was free to change the price of their main product without any restrictions. For instance, without changing contracts with clients, printing new menus, and so on. Under this scenario, by how much do you think you should increase the price of the main product?

24B. Because by increasing the price you would earn more for each item sold but you

might lose some customers, by how much do you think your overall sales would change after such a price change?

25. In your view, what do you think will be the overall rate of inflation in the economy over the next 12 months?

26. And over the next 12 months by how much do you think that average product prices will increase in your industry?

27. By how much do you think that the overall level of economic activity in your industry will be higher or lower 12 months from now?

28. And 12 months from now, what do you think will be the unemployment rate in Italy?

29. 29A. Do you think that your firm will invest in new fixed assets over the next twelve months? Think of machinery or buildings.

29B. If yes, what do you expect the size of new investments to be as a fraction of annual revenues?

30. 30A. Do you think that your firm will adjust its FTE workforce over the next twelve months? Please provide a quantitative answer for the percent change of FTE worker units

30B. If yes, what do you think will be the percentage change of your FTE workforce?

Section 3: Determinants of price setting behavior.

Now, we would like to briefly ask your opinion about how your firm sets the prices of the main product. We will list a set of potential determinants. For each of them, can you please tell us how important you think they are on a scale from 1 to 10?

Existing Contractual agreements with customers: Consumers' inflation and consumers' price expectations; Labor union's price expectations; Your suppliers' pricing strategies; keeping prices below salient thresholds, such as 95 or 99 cents; Customer antagonization, i.e. the risk of losing customers after price increases; Operational and bureaucratic costs, such as printing new menus:

Section 4: Russia-Ukraine War and Uncertainty We are almost done. A couple of remaining questions:

31. On a scale from 1 to 10, how much do you think that the war in Ukraine has increased

the uncertainty about the performance of your firm in the medium run in terms of sales, costs, and profits?

32. On a scale from 1 to 10, how much do you think that the war in Ukraine has increased the uncertainty about economic growth in the medium run?

Section 4: Personal characteristics of survey respondent.

33. What is your age?

34. Are you a man or a woman?

35. Do you hold a college degree?

36. What is your occupation in the firm?

37. How many years of work experience do you have in this firm?

38. How many overall years of work experience do you have?

B. Descriptive Statistics and Other Data Evidence

Figure 0: Binscatter Plot for prior and posterior questions on economy-wide inflation, namely Q25 and Q19, and on own product inflation, namely Q26 and Q20, for the control group.

