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## Unit Cost Expectations and Uncertainty: Firms' Perspectives on Inflation

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**Abstract:** We rely on the Atlanta Fed's Business Inflation Expectations survey to draw inference about firms' inflation perceptions, expectations, and uncertainty through the lens of firms' unit (marginal) costs. Using methods grounded in the survey literature, we find evidence that the concept of "aggregate inflation" as measured through price statistics like the consumer price index hold very little relevance for business decision makers. This lack of relevance manifests itself through experiments (including randomized controlled trials) that show how researchers word questions to elicit inflation expectations and perceptions significantly changes firms' responses. Our results suggest firms have become rationally ignorant of the concept of inflation in a low-inflation environment. Instead, we find that unit (marginal) costs are the relevant lens with which to capture firms' views on the nominal side of the economy. We then investigate both firm-level (micro) and aggregated (macro) probabilistic unit cost expectations. On a firm level, unit costs are an important determinant of firms' price-setting behavior. Aggregating across firms' beliefs, firms' unit cost perceptions strongly comove with official aggregate price statistics, and, importantly, firms' expectations for the nominal side of the economy have little in common with the "prices in general" expectations of households. Rather, firms' aggregated beliefs strongly covary with the inflation expectations of professional forecasters and market participants.

JEL classification: E31, E52

Key words: bimodality, inflation expectations, probability distributions, randomized controlled trials, uncertainty, unit cost

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*“Price stability is that state in which expected changes in the general price level do not effectively alter business or household decisions.”*

–Federal Reserve Chairman Allen Greenspan, July 1996, FOMC Meeting<sup>1</sup>

## 1 Introduction

Since October 2011, the Federal Reserve Bank of Atlanta has conducted the Business Inflation Expectations (BIE) Survey, collecting subjective probability distributions over own-firm future unit costs from a panel of business executives (CFOs, CEOs, and business owners) on an ongoing monthly basis. The BIE is unique across several dimensions. Rather than elicit firms’ aggregate inflation expectations, the BIE focuses on firms’ own anticipated unit cost – a concept synonymous with marginal costs and as we show, a concept relevant for business decision makers. In addition to its unique focus, the BIE elicits unit cost expectations in a probabilistic format following [Manski \(2004\)](#). And, the BIE has been fielded monthly for roughly a decade now, making it the first U.S. business survey focused solely on eliciting inflation expectations, yielding a richer panel structure than typical surveys of households and firms, and allowing for deeper analytical exploration.

We use the BIE to shed light on a puzzle in the literature surrounding inflation expectations: Why do firms and households hold “aggregate inflation” expectations that appear disconnected from actual measured inflation and the inflation expectations of professional forecasters and market participants? From our point of view, there is a short and long answer to that question. The short answer is that “aggregate inflation” in the low-inflation environment we have enjoyed in the U.S. since the mid-90s has rendered that concept irrelevant in the minds of economic actors. In this sense, firms and households have become “rationally ignorant,” in that they do not devote resources to uncovering information on aggregate inflation measures (even when many resources are a few keystrokes away) because whatever perceived benefit of doing so outweighs the cost. The long answer to this question is that due to the lack of relevance that firms in particular place on aggregate inflation measurement, investigating the forward nominal expectations (of firms in particular) requires a different lens. In the case of firms, that lens is unit costs.<sup>2</sup> This concept is undeniably and intimately connected to business decision making, and is a key driving variable for pricing decisions in popular New Keynesian theoretical models of the economy. On a micro level, the majority of firms report planning around anticipated unit cost changes and report unit cost changes influence future price changes. As importantly, on a macro level by eliciting and aggregating firms perceptions and expectations of unit costs, we are able to uncover a tight connection to actual measured inflation statistics and the inflation expectations of professionals and market participants.

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<sup>1</sup><https://www.federalreserve.gov/monetarypolicy/files/FOMC19960703meeting.pdf>

<sup>2</sup>While the terms “unit costs” and “marginal costs” are interchangeable, early cognitive testing revealed that “unit costs” was a term that resonated with the business community. See [Del Negro et al. \(2020\)](#) for a detailed discussion regarding the relationship between marginal cost pressures and inflation.

In this paper we investigate the inflation expectations of firms and attendant uncertainty that surrounds those projections. First, we demonstrate that aggregate notions of inflation (“prices in general”, “prices overall in the economy”, and even official price statistics) hold little weight in the minds of business decision makers. This lack of relevance is borne out through a series of experiments using special questions posed in the BIE panel. Responses to various aggregate inflation concepts vary significantly by question wording and appear to hold very little relevance for firm-level decision making.

Second, we investigate firm-level expectations across a variety of dimensions. We show that firms’ ex ante predictions for unit costs are related to ex post realizations. On average, over our sample period, firms have been a bit too pessimistic with their unit cost expectations. Actual (perceived) cost growth has come in slightly below expectations, on average. Firms that are highly cyclical or volatile industries (manufacturing, construction, mining, finance) tend to have larger absolute forecast errors. Regarding the second moment, more uncertain firms have larger forecast errors, implying that, ex ante, firms realize they are in an uncertain environment. Unlike [Kim and Binder \(2020\)](#) that documents a significant tenure effect in household inflation expectations, we do not see any significant relationship between uncertainty or forecast errors and respondent tenure in the panel.

We use these facts to investigate the relationship between unit costs and price formation on a firm level. We find that firms’ unit costs realizations and expectations are related to firms’ price expectations and realizations. Consistent with the available micro evidence on unit costs and prices (such as [Carlsson and Nordstrom Skans \(2012\)](#)), we find less than unit elasticity of prices to costs (suggesting the presence of nominal frictions). More importantly, we find cursory evidence that, while unit costs appear to matter for price formation, firms’ “aggregate” inflation expectations do not.

Third, at the macro level, BIE inflation expectations are highly correlated with professional forecasters expectations for aggregate inflation measures. Household measures from University of Michigan’s Survey of Consumers are, however, not highly correlated with either. These results hold in comparison to both quarterly expectations from the Survey of Professional Forecasters (SPF) and in monthly expectations from the Blue Chip Panel. Importantly, firms’ aggregated perceived unit cost growth is very highly correlated with official aggregate inflation statistics. These results imply that unit cost expectations are an appropriate measure of inflation expectations, and the concept of unit costs translates into a measure that tracks overall inflation.

## Related Literature

We lean heavily on best practices in the existing survey literature outside of the sphere of economics to ensure that response quality is high and that we are eliciting concepts that are relevant to

respondents. In particular, when designing questions, survey practitioners must avoid embedding assumptions. Unless familiarity or relevance of a topic is undeniable, filter questions or forms of pre-interviewing should be used to “avoid asking questions that do not apply to [respondents],” as evidenced by the comprehensive survey in [Krosnick and Presser \(2010\)](#). In the case of eliciting inflation expectations from business decision makers, it is incumbent on the researcher to assess whether these concepts hold relevance to their decision making. Another concern when relevancy is an issue is social desirability bias – the tendency of respondents not to reveal their lack of familiarity with a concept that, by inclusion in a questionnaire, the researcher is implying the respondent “should” be familiar with (for an in-depth background on this literature see [Parry and Crossley \(1950\)](#), [Locander et al. \(1976\)](#) and [Katosh and Traugott \(1981\)](#)). In our investigation, the combination of a lack of importance firms place on aggregate inflation statistics in addition to the large revisions in responses when confronted with information on actual inflation raises the possibility that social desirability bias is present in questions around “aggregate” inflation concepts.

That the majority of firms rank their own unit costs as more important than the CPI or “aggregate inflation” is also consistent with rational inattention models; see [Sims \(2003\)](#), [Woodford \(2003\)](#) and [Mackowiak and Wiederholt \(2009\)](#). [Sims \(2003\)](#) proposes a rational inattention framework to have endogenous information processing. [Woodford \(2003\)](#) proposes a model in which firms face a signal-extraction problem and pay little attention to aggregate conditions. [Mackowiak and Wiederholt \(2009\)](#) develop a theoretical model that idiosyncratic conditions are more important than aggregate conditions. Our results suggest that firms operating in the current low inflation environment that has persisted since the inception of the BIE in 2011 view unit costs as a more informative input into their pricing decisions than aggregate inflation. We therefore interpret our results as not only providing an answer to why firms in New Zealand devote few resources to collecting and processing information about aggregate inflation as documented in [Coibion et al. \(2018\)](#) but also as showing the direct evidence for rational inattention theories in firms’ inflation expectations formation process.<sup>3</sup>

Our decision of eliciting firms’ unit costs is also rooted and established on the foundation of the New Keynesian model. The Calvo model of optimizing firms with staggered prices makes predictions only about the dynamic relation between prices and nominal marginal cost; see, e.g. [Sbordone \(2005\)](#), [Roberts \(2006\)](#) and [Carlsson and Nordstrom Skans \(2012\)](#). Using measures of marginal cost as the relevant determinant of inflation, instead of an ad hoc output gap, was also independently proposed by [Gali and Gertler \(1999\)](#), who similarly proxied marginal costs with unit costs. We thus contribute to the micro-foundation of the New Keynesian model by providing

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<sup>3</sup>[Baker et al. \(2020\)](#) provide the indirect evidence, via regressions, for state-dependent information processing in predicting output growth and inflation following large unexpected shocks. Using a new survey of German consumers, [Drager and Nghiem \(2021\)](#) find that the impact of consumers’ inflation expectations on current spending patterns is even more pronounced for the small sub-set of consumers who report having heard about rising prices, in line with theories of rational inattention.

the most direct evidence that, when setting individual prices, business executives do not consider aggregate reported prices or the Federal Reserve’s targets, but simply their own marginal cost.

Our paper also contributes to the growing literature that uses probability forecasts to elicit agent perceptions and expectations. This literature goes back to density forecasts made by professional forecasters in the surveys conducted by the Philadelphia Fed and European Central Bank; see, e.g. [Engelberg et al. \(2009\)](#) and [Rich and Tracy \(2010\)](#). Later, the New York Fed adopts a similar methodology in eliciting a household’s distribution of inflation beliefs and [Armantier et al. \(2013\)](#) provide a comprehensive review of this initiative aimed at improving the measurement of household inflation expectations through surveys. Our density forecasts take a similar form – by assigning probabilities to pre-specified bins – as for professional forecasters and households, but now for the case of firms.<sup>4</sup> To our knowledge, the BIE survey is the longest monthly survey of businesses in the United States that elicits probability distributions.

A few recent papers use firm-level surveys to study properties of agent perceptions and expectations. In this respect, we borrow from and build on [Bachmann et al. \(2018\)](#), [Altig et al. \(2020\)](#), [Barrero \(2020\)](#), [Bordalo et al. \(2020\)](#), [Boutros et al. \(2020\)](#) and [Coibion et al. \(2020\)](#). The analysis in [Bryan et al. \(2015\)](#) is the earliest antecedent to our study. We differ from these studies by eliciting firms’ own anticipated unit cost and documenting evidence of bimodality in firm inflation expectations – some firms assign positive probabilities to non-adjacent bins. This bimodality does not exist for surveys of professionals, since in all cases where professional forecasters assign probability to multiple bins, these bins are adjacent. To account for this new feature, we propose a bimodal asymmetric power normal distribution, finding that both parametric (e.g., normal and beta distributions that assume unimodality) and nonparametric distributions significantly underestimate the degree of uncertainty faced by firms.

The rest of the paper proceeds as follows. Section 2 describes the Atlanta Fed’s Business Inflation Expectations Survey. Section 3 discusses the relevance of “aggregate inflation” and its impact on business decision making, uses experimental design to examine the impact of question wording on inflation expectations measurement, and makes the case that nominal marginal (unit) costs are the appropriate lens to elicit inflation expectations from firms. The evaluation of firm-level unit cost beliefs and their associated uncertainty is presented in Section 4, starting with the proposal of the bimodal asymmetric power normal distribution in fitting the probability forecasts. Section 5 evaluates firms aggregated unit cost (inflation) perceptions, expectations and uncertainty, comparing them to official inflation statistics and various well-known measures of household, professional, and market-based inflation expectations. Section 6 concludes. Additional tables and figures are relegated to an online appendix.

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<sup>4</sup>Another business survey is worth mentioning, though it does not provide subjective probability distributions. The CFO Survey conducted by the Duke University elicits forecasts of the one-year return on the S&P 500 and 80% confidence intervals for their forecasts; see [Ben-David et al. \(2013\)](#).

## 2 Business Inflation Expectations Survey

The Business Inflation Expectations (BIE) Survey is an online panel survey of roughly 500 CEOs, CFOs, and business owners of firms headquartered within the 6th Federal Reserve District in the southeastern United States.<sup>5</sup> The BIE has been fielded continually since October 2011. For this paper, we use data from October 2011 through January 2021, a total of 112 successive monthly waves. Nearly 75 percent of the panel consists of C-suite executives and business owners; see Figure A.1. Another 20 percent or so of respondents carry titles like “Controller”, “Director of Finance”, and “Director of Forecasting”. Given the forward-looking and probabilistic nature of the BIE’s main question of interest, it is important to reach decision makers within a firm engaged in strategic operations and planning for the future.

Panel coverage includes firms across every major industry in the private nonfarm sector and a full range of firm sizes (provided that the firm is an employer).<sup>6</sup> The Atlanta Fed engages in a purposive sampling methodology in finding and recruiting new panel members, oversampling firms with 100 employees or more and from cyclical sensitive industries, yet still attempting to maintain an industry composition that is largely reflective of the national economy at the two-digit North American Industry Classification System (NAICS) level.

Table 1 reports the industry and size characteristics of the BIE survey panel. Relative to the physical count of establishments in the U.S. – according to the Census Bureau’s *Statistics of U.S. Businesses* 2017 – the BIE panel is underweighting small firms.<sup>7</sup> Yet, despite their large share of establishments, small firms account for roughly 1/4 of annual payroll in the U.S., whereas firms with 500 employees or more are a smaller fraction of U.S. establishments but account for the lion’s share of employment and payroll. The composition of the BIE panel is broadly reflective of the U.S. economy with the exception of manufacturing, which due to its capital-intensive nature is a small share of establishments or employment in the U.S. but accounts for a relatively large share of the value-added output in the U.S.

One potential criticism of the BIE panel is that it only represents firms from the Southeast U.S., and therefore may not be appropriate to ascribe the inflation expectations of this panel to the whole of the U.S. business population. However, the makeup of the 6th Federal Reserve District closely mirrors that of the U.S., both across firm size and in industrial composition. And, as we demonstrate in Appendix B, the aggregated unit costs (inflation) expectations of the BIE panel are highly correlated with those from the Survey of Business Uncertainty, which is a larger, national

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<sup>5</sup>Specifically, the 6th Federal Reserve District’s footprint consists of Alabama, Florida, and Georgia, the eastern two-thirds of Tennessee, 38 parishes of southern Louisiana, and 43 counties of southern Mississippi.

<sup>6</sup>Table A.1 provides some descriptive statistics on unit cost expectations and uncertainty by firm size and industrial classification.

<sup>7</sup>With the exception of the Census Bureau, practical probability sampling of firms in the United States is largely unfeasible, as business database providers such as Dunn and Bradstreet have difficulty capturing small firms and startups.

panel of U.S. firm expectations and uncertainty.

Importantly, the BIE survey is relatively short with the core questionnaire, consisting of just six questions, and takes roughly 3-5 minutes to complete. We view the simplicity and brevity of the questionnaire as crucial elements to maintaining our relatively high response rate (see Figure A.2) and retention rate (see Figure A.3).<sup>8</sup> As Figure A.2 shows, the response rates have stayed steady around 40 percent for the past 6 years. Our response rates compare favorably to other, voluntary surveys of businesses. For example, in Coibion et al. (2018), their response rate was 20 percent for the first wave.<sup>9</sup> The typical respondent stays with the panel for 1-2 years. Less than 5 percent of respondents fail to complete one survey once they agree to join the panel. And, we have two respondents who have stayed with the panel since its inception – completing every monthly survey we have fielded.

Our main survey question of interest from the BIE survey is the probabilistic 1-year ahead unit cost expectation question; see Figure 1 for an illustration. This question elicits inflation expectations and uncertainties from a firm’s probability assessment of year-ahead unit cost changes. Prior to the inception of the BIE, this probabilistic approach to eliciting inflation expectations had been relegated to surveying professional forecasters or households in the United States; see, e.g. Manski (2004), Engelberg et al. (2009) and Armantier et al. (2013).

The response quality to this question appears to be relatively high. Out of 23,096 observations, in just 415 cases (1.8%) the probabilities did not sum to 100 percent. We also find only 200 instances of respondents assigning 20% to each bin which may indicate Knightian uncertainty. Moreover, as Figure A.4 shows, there does not appear to be any significant tenure effects in the respondent’s probability distributions or forecast errors.

While any fixed-bin approach to eliciting probabilistic expectations could be open to framing/anchoring bias, we find that is not a significant issue with our measure, nor is the fact that the BIE’s sampling frame is geographically located within the 6th district. In Appendix B we compare the results of our probabilistic question (5 pre-set bins) to the more complicated Survey of Business Uncertainty (SBU) set up, which allows the respondent to input 5 estimates and subsequently assign probabilities to those estimates; see Altig et al. (2020) for a detailed description. Interestingly, it appears that the BIE unit cost question and the SBU unit cost question (which was retired in April 2019) capture nearly the same directional information on the first and second moments of unit cost expectations.

In sum, the BIE survey is unique in several dimensions. First is its focus on own-firm unit costs – a relevant concept to firms (see Section 3 for an in-depth discussion of relevancy, question

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<sup>8</sup>An AAPOR response rate 2 calculation is the second (out of 6 levels) most restrictive way to calculate response rates (by including partial responses). See: <https://www.aapor.org/Education-Resources/For-Researchers/Poll-Survey-FAQ/Response-Rates-An-Overview.aspx>

<sup>9</sup>There are myriad reasons to response rates to differ including survey mode, quality of contact information, and method of first contact.



wording, and concepts of aggregate inflation). We argue that unit costs are the appropriate lens for assessing firms’ beliefs on anticipated nominal changes in the economy. Indeed, [Coibion et al. \(2018\)](#) find that overall inflation is not generally perceived as being important to business decisions (or pricing) and firms devote few resources to collecting information about aggregate inflation.

Second, the BIE asks firms to assign probabilities to the pre-specified bins about year-ahead unit costs. These probability distributions provide much richer information than the widespread qualitative responses among surveys of both households and firms (e.g., expecting a variable to ‘increase’, ‘stay the same’ or ‘decrease’). Despite some efforts in using these qualitative responses, such as the quantification approach in [Mankiw et al. \(2004\)](#) and measures for variation in ordinal variables in [Bachmann et al. \(2013\)](#), it is difficult to extract the quantitative measures of expectations. In contrast, the subjective probability distributions in our survey enable us to directly measure expected unit costs and the surrounding uncertainty for each firm.

Third is its panel structure. The monthly online BIE survey asks about five hundred CEOs, CFOs, and business owners for their predictions over time. This unbalanced panel structure contrasts with repeated cross sections in typical surveys of households and firms, and allows us to explore how firms update their expectations and uncertainty in response to new information.

Fourth, our survey panelists come from firms headquartered within the sixth Federal Reserve District, but represent firm distributions at the national level, both across firm size and in industrial composition. And, the inflation expectations of the BIE panel are highly correlated with those from a larger, national panel of U.S. firm expectations.

