Strategic Inattention, Inflation Dynamics, and the Nonneutrality of Money

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This paper studies how competition affects firms' expectations in a new dynamic general equilibrium model with rational inattention and oligopolistic competition where firms acquire information about their competitors' beliefs. In the model, firms with fewer competitors are less attentive to aggregate variables—a novel prediction supported by survey evidence. A calibrated version of the model matches the relationship between firms' numbers of competitors and their uncertainty about aggregate inflation as a nontargeted moment. A quantitative exercise reveals that firms' strategic inattention to aggregates significantly amplifies monetary nonneutrality and shifts output response disproportionately toward less competitive oligopolies by distorting relative prices.

I. Introduction

Almost every modern monetary model relates price changes to firms' expectations about aggregate inflation.[1] However, recent literature documents that firms' inflation expectations are inaccurate and disconnected

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[1] With sticky prices, inflation increases with expected future inflation (Woodford 2003b). In models of information rigidity, it increases with past expectations of current inflation (Lucas 1972; Mankiw and Reis 2002; Reis 2006).

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from aggregate inflation (see, e.g., Kumar et al. 2015; Candia, Coibion, and Gorodnichenko 2021). Furthermore, the accuracy of firms' expectations about aggregate variables correlates with the number of their competitors (Coibion, Gorodnichenko, and Kumar 2018). These facts are inconsistent with our standard models and raise two questions: (1) How does competition affect firms' expectations? (2) What are the macroeconomic implications of the interaction between competition and expectation formation?

This paper develops a new dynamic general equilibrium model with *rational inattention* and *oligopolistic competition* to study these questions. The interaction of these two model ingredients generates an endogenous relationship between the number of firms' competitors and their expectations about aggregate variables. While both rational inattention and oligopolistic competition are necessary for this relationship—hereafter referred to as *strategic inattention*—neither one is sufficient on its own. To examine the quantitative fit of the model, I calibrate it to firm-level survey data and find that it matches the relationship between firms' beliefs and the number of their competitors as a nontargeted moment. Finally, I find that strategic inattention has quantitatively significant implications for output and inflation responses to monetary policy shocks. It amplifies monetary nonneutrality by up to 48% and shifts the output response disproportionately toward less competitive firms.

The basic model of this paper in section II provides a closed-form characterization of oligopolistic firms' optimal beliefs under rational inattention. Rationally inattentive firms make mistakes in perceiving fundamental shocks. Thus, with a *finite* number of competitors, the average prices of firms' competitors exhibit nonfundamental volatility, which is costly to the firms themselves as well as to their competitors through strategic complementarities in pricing. Accordingly, when information acquisition is endogenous, oligopolistic firms are *strategically inattentive*—they have the incentive to pay direct attention to the mistakes of their competitors, even at the expense of paying less attention to the fundamental shocks. Thus, the model predicts an endogenous relationship between competition and firms' beliefs about aggregate variables: firms with fewer competitors and higher strategic complementarities in pricing are less informed about aggregate variables and have more uncertain beliefs.

Strategic inattention also implies that less competitive firms' price changes covary less with their aggregate inflation expectations than with expectations of their competitors' price changes. Firms that compete with only a few others do not optimize their prices relative to an aggregate price index but, rather, relative to the prices of their direct competitors, a feature that is reflected in their beliefs under rational inattention. As firms pay direct attention to the beliefs of their competitors, prices are on average closer to firms' expectations of their competitors' prices than to the aggregate price. Accordingly, expectations about aggregates are no longer the relevant index for firms' pricing decisions. Instead, a more appropriate index for aggregate prices is firms' aggregated expectations of their own competitors' prices. Importantly, strategic inattention creates a wedge between the relevant expectations for prices and aggregate inflation expectations.

Direct motivating evidence from firm-level survey data in section III supports the presence of strategic inattention among firms. First, to assess whether the conditions required by the basic model hold in the data, a novel question is included in a survey of New Zealand firms that measures significant strategic complementarities in pricing. Furthermore, when asked how many direct competitors they face in their main product market, firms report an average of eight competitors. Second, as predicted by the model, firms with fewer competitors are more uncertain about aggregate prices.[2] Third, firms are more aware of their own industry prices than aggregate prices, which is also consistent with the model's prediction that firms should pay direct attention to the beliefs of their competitors.

To study the quantitative implications of strategic inattention, section IV extends the basic static model of the paper to a microfounded dynamic general equilibrium model to explore its macroeconomic implications. Oligopolistic competition is modeled through households' preferences over different varieties, which generates many small oligopolies with heterogeneity in the number of firms operating within them. Firms are rationally inattentive and acquire information about their competitors' beliefs and fundamental shocks over time. On the methodological front, the model requires solving for the equilibrium strategy of a dynamic rational inattention game within every oligopoly, which, to the best of my knowledge, is novel to this paper. I solve these equilibrium strategies by extending recent methods for solving single-agent dynamic rational inattention models.[3]

To validate the model, I calibrate it to the firm-level survey data and find that the model matches firms' strategic inattention to inflation—that is, the relationship between firms' beliefs about aggregate inflation and the number of their competitors—as a nontargeted moment. In the calibrated model, firms in more competitive oligopolies acquire more information and allocate a larger amount of attention toward aggregate shocks, consistent with the empirical evidence that more competitive firms are more informed about aggregates (see the analysis in sec. III and Coibion, Gorodnichenko, and Kumar 2018).

[2] Coibion, Gorodnichenko, and Kumar (2018) document a similar result for the size of forecast errors. The model in this paper also delivers a precise prediction in terms of the *variance* of beliefs, which is tested in sec. III.

[3] In particular, I use the method developed by Afrouzi and Yang (2019), which builds on and generalizes the first-order condition methods developed in Maćkowiak, Matějka, and Wiederholt (2018).

The remainder of the paper in section V studies the *aggregate* and *reallocative* implications of strategic inattention for the propagation of monetary policy shocks to output and inflation. Since firms in less competitive oligopolies acquire less information about aggregate shocks, their price responses to these shocks are smaller and more persistent, both of which amplify monetary nonneutrality. I find that strategic inattention has quantitatively significant *aggregate* effects; it increases the volatility of output due to monetary shocks by up to 48% and increases its half-life by up to 22%. Moreover, it lowers the volatility of inflation caused by monetary shocks by up to 13% and increases its half-life by up to 9%. The fact that inflation responds more persistently to shocks among firms with fewer competitors is consistent with evidence documented by Schoenle (2018).

In addition to affecting the response of aggregate prices and output, strategic inattention also distorts the response of *relative* prices and *concentrates* output response toward oligopolies with fewer firms. Since such oligopolies are more strategically inattentive, their prices respond more sluggishly to expansionary monetary shocks, attracting demand toward more concentrated oligopolies. Thus, more oligopolistic firms contribute *more* to the output response of the economy relative to their steady-state market share. To examine these effects, I define the *concentration multiplier* of oligopolies with K competitors as the ratio of the cumulative response of outputs in those oligopolies relative to the aggregate output response. These multipliers are defined such that they are equal to one in a model without heterogeneity in output response. However, with the heterogeneity caused by strategic inattention, more concentrated oligopolies drive a larger share of the output response. For instance, the cumulative output response in duopolies is 17% larger than the average cumulative output response in the model.