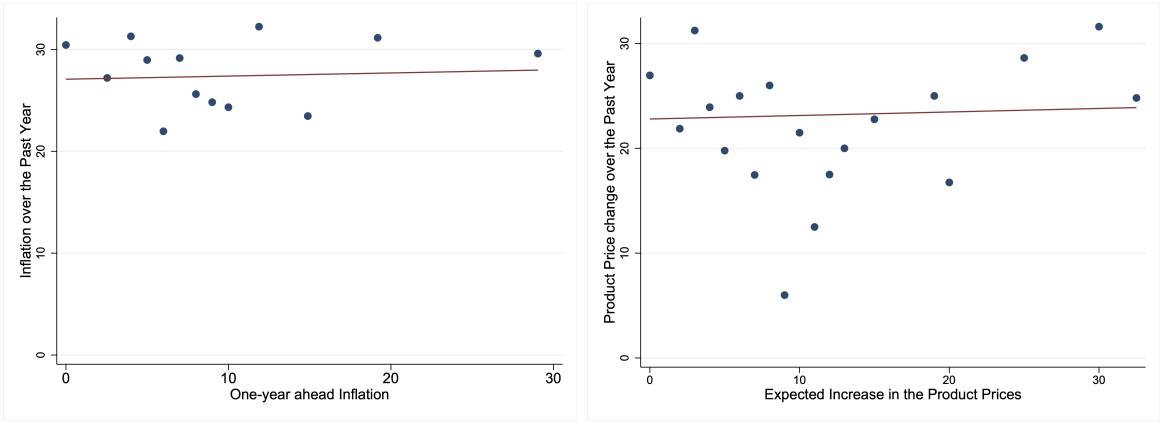
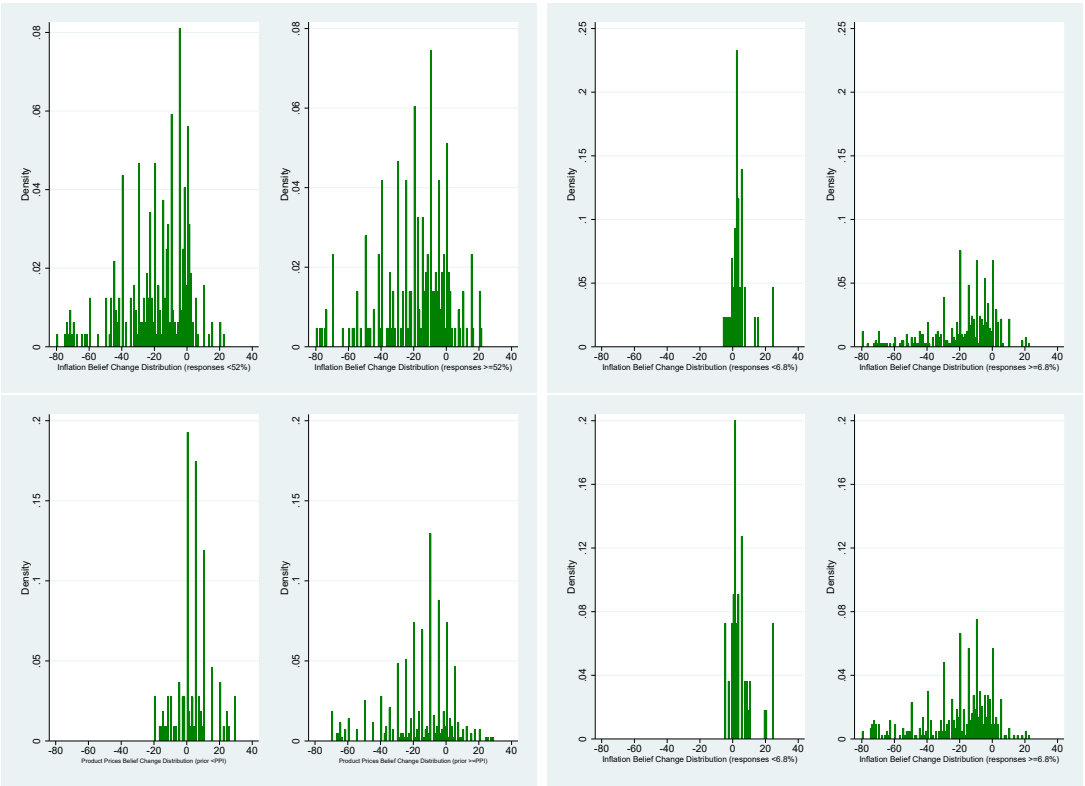


Figure 1: Perception gaps. The panels in the figure present the beliefs' updates, posteriors minus priors, for each treated group separately, broken down in above and below the signal. Data are winsorized at 5%. Group 2 is the one treated with information on oil price forecast, group 3 is the one with consumers' inflation expectation, group 4 is the one treated with information on sectoral inflation expectations, group 5 is the one treated with unions' inflation expectations. For groups 2, 3 and 5 the plots show the perception gap for economy-wide inflation, fro group 4 we focus on perception gap of own-product inflation.