### 3 Unit Costs and Inflation Dynamics

In this section, we provide evidence that firms place little value on “aggregate” inflation concepts, suggesting a lack of relevancy. Conversely, unit costs appear to be very relevant to firms. In two separate experiments, we asked firms to gauge the level of importance they place on aggregate price statistics and inflation in general. The sample was split at random with half of the respondents receiving the “economy’s overall rate of inflation” and the other half receiving “unit costs.” Only a small minority of firms we sampled view the Consumer Price Index or the “economy’s overall rate of inflation” as having a significant influence on their firm’s business and pricing decisions. These results suggest that firms operating in the current low inflation environment that has persisted since the inception of the BIE Survey in 2011 view unit costs as a more informative input into their pricing decisions than aggregate inflation. This finding appears to be related to the rational inattention arguments put forth by [Sims \(2003\)](#), [Woodford \(2003\)](#) and [Mackowiak and Wiederholt \(2009\)](#).

In addition to survey evidence that suggests that nominal marginal (unit) costs are a relevant and important concept that impact business decision making, we appeal to the micro-foundations

of the New Keynesian Phillips Curve to provide a theoretical justification for eliciting nominal marginal (unit) costs and aggregating these responses into measures of business inflation expectations instead of taking the mean of firms' responses to questions over "aggregate" inflation expectations.

Embedded in the relevancy argument is concerns over question wording. We find question wording matters for inflation expectations measurement. In three separate experiments (with the third being a Randomized Control Trial or RCT), utilizing monthly special questions space in the BIE survey, we elicited respondents' aggregate inflation expectations using different phrases to describe the concept of inflation. We find that firms' inflation expectations vary by the type of question and phrasing that surveyors use to elicit an expectation. Importantly, vague phrases like prices "overall in the economy" and "prices in general" do not appear to be conceptually related to what economists consider to be inflation in the minds of business executives, nor are they relevant for business decision making.

This section ends with another RCT by informing firms of the views of professionals. We find that the inflation information treatment had little impact on firms' aggregate inflation expectations and uncertainty for 2021.

### 3.1 The Relevancy of "Aggregate" Concepts of Inflation

A question central to economists' understanding and interpretation of survey measures of inflation expectations is simply whether inflation is a meaningful concept to households and firms. Do people hold well-formed views on "aggregate" inflation and act upon the expectations they hold? Or, given the current low and stable inflation environment are economic actors rationally ignorant of aggregate inflation?

In two separate special questions, we asked firms to gauge the level of importance they place on aggregate price statistics and inflation in general. In January 2015, we asked firms, "On a scale of 1 to 5, with 1 being "no influence," please indicate what level of influence, if any, price statistics such as the Consumer Price Index have on your business decisions?" And, in September 2015, we asked, "On a scale from 1 to 5, with 1 being "no influence," please indicate what level of influence, if any, your expectation regarding the [economy's overall rate of inflation] and [unit costs] has on your pricing decisions?" The sample was split at random with half of the respondents receiving the "economy's overall rate of inflation" and the other half receiving "unit costs."

Figure 2 reports the results of those special questions. Only a small minority of firms we sampled view the Consumer Price Index or the "economy's overall rate of inflation" as having a significant influence on their firm's business and pricing decisions. These results suggest that firms operating in the current low inflation environment view unit costs as a more informative input into their pricing decisions than aggregate inflation.

Related to concerns over relevancy and the potential for social desirability bias, [Kim and Binder](#)

(2020) find significant conditioning effects for both household and firm inflation expectations (“price in general” or “overall inflation”) panels. Yet, when it comes to households’ own-earnings expectations, this effect does not exist. One interpretation is that aggregate inflation is a concept that holds little relevance in the minds of respondents, yet out of a desire to appear informed, these respondents appear to be educating themselves on the topic. Just as panel conditioning doesn’t exist for a relevant concept like households’ own-earnings, we do not find a conditioning effect in the BIE when asking firms for their own unit cost expectations (see Figure A.4). Lack of survey tenure effects in the BIE gives us further confidence in the suitability of eliciting own-firm unit costs.

Unlike “aggregate inflation,” firm decision makers appear to hold expectations about potential changes in their own costs. Their attention to costs has been confirmed in the BIE using various approaches. One significant illustration of firms’ keen focus on cost change is the frequency with which firms plan for or forecast potential cost change. In March 2015, roughly 94 percent of respondents indicated they engage in planning or forecasting of cost change, with the 71 percent noting a planning frequency between daily and quarterly (see Figure A.5).

We find unit costs have a much greater influence on business and pricing decisions than “aggregate” inflation. That is to say unit costs are relevant to businesses, whereas, in the low, stable inflation environment in the U.S. “aggregate” inflation concepts carry little weight in the minds of business executives. While, empirically, this is an interesting finding – one that we show has value both on a micro level in Section 4 and an aggregate level in Section 5 – we first appeal to a theoretical justification for eliciting unit cost expectations from firms.

### 3.2 A Theoretical Justification for Eliciting Unit Cost (Inflation) Expectations

On a fundamental level, the micro-foundations of the New Keynesian model only require individual firms, denoted by  $f$ , set prices as a markup  $\mu_f$ , over their own *nominal* marginal costs  $MC_{f,t}$ . Without frictions that would delay a firm’s ability to adjust prices, a given firm’s pricing decision is represented by<sup>10</sup>

$$P_{f,t} = \mu_f MC_{f,t}. \tag{1}$$

Taking the logs of equation (1) and assuming a constant elasticity of demand, equation (1) becomes:

$$\ln P_{f,t} = \gamma_f + \ln MC_{f,t}, \tag{2}$$

where  $\gamma_f$  is the log of the firm-specific (constant) markup over nominal marginal costs.

To make the above more tractable and allow for price-setting frictions of the Calvo (1983)-type –

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<sup>10</sup>This exposition follows directly from Carlsson and Nordstrom Skans (2012) and was drafted as an internal memo by Bryan et al. (2015).

where only a subset of firms can adjust prices in a given period, equation (2) becomes dependent on firms’ expectations. Firms will consider the (nearly) optimal price today, taking into consideration expected changes in nominal marginal costs between today and an opportunity to adjust price in the future (with some attendant positive probability). As noted by [Carlsson and Nordstrom Skans \(2012\)](#), the popular Calvo economy representation of equation (2) can be expressed as:

$$\ln P_{f,t} = \gamma_f + (1 - \beta\theta)E_t \sum_{k=0}^{\infty} (\beta\theta)^k \ln MC_{f,t+k}. \quad (3)$$

where  $\beta$  is a discount factor and  $\theta$  is the probability that a firm will be allowed to engage in a price adjustment. In the Calvo case, a firm sets prices based on a markup over the weighted average of the discounted stream of nominal marginal costs, where the weight of the  $k$ th term reflects the probability of being stuck with the reset price ( $P_{f,t}$ ) over the next  $k$  periods.

From the perspective of individual firms, pricing decisions in the New Keynesian framework are based on expected future *nominal* marginal costs. This exposition does not preclude firms from holding expectations about some notion of aggregate inflation measure as an input into firms’ formulation of their own nominal marginal cost expectations. Indeed, that process is akin to [Afrouzi \(2020\)](#) – where firms with multiple competitors have a greater likelihood of holding an inflation expectation closer to what economists consider “aggregate” inflation. However, as appears to be the case with rationally inattentive firms in a low inflation environment, the micro-foundations of the New Keynesian framework do not necessitate that firms hold an aggregate inflation expectation. And, such an expectation is likely to be nested in their own unit cost expectations.

Both theory and survey responses suggest that in order to gain useful information on the expectations that firms hold when they are setting prices, researchers should elicit firms’ expectations over nominal marginal (unit) costs.

### 3.3 Wording and Inflation Expectations: Experimental Evidence

As [Shiller \(1997\)](#) highlighted rather famously, the concept of inflation is somewhat difficult for the general public to understand, and that understanding differs markedly from the textbook definition. Households tended to think of inflation as a real phenomenon – something that lowered their standard of living. Given the importance that inflation expectations have in models of the macroeconomy and that inflation appears to be conceptually challenging to grasp, it becomes crucial to demonstrate in surveys of inflation expectations that 1) the respondent understands the concept (i.e. the wording of the question appropriately elicits the concept the surveyors are attempting to elicit) and 2) once properly identified, that concept of inflation influences their decision making. Wording issues are well known in the survey literature. And, on the topic of inflation expectations there is a growing understanding that wording choice can influence the results; see [Armantier et al. \(2013\)](#) and the references therein.

Using experimental design from the Atlanta Fed’s BIE panel, we examine whether changes in question wording matter for inflation expectations measurement in this section and whether the concept of inflation, once appropriately identified, is important to business decision making in the next section.

In September of 2014, the following special question was asked:

“During the next twelve months, by how much do you think prices will change overall in the economy? Please provide a quantitative answer.”

Firms in the BIE panel expected prices “overall in the economy” to increase by 4.6 percent over the year ahead, compared to a 3.7 percent increase reported by the University of Michigan in September of 2014.<sup>11</sup> As shown in the upper panel of Figure 3, there was a tremendous amount of heterogeneity and digit-preference (especially at 2, 3, 5, and 10 percent).

These results are similar to Coibion et al. (2018) and households surveyed by the University of Michigan; see Armantier et al. (2013), among others. Importantly, responses to this vague type of question – which suggest that inflation expectations are held with a wide variance and upwardly biased relative to measured inflation rates – have been used by Kumar et al. (2015) and Binder (2017) to suggest that firms’ inflation expectations exhibit many of the same properties as households’ inflation expectations, concluding that the public is not well informed about the concept of inflation and that central bank communication is lacking.

In October 2014, the following special questions were asked of the BIE panel:

“On a scale from 1 to 5, with 5 being “very familiar”, please choose the option that best describes your level of familiarity with the Consumer Price Index, commonly referred to as CPI (1-5, with 1-unfamiliar and 5-very familiar).”

“Please indicate what probabilities you would attach to the various possible percentage changes to the Core (ex food and energy) Consumer Price Index over the next 12 months. (Values should sum to 100%).”<sup>12</sup>

The lower panel of Figure 3 plots the distributions of core CPI expectations over the year ahead (expected values from the probability vectors multiplied by the mid-point of the bin ranges). Firms’ mean expectation (the average of the cross-section of expected values) for the core CPI over the year-ahead in October 2014 was 1.9 percent, compared to 2.0 percent for professional forecasters

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<sup>11</sup>Note that BIE responses were not truncated, nor were follow-up prompts given to firms with exceeding high responses as the University of Michigan does with its Survey of Consumers.

<sup>12</sup>The same 10 response options (bins) ranging from “will decline” to “4.0 percent or more” used in the SPF were presented to the BIE panelists.

during that quarter.<sup>13</sup> The median response was 2.0 percent and the standard deviation was 0.9 percent.<sup>14</sup>

Firms’ responses to the October 2014 core CPI expectations question were in stark contrast to panelists’ responses to prices “overall in the economy” which occurred just one month prior. As Figure 4 and Table A.2 show, which restrict the panel to only firms that have answered both sets of special questions in addition to the standard monthly question on unit costs, the correlation between firms’ expectations for prices “overall in the economy” and their own unit costs or expectations for core CPI inflation are insignificant. Interestingly, core CPI expectations are positively and significantly correlated with unit cost expectations. This is clear evidence that the concept of “overall” prices is unrelated to expectations about future (core) inflation or future unit costs. The implication that we draw from this analysis is that the phrasing and wording of the question matters a great deal to the respondent’s understanding of the question, and, therefore how the researcher ought to interpret their findings.<sup>15</sup>

### 3.4 Providing a Clue that “Prices in General” means CPI: A Randomized Control Trial

Another test of whether respondents’ understanding of inflation changes with wording comes from the July 2015 special question. In this randomized controlled trial (RCT), panelists were asked the University of Michigan’s Survey of Consumers sequence of questions to elicit a 1-year ahead “prices in general” expectation. The panel (185 responses) was randomly assigned to two groups. The first group (control) got the Michigan sequence for “prices in general.” The second group (treatment) received information that prices in general is synonymous to inflation as measured by the CPI using a parenthetical containing the phrase: “Like those measures by the Consumer Price Index.” The additional treatment language was designed to reinforce to the respondents that “prices in general”, as macro textbooks suggest, is akin to measured inflation.

Specifically, firms were asked

“During the next 12 months, do you think that prices in general (information treatment: “like those measured by the Consumer Price Index”) will go up, or go down, or stay where they are now?”

[If respondents indicated “go up or go down”]“By about what percent do you expect

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<sup>13</sup>Perhaps incidentally, the 12-month growth rate in the core CPI through October 2015 was 1.9 percent.

<sup>14</sup>One potential source for the relatively higher variance of expectations on the part of firms is that the BIE special question asked for inflation over a 12-month horizon. The SPF asks for a Q4/Q4 concept.

<sup>15</sup>Two caveats are in order. First, because the special questions are posed roughly 30-days apart, we cannot control for changes in measured inflation or news stories regarding inflation influencing firm’s responses. There are also differences in the form of the special question that may impart a framing bias (probabilistic responses vs. open-ended “free” text boxes).

prices (like those measured by the Consumer Price Index) to go up or down on average, during the next 12 months?”

[If respondents indicated “stay where they are”] “When you say prices will stay the same, do you mean that prices will go up at the same rate as now, or that prices in general will not go up during the next 12 months?”

As shown in Figure 5, inclusion of the phrase “like those measured by the Consumer Price Index” has a sizeable effect on the distribution of responses to the “prices in general” expectations question, leading to a mean response that is 1.1 percentage points lower and a range of responses that is more tightly distributed. Our interpretation of these results is that inclusion of the treatment phrase clued-in respondents that the phrase “prices in general” is equivalent to measured inflation.<sup>16</sup>

Figure 6 provides further evidence that the inclusion of the treatment phrase (“like those measured by the Consumer Price Index”) informs the respondent that the question is, indeed, attempting to elicit an inflation expectation. The figure relates a panelist’s core CPI inflation expectation (from the October 2014 special question) to the respondent’s “prices in general” expectation from July 2015 for the 154 respondents that answered both sets of special questions. The correlation between the control group’s “prices in general” expectation and their core CPI inflation expectation is -0.08 and insignificant. However, the treatment group’s “prices in general (like those measured by the Consumer Price Index)” expectation is positively correlated (0.27) and statistically significant at the 5 percent level.

In summary, we show that firms’ inflation expectations vary by the type of question and phrasing that surveyors use to elicit an expectation. Importantly, vague phrases like prices “overall in the economy” and “prices in general” do not appear to be conceptually related to what economists consider to be inflation. And, importantly, firms’ responses to questions regarding “aggregate inflation” suggest that the concept is not relevant to business decision making in a low-inflation environment.

### 3.5 Informing Firms of the Views of Professionals: A Randomized Controlled Trial

Of key interest to monetary policymakers and economists alike is whether businesses respond to and incorporate information on the inflation projections and attendant uncertainty when forming their own expectations. Studies such as Coibion et al. (2018) and Coibion et al. (2020) find mixed evidence that firms in a RCT setting incorporate information on the inflation expectations of professionals or the inflation projections (and goals) of monetary policymakers into firm’s point estimates of inflation expectations. And, importantly, whether this new information provides a

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<sup>16</sup>While the phrase “prices in general” was used instead of prices “overall in the economy”, as Bryan et al. (2015) point out, both phrases are ambiguous.

lasting, significant impact on key firm decisions, such as hiring plans. We advance these RCTs to study the impact of information about the uncertainty around monetary policymakers’ inflation expectations on firms’ own unit cost expectations and uncertainty.

In October 2020, we asked firms for their highest and lowest potential expectations for Personal Consumption Expenditures (PCE) inflation in 2021. In this experiment, we wanted to test whether giving business decision makers information on the *uncertainty* (in the form of confidence interval) around monetary policymakers’ projections influenced their inflation projections in October, and to see if this information impacts firms’ own unit cost expectations over the year ahead a month later in November 2020. To make sure that the information we were supplying was about the second moment only, we provided both the control and the treatment groups with the median expectation for PCE inflation over calendar year 2021 from the FOMC’s Summary Economic Projections (SEPs) on September 15, 2020. For the treatment group we provided the 70 percent confidence interval around those projections based on the historical forecast errors of professionals (excerpted from the minutes of the September 2020 FOMC meeting).

Specifically, we asked

“The median expectation of monetary policymakers for inflation over calendar year 2021 was 1.7 percent (as of September 15th). [Treatment: Based on forecasts over the past 20 years, there is a 70 percent chance that actual inflation will be in the range of 0.7 percent to 2.7 percent over calendar year 2021.] What is your best estimate for the highest and lowest potential rate of inflation over calendar year 2021?”

Panel A of Table 2 provides some simple descriptive statistics on firms’ inflation expectations for 2021, separated by whether they receive the treatment about the uncertainty of these projections. Two interesting facts emerge from Panel A. First, firms’ lowest and highest potential inflation expectations for 2021 are higher, on average, than that of professionals. This finding, in the light of other literature on household and business inflation expectations, is not all that unusual. However, firms’ spread between “highest possible” and “lowest possible” is fairly similar to the 70 percent confidence interval provided to the treatment group. And, perhaps more interesting, is that the control group had a nearly identical spread between their projections for the highest and lowest possible inflation in calendar year 2021.

There is another, rather important, aspect of these results that we need to point out. Table A.3 recreates Table 2 without excluding outliers. There were a handful of firms (four respondents in the treatment group and two in the control group) that, even after receiving policymakers’ expectations for 2021 (and, for the treatment group a 70 percent confidence interval), responded with expectations for lowest or highest possible anticipated 2021 inflation in excess of 10 percent. We find this interesting because it implies that these firms either hold expectations for aggregate inflation that are roughly an order of magnitude above that of monetary policymakers, they still



don't understand the guidance, or, perhaps most likely, that the concept of aggregate inflation isn't meaningful enough for them to answer honestly.

The inflation information treatment had little impact on firms' aggregate inflation expectations and uncertainty for 2021. And, as shown in panel B of Table 2, we can still see the information provided to firms in October had no discernable impact on their own unit cost expectations and uncertainty.

While these are null findings, they are not surprising to us. Our previous work (both in this paper and in other projects) highlight that firms don't hold well-formed priors around aggregate inflation. Treating businesses with information on monetary policymakers' aggregate inflation expectations does not have a meaningful or durable impact on firms' unit cost expectations or uncertainty. Hence, informing the public about aggregate inflation will not have meaningfully changed firms' inflation expectations.

Firms themselves tell us that providing information about aggregate inflation through the projections of monetary policymakers does not heavily influence unit costs and prices forecasts (see Figure 7 on influence of monetary policymakers' inflation projections). Just 1.4 percent of respondents suggested these inflation projections directly influenced their own-costs or own-prices forecasts. Again, as our other results on the relevancy of "aggregate inflation" suggest, policymakers' views of the inflationary environment are not a material input into businesses' forecasts for unit costs or prices. In sum, U.S. firms operating in a low inflation environment appear to be rationally inattentive to aggregate inflation, and thus, policymakers expectations for aggregate inflation. For the remainder of the paper we turn our focus to what firms' unit cost expectations can tell us at the micro and macro level.

## 4 Inflation Expectations and Uncertainty: Micro Evidence

In this section we document some simple facts and relationships in the BIE microdata to demonstrate that firms are answering survey questions in a reasonable way.

### 4.1 Analyzing the Probability Forecasts

Two issues arise in using firm's subjective distributions. First, the histograms have open intervals at both ends. We close these open intervals by using the same width of the middle intervals. Second, many firms assign probabilities to one or two intervals, implying very small degrees of freedom. This concern prompts us to consider reconstructing the histograms by simulating observations. Specifically, we generate 1,000 samples uniformly within each interval, with supports equal to the range of the interval and the sample size being proportional to the probability assigned to each interval. The histograms of the reconstructed data sets are indistinguishable from the originals.

We estimate the mean and variance of each firm’s density forecast both parametrically and non-parametrically. For nonparametric estimation, we assume that the probability is concentrated at the midpoint of each interval.