The final step in section V is a conceptual decomposition that inspects the mechanisms that are at work in the quantitative model. It is well known that real rigidities significantly amplify monetary nonneutrality (Woodford 2003a). Since strategic complementarities in the dynamic model are endogenous to the environment of firms and vary with competition, it may as well be that all the quantitative results are driven by differences in real rigidities across oligopolies rather than by strategic inattention. But this is not the case. In fact, real rigidities work against strategic inattention in the calibrated model because firms with more competitors have higher strategic complementarities.

Therefore, oligopolistic competition has two opposing effects on monetary nonneutrality. Firms with fewer competitors pay less attention to monetary shocks due to strategic incentives, which *amplifies* monetary nonneutrality (the strategic inattention channel). However, firms with fewer competitors also have lower strategic complementarities, which *attenuates* monetary nonneutrality (the real rigidities mechanism). While both effects are significant, the strategic inattention mechanism dominates and amplifies monetary nonneutrality in oligopolies with fewer competitors.

To further investigate these mechanisms, I also derive an analytical decomposition in the static model and show that monetary nonneutrality decreases with the number of competitors as long as demand elasticities increase with the number of competitors. In a complementary exercise, I also solve the dynamic model under strategic complementarities that decrease with the number of competitors. In this model, the strategic inattention channel is mitigated because lower strategic complementarities of more competitive firms attenuate their incentives to acquire more information but are not enough to overturn the effect of larger demand elasticities on information acquisition. Accordingly, firms with more competitors acquire more information in this model as well, and strategic inattention continues to amplify monetary nonneutrality when the number of competitors is smaller.

Related literature.—This paper is motivated by the recent literature that investigates how firms' expectations are related to their environment. The most related work in this area is Coibion, Gorodnichenko, and Kumar (2018), which provides direct evidence for the relationship between firms' number of competitors and their expectations. To the best of my knowledge, the model in this paper is the first to provide an explanation for this relationship and to investigate its implications. Most notably, in the model, inflation responds more persistently to shocks among firms with fewer competitors. Schoenle (2018) documents a similar relationship in the US Producer Price Index data and provides evidence for this mechanism.

The model proposed in this paper is mainly related to the vast literature on rational inattention (Sims 1998, 2003) and especially its applications to pricing models and business-cycle dynamics (most notably, Maćkowiak and Wiederholt 2009, 2015; Matějka 2016).[4] The previous work in this literature has mainly focused on monopolistic competition models. The main contribution of this paper is to study the consequences of rational inattention in *oligopolistic* competition models, which is essential to the main objective of this study: aiming to understand the effects of competition on firms' expectations and, through this, its effects on inflation dynamics and monetary nonneutrality.

[4] For recent discussions, see also Pasten and Schoenle (2016), Stevens (2019), and Yang (2022); for a detailed review of this literature, see Maćkowiak, Matějka, and Wiederholt (2023). More broadly, the paper is also related to the literature on the effects of information rigidities and monetary policy (e.g., Lucas 1972; Mankiw and Reis 2002; Woodford 2003b; Reis 2006; Nimark 2008; Angeletos and La'O 2009; Angeletos and Lian 2016; Melosi 2016; Baley and Blanco 2019).

The oligopolistic structure of competition studied here is related to the literature that has focused on its macroeconomic implications (Rotemberg and Saloner 1986; Rotemberg and Woodford 1992; Atkeson and Burstein 2008). While this paper's main focus is to understand the interaction of oligopolistic competition with rational inattention, the implications of the model for monetary nonneutrality complement concurrent work by Mongey (2021) and Wang and Werning (2022), which focus on the interactions of nominal rigidities with oligopolies. These three models provide a unified view of how competition affects output and inflation dynamics but under different mechanisms.[5] In particular, the mechanism of interest here is strategic inattention, which affects aggregate dynamics through firms' *expectations* in a microfounded model with endogenous information acquisition.

The model's implications for inflation dynamics and monetary nonneutrality are also of particular interest given the recent evidence on the rise of concentration (see, e.g., Autor et al. 2020; Covarrubias, Gutiérrez, and Philippon 2020; Kwon, Ma, and Zimmermann 2023). My results suggest that these trends are also changing the landscape of monetary policy by affecting the propagation of these shocks to real and nominal variables.

This paper is also related to the literature on incentives to learn about others' beliefs in strategic environments (Hellwig and Veldkamp 2009; Myatt and Wallace 2012). I depart from this literature by focusing on an unrestricted set of available information and examining how the number of players affects information acquisition incentives in a dynamic general equilibrium model. In that sense, the paper is also related to Denti (2023), which studies unrestricted information acquisition with a finite set of actions and states, and Hébert and La'O (2023), which studies large static games with more general information cost functions.

II. Static Model

This section studies the effect of oligopolistic competition on expectations in a static model with analytical solutions. It shows that oligopolistic firms pay attention to their competitors' beliefs, leading to correlated nonfundamental mistakes in equilibrium. While the main article focuses on the economic implications, appendix C (apps. A–M are available online)

[5] Studying monetary nonneutrality with monopolistic competition under each of these frictions has a long history. For information friction models, see Lucas (1972) and Woodford (2003a). For random price adjustments in New Keynesian models, see Woodford's (2003b) review of that literature. For price adjustment under menu costs, see, e.g., Caplin and Spulber (1987), Golosov and Lucas (2007), and Nakamura and Steinsson (2010).

provides a rigorous treatment, with proofs of propositions presented in appendix section C.9.

A. *The Environment*

There are a large number of sectors in the economy, indexed by $j \in J$, each with K price-setting firms that compete with one another. Firms' profits depend on a fundamental shock, $q \sim \mathcal{N}(0, 1)$. Given q and prices $(p_{l,m})_{(l,m)\in J\times K}$, firm j,k experiences quadratic profit losses from charging a price $p_{j,k}$:

$$L_{j,k}(q, (p_{j,k})_{(j,k)\in J\times K}) = \left(p_{j,k} - (1-\alpha)q - \alpha\frac{1}{K-1}\sum_{l\neq k} p_{j,l}\right)^2,$$

where $\alpha \in [0, 1)$ denotes the degree of *within*-sector strategic complementarity.[6] In section IV, I derive this loss function as a second-order approximation of firms' profits and relate α to demand parameters.