	mean (control)	sd (control)	mean (group2)	sd (group2)	b	t
age	47.44	11.01	47.82	10.19	-0.39	(-0.56)
gender	1.50	0.50	1.48	0.050	0.01	(0.44)
college degree	0.28	0.45	0.30	0.46	-0.02	(-0.02)
firm experience	17.02	12.71	16.14	11.39	0.88	(1.11)
total experience	24.39	11.83	24.60	10.89	-0.21	(-0.28)
N	475		454		929	

	mean (control)	sd (control)	mean (group3)	sd (group3)	b	t
age	47.44	11.01	47.77	10.84	-0.33	(-0.48)
gender	1.50	0.50	1.48	0.050	0.02	(0.62)
college degree	0.28	0.45	0.30	0.46	-0.02	(-0.69)
firm experience	17.02	12.71	16.85	12.28	0.18	(0.23)
total experience	24.39	11.83	24.70	11.38	-0.31	(-0.42)
N	475		536		1011	

	mean (control)	sd (control)	mean (group3)	sd (group3)	b	t
age	47.44	11.01	47.77	10.84	-0.33	(-0.48)
gender	1.50	0.50	1.48	0.050	0.02	(0.62)
college degree	0.28	0.45	0.30	0.46	-0.02	(-0.69)
firm experience	17.02	12.71	16.85	12.28	0.18	(0.23)
total experience	24.39	11.83	24.70	11.38	-0.31	(-0.42)
N	475		536		1011	

	mean (control)	sd (control)	mean (group4)	sd (group4)	b	t
age	47.44	11.01	47.00	11.04	0.44	(-0.63)
gender	1.50	0.50	1.51	0.050	-0.01	(-0.42)
college degree	0.28	0.45	0.37	0.48	-0.08**	(-2.85)
firm experience	17.02	12.71	16.78	11.65	0.24	(0.31)
total experience	24.39	11.83	23.84	11.60	0.56	(0.75)
N	475		541		1016	

	mean (control)	sd (control)	mean (group5)	sd (group5)	b	t
age	47.44	11.01	47.94	10.50	-0.51	(-0.73)
gender	1.50	0.50	1.47	0.050	0.03	(0.85)
college degree	0.28	0.45	0.35	0.48	-0.07*	(-2.34)
firm experience	17.02	12.71	17.21	11.72	-0.19	(-0.24)
total experience	24.39	11.83	24.79	11.01	-0.40	(-0.54)
N	475		494		965	

Table 5: Mean and Standard Deviations for Firms' Demographic Variables across the Control and all Treated Groups. The tables includes the t-stat.

Table 6: Means, Standard Deviations and t-stats for all Firms' Balance Sheet Variables.

	mean(control)	sd(control)	mean(group2)	sd(group2)	b	t
Sales	14131421.75	60213329.37	11090161.93	27354780.22	3041259.82	(0.91)
Value Added	14423457.13	60701839.42	11643185.32	28733052.00	2780271.81	(0.82)
Revenues	14194968.86	60276562.74	10680569.94	26329297.43	3514398.92	(1.06)
Acquisitions	4169888.85	14266423.05	4363166.29	10888797.08	-193277.44	(-0.21)
Gen Exp	6325332.51	46390259.41	3553116.84	13431042.35	2772215.67	(1.14)
EBITDA	938877.77	3179658.88	844092.80	3025500.64	94784.98	(0.42)
Op Income	699874.25	2778730.92	792561.03	3148868.58	-92686.78	(-0.43)
Profit/Loss	464664.66	2139007.61	514896.67	2452353.88	-50232.01	(-0.30)
Cash Flow	956008.72	3221988.09	996425.40	3802989.60	-40416.68	(-0.16)
Tot Assets	15396941.70	56807237.08	19853734.29	88381213.26	-4456792.59	(-0.82)
Net Worth	6782576.27	37012559.35	6820614.89	25393231.87	-38038.62	(-0.02)
Debt Ratio	65.82	29.10	64.64	22.75	1.18	(0.63)
ROE	7.35	29.58	1.23	96.83	6.12	(1.16)
ROI	3.40	10.63	3.62	16.96	-0.22	(-0.22)
ROS	4.40	12.59	5.76	14.95	-1.36	(-1.36)
Liquidity	176.03	149.57	171.96	133.77	4.07	(0.40)
Employees	69.48	221.07	57.10	154.74	12.37	(0.80)
Obs	394		371		765	