Following [Giordani and Söderlind \(2003\)](#) and [Engelberg et al. \(2009\)](#), we fit normal and beta distributions to the histograms. Compared to nonparametric estimation, fitting these two distributions enables shaper empirical analysis, but imposes assumptions about the shapes of the histograms – in particular, that they are unimodal. While the assumption of unimodality is not problematic in SPF density forecasts, some firms in the BIE survey assign positive probabilities to non-adjacent bins.<sup>17</sup>

To accommodate the bimodality, we adopt the bimodal asymmetric power normal (BAPN) distribution, proposed by [Bolfarine et al. \(2018\)](#). Let  $\phi$  be the probability density function of standard normal distribution, and  $\Phi$  be its cumulative distribution function. The density of the BAPN model is given by

$$h(x) = 2\gamma c_\gamma \phi(x) \Phi(|x|)^{\gamma-1} \Phi(\lambda x), \quad (4)$$

for  $x \in \mathbf{R}$  with  $c_\gamma = \frac{2(\gamma-1)}{2\gamma-1}$ ,  $\gamma > 0$  and  $\lambda \in \mathbf{R}$ . The distribution is bimodal if  $\gamma > 1$ , with larger  $\gamma$  denoting greater separation between modes.  $\lambda$  controls the amount of skewness, with left skewness for  $\lambda > 0$ . Note that, as  $|\lambda|$  increases, bimodality becomes less pronounced. The BAPN model, denoted by  $BAPN(\gamma, \lambda)$ , nests two other popular distributions, with  $BAPN(1, 0)$  being standard normal and  $BAPN(1, \lambda)$  being skew normal distribution. A desirable feature of the BAPN model is its non-singular information matrix that guarantees large sample properties of the maximum likelihood estimators.

As an illustration, we make comparisons between BAPN, normal and beta model fitting in Appendix C; see Figures C.1–C.3. For histograms being moderately bimodal and strongly bimodal, the BAPN provides the best fit when compared with normal and beta models. This visual inspection is further collaborated by descriptive measures and formal tests, such as Bayesian Information Criterion, Mean Squared Error between the fitted and the empirical cumulative distribution function, and the Kolmogorov-Smirnov test having the fitted model as the null model against the two-sided alternative; see Table C.1.

Bimodality appears to be somewhat unique to business expectations. Professional forecaster expectations from the SPF do not exhibit any material bimodality; see [Binder et al. \(2020\)](#). Approximately 2 percent of firms’ subjective probabilistic year-ahead unit cost distributions exhibit bimodality (Table 3). Instances of bimodality in the BIE exist across every major private industrial sector, although they are slightly more prevalent in durable and nondurable manufacturing sectors, and in “other” services. We contacted a small subsample (10-15 respondents) regarding the bimodality they expressed in their probabilistic unit cost expectations. Nearly every respon-

<sup>17</sup>[Binder et al. \(2020\)](#) find that this bimodality does not exist for surveys of professionals in ECB SPF dataset, since in all cases where professional forecasters assign probability to multiple bins, these bins are adjacent.

dent was able to articulate a scenario-based reason for reporting anticipated bimodality. It also appears that, in this small handful of responses, bimodality was meant to convey some sort of conditionality to their forecasts (i.e. “If transportation costs rise by X, then my costs will likely be Y”). Not only do these instances of bimodality justify the BAPN estimator, but the responses to follow-up interviews indicate that respondents are putting thought into their responses around unit costs (and that unit costs are a meaningful concept followed closely by business decision makers). Also, as shown in Table A.1, nonparametrically calculating unit cost uncertainty systematically underestimates uncertainty relative to a parametric approach.

Therefore, in all subsequent analysis, we fit the BAPN model to histograms – with  $\gamma > 1$  to capture the bimodality and  $0 < \gamma \leq 1$  to capture the unimodality. We use the mean and variance of the BAPN distribution as the first- and second-moment of inflation expectations at the firm level, and compare these parametric estimates to nonparametric counterparts when appropriate.

Figure 8 shows bin-scatters for both the parametric and nonparametric means of the 5-bin probabilistic distribution of a given firm’s 1-year ahead unit cost growth to a given firm’s ex post perceived unit cost growth over the past year. The unit cost expectations are on the horizontal axis and the vertical axis plots unit cost growth over the ensuing 12 month time period. The bin-scatters show a tight positive relationship between firm’s unit cost forecasts and their realized (perceived) unit cost growth over that 12 month period. Using both parametric and nonparametric expected values, we see that the mean error (i.e. unit cost growth at time  $t$  minus expected cost growth at  $t - 12$ ) is slightly negative.<sup>18</sup> Firms, especially larger ones, over this period have been a bit too pessimistic with their unit cost expectations.

Figure 9 shows that the more uncertain a given firm is about their future unit costs – that is, the higher the variance of their subjective probability distribution – the larger their absolute forecast errors tend to be. In other words, firms tend to *know what they don’t know*. Furthermore, firms that are highly cyclical or volatile industries (manufacturing, construction, mining and finance) tend to have larger absolute forecast errors.

## 4.2 Unit Costs and Prices on a Firm Level

For unit cost expectations to be an important determinant of future inflation, these expectations must feed through into expectations and realizations for price changes. Surveying firms around price change expectations can be complicated by nominal frictions (i.e. price stickiness). For example, over the course of 2019 and into 2020 a battery of special questions were posed to the BIE panel that included a question eliciting firms’ recent (3-month) price changes for the product/product line or service responsible for the largest share of the firm’s revenue (a “representative” price). This question was fielded once per quarter over a four quarter period and out of the resulting 1,112

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<sup>18</sup>The forecast error averaged across firms is -0.18 from the parametric method and -0.17 from the nonparametric method.

usable responses, 367 or 1/3 were zero (indicating the potential presence of nominal frictions). This is consistent with studies such as [Bils and Klenow \(2004\)](#) and [Klenow and Kryvtsov \(2008\)](#) that suggest firms typically change their selling price less often than once a quarter (excluding temporary sale prices, the typical frequency of price change rises to nearly once a year). This is also consistent with theoretical treatments of nominal frictions, particularly rational inattention models proposed by [Woodford \(2003\)](#) and [Mackowiak and Wiederholt \(2009\)](#), where firms pay much more attention to their own unique conditions rather than aggregate conditions. In surveys, this price stickiness is first documented by [Blinder \(1991\)](#). In part for this reason, for reasons related to the microfoundations of the New Keynesian model, and for reasons related to firm’s survey responses, the BIE chose to elicit unit costs instead of prices in its core questionnaire.<sup>19</sup>

Firms’ unit cost expectations are related to their average (or representative) price change expectations. We aggregate the responses to three special questions on the year-ahead price expectations of firms and relate them to year-ahead unit cost expectations.<sup>20</sup> [Table 4](#) shows the results of simple OLS regressions of year-ahead price change expectations (for the given month) against firms’ unit cost expectations and trailing year-over-year unit cost realizations. [Figure 10](#) shows a binscatter of the results from specification (4) in [Table 4](#).

As indicated by the regression results and binscatter, firms’ year-ahead unit cost expectations covary strongly with year-ahead price expectations across all three periods. As suggested by the empirical investigation of unit costs and price changes of [Carlsson and Nordstrom Skans \(2012\)](#), expectations of future unit costs appear to play a role in firms’ price formation strategies. However, this relationship is not one-for-one (likely due to aforementioned impediments to continuous price adjustments).

While unit cost realizations do not appear to play a significant role in forward price change expectations, they do appear to be significantly related to realized short-run price changes. In the final column of [Table 4](#) we regress firms’ short-run (3-month) major (representative) product/service price changes on lagged unit cost expectations and current realized (year-over-year) unit cost growth. The results suggest that unit cost realizations are positively and significantly related to price changes (along with past unit cost expectations). While these relationships are positive, significant, and economically meaningful, they are not overly tight. This is to be expected given the short-run (“sticky”) frequency over which realized price changes are measured. This could also be due to changes in markups, changes in competitive conditions, or other nominal rigidities.

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<sup>19</sup>Given the time constraints in the survey, responses to price expectations and realizations were gathered from special questions.

<sup>20</sup>In June 2013, the BIE elicited probabilistic year-ahead expectations of firms’ average prices using the same format as the core BIE unit cost expectations question. In February 2019, the BIE elicited probabilistic year-ahead “representative” price change expectations using the SBU format (see [Altig et al. \(2020\)](#)). And, in December 2020, firms were asked to provide their point estimates for the percentage change in the product/product line or service responsible for the largest share of revenue. Detailed wording for all special questions posed to the BIE panel can be found here: <https://www.frbatlanta.org/research/inflationproject/bie/special-questions>.

Still, these results suggest that, at a firm level, changes in unit costs are an important driver of price changes.

However, in a series of special questions elicited over the course of January 2019 through January 2020, we find little evidence that firms' year-ahead ex ante aggregate inflation expectations are related to their ex post year-over-year price change. Table 5 shows the simple correlations between firms' realized price changes over the past year, aggregate (CPI-based) inflation expectations (elicited in January 2019), firms' year-ahead expected price changes as of February 2019, lagged unit cost expectations, and firms' unit cost growth over the past year. In stark contrast to firms' year-ahead price expectations, firms' expectations for aggregate (CPI) inflation are uncorrelated with reported price changes in the cross section. This result conforms to the notion that aggregate inflation expectations are not relevant (or central) to firms' price-setting behavior. As they reported to direct questions on the usefulness of aggregate inflation (see Figure 2), firms appear to pay more attention to their own idiosyncratic conditions.

The results in Table 5 are also consistent with the [Mackowiak and Wiederholt \(2009\)](#) rational inattention model. Firms in this model allocate almost all attention to idiosyncratic rather than aggregate conditions. As evidence of the dominance of idiosyncratic conditions, we decompose the variation in realized unit cost growth into its common (aggregate), sectoral, and idiosyncratic (firm-specific) components using the panel variance decomposition methods.<sup>21</sup> We find that the relative standard deviation of the sector-specific component is about 4 times as large as the aggregate component of unit cost growth. The relative variation of the idiosyncratic component is approximately 7 times that of the aggregate. These are similar to what [Carlsson and Nordstrom Skans \(2012\)](#) found using Swedish firm-level production data. Extending their work by applying this decomposition to firm-level unit cost expectations reveals a relative standard deviation of the sectoral component and the idiosyncratic component of 4 times and 9 times as large as the aggregate variation, respectively.

The combined evidence from special questions and the variance decompositions of unit cost growth and unit cost expectations suggest that firms pay much more attention to their own firm-level behavior rather than an aggregate notion of inflation. And this focus on own-firm, idiosyncratic, variation is borne out in the panel variance decompositions of unit cost growth and expectations. In the next section, we then collect all these, seemingly disparate, firm-level views on costs to see if the aggregated experiences and expectations of firm-level views can be useful lens into the aggregate economy.

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<sup>21</sup>The variance decomposition follows a two-stage panel regression strategy. First, the aggregate component is uncovered by regressing unit cost growth (unit cost expectations) on time dummies and clustering standard errors at the firm level. The second stage takes the residual series and separates it into sectoral (2-digit NAICS) component and an idiosyncratic component. The standard deviations of these components are available upon request.

## 5 Inflation Expectations and Uncertainty: Macro Evidence

In this section, we provide evidence that firms’ judgments about expected unit costs are correlated with other well-known measures of inflation expectations and that firms’ perceptions about current unit costs track movements in measured inflation. We also exploit the probabilistic nature of the BIE’s inflation expectations question to show that firms’ subjective uncertainty is correlated with market-based measures of uncertainty and professional forecaster disagreement about future inflation.

### 5.1 Inflation Expectations and Perceptions

We find that businesses’ aggregated unit cost (inflation) expectations are correlated with professional forecasters’ inflation expectations and market-based measures of inflation compensation, but do not co-move with household inflation expectations. Specifically, we aggregate the expected value of the individual firm’s unit cost expectations from the BIE survey using an industry-weighted average by month. Quarterly estimates are calculated by averaging over the three months of the quarter. We compare the 1-year ahead unit cost expectations from the BIE survey to the inflation expectations from households (University of Michigan’s Survey of Consumers), Professional forecasters (Philadelphia Fed SPF and the Blue Chip), and TIPS-based measures of inflation compensation.<sup>22</sup>

Table 6 reports the pairwise correlations and statistical significance for inflation expectations. Business inflation expectations are highly and significantly correlated with professional forecasters’ expectations for a variety of alternative inflation statistics (CPI, core CPI, core PCE, and GDP deflators). Interestingly, movements in household inflation expectations are negatively correlated with those of both businesses and professionals. This finding is particularly interesting as it dovetails with our analysis in the previous section that suggests the vague nature of “prices in general” is not synonymous with what economists would consider the concept of inflation. Figure 11 provides a time-series visual of how tightly BIE inflation expectations co-move with professionals’ expectations.<sup>23</sup>

Perhaps as compelling is that firms’ collective judgment over the trajectory in their own unit costs lines up with measured inflation. Figure 12 shows that firms’ unit cost growth over the past year carries a correlation coefficient of 0.81 with the BEA’s GDP Price Index – the broadest measure of inflation as it tracks price changes of all goods and services produced in the U.S.<sup>24</sup> This suggests that changes in firms’ unit costs are indeed closely related to the changes in the prices they charge

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<sup>22</sup>We focus on 5-year break-even and 5-year/5-year forward inflation compensation measures because these measures are the most often cited in the press and by members of the FOMC.

<sup>23</sup>Table A.4 shows that these correlations hold on a monthly time frequency as well and using a different set of professional forecasters’ inflation expectations. And, Figure A.6 shows the time-series comovement of firm, household, and professional expectations on a monthly frequency.

<sup>24</sup>Firms’ aggregated unit cost expectations also covary highly with the PCE Price Index (correlation of 0.58) and Core PCE Price Index (0.63).

for their goods and services. Moreover, the BIE survey is eliciting this unit cost growth information in a way that preserving this relationship. In short, unit cost perceptions and expectations appear to be the lens with which businesses are viewing nominal fluctuations in the economy. It appears that, in order to elicit firms’ views on inflation in this low-inflation environment, one good strategy is to elicit firms’ unit cost expectations.

Figure 13 plots firms’ 1-year ahead inflation forecast uncertainty versus the probabilistic short-run inflation uncertainty from the New York Fed’s Survey of Consumer Expectations and the Philadelphia Fed’s SPF professional forecaster disagreement. While we acknowledge that disagreement may potentially be a poor proxy for uncertainty (see Rich and Tracy (2010)), we proceed in comparing firms’ and households’ probabilistic uncertainty measures to disagreement among professional forecasters. Our analysis in this area is simply comparative. Interestingly, all three measures indicate a lessening of uncertainty (tightening up in subjective probability distributions for firms and households) prior to the onset of COVID-19.<sup>25</sup>

## 5.2 Inflation Expectations and Uncertainty Since the Onset of COVID-19

As highlighted by Meyer et al. (2020), the disconnect between firms and professionals expectations and the expectations of households widened after the onset of the COVID-19 pandemic. In April 2020, firms’ inflation expectations fell to an all-time low (going back to 2011), mirroring the decline in professional forecaster expectations. In later 2020, firms and professionals’ inflation expectations then began to rebound to more “normal” levels. In stark contrast, households’ inflation expectations jumped markedly at the onset of the pandemic, alongside a sharp increase in the prices of grocery store items (which, over the first 4 months of the pandemic comprised the entirety of the upper tail of the CPI price change distribution). In regards to inflation uncertainty, the New York Fed’s measures of short-run uncertainty rose disproportionately relative to the uncertainty expressed by firms and professionals. Meyer et al. (2020) highlight that households may be disproportionately responding to sharp increases in the price of salient grocery store items rather than expressing a belief that aggregate inflation will rise.

## 6 Conclusion

The viewpoint espoused by Chairman Greenspan in the opening quote follows that in an environment with low and stable prices, firms and households will have little incentive to seek information on aggregate inflation in the first place and will engage in rational inattention. This has direct implications for monetary policymakers attempting to measure the extent to which inflation ex-

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<sup>25</sup>In the BIE survey, we can trace the tightening up in subjective probability distributions in firms’ upper tail estimates. In short, firms slowly began to put less and less probability mass in the upper two bins of the discrete distribution.

pectations are “anchored.” In particular, if firms do not pay attention to aggregate inflation in a low-inflation environment or aggregate inflation measures such as the CPI are not significant inputs into pricing decisions, then surveying firms on their *aggregate* inflation expectations is not a useful exercise.

We confirm this conjecture by taking advantage of the Atlanta Fed Business Inflation Expectations survey that elicits firm’s probability assessment about future unit costs. We find that firm inflation expectations bear little in common with the “prices in general” expectations reported by households, but are highly correlated with professional forecasters’ inflation expectations and market-based measures of inflation compensation. The concept of inflation not only matters for inflation expectations measurement, but also is important to business decisions and policymakers. Managers over our sample period are a bit too pessimistic with their unit cost expectations, and are over-confident in that ex post uncertainty is much higher than ex ante uncertainty. We see substantial heterogeneity across firms in both expectations and uncertainty, as evidenced by bimodal probability distributions.

Importantly, this paper highlights that the beliefs held by firms about prices and costs *that matter to them* are informative about the state of the macroeconomy. Heterogenous-agent macroeconomic models highlight the usefulness of gathering disaggregate survey expectations and realizations. As we show in the case of the inflation expectations of firms, further work in carefully aggregating firm-level beliefs is warranted. It isn’t enough to simply ask firms for an *aggregate* inflation expectation. Getting the detailed survey questions right at the micro level (and then aggregating up) is crucial to our understanding of macro-level phenomena.



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**Panel A: Representativeness by Firm Size**

	BIE	United States			Sixth Federal Reserve District States		
		Establishments	Employment	Annual Payroll	Establishments	Employment	Annual Payroll
Small (1–99 employees)	50.9	78.0	33.0	26.7	77.2	31.2	26.5
Medium (100–499 employees)	27.4	4.9	14.1	13.6	4.4	12.7	12.5
Large (500+ employees)	21.6	17.1	52.9	59.7	18.4	56.2	61.0

**Panel B: Representativeness by Industry**

	BIE	United States			Sixth Federal Reserve District States			Private (Nonfarm) GDP
		Establishments	Employment	Annual Payroll	Establishments	Employment	Annual Payroll	
Construction	11.9	9.1	5.1	5.9	8.5	5.1	5.9	5.1
Manufacturing	18.0	3.7	9.1	10.2	3.0	8.0	9.4	18.8
Educational services	1.7	1.3	2.9	2.1	1.2	2.1	1.7	1.6
Finance and Insurance	11.9	6.1	5.0	9.6	6.5	4.4	7.5	9.5
Health care and social assistance	3.2	11.5	15.8	14.8	11.1	14.5	15.6	7.9
Information	1.3	2.0	2.7	5.3	1.8	2.2	3.7	5.8
Leisure and hospitality	3.0	11.1	12.8	5.3	10.1	13.5	6.0	4.7
Mining and utilities	2.0	0.6	1.0	1.8	0.5	0.8	1.5	3.3
Other services except government	2.8	9.8	4.3	2.7	9.4	4.2	2.7	2.3
Professional and business services	13.0	17.8	18.9	23.8	18.8	22.4	26.4	12.9
Real estate and rental and leasing	7.8	5.2	1.7	1.7	5.7	1.8	1.9	12.4
Retail and wholesale trade	18.4	18.8	17.0	13.1	20.3	17.2	13.4	12.2
Transportation and warehousing	5.0	3.0	3.8	3.6	3.0	4.0	4.4	4.1

**Sources:** Census Bureau Statistics of U.S. Businesses 2017; Bureau of Economic Analysis; Federal Reserve Bank of Atlanta’s Business Inflation Expectations Survey.