Firms are rationally inattentive. They acquire information subject to a finite attention capacity and choose a pricing strategy that maps their information set to a price. To understand firms' incentives in information acquisition, I model the information choice set such that firms can directly choose the joint distribution of their price with q and others' prices. While this is a well-known feature of single-agent rational inattention problems, it is not immediately clear how this would work in a game-theoretic setting. How can a firm directly acquire information about other firms' beliefs in a simultaneous game? Appendix section C.1 formalizes the answer by constructing a *rich* set of available signals, denoted by $\mathbb{S}$, as the vector space generated by the fundamental q and a set of countably infinite independent normal random variables. As shown formally in the proof of lemma C.2 in appendix section C.1, any deviation in joint Gaussian distributions can then be generated by a random variable in this vector space.[7]

Therefore, a pure strategy for firm j,k is to choose a set of signals, $S_{j,k} \subseteq \mathbb{S}$, and a pricing strategy that is measurable with respect to the σ-algebra generated by its signals, $p_{j,k} : S_{j,k} \to \mathbb{R}$. Given a strategy profile for others, $(S_{l,m} \subseteq \mathbb{S})_{(l,m)\neq(j,k)}$, firm j,k solves

$$\min_{S_{j,k}\subseteq\mathbb{S}} \mathbb{E}\left[\min_{p_{j,k}:S_{j,k}\to\mathbb{R}} \mathbb{E}\left[\left(p_{j,k}(S_{j,k}) - (1-\alpha)q - \alpha\frac{1}{K-1}\sum_{l\neq k} p_{j,l}(S_{j,l})\right)^2 \middle| S_{j,k}\right]\right] \quad (1)$$
$$\text{s.t.} \quad \mathcal{I}(S_{j,k}; q, (p_{l,m}(S_{l,m}))_{(l,m)\neq(j,k)}) \leq \kappa.$$

[6] Here q and $(p_{j,k})_{j\in J,k\in K}$ can be interpreted as log deviations from a steady-state symmetric equilibrium.

[7] My definition of a rich information set corresponds to the concept of flexible information acquisition in Denti (2023).

Here $\mathcal{I}(S_{j,k}; q, (p_{l,m}(S_{l,m}))_{(l,m)\neq(j,k)})$ is Shannon's mutual information function and measures the amount of information that firms' signals contain about q and others' prices. Moreover, the constraint requires that a firm cannot acquire more than κ *nats* of information.[8] I start by assuming that κ is exogenous to study how firms allocate a fixed κ across q and other firms' prices. I relax this assumption starting in section II.D to also study how oligopoly parameters affect the choice of κ itself.

Definition 1. A pure-strategy Gaussian equilibrium for this economy is a strategy profile $(S_{j,k} \subseteq \mathbb{S}, p_{j,k} : S_{j,k} \to \mathbb{R})_{(j,k)\in J\times K}$ from which no firm has an incentive to deviate and $(q, (p_{j,k})_{(j,k)\in J\times K})$ has a multivariate Gaussian distribution.

It can be shown that in all equilibria each firm observes only one signal, collinear with their price.[9] Let us denote strategies with this property, where the signal recommends the optimal price generated by its σ-algebra $(S_{j,k} \in \mathbb{S}, p_{j,k} = S_{j,k})$, as *recommendation strategies*. Proposition C.1 in appendix section C.1 shows that all strategies are weakly dominated by feasible recommendation strategies. Thus, we can focus on recommendation strategies without loss of generality.

It then follows that all equilibria are unique in the joint distribution that they imply for firms' prices and q, which is shown in appendix section C.2. The optimality of recommendation strategies combined with the uniqueness of the equilibrium in the joint distribution of prices and q allow us to directly focus on how firms' prices are related to one another. Let $p_{j,k} = S_{j,k}$ represent the price that firm j,k charges in the equilibrium. Proposition C.1 further characterizes these equilibrium prices as

$$p_{j,k} = \lambda \times \left((1-\alpha)q + \alpha\frac{1}{K-1}\sum\nolimits_{l\neq k} p_{j,l}\right) + z_{j,k}, \quad z_{j,k} \perp (q, S_{m,l})_{(m,l)\neq(j,k)}$$
$$\mathbb{E}[z_{j,k}] = 0, \quad \mathbb{V}\mathrm{ar}(z_{j,k}) = \lambda(1-\lambda)\mathbb{V}\mathrm{ar}\left((1-\alpha)q + \alpha\frac{1}{K-1}\sum\nolimits_{l\neq k} p_{j,l}\right), \tag{2}$$

where $\lambda \equiv 1 - e^{-2\kappa}$ represents a change of variables and has the interpretation of firms' optimal Kalman gains on their equilibrium signals. Moreover, $z_{j,k}$ represents noise in prices introduced by rational inattention. We see that a larger capacity, κ, increases the covariance of prices with q and decreases the variance of the rational inattention noise in the signal if the signal was normalized to be of the form "ideal price plus noise." However, note that κ has a nonmonotonic effect on the variance

[8] Every *nat* is equal to $\log_2(e) \approx 1.443$ bits. For details about Shannon's mutual information function, see app. B.

[9] This extends the equivalent result in single-agent rational inattention problems to our game-theoretic setting (see, e.g., Steiner, Stewart, and Matějka 2017; Maćkowiak, Matějka, and Wiederholt 2018; Afrouzi and Yang 2019).

of the rational inattention noise in the price itself, as seen in the expression for $\mathbb{V}\text{ar}(z_{j,k})$ above. This is because higher κ decreases the noise variance in the normalized signals but also increases how much weight firms put on these signals in setting their prices. Thus, the variance of the noise in prices is a U-shaped function of κ.

B. *Economics of Attention Allocation*

Rationally inattentive firms make mistakes in observing q—captured by $z_{j,k}$ above—which affects their prices and the profits of their competitors. This section shows that firms choose to have correlated mistakes, which creates a wedge between their expectations of industry versus aggregate prices.

Define a mistake as the part of a firm's price that is orthogonal to q. Then, any firm's price can be decomposed into its projection on q and its mistake:

$$p_{j,k} = \delta q + v_{j,k},\, v_{j,k} \perp q, \quad \delta \in \mathbb{R}.$$

The vector $(v_{j,k})_{j,k \in J \times K}$ contains the *mistakes* of firms in the equilibrium, whose joint distribution is determined endogenously. Importantly, these mistakes may not be independent across firms, as managers of competing firms optimally attend to others' mistakes.

With Gaussian distributions, a firm's attention to a shock—that is, the mutual information between its information set and the shock—increases with the absolute correlation of the firm's price with that shock.[10] Building on this, appendix section C.3 shows that when others play a strategy in which $[1/(K-1)]\Sigma_{l \neq k} p_{j,l} = \delta q + v_{j,-k}$, firm j,k's problem can be recast into choosing two separate correlations:

$$\max_{\rho_q \geq 0, \rho_v \geq 0} \rho_q + \frac{\alpha \sigma_v}{1 - \alpha(1 - \delta)} \rho_v \quad \text{s.t.} \quad \rho_q^2 + \rho_v^2 \leq \lambda \equiv 1 - e^{-2\kappa}.$$

Here $\sigma_v \equiv \sqrt{\mathbb{V}\text{ar}(v_{j,-k})}$ represents the standard deviation of the average mistakes of j,k's competitors, ρ_q represents the correlation of the firm's signal with the fundamental, and ρ_v represents its correlation with the average mistake of its competitors. The following proposition states the properties of the equilibrium.