	mean(control)	sd(control)	mean(group3)	sd(group3)	b	t
Sales	14131421.75	60213329.37	10165408.12	42416637.23	3966013.63	(1.09)
Value Added	14423457.13	60701839.42	10398355.13	43088013.11	4025102.00	(1.10)
Revenues	14194968.86	60276562.74	10100359.76	42277374.69	4094609.10	(1.13)
Acquisitions	4169888.85	14266423.05	2871722.06	7582926.53	1298166.79	(1.62)
Gen Exp	6325332.51	46390259.41	3217457.60	17164690.22	3107874.92	(1.26)
EBITDA	938877.77	3179658.88	2440557.09	29068112.61	-1501679.31	(-1.08)
Op Income	699874.25	2778730.92	1134189.43	13722245.15	-434315.19	(-0.65)
Profit/Loss	464664.66	2139007.61	541056.47	8284703.08	-76391.81	(-0.19)
Cash Flow	956008.72	3221988.09	1944884.25	22632774.68	-988875.53	(-0.91)
Tot Assets	15396941.70	56807237.08	35604683.86	4.39e+08	-2.02e+07	(-0.96)
Net Worth	6782576.27	37012559.35	16456994.17	2.21e+08	-9674417.90	(-0.91)
Debt Ratio	65.82	29.10	65.82	24.05	-0.00	(-0.00)
ROE	7.35	29.58	-0.40	87.27	7.75	(1.74)
ROI	3.40	10.63	2.74	16.33	0.66	(0.70)
ROS	4.40	12.59	3.30	20.94	1.10	(0.93)
Liquidity	176.03	149.57	172.72	139.60	3.31	(0.33)
Employees	69.48	221.07	47.79	105.39	21.68	(1.58)
Obs	394		447		841	

	mean(control)	sd(control)	mean(group4)	sd(group4)	b	t
Sales	14131421.75	60213329.37	11943843.43	45593125.09	2187578.32	(0.59)
Value Added	14423457.13	60701839.42	12283617.63	46216728.19	2139839.50	(0.57)
Revenues	14194968.86	60276562.74	11909162.27	45586234.03	2285806.58	(0.62)
Acquisitions	4169888.85	14266423.05	4371432.51	15821970.13	-201543.66	(-0.20)
Gen Exp	6325332.51	46390259.41	4319065.87	32769698.97	2006266.64	(0.72)
EBITDA	938877.77	3179658.88	1241305.67	7731332.47	-302427.90	(-0.76)
Op Income	699874.25	2778730.92	842732.71	6390628.61	-142858.47	(-0.43)
Profit/Loss	464664.66	2139007.61	618142.38	5769603.62	-153477.72	(-0.53)
Cash Flow	956008.72	3221988.09	1386259.97	8231955.85	-430251.25	(-1.03)
Tot Assets	15396941.70	56807237.08	18057402.51	77278963.93	-2660460.81	(-0.58)
Net Worth	6782576.27	37012559.35	8073555.01	42134676.64	-1290978.74	(-0.48)
Debt Ratio	65.82	29.10	64.08	23.62	1.74	(0.95)
ROE	7.35	29.58	-2.37	94.53	9.71*	(2.05)
ROI	3.40	10.63	3.23	11.01	0.17	(0.23)
ROS	4.40	12.59	3.29	19.93	1.10	(0.98)
Liquidity	176.03	149.57	173.86	155.55	2.17	(0.21)
Employees	69.48	221.07	51.51	111.84	17.96	(1.30)
Obs	394		455		849	