**Notes:** This table reports the share of U.S. firms. The Atlanta Fed territory covers the Sixth Federal Reserve District, which includes Alabama, Florida, Georgia, and portions of Louisiana, Mississippi, and Tennessee.

Table 1: BIE Panel Representativeness

<b>Panel A: Lowest and Highest Forecasts for 2021 inflation</b>				
	Mean	P25	P75	N
<b><u>Treatment Group</u></b>				
Lowest potential rate of inflation	1.17	1.00	1.50	95
Highest potential rate of inflation	3.01	2.00	3.50	95
Spread (highest - lowest)	1.84	1.00	2.00	95
<b><u>Control Group</u></b>				
Lowest potential rate of inflation	1.23	1.00	1.50	102
Highest potential rate of inflation	3.07	2.50	3.50	102
Spread (highest - lowest)	1.84	1.50	2.00	102
<b>Panel B: Revisions to Expectations and Uncertainty</b>				
	Mean	P25	P75	N
<b><u>Treatment Group</u></b>				
Difference in unit cost expectations (Nov - Oct)	0.01	-0.40	0.20	85
Difference in unit cost uncertainty (Nov - Oct)	-0.03	-0.28	0.12	85
<b><u>Control Group</u></b>				
Difference in unit cost expectations (Nov - Oct)	0.14	-0.40	0.70	87
Difference in unit cost uncertainty (Nov - Oct)	-0.22	-0.60	0.33	87

Note: Results obtained via RCT special questions posed to the panel on October 2020. The median expectation of monetary policymakers for inflation over calendar year 2021 was 1.7 percent (as of September 15th, 2020). Treatment: [Based on forecasts over the past 20 years, there is a 70 percent change that actual inflation will be in the range of 0.7 percent to 2.7 percent over calendar year 2021.] Question: What is your best estimate for the highest and lowest potential rate of inflation over calendar year 2021? 212 panelists responded to the core BIE questionnaire in October 2020. Responses above 10% were excluded from these tables (4 from the treatment group and 2 from the control group). T-tests reject the notion that these differences are statistically significant at the 10% level.

Table 2: RCT: Influence of Monetary Policymakers' Inflation Projections on Unit Costs and/or Prices Expectations

<b>Panel A: Instances of Bimodality</b>			
	Count	Unit-Cost Expectation (Mean)	Parametric Uncertainty (Mean)
Bimodal distributions	338	1.88	5.95
Unimodal distributions	22025	1.90	2.73

<b>Panel B: Distribution of Bimodality</b>		
<u>Sector</u>	<u>Count</u>	<u>Share of Responses</u>
<i>Goods-producing</i>	132	2.03
Construction	25	1.33
Durable manufacturing	51	2.05
Nondurable manufacturing	54	3.19
Mining and Utilities	2	0.32
<i>Service-providing</i>	206	1.30
Educational services	1	0.18
Finance and Insurance	25	1.12
Health Care & Social Assistance	20	2.18
Information	10	1.63
Leisure and Hospitality	3	0.41
Transportation and Warehousing	5	0.52
Professional and business services	23	0.78
Real Estate & Rental, Leasing	24	1.04
Other services (excluding government)	22	6.01
<u>Firm size</u>		
Small (1-99)	156	1.56
Medium (100-499)	138	2.21
Large (500+)	44	0.72

Source: Authors' calculations.

Table 3: Instances of Bimodality in Firms' 1-Year Ahead Unit Cost Expectations

	(1)	(2)	(3)	(4)	(5)
Unit cost expectation	0.4261*** (0.0808)	0.2615** (0.1039)	0.1479** (0.0737)	0.3242*** (0.0568)	0.3828** (0.1614)
Year-over-year unit cost change	0.0438 (0.687)	0.0751 (0.0818)	0.0205 (0.0486)	0.0198 (0.0376)	0.4198*** (0.1224)
Sales level	0.1762** (0.2826)	-0.0147 (0.10678)	0.1242* (0.0647)	0.1091** (0.0507)	- -
Sector FE	N	N	N	N	Y
N	184	91	183	458	864
$R^2$	0.2015	0.1755	0.0835	0.1574	0.0360

Source: FRBA Business Inflation Expectations (BIE) Survey.

Notes: In Columns (1) to (4), regressions are estimated via OLS of the form:  $E_t p_{f,t+h} = \beta E_t \pi_{f,t+1} + \theta \pi_{f,t}^{perc} + \lambda s_{f,t} + \epsilon_{f,t}$ , where  $E_t p_{f,t+h}$  is year-ahead price change expectations (for a given month),  $E_t \pi_{f,t+1}$  is firms' unit cost expectations,  $\pi_{f,t}^{perc}$  is year-over-year unit cost realizations, and  $s_{f,t}$  is sales level. Columns (1) through (3) use the responses to special questions on expected prices elicited in June 2013, February 2019 and December 2020, respectively. Column (4) reports the result from a pooled regression across these three special surveys. In Column (5), we regress firms' short-run (3-month) major (representative) product/service price changes on lagged unit cost expectations and current realized (year-over-year) unit cost growth. Given changes in question formatting, responses were normalized and winsorized at the 2.5% and 97.5% levels. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Relationship Between Unit Cost Expectations and Price Change Expectations

Variables	(1)	(2)	(3)	(4)	(5)
(1) Realized Price Change	1.000				
(2) Aggregate Inflation Expectation	0.010	1.000			
(3) Expected Price Change	0.468***	0.046	1.000		
(4) Lagged Unit Cost Expectation	0.101	0.065	0.235**	1.000	
(5) Unit Cost Growth	0.171**	0.031	0.248**	0.307***	1.000

Source: FRBA Business Inflation Expectations (BIE) Survey.

Notes: (1) Realized price change is the winsorized (2.5%, 97.5%) and annualized 3-month price change realizations gathered from respondents quarterly from January 2019 to January 2020. (2) Aggregate Inflation is probabilistic 1-year ahead CPI expectations elicited in January 2019. (3) Expected price change is the probabilistic 1-year ahead price change expectations elicited in February 2019. (4) Lagged 1-year ahead unit cost expectations were gathered from respondents in January 2019. (5) Unit cost growth is the perceived unit cost growth over the past 12 months from the January 2020 survey. Pairwise correlations reported. \*\*\*, \*\*, and \* correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5: Realized Price Changes and Expectations: January 2019 to January 2020



Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) BIE 1yr	1.000						
(2) UM 1 yr	0.028	1.000					
(3) SPF 1yr CPI	0.634***	-0.335**	1.000				
(4) SPF 1yr PCE	0.596***	-0.071	0.781***	1.000			
(5) SPF 1yr PGDP	0.874***	-0.323***	0.81***	0.698***	1.000		
(6) SPF 1yr Core CPI	0.713***	-0.520***	0.804***	0.728***	0.806***	1.000	
(7) SPF 1yr Core PCE	0.679***	-0.401***	0.748***	0.816***	0.805***	0.916***	1.000

Note: The sample period starts in 2011q1 and ends in 2020q4. The comparisons use the mean BIE and the median measures for the University of Michigan's Survey of Consumers (UM) and Philadelphia Fed Survey of Professional Forecasters (SPF), as the medians are more widely cited in academic research, by policymakers, and in newswires. Using the mean UM and SPF measures does not qualitatively (or quantitatively) alter the results. \*, \*\*, and \*\*\* denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6: Time Series Correlations between Short-Run Inflation Expectations

Projecting ahead, to the best of your ability, please assign a percent likelihood to the following changes to **UNIT COSTS** over the next twelve months. (Values should sum to 100%)

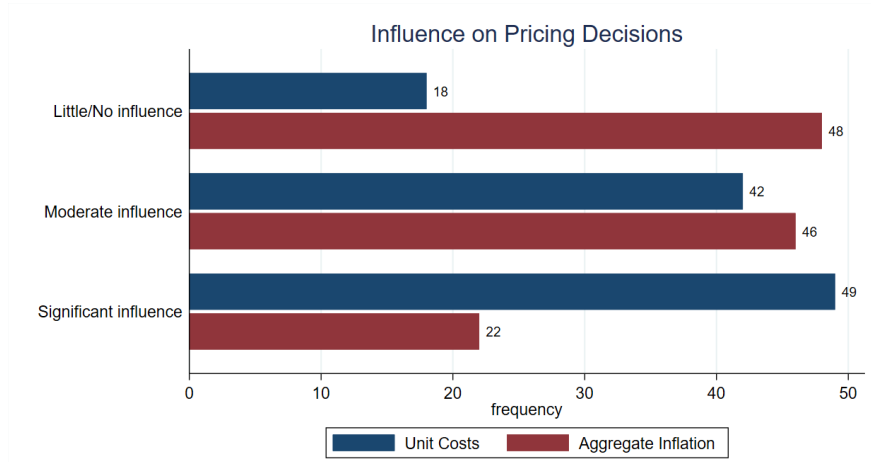
*For example, if you think each of these is equally likely, you might answer 20% for each:*

Unit costs down (less than -1%)	20
Unit costs about unchanged (-1% to 1%)	20
Unit costs up somewhat (1.1% to 3%)	20
Unit costs up significantly (3.1% to 5%)	20
Unit costs up very significantly (more than 5%)	20
<b>Total</b>	<b>100</b>

Unit costs down (less than -1%)	<input type="text" value="0"/>	%
Unit costs about unchanged (-1% to 1%)	<input type="text" value="0"/>	%
Unit costs up somewhat (1.1% to 3%)	<input type="text" value="0"/>	%
Unit costs up significantly (3.1% to 5%)	<input type="text" value="0"/>	%
Unit costs up very significantly (more than 5%)	<input type="text" value="0"/>	%
<b>Total</b>	<input type="text" value="0"/>	%

Source: FRBA Business Inflation Expectations (BIE) Survey.  
 Notes: The above figure is a screenshot of the actual current questionnaire fielded using Qualtrics. A sum of probabilities is calculated in real-time and shown in red if it does not sum to 100 percent. A respondent is not required to have probabilities sum to 100 percent before continuing on with the questionnaire. In practice, approximately 1 percent of responses to this question sum to something other than 100 percent.

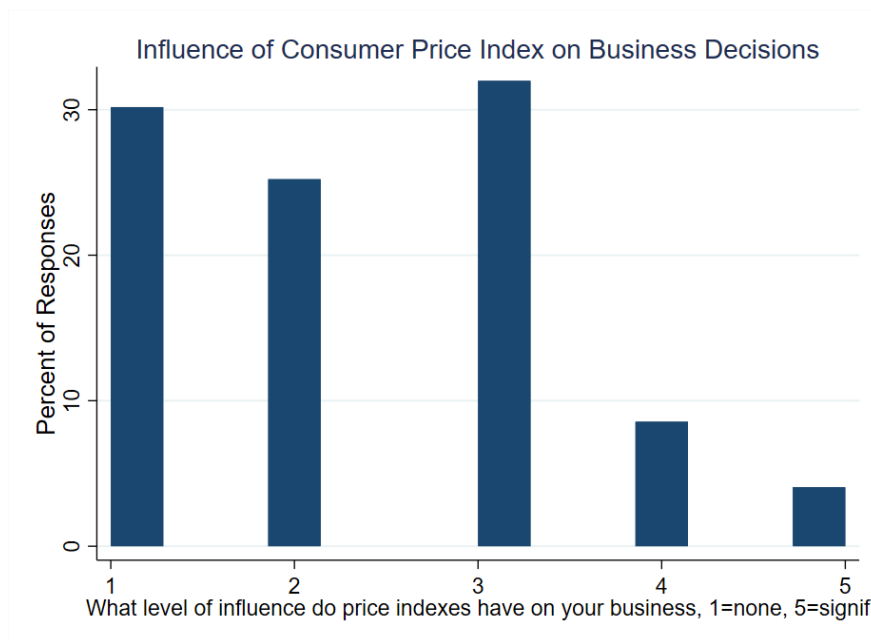
Figure 1: BIE Survey Questionnaire: Probabilistic Unit Cost Expectations



(a) Influence of Inflation on Firms' Pricing Decisions

Source: FRBA Business Inflation Expectations (BIE) Survey, September 2015.

Notes: The above bar graph plots the results of a September 2015 special question. Question: On a scale from 1 to 5, with 1 being “no influence,” please indicate what level of influence, if any, your expectation regarding [the economy’s overall rate of inflation (given to panel A)] [your own unit costs (given to panel B)] has(have) on your pricing decisions? 1 - no influence; 2, 3- moderate influence, 4, 5-significant influence.



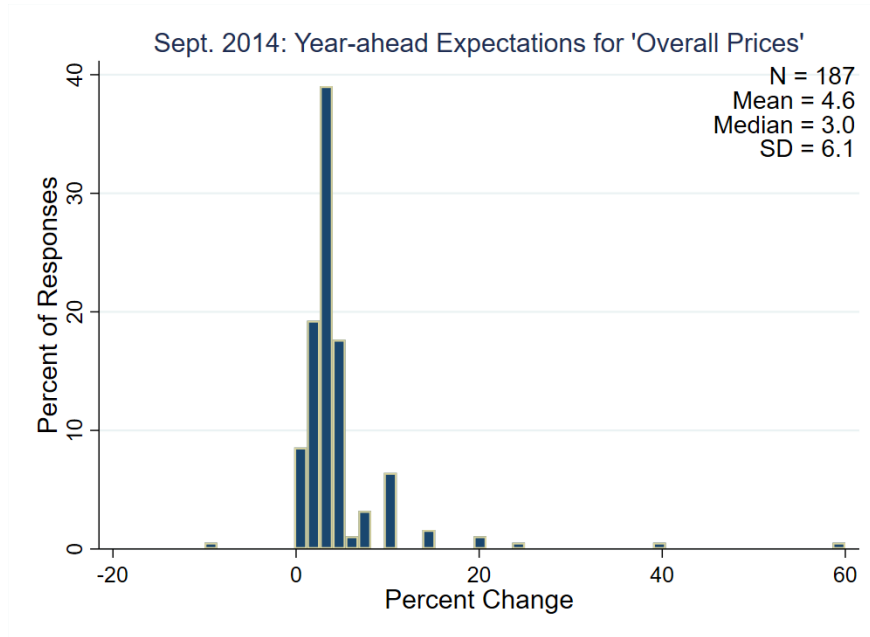
(b) Influence on Business Decisions

Source: FRBA Business Inflation Expectations (BIE) Survey, January 2015.

Notes: The above bar graph plots Likert scale responses to a January 2015 special question that elicits what level of influence do price indexes (like the Consumer Price Index, or CPI) have on your business decisions. Response options ranged from 1 (none) to 5 (significant).

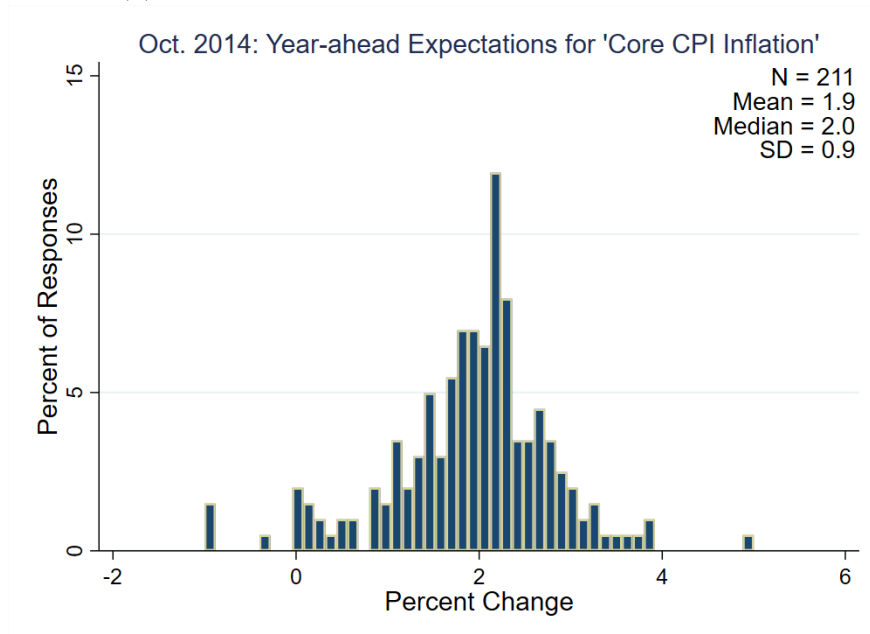
Figure 2: Influence of Inflation on Business Decisions and Pricing Decisions

(a) Firms' Expectations for "Prices Overall in the Economy"



Source: FRBA Business Inflation Expectations (BIE) Survey. Special question results from September 2014.  
Note: The above histogram plots the results of a special question in the September 2014 survey.

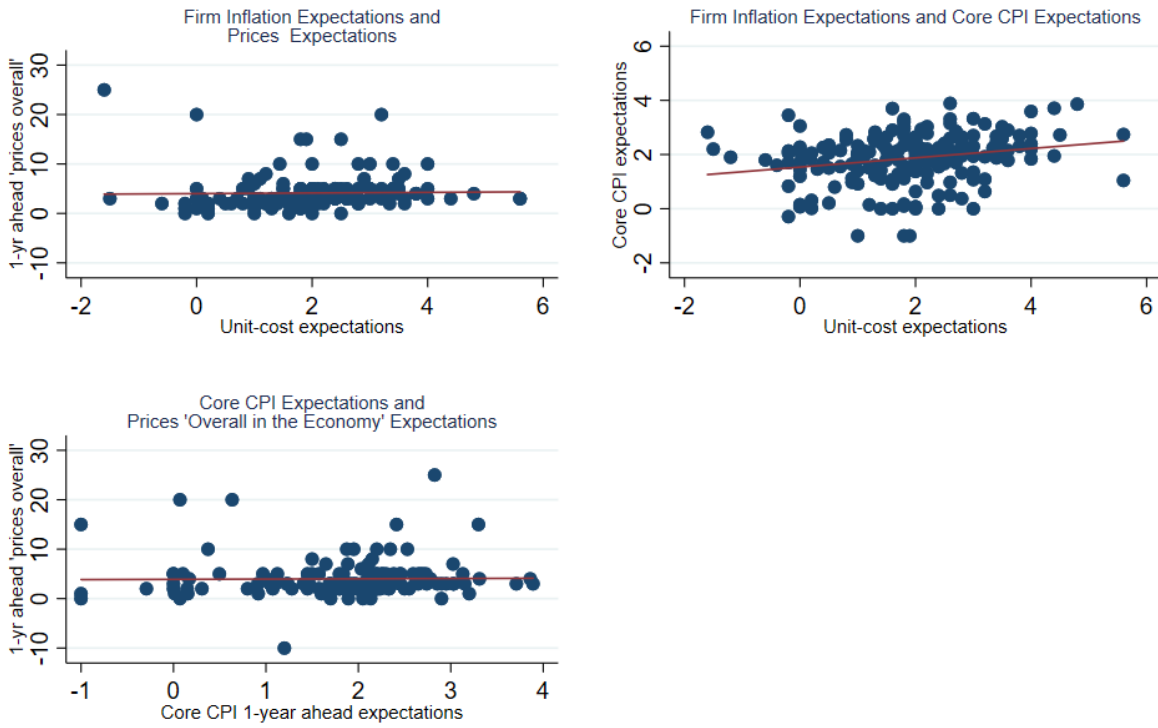
(b) Firms' Year-Ahead Core CPI Inflation Expectations



Source: FRBA Business Inflation Expectations (BIE) Survey.  
Notes: The above histogram plots the results of a special question in the October 2014 survey. Specifically, this is a distribution of firm's expected values of probabilistic core CPI projections. The expected value was calculated nonparametrically by taking the weighted average of the share of the probability mass in each bin multiplied by its midpoint. Values of -1 and 5 were used for the left-censored and right-censored bins, respectively.