PROPOSITION 1. In equilibrium, (1) firms pay strictly positive attention to the mistakes of their competitors ($\rho_v^* > 0$) if $\alpha > 0$ and K is finite, (2) firms do not pay attention to mistakes of those in other industries ($\forall (j, k), (l, m)$ if $j \neq l$, $p_{j,k} \perp p_{l,m} | q$), and (3) firms' knowledge of the fundamental increases in the number of their competitors and decreases in the degree of strategic complementarity:

[10] For two normal random variables X and Y with correlation ρ, $\mathcal{I}(X, Y) = -(1/2)\ln(1 - \rho^2)$, which is increasing in ρ^2.

$$\frac{\partial}{\partial K}\rho_q^* > 0, \frac{\partial}{\partial \alpha}\rho_q^* < 0. \tag{3}$$

Firms pay strictly positive attention to the mistakes of their own competitors, because they are affected by them, but not to the mistakes of firms in other industries. Since mistakes are orthogonal to q, fixing κ, any attention to others' mistakes has to be traded off with attention to the fundamental. With a larger α, a firm's profits depend more on competitors' mistakes and the payoff of attending to these mistakes is higher. Also, with a larger K, the average mistake of a firm's competitors is less variable (σ_v is smaller), which implies that more competitive firms substitute their attention toward the fundamental q.[11]

C. *Comovement of Prices and Expectations*

Conventional models relate firms' prices to their expectations of aggregate prices. However, empirical evidence on firms' expectations shows that there is a disconnect between firms' prices and their expectations of aggregate inflation (Coibion, Gorodnichenko, and Kumar 2018). The model in this section provides an explanation for this disconnect by showing that, at least with high strategic complementarities, firms' prices are related mainly to their expectations of their *competitors' prices*:

$$p = (1-\alpha)\overline{\mathbb{E}^{j,k}[q]} + \alpha\overline{\mathbb{E}^{j,k}[p_{j,-k}]}.$$

The key notion here, as formalized in the proposition below, is that rational inattention with oligopolies predicts a wedge between aggregate prices and firms' average expectations of the aggregate price.

PROPOSITION 2. In equilibrium, the realized price is closer in absolute value to the average expectations from own-industry prices than the average expectation of the aggregate price itself:

$$\left|p - \overline{\mathbb{E}^{j,k}[p_{j,-k}]}\right| < \left|p - \overline{\mathbb{E}^{j,k}[p]}\right|.$$

This result relies on firms' incentives to pay attention to the mistakes of their competitors. In equilibrium, the signals that firms observe are more informative of their own sector's prices:

$$S_{j,k} = \underbrace{\overbrace{p}^{=\delta q\text{. covaries with aggregate price}} + u_j}_{\text{covaries with industry prices}} + e_{j,k}, \tag{4}$$

[11] The proof of proposition 1 deals with the subtlety that σ_v is an equilibrium object and formalizes this argument.

where we have decomposed the mistake of firm j,k as $v_{j,k} = u_j + e_{j,k}$, where $u_j \perp p$ represents the common mistake in sector j and $e_{j,k}$ represents the independent part of firm j,k's mistake. Since $\mathbb{V}\mathrm{ar}(u_j) \neq 0$ (by proposition 1), this signal reveals more information about industry prices. Thus, oligopolistic firms are more informed about their industry prices than the aggregate price, even without any idiosyncratic shocks.

Moreover, these optimal signals generate correlated posteriors such that firms cannot distinguish between changes in fundamental q and their competitors' beliefs. Specifically, realizations of firms' optimal signals inform them of changes to their desired prices but do not reveal the source of those changes. Therefore, while an increase in q causes an increase in firms' prices, the strength of a firm's response to such a change depends on how strongly its signal covaries with both q and its competitors' prices. This is similar to the mechanism discussed in Hellwig and Venkateswaran (2009), where firms in a setting with exogenous information and a continuum of firms respond quickly to aggregate changes, even though they are not as well informed about aggregates. As such, it can be shown that in spite of lower attention to q when K is smaller, the number of firms does not directly affect the covariance of aggregate price with the fundamental. Equation (C.6) in appendix section C.2 derives the aggregate price as $p = \delta q$ in the symmetric equilibrium, where

$$\delta = \frac{\lambda - \alpha\lambda}{1 - \alpha\lambda}, \tag{5}$$

which increases with capacity through λ and decreases with α but does not directly depend on K.

The independence of δ from K is a direct consequence of firms' correlated posteriors discussed above. With more competitors, firms pay more attention to the fundamental q, but with a fixed κ this increased attention to q comes at the expense of reduced attention to competitors' mistakes, which lowers the covariance of their price with their expectation of their competitors' prices. This is formalized in the following proposition, which is proved and discussed in more detail in appendix section C.9.

Proposition 3. *Fixing the information capacity κ, higher attention to the fundamental q is compensated by lower attention to competitors' mistakes, so much so that the covariance of aggregate price with the fundamental is independent of the number of firms K.*

The substitution channel in proposition 3 is a general force, but the independence of δ from the number of competitors also relies on the fixed capacity assumption and the static environment. We investigate the role of these assumptions by endogenizing capacity first and postponing dynamics to section IV.

D. *Endogenous Choice of Information Processing Capacity*

So far, we have studied how oligopolistic firms allocate a fixed amount of capacity, κ, as a function of the oligopoly parameters α and K. In this section, I endogenize κ and analyze how the oligopoly structure affects firms' optimal capacity, as well as the degree of monetary nonneutrality in the economy.

Optimal information capacity.—Consider this extension of the firms' problem in equation (1):

$$\min_{\kappa_{j,k}\geq 0}\left\{\min_{S_{j,k}\subseteq \mathbb{S}}\mathbb{E}\left[\min_{p_{j,k}:S_{j,k}\to\mathbb{R}}\mathbb{E}\left[\frac{1}{2}B(p_{j,k}(S_{j,k})-p^*_{j,k}(S_{j,-k}))^2\,|S_{j,k}\right]\right]+\omega\kappa_{j,k}\right\} \tag{6}$$

$$\text{s.t. } \mathcal{I}(S_{j,k};q,(p_{l,m}(S_{l,m}))_{(l,m)\neq(j,k)})\leq\kappa_{j,k},\quad p^*_{j,k}(S_{j,-k})\equiv(1-\alpha)q+\alpha\frac{1}{K-1}\textstyle\sum_{l\neq k}p_{j,l}(S_{j,l}),$$

where now, in addition to choosing $S_{j,k}$, firm j,k also chooses the capacity $\kappa_{j,k}\geq 0$, subject to a cost $\omega\kappa_{j,k}$, where $\omega>0$ is a new parameter that captures the cost of producing capacity. Moreover, the new parameter $B>0$ captures the *curvature* of the firm's profit function and is microfounded in section IV.