	mean(control)	sd(control)	mean(group5)	sd(group5)	b	t
Sales	14131421.75	60213329.37	19338015.77	1.43e+08	-5206594.02	(-0.67)
Value Added	14423457.13	60701839.42	19972560.87	1.48e+08	-5549103.74	(-0.69)
Revenues	14194968.86	60276562.74	19406387.73	1.43e+08	-5211418.87	(-0.67)
Acquisitions	4169888.85	14266423.05	3960812.78	14164508.76	209076.07	(0.21)
Gen Exp	6325332.51	46390259.41	6488793.64	64481622.84	-163461.13	(-0.04)
EBITDA	938877.77	3179658.88	2737277.25	41305789.08	-1798399.48	(-0.86)
Op Income	699874.25	2778730.92	1101551.87	9586593.78	-401677.63	(-0.80)
Profit/Loss	464664.66	2139007.61	478097.45	6455261.15	-13432.79	(-0.04)
Cash Flow	956008.72	3221988.09	2444772.93	36191194.38	-1488764.21	(-0.82)
Tot Assets	15396941.70	56807237.08	25804688.92	2.29e+08	-1.04e+07	(-0.88)
Net Worth	6782576.27	37012559.35	8679279.09	62036368.93	-1896702.82	(-0.52)
Debt Ratio	65.82	29.10	67.93	23.67	-2.11	(-1.12)
ROE	7.35	29.58	4.83	61.23	2.52	(0.73)
ROI	3.40	10.63	2.65	11.52	0.75	(0.95)
ROS	4.40	12.59	3.34	15.77	1.06	(1.05)
Liquidity	176.03	149.57	170.07	139.46	5.96	(0.58)
Employees	69.48	221.07	65.37	213.37	4.10	(0.23)
Obs	394		397		791	

Table 7: Tests for equality of group means assuming homogeneous (top) and heterogeneous (bottom) covariance matrices. Wilks' Lambda ranges from 0 to 1, with lower values indicating stronger group differences. Lawley-Hotelling trace is a multivariate analogue of the F-test. Roy's Largest Root reflects the strongest single-group separation. The Wald chi-squared test assesses joint significance of group differences; James' approximation adjusts it to account for heterogeneity in covariance matrices.

			Demographics		
	Statistic	F(df1,	df2)	=F	Prob > F
Wilks' lamda	0.9924	20.0	8086.9	0.94	0.5414
Lawley-Hotelling trace	0.0077	20.0	9746.0	0.93	0.5416
Roy's largest root	0.0046	5.0	2441.0	2.27	0.0455
	Wald chi2(20)	=	18.47		
	Prob> chi2	=	0.5562	chi-squared approximation	
	Prob> chi2	=	0.5669	James' approximation	

			Balance Sheet Variables		
	Statistic	F(df1,	df2)	=F	Prob > F
Wilks' lamda	0.9662	68.0	6112.4	0.79	0.8937
Lawley-Hotelling trace	0.0346	68.0	6222.0	0.79	0.8946
Roy's largest root	0.0118	17.0	1560.0	1.08	0.3661
	Wald chi2(68)	=	74.57		
	Prob> chi2	=	0.2734	chi-squared approximation	
	Prob> chi2	=	0.3706	James' approximation	

Table 8: Kolmogorov-Smirnov test for equality of distributions for different treatment groups. The table reports the p-values for the null hypothesis that the two sample distributions are equal.

Prior of economy-wide inflation					
	Control	Oil Price	Consumer	Competitor	Worker
Oil Price	0.699	X			
Consumer Expectations	0.581	0.024	X		
Competitor Expectations	0.794	0.177	0.271	X	
Unions Expectations	0.997	0.924	0.149	0.431	X
Prior of own-product inflation					
	Control	Oil Price	Consumer	Competitor	Worker
Oil Price	0.700	X			
Consumer Expectations	0.911	0.889	X		
Competitor Expectations	0.940	0.981	0.988	X	
Unions Expectations	0.773	0.995	0.877	0.999	X