Figure 3: Expectations for Overall Prices and Core CPI

## Measures of Firm Inflation Expectations

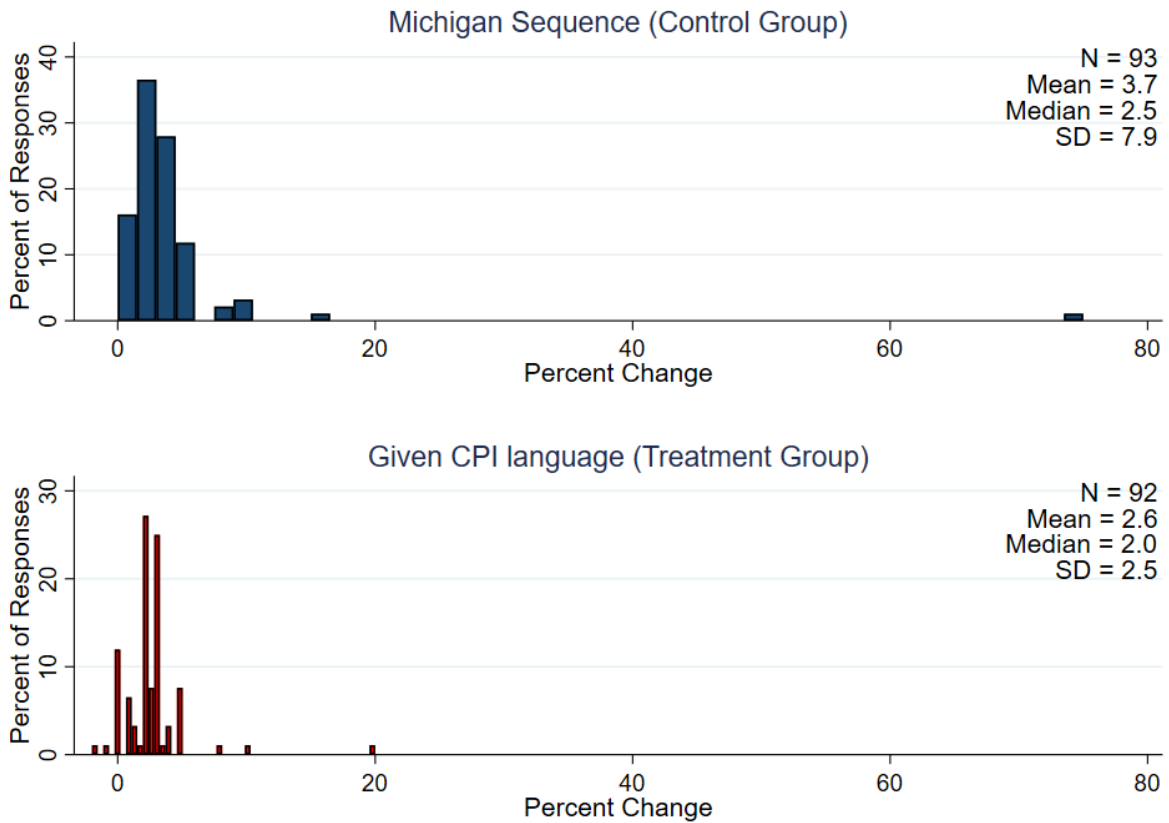


Note: These scatterplots are truncated to remove an outlier. There was one respondent that expected prices overall in the economy to increase by 60 percent over the year-ahead.

Source: FRBA Business Inflation Expectations (BIE) Survey.

Notes: Comparison between firms' unit costs, prices "overall in the economy," and core CPI inflation expectations utilizing core survey results and results to special questions posed in September and October 2014. The sample is restricted to the 151 firms that responded to all three questions.

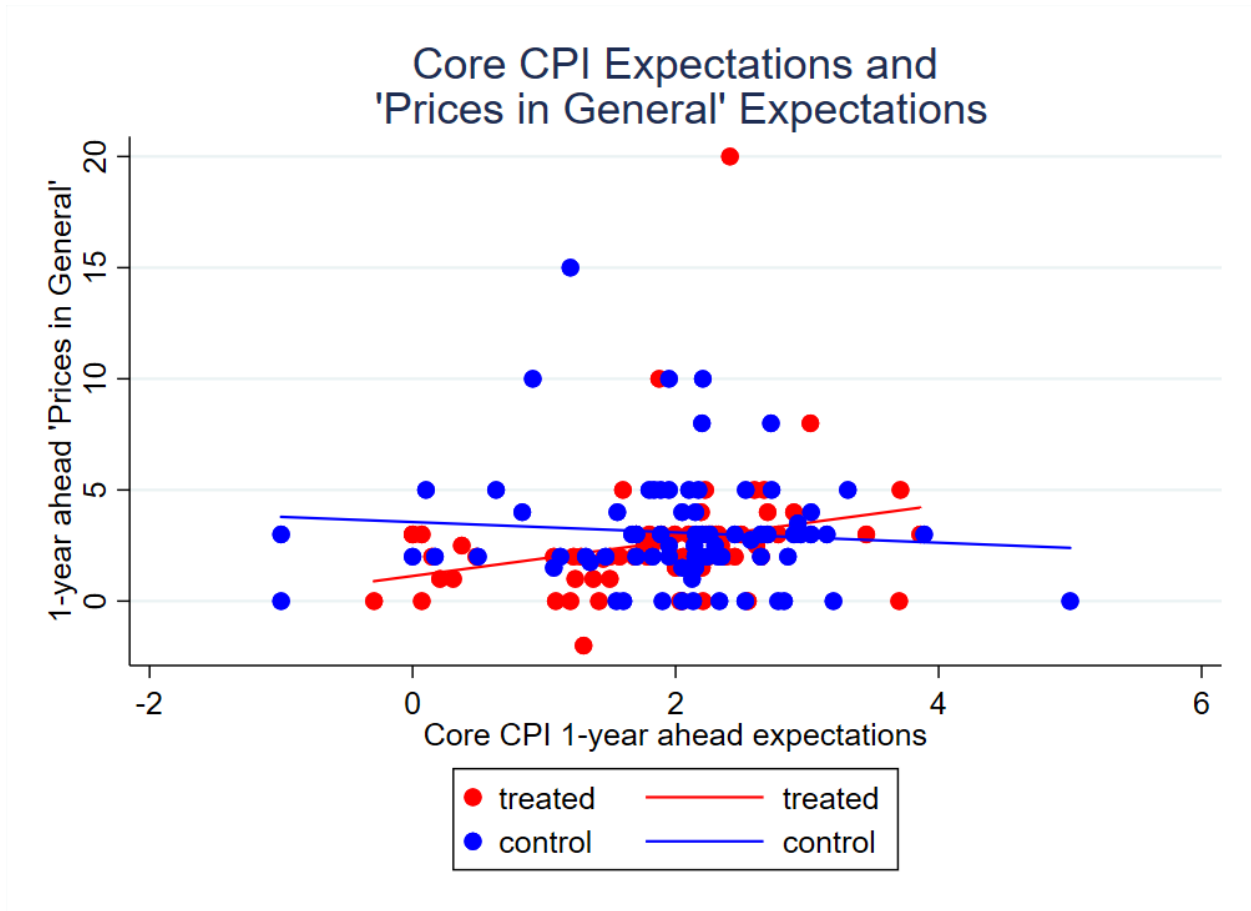
Figure 4: Alternative Measures of Firm Inflation Expectations



Source: FRBA Business Inflation Expectations (BIE) Survey, July 2015.

Notes: These histograms use the results of a module of special questions in the July 2015 survey that included a randomized controlled trial designed to measure the impact of a respondent’s understanding of the “prices in general” by giving half the panel at random a key phrase alikening “prices in general” to the Consumer Price Index.

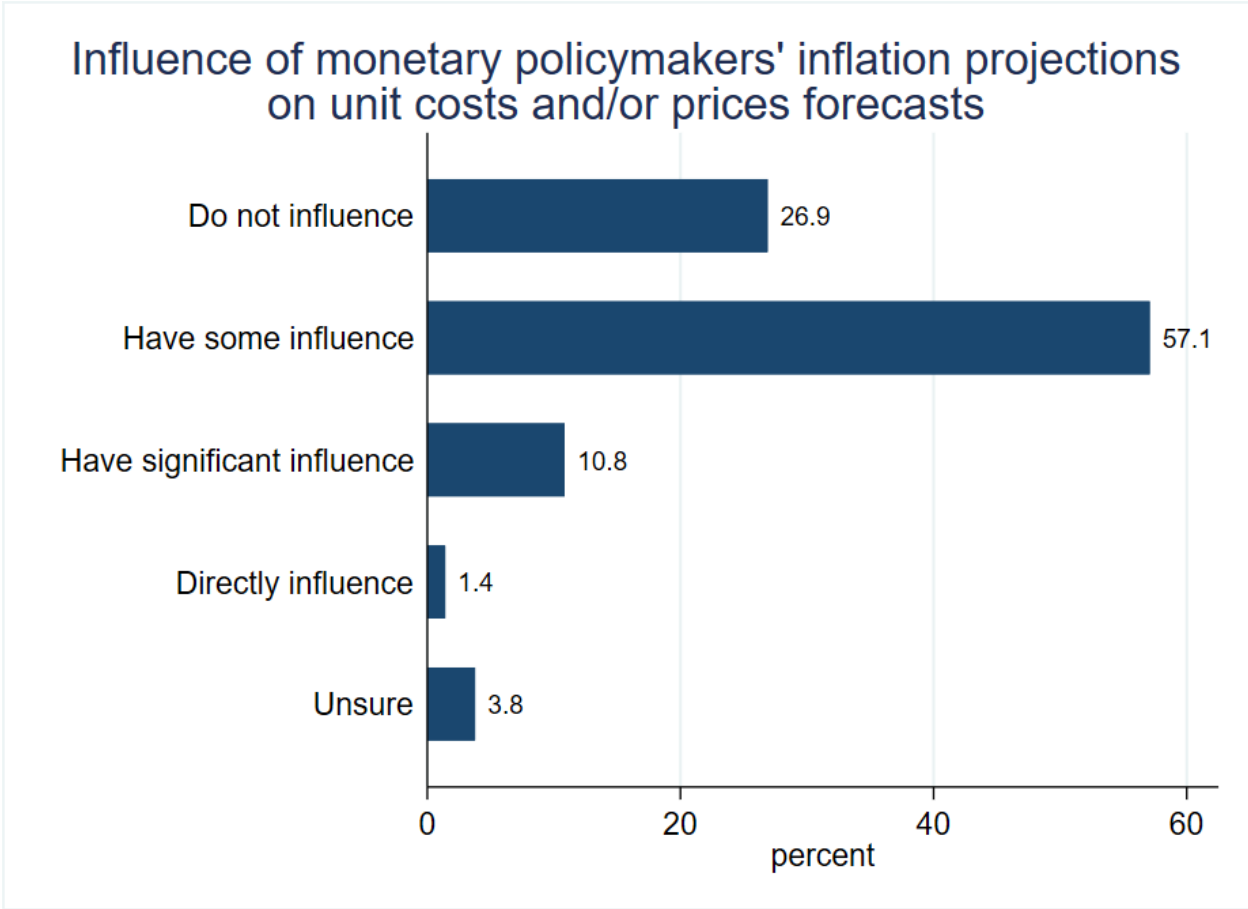
Figure 5: The Effect of Wording on Firm Inflation Expectations (A Randomized Controlled Trial)



Source: FRBA Business Inflation Expectations (BIE) Survey.

Notes: The above scatterplots use the results of special questions from October 2014 and July 2015. 154 respondents answered both sets of special questions. The control group was given the University of Michigan’s sequence for “prices in general” expectations and the treatment group received a parenthetical noting that “prices in general” were “like those measured by the Consumer Price Index.” The y-axis was truncated to 20 percent to more clearly show the variation between the two groups.

Figure 6: RCT: Treatment Effect on the Relationship between Core CPI and “Prices in General” Inflation Expectations

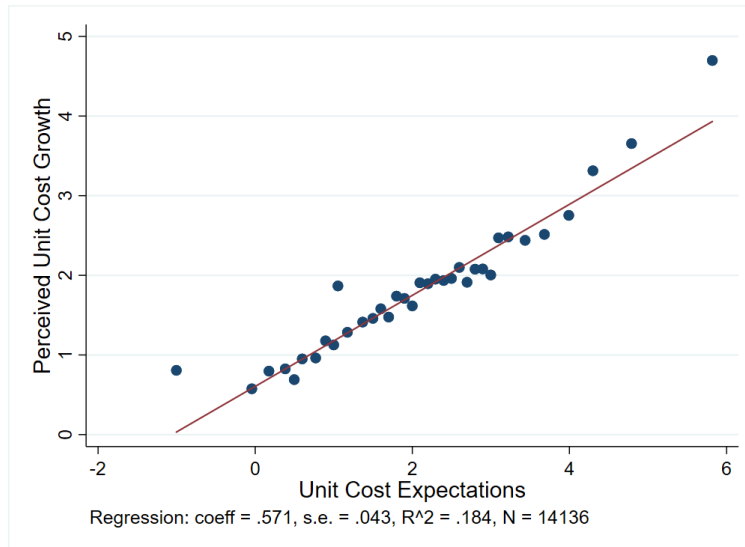


Sources: FRBA Business Inflation Expectations (BIE) Survey

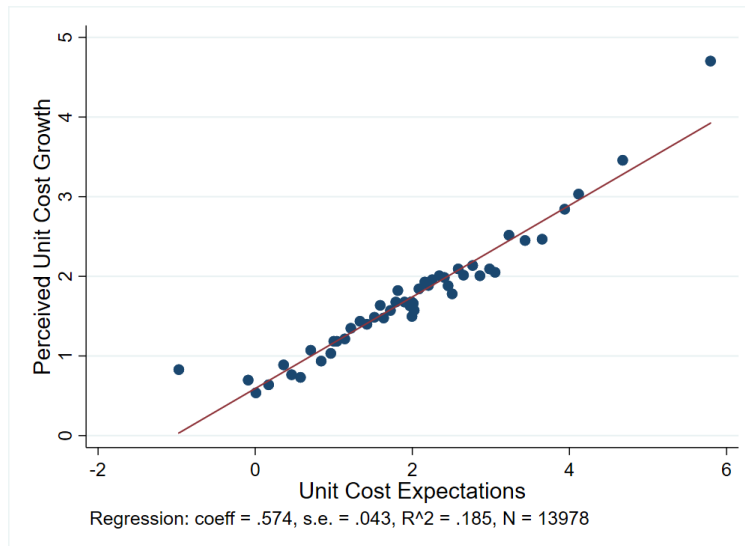
Notes: The above bar graph plots the results of a October 2020 special question. Question: Which of the following best describes how useful, if at all, the inflation expectations of monetary policymakers are when forecasting potential changes to your own unit costs and/or prices? Response options: [The inflation forecasts of monetary policymakers] (1) do not influence my expectations, (2) have some influence on my expectations, (3) have significant influence on my expectations, (4) directly influence my expectations, (5) unsure

Figure 7: (RCT) Influence of Monetary Policymakers' Inflation Projections on Unit Costs and/or Prices Expectations





(a) Nonparametric

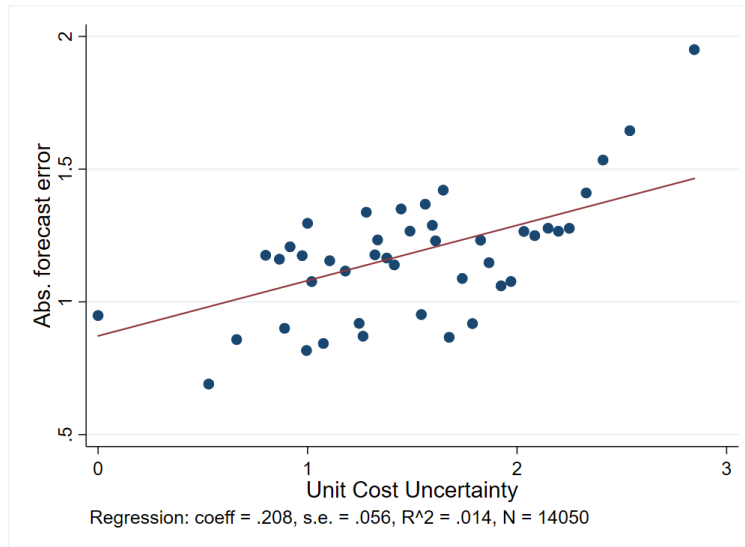


(b) Parametric

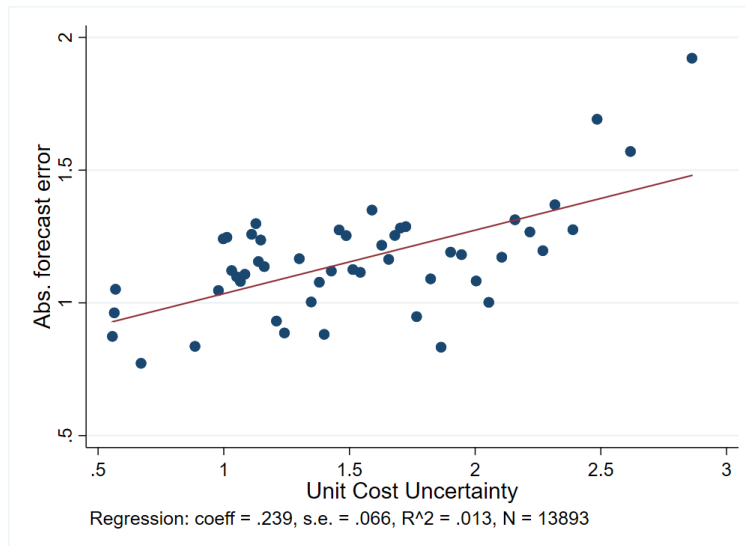
Source: FRBA Business Inflation Expectations (BIE) Survey

Note: These binscatters (50 bins) compare respondents' 1-year ahead unit cost expectations (lagged by 12 months) to their realized (perceived) year-over-year unit cost growth outcomes. Statistics below the figure correspond to the population OLS regression using all available data.