Since we have already solved what the optimal attention strategy of firms is for a given κ, we can plug in this optimal allocation and rewrite the problem simply in terms of $\kappa_{j,k}$, derived in appendix section C.4:

$$\min_{\kappa_{j,k}\geq 0}\left\{\frac{1}{2}e^{-2\kappa_{j,k}}BV^*_{j,-k}+\omega\kappa_{j,k}\right\}, \tag{7}$$

where $V^*_{j,-k}$ represents the unconditional variance of firm j,k's ideal price given others' strategies, $p^*_{j,k}(S_{j,-k})$. The coefficient $e^{-2\kappa_{j,k}}$ captures the notion that by choosing a higher capacity, firms can reduce their expected losses from mispricing, in proportion to the curvature of their profit function B. Given the equilibrium strategy of other firms, which determines $V^*_{j,-k}$, the optimal capacity $\kappa^*_{j,k}$ is

$$\kappa^*_{j,k}=\frac{1}{2}\max\{0,\ln(BV^*_{j,-k}/\omega)\}. \tag{8}$$

Here the max operator captures the possibility of the constraint $\kappa_{j,k}\geq 0$ binding, which happens if the cost ω is too high relative to the expected losses from mispricing. Moreover, holding ω fixed, the optimal capacity $\kappa^*_{j,k}$ is increasing in the curvature of the firm's profit function B and the volatility of the ideal price $V^*_{j,-k}$, both of which increase the firms' expected losses from mispricing.

Equilibrium capacity.—To understand how $\kappa^*_{j,k}$ depends on the oligopoly parameters, we need to characterize $V^*_{j,-k}$ and $\kappa^*_{j,k}$ jointly. As before, the change of variable $\lambda^*=1-e^{-2\kappa^*}$ is useful, where λ^* represents the optimal Kalman gain of firms on their equilibrium signals and increases with κ^*. Then, a symmetric equilibrium is characterized by the following two equations, as derived in appendix section C.5:

$$V^* = \left(\frac{1-\alpha}{1-\alpha\lambda^*}\right)^2 \frac{K-1+\alpha\lambda^*}{K-1+\alpha\lambda^*[(1-\alpha)/(1-\alpha\lambda^*)]}, \tag{9}$$

$$\lambda^* = \max\{0, 1-\frac{\omega}{BV^*}\}, \tag{10}$$

where we have dropped indexes j,k and $j,-k$ due to symmetry. Here the first equation gives the variance of firms' ideal prices as a function of their optimal capacities in a symmetric equilibrium. Moreover, the second equation is a reformulation of equation (8) in terms of λ^*, where again the max operator captures the possibility of the constraint $\kappa \geq 0$ binding—in which case $\lambda^* = 1 - e^{-2\kappa^*} = 0$.

Importantly, endogenous capacity can lead to a multiplicity of symmetric equilibria with either $\lambda^* = 0$ or $\lambda^* > 0$, as discussed in appendix section C.6. This is because strategic complementarity in pricing introduces strategic complementarity in information acquisition, as discussed in Hellwig and Veldkamp (2009), albeit in a setting with a continuum of agents.[12] With high α or ω, if a firm's competitors choose $\lambda^* = 0$, then the value of information could fall enough that the firm itself has no incentive to deviate from such a strategy. However, if ω or α are small enough—precisely, if $\omega < B(1-\alpha)^2\,\mathbb{V}\text{ar}(q)$, with $\mathbb{V}\text{ar}(q)$ normalized to one here—this does not happen and there is a unique equilibrium with $\lambda^* > 0$. In the main text, I focus on this equilibrium because it is the closest to the one studied in the dynamic model.

PROPOSITION 4. When $\omega < B(1-\alpha)^2\,\mathbb{V}\text{ar}(q)$, there is a unique symmetric equilibrium where λ^* decreases with ω,α and K and increases with B.

A higher ω increases the cost of information, leading to lower-capacity κ^* and $\lambda^* = 1 - e^{-2\kappa^*}$. A higher B increases the value of information due to higher curvature of the profit function, leading to higher λ^*. Moreover, holding other parameters fixed, a higher α reduces the direct weight firms put on the fundamental and decreases the variance of firms' ideal prices, lowering λ^*. Similarly, all else equal, a higher K decreases the variance of firms' ideal prices due to the law of large numbers and leads to lower λ^*.

Attention to the fundamental.—The relationship between λ^* and K affects how firms pay attention to the fundamental q. Holding capacity constant, proposition 1 shows that firms with more competitors pay more attention to the fundamental because the law of large numbers reduces the average size of their competitors' mistakes, reducing the value of information on the margin. With endogenous capacity, firms internalize this effect and opt for a smaller capacity, which reduces their total attention to shocks,

[12] While the setting in Hellwig and Veldkamp (2009) is different enough that making exact comparisons would require a lengthier discussion, the information acquisition incentives that arise under strategic complementarities are similar. However, the main focus here is to study how these incentives vary with K and affect the propagation of shocks.

including q. However, it can be shown that this secondary effect is small for small values of ω/B, and attention to the fundamental, ρ_q^{*2}, remains increasing with K in such a case. A more detailed discussion of how ρ_q^{*2} varies with K can be found in appendix section C.7, and an intuitive representation is provided in appendix section C.8 using the following approximation of ρ_q^{*2} in the unique equilibrium:

$$\rho_q^{*2}\left(\frac{\omega}{B}, \alpha, K\right) = 1 - \frac{\alpha + (1-\alpha)(K-1)}{(K-1+\alpha)(1-\alpha)}\frac{\omega}{B} + \mathcal{O}\left(\left\|\frac{\omega}{B}\right\|^2\right). \quad (11)$$

This expansion approximates ρ_q^{*2} in the unique symmetric equilibrium around the full-information benchmark—that is, $\omega = 0$. It is an appropriate approximation because the unique equilibrium requires that $\omega/B < (1-\alpha)^2\, \mathbb{V}\mathrm{ar}(q) < \mathbb{V}\mathrm{ar}(q) = 1$. Importantly, it shows that for small ω/B, attention to the fundamental increases with K as well as B and decreases with α and ω.

Covariance of prices with the fundamental.—Let us conclude this section by revisiting the covariance of prices and the fundamental, δ in equation (5), now under endogenous capacity. This equation shows that, all else equal, the covariance decreases with α both directly and indirectly through λ^* and decreases with K indirectly through λ^*. While we can use the predictions of proposition 4 to perform these comparative statics, a more intuitive way is to do an approximation of δ around the full-information benchmark, $\omega = 0$, similar to the one used for ρ_q^{*2}. As derived in appendix section C.8,

$$\delta^*\left(\frac{\omega}{B}, \alpha, K\right) = 1 - \frac{\omega}{B(1-\alpha)} - \frac{(K-1)\alpha}{K-1+\alpha}\left(\frac{\omega}{B(1-\alpha)}\right)^2 + \mathcal{O}\left(\left\|\frac{\omega}{B}\right\|^3\right). \quad (12)$$

This approximation accurately captures the comparative statics discussed, but it is also an appropriate end point for our analysis of the static model. My approach so far has been to separately study the effects of α, K, and ω/B, which has been helpful in isolating the mechanisms at work. However, this approach ignores the microfoundations of B and α. As we see in the dynamic model, both α and B also depend on K, creating a cascade of interactions through which δ and monetary nonneutrality vary with K. Armed with the intuition from the static model, I first provide some motivating evidence and then turn to the dynamic model to study the implications of strategic inattention for the transmission of monetary policy in a microfounded setting.

III. Motivating Facts from Survey Data

Using the survey of firms' expectations from New Zealand conducted by Coibion, Gorodnichenko, and Kumar (2018) and Coibion et al. (2021), this section provides motivating evidence for the predictions of the model in the above section.[13] Relative to previously documented facts, (1) I implement a new survey question that identifies the degree of strategic complementarity for firms and (2) I document that firms with more competitors are less uncertain about aggregate inflation.