C. Model's Appendix

Firms choose optimal beliefs to optimize their objective function

$$V(\pi,a,s)=\max_{p}\min_{a}\sum_{\omega\in\Omega}\frac{p(s\mid\omega)\pi(\omega)}{\sum_{\omega'\in\Omega}p(s\mid\omega')\pi(\omega')}u(a,\omega)+\sigma\left[\sum_{\omega\in\Omega}\sum_{s\in\S}p(s'\mid\omega)ln\frac{p(s'\mid\omega)}{\overline{p}(s'\mid\omega)}\right] \quad (9)$$

Let us write for convenience:

$$\gamma(\omega)=\frac{\overline{p}(s\mid\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)}{\overline{p}(s\mid\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(s\mid\omega))\cdot(1-\pi(\omega))}. \quad (10)$$

Substituting the optimal belief in the entropy constraint delivers:

$$\sigma\left[\sum_{\omega\in\Omega}\sum_{s\in\S}p(s'\mid\omega)ln\frac{p(s'\mid\omega)}{\overline{p}(s'\mid\omega)}\right]=\sigma[\sum_{\omega\in\Omega}p(s\mid\omega)ln\frac{\frac{\overline{p}(s|\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)}{\overline{p}(s|\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(s|\omega))\cdot(1-\pi(\omega))}}{\overline{p}(s\mid\omega)}+$$

$$+\sum_{\omega\in\Omega}\sum_{s'\in\S}p(s'\mid\omega)ln\frac{\frac{\overline{p}(\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)}{\overline{p}(\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(\omega))\cdot(1-\pi(\omega))}}{\overline{p}(s'\mid\omega)}]=$$

$$=\sum_{\omega\in\Omega}p(s\mid\omega)m-\sigma[\sum_{\omega\in\Omega}p(s\mid\omega)ln(\overline{p}(s\mid\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(s\mid\omega))\cdot(1-\pi(\omega)))-$$

$$-\sum_{\omega\in\Omega}\sum_{s'\in\S}p(s'\mid\omega)ln(\overline{p}(s\mid\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(s\mid\omega))\cdot(1-\pi(\omega)))]=$$

$$=\sum_{\omega\in\Omega}p(s\mid\omega)m-\sigma\sum_{\omega\in\Omega}[ln(\overline{p}(s\mid\omega)exp(-\frac{m}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(s\mid\omega))\cdot(1-\pi(\omega)))]$$

Note that the first term is zero since $\frac{dE_\gamma u(a,\omega)}{dp(s|\omega)}=0$, hence:

$$V(\pi,a,s)=\max_{a}E_{\gamma(a)}u(a,\omega)+\sigma\sum_{\omega\in\Omega}[ln(\overline{p}(s\mid\omega)exp(-\frac{\frac{dE_\gamma u(a,\omega)}{dp(s|\omega)}}{\sigma})\cdot\pi(\omega)+(1-\overline{p}(s\mid\omega))\cdot(1-\pi(\omega)))] \quad (11)$$

or else:

$$V(\pi,a,s)=\max_{a}\sum_{\omega\in\Omega}\frac{p(s\mid\omega)\pi(\omega)}{\sum_{\omega'\in\Omega}p(s\mid\omega')\pi(\omega')}u(a,\omega)+$$

$$+\sigma\sum_{\omega\in\Omega}[ln(\overline{p}(s\mid\omega)exp(-\frac{1}{\sigma}\cdot\left(\frac{\pi(\omega)}{E_p\pi(\omega)}\left[u(a,\omega)-E_\gamma u(a,\omega)\right]\right))\cdot\pi(\omega)+(1-\overline{p}(s\mid\omega))\cdot(1-\pi(\omega)))]$$

Firms' objective function is given by their profits and we can assume a simple quadratic form for it. Hence $u(a,\omega)=\frac{(a-s)^2}{2}+\frac{(a-A)^2}{2}$, where the second term, $\frac{(a-A)}{2}$, captures the cost of

deviating from competitors' actions. If firms set their price too far from their competitors they are going to loose either market shares or revenues.

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