Figure 8: Firm's Unit Cost Expectations vs. Realizations (Perceptions)



(a) Nonparametric

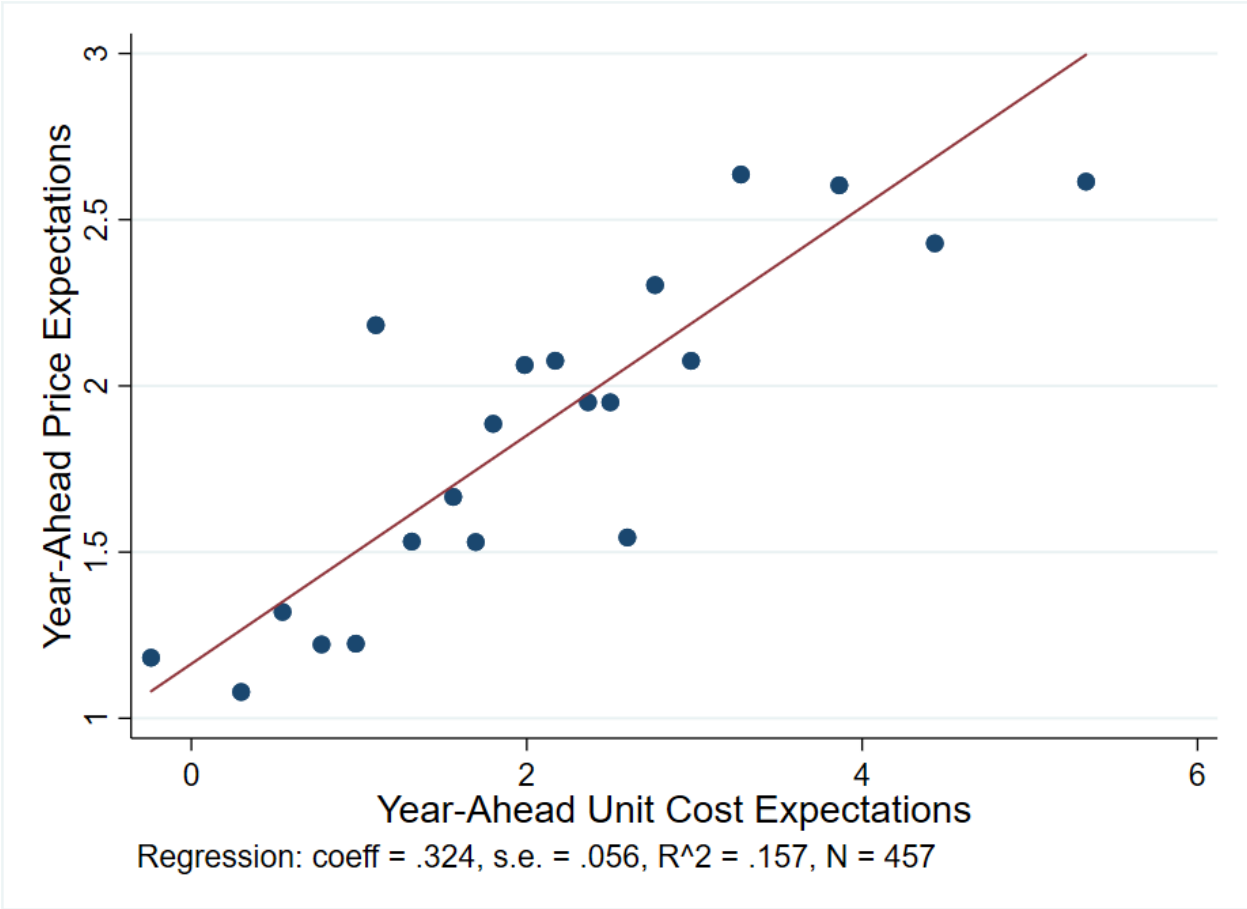


(b) Parametric

Source: FRBA Business Inflation Expectations (BIE) Survey

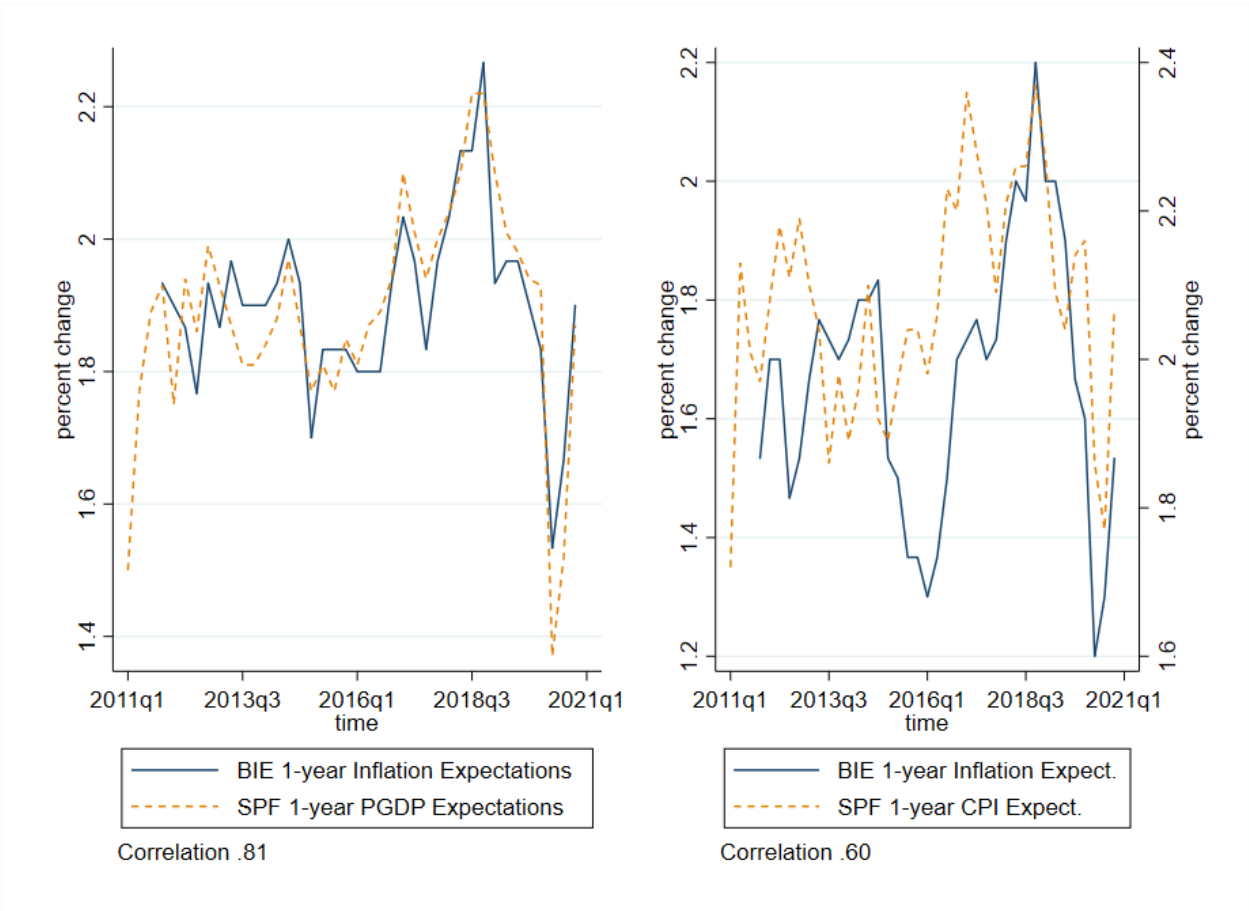
These binscatters (50 bins) compare respondents' 1-year ahead unit cost uncertainty (lagged by 12 months) to their realized absolute forecast errors (unit cost outcome minus 12-month lagged unit cost projection). Statistics below the figure correspond to the population OLS regression using all available data.

Figure 9: Firm's Uncertainty vs. Absolute Forecast Errors



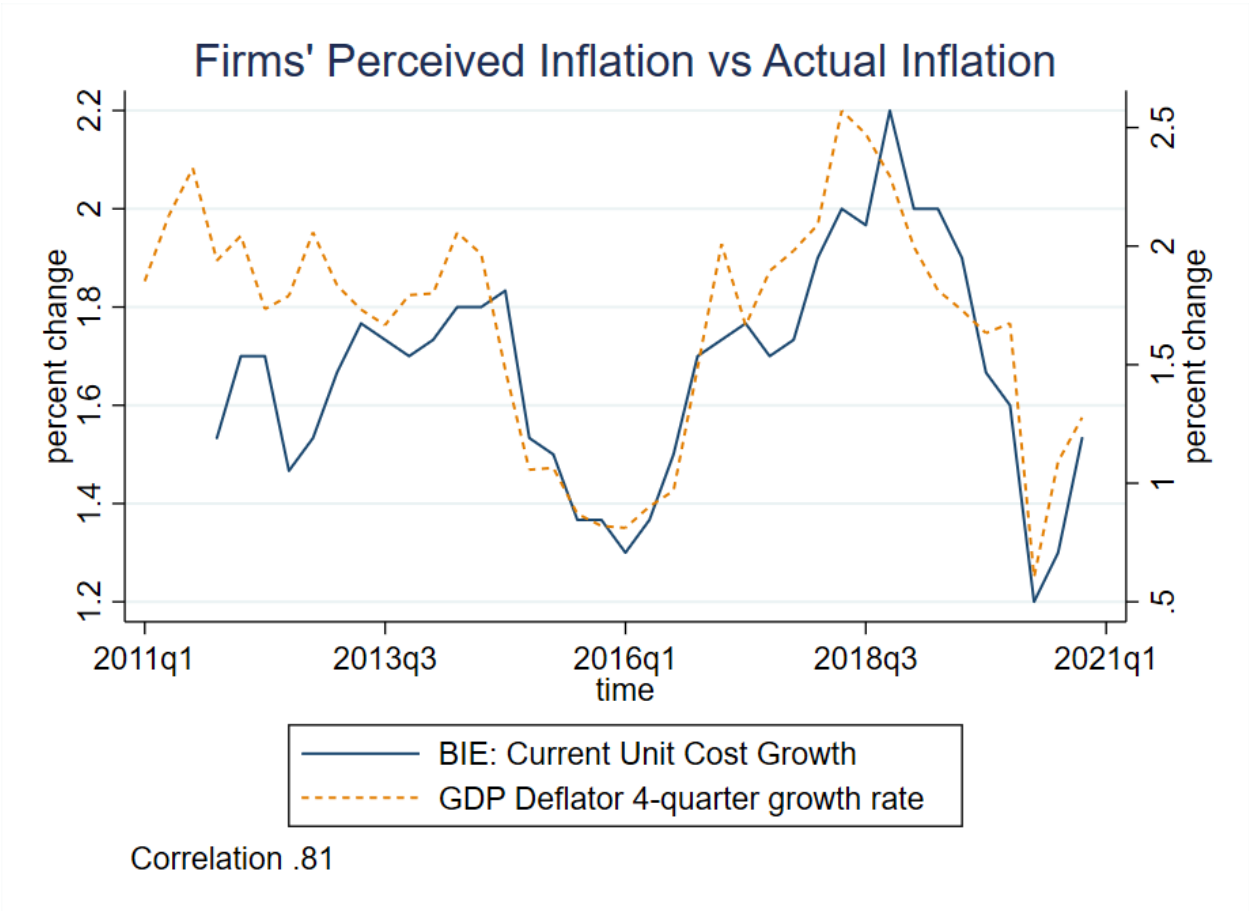
Source: FRBA Business Inflation Expectations (BIE) Survey.  
 Notes: The above binscatter (25 bins) compare respondents' 1-year ahead unit cost expectations to their 1-year ahead representative price expectations. Special questions on expected prices were elicited in June 2013, February 2019, and December 2020. Given changes in question formatting, responses were normalized and winsorized at the 2.5% and 97.5% levels.

Figure 10: Unit Cost and Price Expectations



Sources: FRBA Business Inflation Expectations (BIE) Survey; FRBP Survey of Professional Forecasters  
 Notes: These responses are quarterly, beginning in 2011q1 (for the Survey of Professional Forecasters) and 2011q3 for the BIE and running through 2020q4. For the right panel, the BIE series is plotted on the left axis and the SPF series on the right.

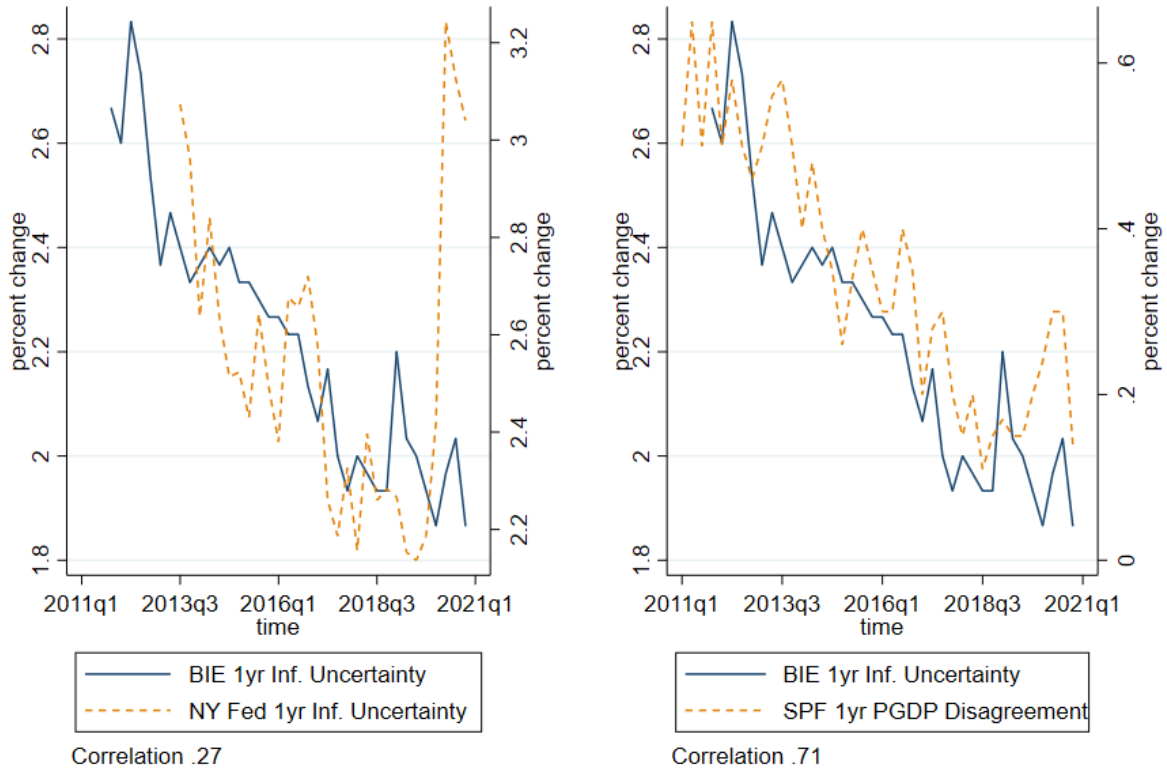
Figure 11: Year-Ahead Inflation Expectations of Firms and Professionals



Sources: Bureau of Economic Analysis; FRBA Business Inflation Expectations (BIE) Survey.  
 Notes: The sample period begins in 2011Q3 and ends in 2020Q4. The BIE series are weighted by industry-share of GDP and quarterly averages are plotted. Given the nature of the panel, the most apt comparison is to the broadest notion of overall inflation (i.e. GDP price index). The BIE series is plotted on the left axis and the GDP Price Index is plotted on the right axis.

Figure 12: Firms' Realized (Perceived) Inflation vs. Actual Measured Inflation

## Survey Measures of Inflation Uncertainty



Sources: FRBA Business Inflation Expectations (BIE) Survey; FRBP Survey of Professional Forecasters; FRBNY Survey of Consumer Expectations

Note: For each graph above, the BIE series is plotted on the left-hand axis and the comparison series on the right.

Figure 13: Survey Measures of Inflation Uncertainty

## Online Appendix

### Unit Cost Expectations and Uncertainty: Firms' Perspectives on Inflation by Meyer, Parker and Sheng

This online appendix contains the following three items. First, in Appendix A we provide additional tables and graphs. Second, in Appendix B we compare the Atlanta Fed's BIE Survey probabilistic binned response approach to a more flexible approach used by the Survey of Business Uncertainty. Third, Appendix C illustrates fitting the bimodal asymmetric power normal distribution to three histograms, compared to fitting the normal and beta distribution.

#### **Appendix A Additional Tables and Graphs**

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<b>Business Inflation Expectations Survey: Descriptive Statistics (Weighted Mean)</b>							
	Unit cost expecta- tions	Unit cost percep- tions	Nonparam uncer- tainty	Parame. uncer- tainty	Forecast error	Abs. forecast error	N
Overall BIE panel	1.94	1.72	2.16	2.50	-0.21	1.14	13,812
std. err	0.011	0.014	0.015	0.015	0.013	0.009	
By Firm Size							
Small (1-99 employees)	2.05	1.87	2.03	2.36	-0.16	1.06	5,955
std. err	0.017	0.021	0.022	0.022	0.018	0.013	
Medium (100-499 employees)	1.91	1.64	2.40	2.73	-0.26	1.32	3,918
std. err	0.019	0.028	0.029	0.029	0.029	0.021	
Large (500+ employees)	1.75	1.52	2.15	2.49	-0.24	1.08	3,939
std. err	0.018	0.024	0.027	0.027	0.024	0.017	
By Nonfarm Private Industry (2-Digit NAICS)							
Construction	2.36	2.14	2.38	2.72	-0.31	1.14	1,075
std. err	0.049	0.058	0.061	0.062	0.049	0.036	
Durable goods manufacturing	1.97	1.69	2.28	2.62	-0.33	1.58	1,545
std. err	0.036	0.053	0.037	0.037	0.054	0.038	
Educational services	2.13	1.74	1.91	2.25	-0.29	0.87	381
std. err	0.046	0.043	0.076	0.075	0.061	0.044	
Finance and insurance	1.30	1.00	1.96	2.30	-0.31	1.20	1,254
std. err	0.031	0.045	0.056	0.056	0.045	0.031	
Health care and social assistance	1.88	1.62	2.74	3.09	-0.30	1.13	594
std. err	0.042	0.060	0.079	0.079	0.062	0.043	
Information	2.64	2.48	1.86	2.19	-0.07	0.90	387
std. err	0.069	0.082	0.086	0.086	0.061	0.040	
Leisure and hospitality	2.05	1.69	1.60	1.94	-0.36	0.95	432
std. err	0.068	0.068	0.065	0.065	0.063	0.046	
Mining and utilities	1.61	1.20	2.13	2.47	-0.46	1.06	408
std. err	0.056	0.072	0.065	0.065	0.069	0.050	
Nondurable goods manufacturing	1.86	1.66	2.63	2.94	-0.15	1.46	982
std. err	0.046	0.064	0.080	0.076	0.063	0.043	
Other services except government	2.29	1.99	2.72	3.05	-0.01	0.95	136
std. err	0.078	0.105	0.197	0.198	0.126	0.096	
Professional and business service	2.31	2.02	2.24	2.57	-0.22	1.12	1,770
std. err	0.031	0.041	0.040	0.040	0.037	0.026	
Real estate and rental and lease	1.75	1.56	1.93	2.26	-0.17	1.04	1,408
std. err	0.030	0.034	0.042	0.042	0.037	0.025	
Retail and wholesale trade	1.88	1.74	2.15	2.49	-0.14	1.04	2,861
std. err	0.021	0.028	0.030	0.031	0.026	0.018	
Transportation and warehousing	2.21	2.02	1.79	2.12	-0.24	1.01	579
std. err	0.045	0.052	0.068	0.068	0.060	0.043	

Source: Authors' calculations.

Note: This sample begins in October 2011 and runs through January 2021 but restricts the observations to those for which we are able to calculate direct( $t$ ,  $t+12$ ) forecast errors. The resulting 13,812 observations comprise 61 percent of all useable observations (complete responses to the questionnaire). Responses are weighted by industry-share of GDP.

Table A.1: Descriptive Statistics



Variables	Unit Cost	Core CPI	Price Overall
Unit Cost	1.000		
Core CPI	0.265***	1.000	
Price Overall	0.062	0.046	1.000

Source: FRBA Business Inflation Expectations (BIE) Survey.

Notes: This table reports the correlations between the same firms' unit costs, "prices overall in the economy," and core CPI inflation expectations. The results are from the main survey and successive special questions in September and October 2014. The sample is restricted to the 151 firms that responded to all three questions. \*, \*\*, \*\*\* denote significance at the 10%, 5%, and 1% levels.