Number of competitors and strategic complementarity.—Two of the key parameters of the model are the number of a firm's direct competitors and the degree of strategic complementarity. Two questions in the survey measure these within a representative sample.

The first question asks firms, "How many direct competitors does this firm face in its main product line?" Column 2 in table A.1 (tables A.1–M.3 are available online in apps. A–M, respectively) presents a breakdown of firms' answers from the sixth and eighth waves of the survey based on their industries. The average response in the sample is eight, which is also fairly uniform across different industries. Moreover, figure A.1 (figs. A.1–M.1 are available online in apps. A–M, respectively) shows the distribution of firms' responses in the sixth wave, with 45% of firms reporting six or fewer direct competitors.

As for the degree of strategic complementarity, I rely on the following survey question:[14] "Suppose that you get news that the general level of prices went up by 10% in the economy.

a) By what percentage do you think your competitors would raise their prices on average?
b) By what percentage would your firm raise its price on average?
c) By what percentage would your firm raise its price if your competitors did not change their price at all in response to this news?"

The question proposes a change in the firms' environment due to aggregate variables, which affects both their costs and those of their competitors.[15] The question then measures three different quantities that allow me to disentangle the degree of strategic complementarity:

[13] This survey was conducted in a random sample of firms with broad sectoral coverage. The data I use here are described in detail in Coibion, Gorodnichenko, and Kumar (2018) and Coibion et al. (2021) and are publicly available in the published replication packages of those articles.

[14] The challenge for estimating this parameter using price data is that it is hard to find exogenous variations in the prices of a firm's competitors that are not correlated with aggregates or the firm's own costs. There has been some recent progress in this area: Amiti, Itskhoki, and Konings (2019) use international shocks as instruments for shocks that move competitors' prices and provide estimates of strategic complementarities for Belgian manufacturing firms. More recently, Burya and Mishra (2023) use the ACNeilsen barcode scanner data to estimate this object for the retail sector in the United States.

[15] I am grateful to anonymous referees for pointing out the following caveats with the framing of this question. First, the question takes for granted that firms partially associate a change in the general level of prices with a change in their nominal costs. This is a model-consistent assumption but might not hold in reality. A more accurate framing would be to

$$p_{j,k} = \overbrace{\underbrace{(1-\alpha)\mathbb{E}^{j,k}[q]}_{\text{answer to } c} + \alpha\underbrace{\mathbb{E}^{j,k}[p_{j,-k}]}_{\text{answer to } a}}^{\text{answer to } b}. \tag{13}$$

The average α implied by the responses of firms to this question is 0.82 and fairly uniform across different industries, as reported in column 4 of table A.1.[16] Coibion et al. (2021) follow my approach here and estimate similar strategic complementarities. Appendix D also examines the relationship between firms' number of competitors and the degree of strategic complementarity and shows that while varying slightly and nonmonotonically with K, the average α within equal quantiles and deciles of K remains, on average, in the interval [0.8, 0.9].

Uncertainty about inflation versus number of competitors.—We can also directly test the prediction of the model that firms with more competitors should pay more attention to the aggregates. In the sixth wave of the survey in 2016, firms were asked to report the distribution of their beliefs for aggregate inflation: "Please assign probabilities (from zero to 100) to the following ranges of overall price changes in the economy over the next 12 months for New Zealand." Firms were then asked to assign probabilities to a set of equally sized bins.[17] To test the model's prediction, I run the following regression:

$$\log(\sigma_i^\pi) = \beta_0 + \beta_1 \log(K_i) + \varepsilon_i, \tag{14}$$

where σ_i^π represents firm i's subjective uncertainty about the aggregate inflation—that is, the standard deviation of their reported distribution for inflation—and K_i represents the firm's reported number of competitors.

The model's prediction translates to the null hypothesis that $\beta_1 < 0$.[18] Table 1 reports the result of this regression and finds $\beta_1 < 0$ and significant. This result is robust to including firm controls such as firms' age and size (measured by employment in the main product line) as well as industry fixed effects.

This relationship is not reconcilable with full-information rational expectation models or, to the best of my knowledge, other macroeconomic

propose a hypothetical scenario for an increase in nominal costs directly. Second, similar to the question about the number of competitors, a more precise framing of this question should refer to firms' *direct* competitors.

[16] For reference, the usual calibration for the strategic complementarity in the United States in monopolistic competition models is around 0.9 (see, e.g., Mankiw and Reis 2002; Woodford 2003b), which is slightly larger than what I estimate here.

[17] Firms were asked to assign probabilities to bins ranging from −25% to 25% in 5% increments. The wide range is to avoid priming concerns, especially that firms assign positive probabilities to high inflation rates.

[18] In the model, $\sigma_i^{\pi 2} \equiv \mathbb{V}\text{ar}(q|S_{j,k}) = (1-\rho_q^{*2})\mathbb{V}\text{ar}(q)$, which is strictly increasing in firms' attention to the fundamental, measured by ρ_q^{*2}. Thus, the predictions of the static model for how ρ_q^{*2} should vary with K translate to predictions about σ_i^π.

TABLE 1
Subjective Uncertainty of Firms and the Number of Competitors

	$\log(\sigma^\pi)$ (1)	$\log(\sigma^\pi)$ (2)
$\log(K)$	−.116	−.115
	(.012)	(.013)
Observations	1,661	1,661

Note.—Column 1 reports the result of regressing the log standard deviation of firms' reported distribution for their forecast of aggregate inflation on the log of their number of competitors. Column 2 reports the same coefficient while controlling for firm age, firm size measured by employment in the main product line, and fixed effects for construction, manufacturing, professional and financial services, and trade industries. Robust standard errors are reported in parentheses.

models of information rigidity before this paper, and it indicates the importance of strategic incentives in how much firms pay attention to aggregate variables.

Knowledge about industry versus aggregate inflation.—The model also predicts that firms are more aware of their competitors' prices than the aggregate price. In the fourth wave of the survey conducted in 2014, firms were asked to provide their nowcasts of industry and aggregate yearly inflation. Consistent with this prediction, table 2 shows that the average absolute nowcast error for industry inflation (1.16 percentage points) is lower than the average absolute nowcast error for aggregate inflation (3.50 percentage points). Additionally, in figure A.2 we see that these distributions are oppositely skewed: for nearly two-thirds of firms, their nowcast error for aggregate inflation is larger than the average error, while the reverse is true for industry inflation.

TABLE 2
Size of Firms' Nowcast Errors

		Industry Inflation		Aggregate Inflation	
Industry	Observations (1)	Mean (2)	Standard Deviation (3)	Mean (4)	Standard Deviation (5)
Construction	57	.62	.51	4.55	2.75
Manufacturing	415	1.46	1.92	2.73	2.29
Financial services	477	1.33	1.45	4.73	2.31
Trade	307	.59	.91	2.44	2.13
Total	1,256	1.16	1.54	3.50	2.51

Note.—This table reports summary statistics for the size of firms' nowcast errors in perceiving aggregate inflation vs. industry inflation for the 12 months ending in December 2014 (from wave 4 of the survey). Industry (aggregate) inflation nowcast errors are defined as the absolute difference between firms' nowcasts and the actual industry (aggregate) inflation rate in that year.