Table A.2: Correlations between 1-Year Ahead Firm Inflation Expectations Measures

<b>Panel A: Lowest and Highest Forecasts for 2021 inflation</b>				
	Mean	P25	P75	N
<b><u>Treatment Group</u></b>				
Lowest potential rate of inflation	2.42	1.00	1.65	99
Highest potential rate of inflation	4.78	2.00	4.00	99
Spread (highest - lowest)	2.36	1.00	2.35	99
<b><u>Control Group</u></b>				
Lowest potential rate of inflation	1.73	1.00	1.50	104
Highest potential rate of inflation	4.40	2.50	3.50	104
Spread (highest - lowest)	2.67	1.50	2.00	104
<b>Panel B: Revisions to Expectations and Uncertainty</b>				
	Mean	P25	P75	N
<b><u>Treatment Group</u></b>				
Difference in unit cost expectations (Nov - Oct)	0.01	-0.40	0.20	85
Difference in unit cost uncertainty (Nov - Oct)	-0.03	-0.28	0.12	85
<b><u>Control Group</u></b>				
Difference in unit cost expectations (Nov - Oct)	0.14	-0.40	0.70	87
Difference in unit cost uncertainty (Nov - Oct)	-0.22	-0.60	0.33	87

Source: FRBA Business Inflation Expectations (BIE) Survey

Notes: Results obtained via RCT special questions posed to the panel on October 2020. The median expectation of monetary policymakers for inflation over calendar year 2021 was 1.7 percent (as of September 15<sup>th</sup>, 2020). Treatment: [Based on forecasts over the past 20 years, there is a 70 percent change that actual inflation will be in the range of 0.7 percent to 2.7 percent over calendar year 2021.] Question: What is your best estimate for the highest and lowest potential rate of inflation over calendar year 2021? 212 panelists responded to the core BIE questionnaire in October 2020. T-tests reject the notion that these differences are statistically significant at the 10% level.

Table A.3: RCT: Influence of Monetary Policymakers' Inflation Projections on Unit Costs and/or Prices Expectations (With All Observations)

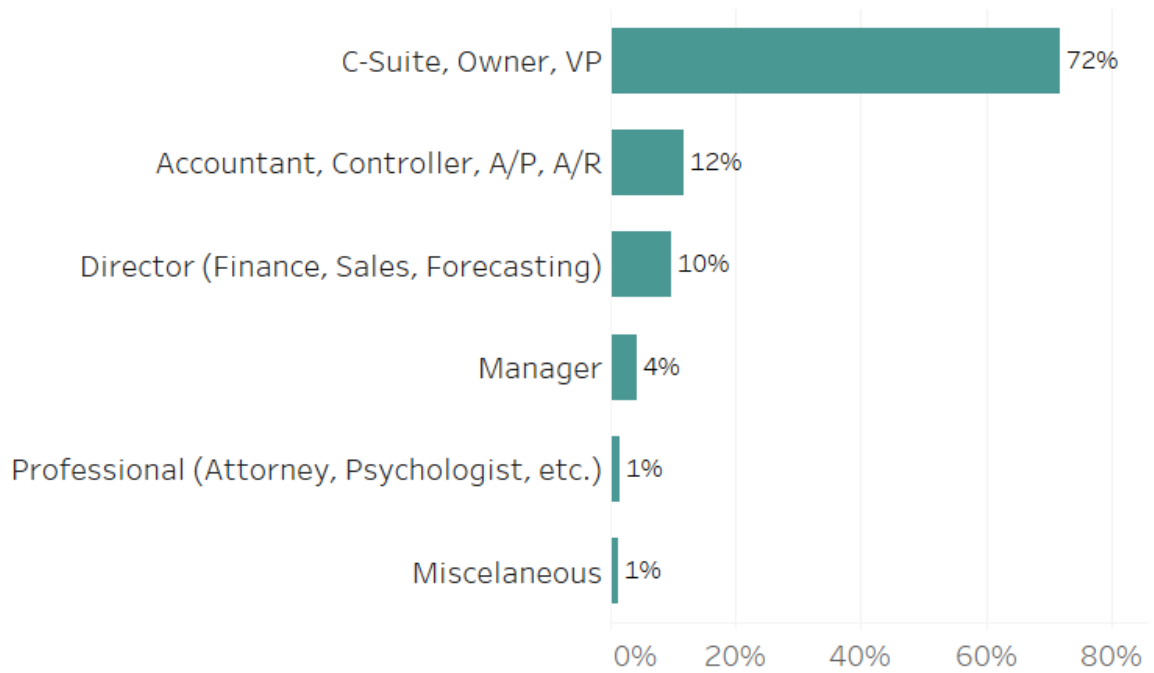
Variables	(1)	(2)	(3)	(4)	(5)
(1) BIE 1yr	1.000				
(2) BlueChip 1yr CPI	0.376***	1.000			
(3) BlueChip 1yr PGDP	0.691***	0.479***	1.000		
(4) UM 1yr	0.066*	-0.112	-0.224**	1.000	
(5) TIPS 5yr forward	0.303***	-0.047	0.091	0.727***	1.000

Sources: FRBA Business Inflation Expectations (BIE) Survey; Blue Chip Economist Panel; University of Michigan's Survey of Consumers; Haver Analytics

Notes: The sample starts in October 2011 and ends in January 2021. The comparisons use the mean BIE and the median measures for the University of Michigan's Survey of Consumers (UM). The Blue Chip 1-year ahead is calculated from consensus forecasts. TIPS breakeven and forward inflation rate calculated by Haver Analytics. \*, \*\*, \*\*\* denote significance at the 1%, 5%, and 10% levels, respectively.

Table A.4: Time-series Correlations between Monthly Inflation Expectations

## BIE Survey - Panel Member Composition by Title

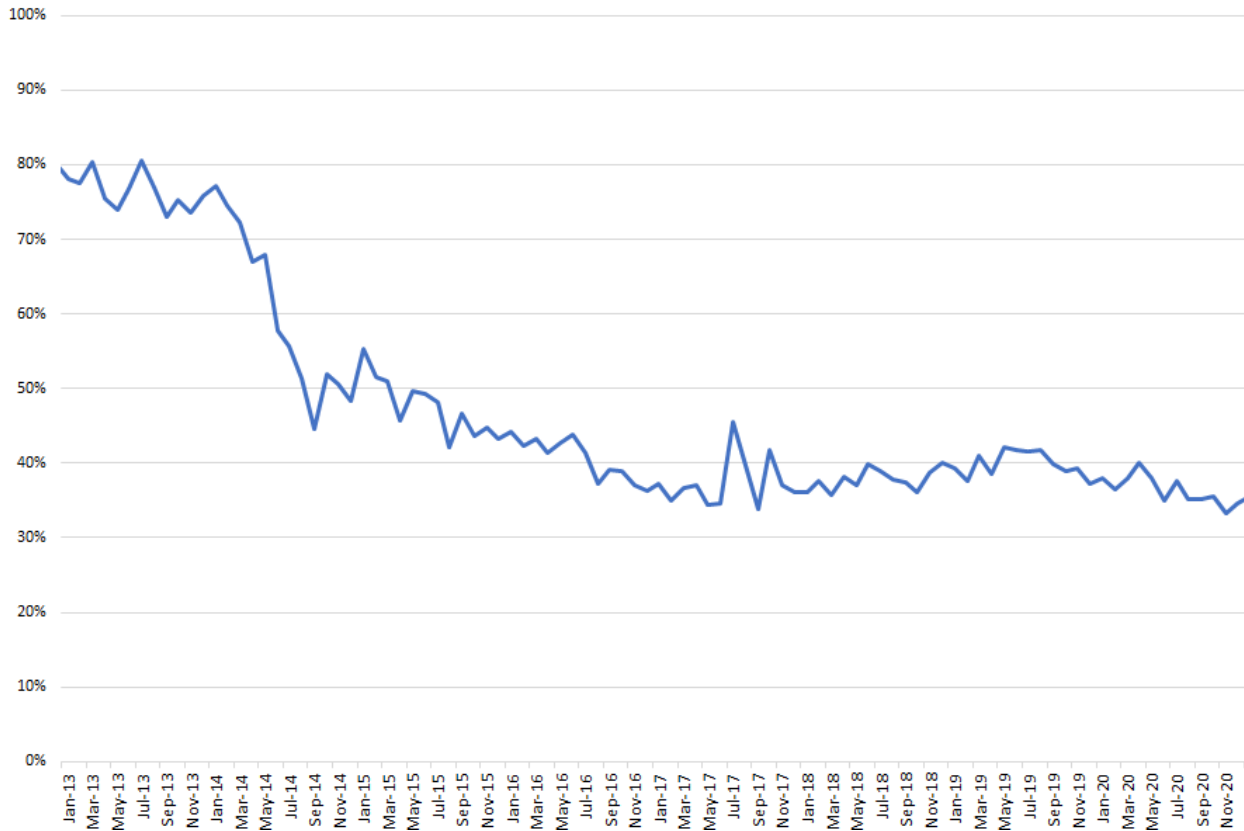


Source: FRBA Business Inflation Expectations (BIE) Survey

Notes: These shares are reflective of the existing panel as of December 2019. Titles are reported and confirmed during the recruiting process. Of “C-suite” respondents, we aim at garnering participation from CFOs in particular.

Figure A.1: BIE Panel Member Composition by Title

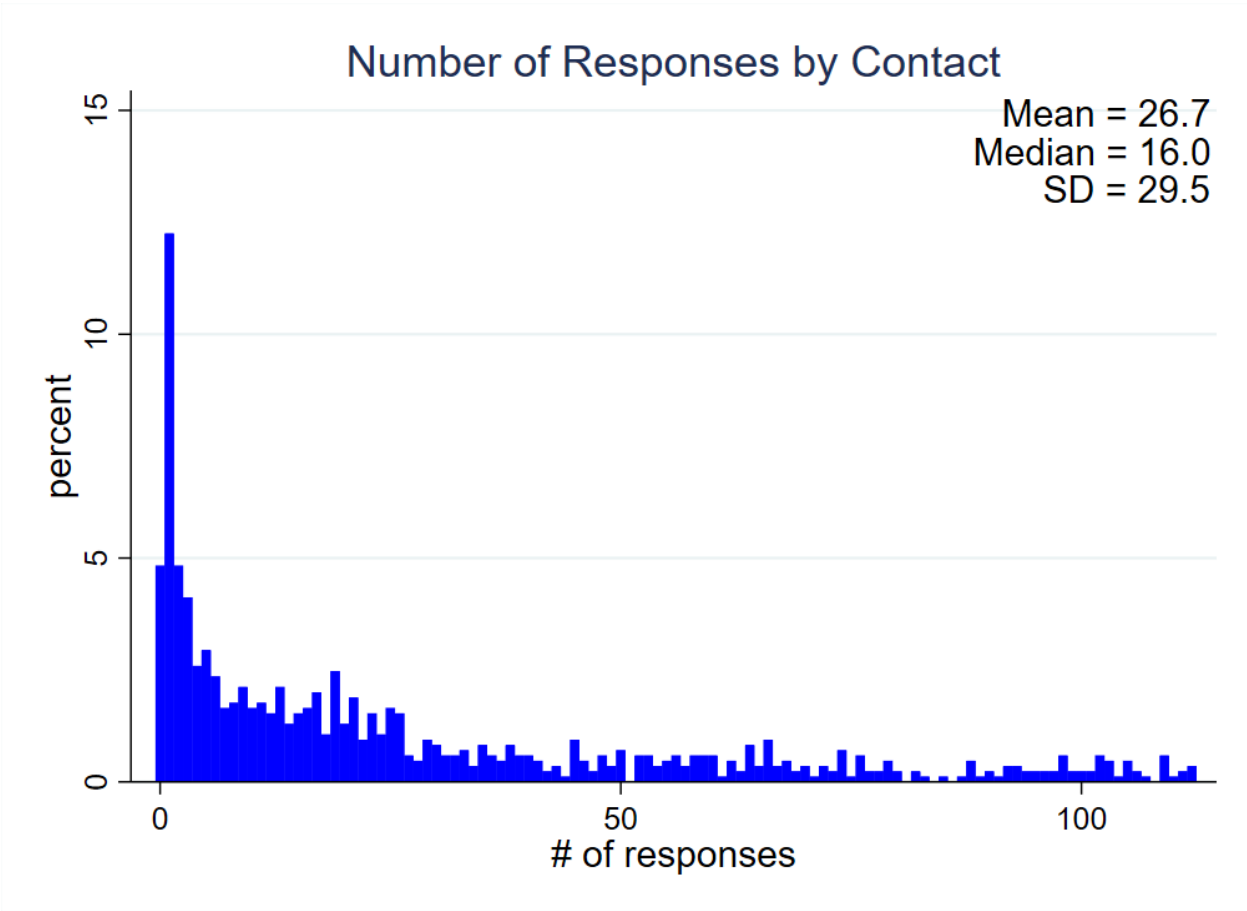
**BIE Survey**  
Monthly Response Rates



Source: FRBA Business Inflation Expectations (BIE) Survey

Notes: AAPOR Response Rate 2 Calculation = (partial and completed responses)/(number of survey invitations sent). See the American Association for Public Opinion Research 2016 Standard Definitions: Final Dispositions of Cases and Outcome Rates for Surveys. 9th edition. In late 2012, the BIE Survey transitioned to a web-hosted survey software. Prior to this transition, it was not possible to assess noncontact rates. Response rates from November 2012 to June 2014 were higher than average due to the culling of unresponsive panel members prior to the transition to a new survey platform.

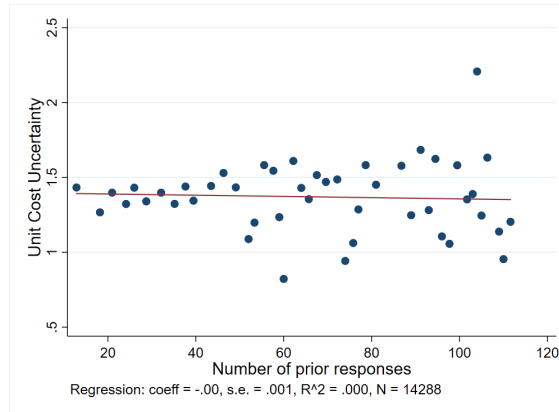
Figure A.2: BIE Survey Monthly Response Rate



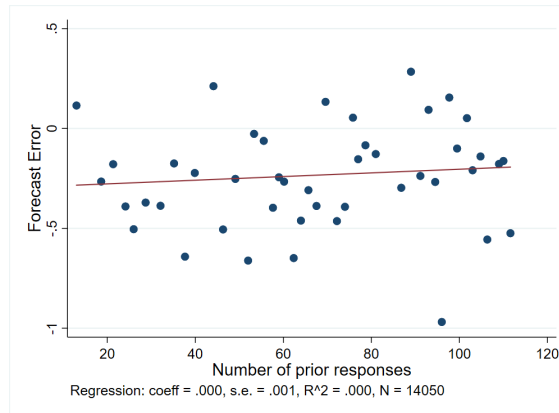
Source: FRBA Business Inflation Expectations (BIE) Survey

Notes: The above bar graph uses the complete history of the BIE from October 2011 through January 2021. A “complete” response means a respondent filled out the entire core questionnaire.

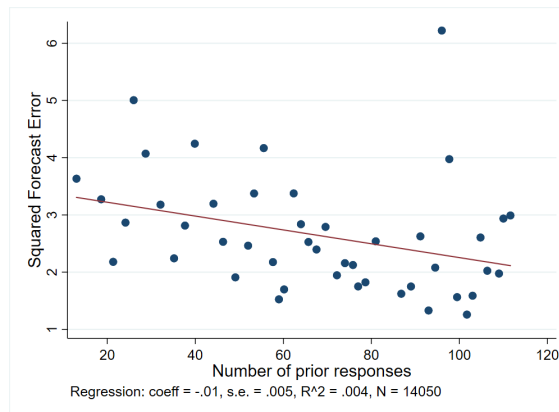
Figure A.3: Survey Retention: Number of Complete Responses by Panelist



(a) Forecast Error



(b) Squared Forecast Error



(c) Unit Cost Uncertainty

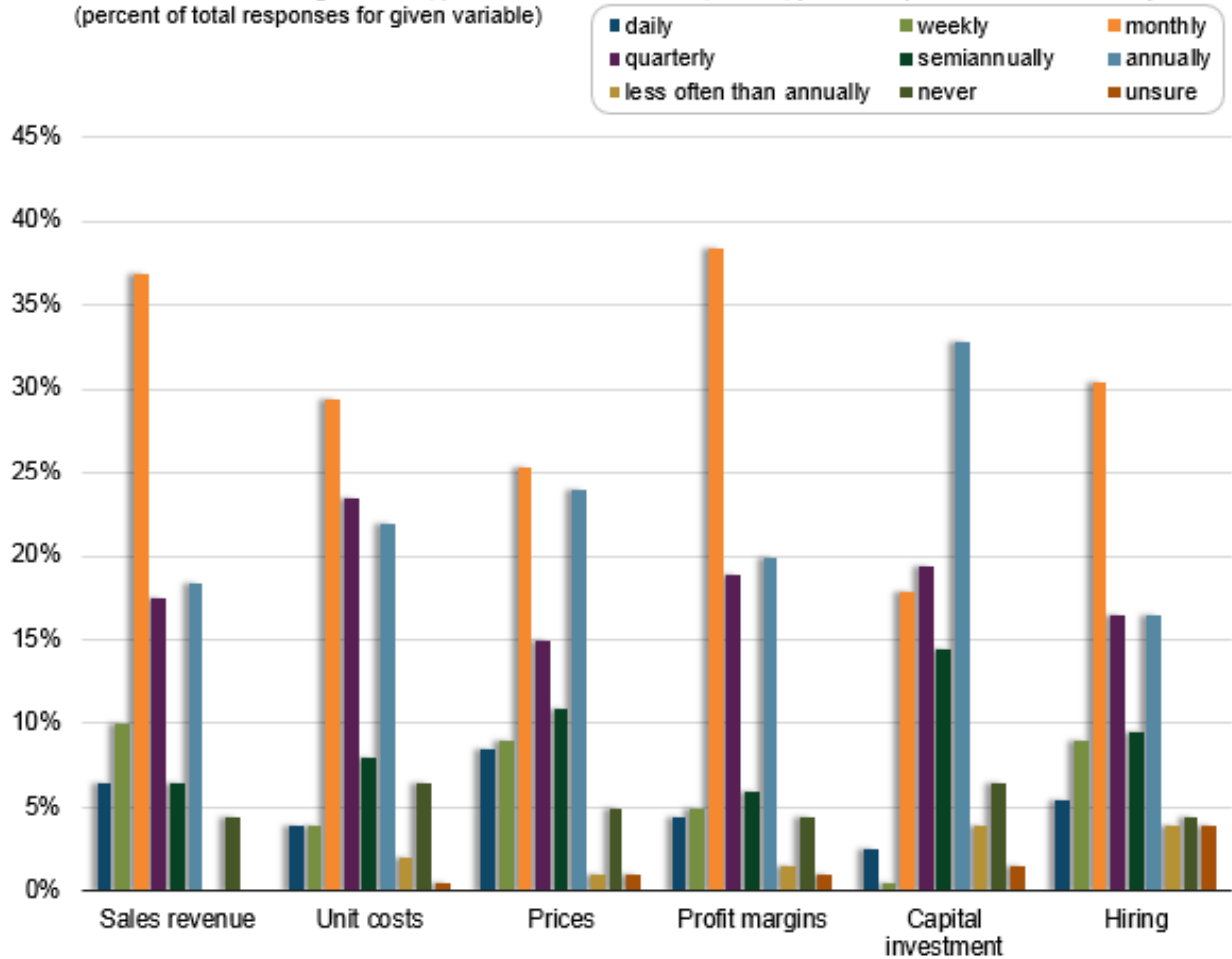
Source: FRBA Business Inflation Expectations (BIE) Survey

Notes: These binscatters (50 bins) compare respondents' (a) forecast error, (b) squared forecast error, and (c) uncertainty. Statistics below the figure correspond to the population OLS regression. Data are from October 2011 through January 2021.