IV. A Microfounded Dynamic Model

This section microfounds and extends the static model of section II to a dynamic general equilibrium model to quantitatively analyze the effects of strategic inattention for the propagation of monetary policy shocks. Derivations and proofs of propositions in this section are included in appendixes F and H.

A. *Environment*

Households.—The economy consists of a large number of sectors, $j \in J \equiv \{1, \dots, J\}$. Each sector j consists of $K_j \geq 2$ firms that produce weakly substitutable goods, where K_j is drawn from a distribution $\mathcal{K}$. The representative household takes the prices of these goods as given and decides how much to demand from each firm's product. The aggregate time-t consumption of the household is

$$C_t \equiv \prod_{j \in J} C_{j,t}^{J^{-1}}, \quad C_{j,t} \equiv \Big(K_j^{-1} \sum_{k \in K_j} C_{j,k,t}^{(\eta-1)/\eta}\Big)^{\eta/(\eta-1)}, \tag{15}$$

where $C_{j,t}$ represents the composite demand of the household for sector j, determined by a constant elasticity of substitution (CES) aggregator with the elasticity of substitution $\eta > 1$.[19] Moreover, the aggregate consumption, C_t, is a Cobb-Douglas aggregation of the composite goods across sectors. Therefore, the representative household's problem is

$$\begin{aligned} &\max_{((C_{j,k,t})_{(j,k) \in J \times K}, C_t, L_t, B_t)_{t=0}^{\infty}} \quad \mathbb{E}_0^f \textstyle\sum_{t=0}^{\infty} \beta^t [\log(C_t) - L_t] \\ \text{s.t.} \quad &\textstyle\sum_{j,k} P_{j,k,t} C_{j,k,t} + B_t \leq W_t L_t + (1 + i_{t-1}) B_{t-1} + \sum_{j,k} \Pi_{j,k,t} - T_t, \end{aligned} \tag{16}$$

where $\mathbb{E}_t^f[.]$ represents the full-information rational expectations operator at time t,[20] C_t represents the aggregate consumption, L_t represents the labor supply of the household, B_t represents their demand for nominal bonds, W_t represents the nominal wage, i_t represents the net nominal interest rate, $\Pi_{j,k,t}$ denotes the profit of firm j,k at time t, and T_t represents a lump sum transfer that is used to eliminate long-run inefficiencies of imperfect competition.

The within-sector CES aggregator leads to the following demand function for firm j,k:

$$C_{j,k,t} = Q_t \mathcal{D}(P_{j,k,t}; P_{j,-k,t}), \quad \mathcal{D}(P_{j,k,t}; P_{j,-k,t}) \equiv J^{-1} \frac{P_{j,k,t}^{-\eta}}{\sum_{l \in K_j} P_{j,l,t}^{1-\eta}}, \tag{17}$$

[19] A more general aggregator can be considered here (e.g., Rotemberg and Woodford 1992). I derive the implied demand under a generic aggregator in app. F. Another specific case is the Kimball aggregator, which I discuss in app. G.

[20] To study the effects of rational inattention under imperfect competition among firms, I assume that households are fully informed about prices and wages, which is a common assumption in the literature (see, e.g., Melosi 2016).

where $Q_t \equiv P_t C_t$ represents the nominal aggregate demand, with P_t denoting the price of the bundle C_t. Moreover, $P_{j,k,t}$ represents firm j,k's price at t, and $P_{j,-k,t}$ is the vector of other firms' prices in sector j. Furthermore, the household's intertemporal Euler and labor supply equations are given by

$$W_t = Q_t, \quad 1 = \beta(1 + i_t)\mathbb{E}_t^f[\frac{Q_t}{Q_{t+1}}].$$

Firms.—Firms are rationally inattentive. At each period t, given their information set from the previous period, they choose which signals to observe from a rich set of *available signals*, $\mathbb{S}^t$, subject to an information processing constraint.[21] At each t, firm j,k can choose its information processing with a cost that is denominated in labor, where the real cost of producing every unit of capacity is $\omega \mathrm{rs}_j$ units of labor. Thus, if $L^i_{j,k,t}$ denotes the amount of labor that the firm j,k uses for producing capacity, then $\kappa_{j,k,t} = (\omega \mathrm{rs}_j)^{-1} L^i_{j,k,t}$. Here $\omega > 0$ is the parameter that governs the cost of information, and $\mathrm{rs}_j = (JK_j)^{-1}$ represents the revenue share (or relative size) of the firm in the *full-information* symmetric equilibrium. This implies that the nominal cost of producing capacity $\kappa_{j,k}$ is $W_t L^i_{j,k,t} = W_t \omega \mathrm{rs}_j \kappa_{j,k,t}$, where W_t represents the nominal wage. Moreover, the assumption that the labor cost of information is proportional to the firms' relative size in the full-information benchmark (rs_j) hinges on three reasons. First, it makes the analysis consistent with the empirical evidence, since all the regressions presented in this paper about strategic inattention and the references to the literature control for firms' relative size. Second, from a theoretical perspective, it makes firms' rational inattention problems size-independent so that as we take the monopolistic competition limit, information acquisition does not become infinitely costly for firms (I revisit this in more detail below when I derive a second-order approximation to the firms' problem). Finally, in the absence of this assumption, information would be relatively more costly for smaller firms to acquire, which is inconsistent with the evidence on how firm size correlates with attention—if anything, larger firms are *more* inattentive to aggregate variables (Coibion, Gorodnichenko, and Kumar 2018; Candia, Coibion, and Gorodnichenko 2021).[22]

After firms make their information choices, all new shocks and signals are drawn and each firm observes the realization of its signals. Firms then choose their prices conditional on their information sets,[23] after which demand for each variety is realized. Firms then hire enough labor

[21] See app. E for the formal specification of $\mathbb{S}^t$.

[22] Similar assumptions are common in menu cost models. See, e.g., Gertler and Leahy (2008), where menu costs are assumed to be proportional to firms' relative size so that pricing decisions are size-invariant.

[23] Since my main objective is to examine the real effects of monetary policy through endogenous information acquisition, I abstract away from other sources of monetary nonneutrality and in particular assume that prices are perfectly flexible.

to produce with a production function that has decreasing returns in labor, $Y_{j,k,t} = (L^{p}_{j,k,t})^{1/(1+\gamma)}$, and meet their demand.