Figure A.4: Tenure Effects

### Frequency of Firm Planning or Forecasting

For each of the following variables, please indicate how often, if at all, you make plans or forecasts of any kind. (percent of total responses for given variable)



Source: Atlanta Fed Business Inflation Expectations (BIE) Survey

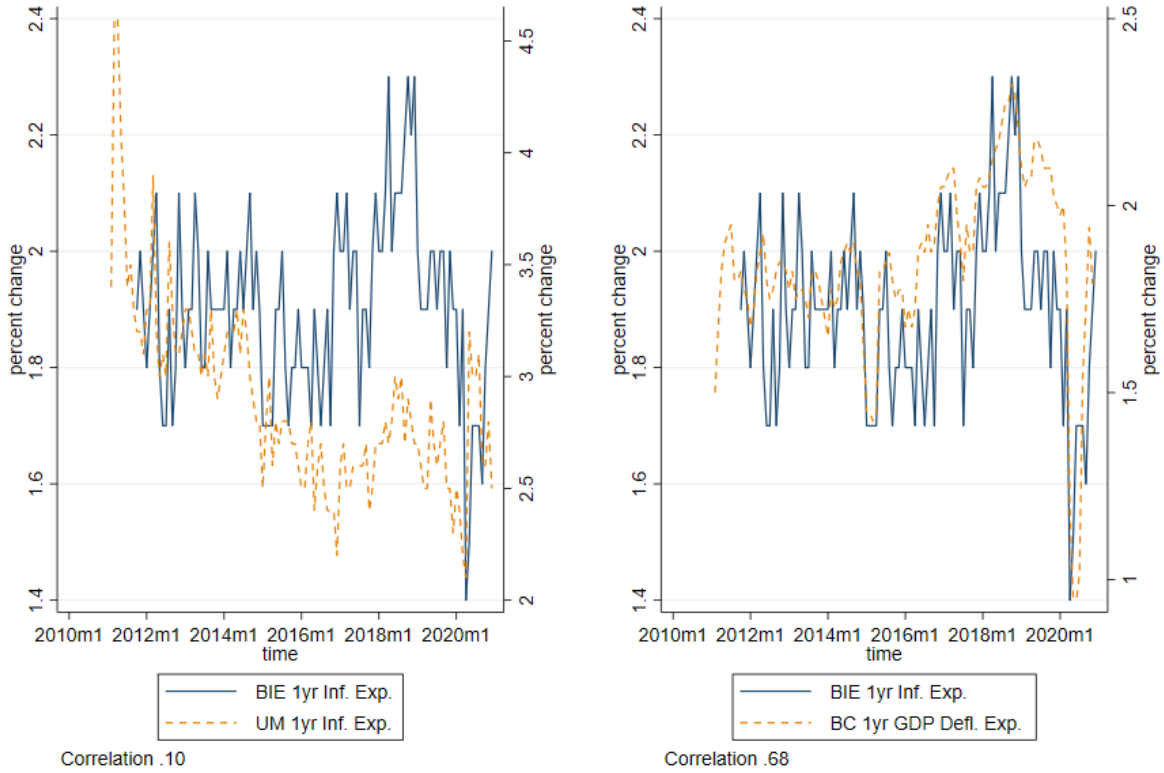
Source: FRBA Business Inflation Expectations (BIE) Survey

Note: Elicited from panelists as of March 2015.

Figure A.5: Firms Planning and Forecasting Frequencies



## Monthly 1-Year Inflation Expectations



Sources: Blue Chip Economist Panel; University of Michigan Survey of Consumers; FRBA Business Inflation Expectations (BIE) Survey

Note: The sample period goes from January 2011 through January 2021. For each graph above, the BIE series is plotted on the left-hand axis and the comparison series on the right.

Figure A.6: Short-Run (1-year ahead) Survey Inflation Expectations (Monthly Frequency)

## Appendix B Comparison of BIE to SBU

Two potential concerns arise in using the BIE survey. First, because the BIE only covers firms in the Southeast, it might not be nationally representative and the signal quality of the survey will likely suffer. Second, the question design itself – which is favored by [Manski \(2004\)](#) – is subject to framing bias. Because the quantitative suggestions for each bin width may be too narrow relative to the observed (perceived) distribution of actual unit cost expectations, the binned approach may potentially bias the results.

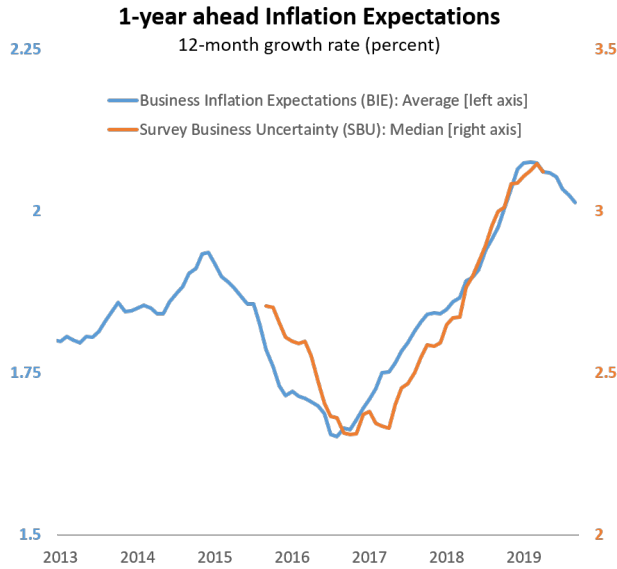
In an attempt to address both of these concerns, we compare the Atlanta Fed’s BIE Survey probabilistic binned response approach to a more flexible approach used by the Survey of Business Uncertainty (SBU); see [Altig et al. \(2020\)](#) for details regarding this survey. The SBU is a national survey of businesses that draws from every major industry in the nonfarm private sector and covers a full range of firm sizes. From its inception in 2014 until April of 2019, the SBU elicited responses for 1-year ahead unit costs expectations from a very flexible probabilistic setup – first asking firms for 5 quantitative estimates (support points) ranging from “lowest” to “highest” for the possible outcomes of unit costs over the year ahead and then asking respondents to fill in the attendant probabilities that correspond to each one of those outcomes.<sup>26</sup>

Figure [B.1](#) addresses, to a large extent the framing bias in the BIE relative to the SBU, as the mean for the aggregate time series for BIE unit costs expectations is roughly a full percentage point lower than its SBU counterpart. However, there appears to be a tradeoff between framing bias and inflation signal. Table [B.1](#) shows the correlations between the BIE and SBU unit cost 1-year ahead expectations and uncertainty measures over various moving averages (1-, 3-, 6-, and 12-month growth rates). The BIE aggregate is a simple weighted average and the SBU aggregate is either a 2-percent winsorized (1-percent on each tail) weighted average or weighted median. All series are weighted by industry share of GDP.

Table [B.1](#) reveals that the BIE aggregate is more highly correlated with the SBU median than the mean and that correlations between the two surveys grows over time. This holds for both the first and second moments of these survey responses. The results suggest that while framing bias from a probabilistic binned approach may alter the level of the aggregate expectation and uncertainty, it comes with a positive tradeoff of a stronger signal-to-noise ratio.

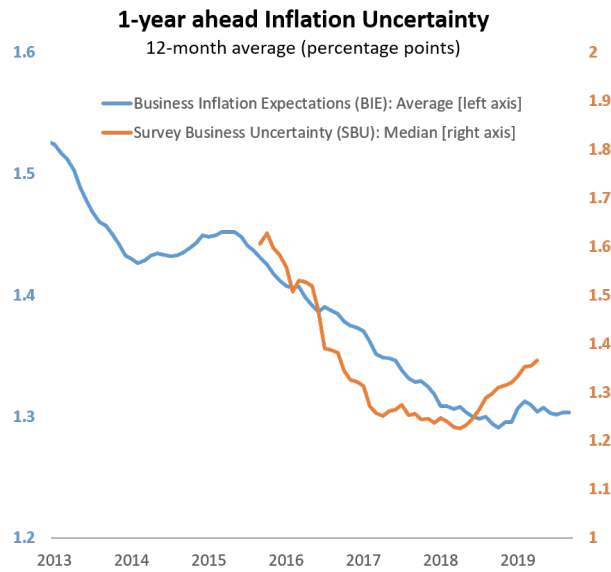
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<sup>26</sup>The SBU group, including researchers at Stanford University, the University of Chicago’s Booth School, and the Federal Reserve Bank of Atlanta, jointly agreed to retire the unit-cost question in April 2019, in an effort to streamline the survey instrument and in large part due to the seeming redundancy between the BIE and SBU output for unit costs.



Sources: FRBA Business Inflation Expectations (BIE) Survey and Survey of Business Uncertainty (SBU).

(a) Inflation Expectations



(b) Inflation Uncertainty

Sources: FRBA Business Inflation Expectations (BIE) Survey and Survey of Business Uncertainty (SBU).  
Notes: The BIE data are the smoothed average of the cross section of individual expected values. The SBU data are the smoothed median of the cross section of individual expected values. SBU data sample runs from October 2014 through April 2019. Both data series are weighted by industry-share of GDP.

Figure B.1: Comparison between BIE and SBU Unit Cost Expectations and Uncertainty

BIE 1-year Ahead Unit Cost Expectations		BIE 1-year Ahead Unit Cost Uncertainty	
<b>1-month growth rates</b>		<b>1-month averages</b>	
SBU: Median	0.68	SBU: Median	0.43
SBU: Winsorized Mean	0.26	SBU: Winsorized Mean	0.40
<b>3-month growth rates</b>		<b>3-month averages</b>	
SBU: Median	0.84	SBU: Median	0.66
SBU: Winsorized Mean	0.34	SBU: Winsorized Mean	0.57
<b>6-month growth rates</b>		<b>6-month averages</b>	
SBU: Median	0.90	SBU: Median	0.78
SBU: Winsorized Mean	0.42	SBU: Winsorized Mean	0.64
<b>12-month growth rates</b>		<b>12-month averages</b>	
SBU: Median	0.93	SBU: Median	0.81
SBU: Winsorized Mean	0.44	SBU: Winsorized Mean	0.71

Sources: FRBA Business Inflation Expectations (BIE) Survey and Survey of Business Uncertainty (SBU).  
Notes: The Survey of Business Uncertainty (SBU) fielded probabilistic unit cost expectations questions from its inception until April 2019. The data period we analyze is from October 2014 through April 2019. The 3-, 6-, and 12-month samples begin in December 2014, March 2014, and September 2015, respectively. For more information on the SBU, see [Altig et al. \(2020\)](#).

Table B.1: Comparison between BIE and SBU Probabilistic Inflation Expectations

The higher correlation between the mean BIE measures and the median SBU measures suggests that there are some idiosyncratic responses to unit cost growth that are pushing the averages away from the median. This type of idiosyncratic volatility is bounded in the BIE survey (as a response of “unit costs up significantly” is coded as 6 percent). Also encouraging from the standpoint of the BIE survey is that time series smoothing leads to very high correlations (coefficients as high as 0.93 over 12-month windows) between the BIE and the SBU median. These results suggest that at the very least *directionally* the BIE survey is yielding actionable information on the inflation expectations and uncertainty of firms. Eliciting this information using a probabilistic binned response approach dampens the inflation and its volatility when compared to a much more flexible probabilistic question design. Perhaps as important is that, while the BIE is a regional survey, the inflation expectations signal is very similar to that we would take from a national surveying effort.

## Appendix C Fitting the Bimodal Asymmetric Power Normal Distribution to Histograms

This appendix illustrates fitting the bimodal asymmetric power normal (BAPN) distribution to three histograms, compared to fitting the normal and beta distribution. Figures C.1 - C.3 display the histograms and the fitted curves. For unimodal histogram (case a), the beta model seems to be more appropriate than other models. For histograms being moderately bimodal (case b) and strongly bimodal (case c), the BAPN provides the best fit when compared with normal and beta models. This visual inspection is further collaborated by descriptive measures and formal tests, as discussed below.

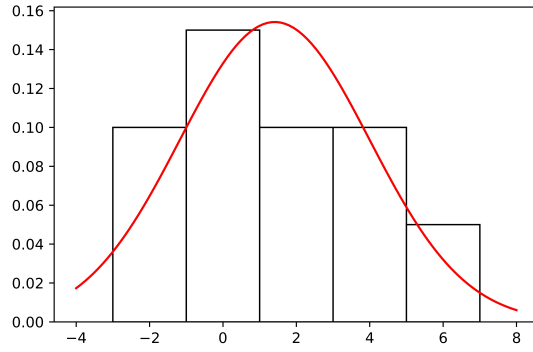
Following Andrade and Rathie (2016), we calculate three summary statistics in fitting parametric distributions to histograms. Bayesian Information Criterion (BIC) is obtained from the likelihood function when fitting each parametric distribution; see Table C.1. The second measure is the Mean Squared Error (MSE) between the fitted and the empirical cumulative distribution function. The third is the  $p$ -value from the Kolmogorov-Smirnov (KS) test having the fitted model as the null model against the two-sided alternative. For the unimodal histogram (case a), the beta model fits the data well according to BIC and KS test. For the two cases with bimodality, all statistics point strongly to the BAPN model: the lowest BIC and MSE, and the largest  $p$ -value for the KS test.

	Illustration 1			Illustration 2			Illustration 3		
	Beta	Normal	BAPN	Beta	Normal	BAPN	Beta	Normal	BAPN
BIC	4684	4774	4774	5525	4634	4569	3618	5072	3173
MSE	0.016	0.018	0.001	0.014	0.012	0.0001	0.086	0.089	0.0004
KS	0.11	<0.01	<0.01	0.04	<0.01	0.48	<0.01	<0.01	0.07

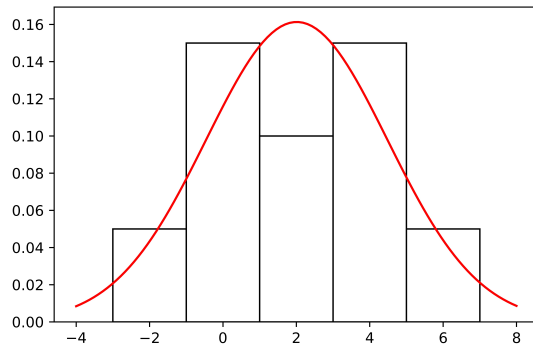
Note: This table reports the summary statistics in fitting parametric distributions to three examples illustrated in Figures C.1–C.3. BIC refers to Bayesian Information Criterion, calculated based on the likelihood function when fitting each parametric distribution. MSE is calculated as the Mean Squared Error between the fitted and the empirical cumulative distribution function. KS is the  $p$ -value calculated from the Kolmogorov-Smirnov test having the fitted model as the null model against the two-sided alternative. We fit normal distribution (Normal), generalized beta distribution with fixed support (Beta), and bimodal asymmetric power normal distribution (BAPN) to the reconstructed histograms.

Table C.1: Summary Statistics for Three Examples

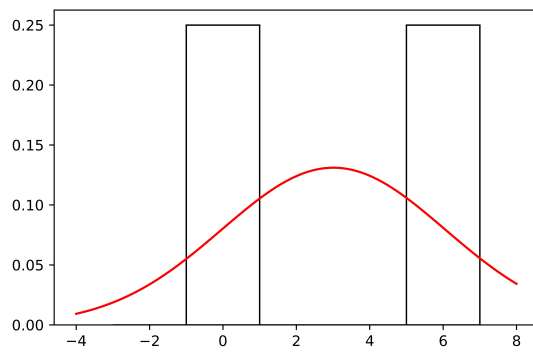
Therefore, in our analysis, we fit the BAPN model to histograms – with  $\gamma > 1$  to capture the bimodality and  $0 < \gamma \leq 1$  to capture the unimodality. We use the mean and variance of the BAPN distribution as the first- and second-moment of inflation expectations at the firm level, and compare these parametric estimates to nonparametric counterparts when appropriate.



(a) Illustration 1

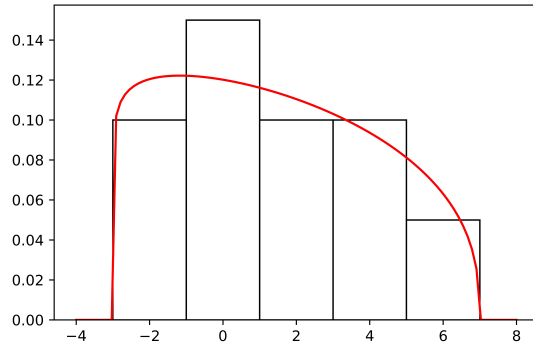


(b) Illustration 2

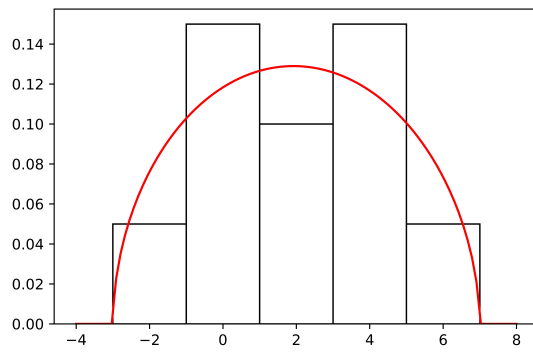


(c) Illustration 3

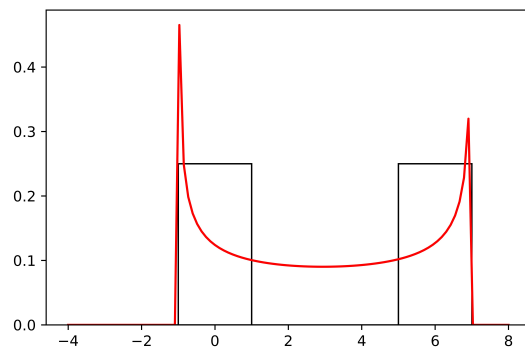
Figure C.1: Fitting Normal Distribution



(a) Illustration 1



(b) Illustration 2

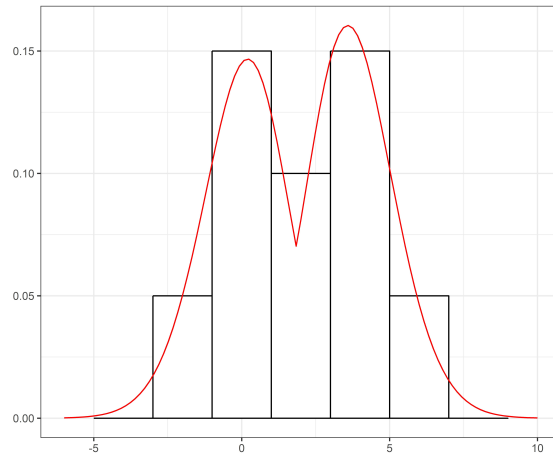


(c) Illustration 3

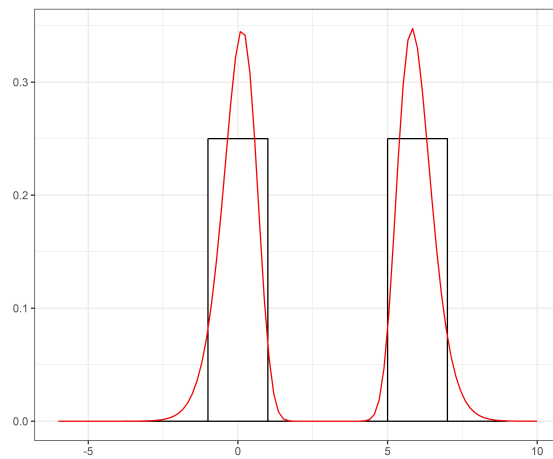
Figure C.2: Fitting Generalized Beta Distribution



(a) Illustration 1



(b) Illustration 2



(c) Illustration 3

Figure C.3: Fitting Bimodal Asymmetric Power Normal Distribution