Formally, a strategy for firm j,k at t is to choose an information processing capacity conditional on their initial information set, $\kappa_{j,k,t} : S^{t-1}_{j,k} \to \mathbb{R}_+$, a set of signals to observe, $S_{j,k,t} \subset \mathbb{S}^t$, and a pricing strategy that maps its information set to their optimal actions, $P_{j,k,t} : S^t_{j,k} \to \mathbb{R}$, where $S^t_{j,k} = \{S_{j,k,\tau}\}^t_{\tau=0}$ represents the firm's information set at time t. Given a strategy for all the other firms in the economy, firm j,k maximizes the net present value of their profits given their information set from the previous period:

$$\max_{\{S_{j,k,t} \subset \mathbb{S}^t, P_{j,k,t}(S^t_{j,k}), \kappa_{j,k,t}(S^{t-1}_{j,k})\}_{t\geq 0}}$$

$$\mathbb{E}\Bigg[\sum_{t=0}^{\infty} \underbrace{\beta^t Q_t^{-1}}_{\text{discount factor}} \Big(\underbrace{P_{j,k,t}\, Y^d_{j,k,t}}_{\text{revenue}} - \underbrace{(1-\bar{s}_j) W_t (Y^d_{j,k,t})^{1+\gamma}}_{\text{production cost}} - \underbrace{(1-\bar{s}_j) W_t \times \omega \mathrm{rs}_j \times \kappa_{j,k,t}}_{\text{cost of attention}}\Big) \Big| S^{-1}_{j,k}\Bigg] \tag{18}$$

$$\text{s.t. } Y^d_{j,k,t} = Q_t \mathcal{D}(P_{j,k,t}; P_{j,-k,t}), \qquad \text{(demand)}$$

$$\mathcal{I}(S_{j,k,t}; (Q_\tau, P_{l,m,\tau}(S^\tau_{l,m}))^{(l,m)\neq(j,k)}_{\tau\leq t} | S^{t-1}_{j,k}) \leq \kappa_{j,k,t}, \quad \text{(information processing constraint)}$$

$$S^t_{j,k} = S^{t-1}_{j,k} \cup S_{j,k,t},\ S^{-1}_{j,k} \text{ given}, \qquad \text{(evolution of the information set)}$$

where $\mathcal{I}(.;.)$ is Shannon's mutual information function as before and the information processing constraint bounds the amount of information that the firm can acquire at time t by its chosen capacity $\kappa_{j,k,t}$. Moreover, $\bar{s}_j$ represents a constant hiring subsidy to firms in sector j that eliminates the steady-state inefficiencies from imperfect competition (see Galí 2015, 73).[24]

Monetary policy and general equilibrium.—Following the literature (see, e.g., Mankiw and Reis 2002; Woodford 2003a; Golosov and Lucas 2007; Nakamura and Steinsson 2010), I assume that monetary policy controls the growth of nominal aggregate demand and model it as a first-order autoregressive process with persistence ρ:

$$\Delta\log(Q_t) = \rho\Delta\log(Q_{t-1}) + u_t. \tag{19}$$

Equilibrium.—A general equilibrium is an allocation for the household, $\Omega^H \equiv \{(C_{j,k,t})_{j\in J,k\in K_j}, L^s_t, B_t\}^\infty_{t=0}$, a strategy profile for firms given an initial set of signals

$$\Omega^F \equiv \{(S_{j,k,t} \subset \mathbb{S}^t, P_{j,k,t}, \kappa_{j,k,t}, L^p_{j,k,t}, Y^d_{j,k,t})^\infty_{t=0}\}_{j\in J,k\in K_j} \cup \{S^{-1}_{j,k}\}_{j\in J,k\in K_j},$$

and a set of prices $\{i_t, P_t, W_t\}^\infty_{t=0}$ such that (*a*) given prices and Ω^F, Ω^H solves the household's problem in equation (16); (*b*) given prices and

[24] Here the presence of $\bar{s}_j$ makes solving the model convenient by ensuring that all relative prices are the same in the full-information economy, but it is not necessary and does not alter the economic forces at work.

Ω^H, no firm has an incentive to deviate from Ω^F; (*c*) $\{Q_t \equiv P_t C_t\}_{t=0}^{\infty}$ satisfies the monetary policy rule in equation (19); and (*d*) labor and goods markets clear.

B. Sources of Strategic Complementarity

Strategic complementarities are key for understanding how firms allocate their attention. Therefore, it is useful to briefly discuss the sources of strategic complementarities in the model.

The first source of strategic complementarity is the sensitivity of optimal markups to prices in oligopolies. It is well known that CES demand with monopolistic competition implies constant demand elasticities and markups. With oligopolies, however, the granularity of firms implies that any change in a single firm's price alters the distribution of demand across its competitors and affects demand elasticities. The best response of a firm shows this relationship:

$$P^*_{j,k,t} = \underbrace{\frac{\varepsilon_D(P^*_{j,k,t}, P_{j,-k,t})}{\varepsilon_D(P^*_{j,k,t}, P_{j,-k,t}) - 1}}_{\text{optimal markup}} \times \underbrace{(1 - \bar{s}_j)(1 + \gamma) Q_t^{1+\gamma} \mathcal{D}(P^*_{j,k,t}; P_{j,-k,t})^{\gamma}}_{\text{marginal cost}}, \qquad (20)$$

where $P^*_{j,k,t}$ represents the implied optimal price given Q_t and $P_{j,-k,t}$ and the optimal markup has the familiar expression in terms of the elasticity of a firm's demand, $\varepsilon_D(P_{j,k,t}, P_{j,-k,t}) \equiv -(\partial Y_{j,k,t}/\partial P_{j,k,t})(P_{j,k,t}/Y_{j,k,t})$. As in Atkeson and Burstein (2008), it is informative to write these elasticities in terms of firms' market shares:

$$\varepsilon_D(P_{j,k,t}, P_{j,-k,t}) = \eta - (\eta - 1) m_{j,k,t}, \quad m_{j,k,t} \equiv \frac{P_{j,k,t} Y^d_{j,k,t}}{\sum_{l \in K_j} P_{j,l,t} Y^d_{j,l,t}}. \qquad (21)$$

An immediate observation is that the *level* of optimal markups increases in a firm's market share:

$$\mu(P^*_{j,k,t}, P_{j,-k,t}) \equiv \frac{\varepsilon_D(P^*_{j,k,t}, P_{j,-k,t})}{\varepsilon_D(P^*_{j,k,t}, P_{j,-k,t}) - 1} = \frac{\eta}{\eta - 1} + \frac{1}{\eta - 1} \frac{m_{j,k,t}}{1 - m_{j,k,t}}. \qquad (22)$$

Moreover, one can derive the degree of strategic complementarity for a given set of prices by differentiating the firm's best response. To build intuition, let us start with the case of $\gamma = 0$:

$$\left. \frac{dP^*_{j,k,t}}{P^*_{j,k,t}} \right|_{\gamma=0} = \frac{dQ_t}{Q_t} + \underbrace{(1 - \eta^{-1}) m_{j,k,t}}_{\text{strategic complementarity}} \left(\underbrace{\frac{\sum_{l \neq k} m_{j,l,t} dP_{j,l,t}/P_{j,l,t}}{\sum_{l \neq k} m_{j,l,t}}}_{\text{average price change of others}} - \underbrace{\frac{dQ_t}{Q_t}}_{\text{change in wage}} \right). \qquad (23)$$

An important observation is that strategic complementarity $\alpha^{\gamma=0}_{j,k,t} \equiv (1 - \eta^{-1})m_{j,k,t}$ *increases* with the firm's own market share. But why should a firm's price be *more* sensitive to competitors' prices when those competitors hold *lower* market share? This becomes more puzzling in an extreme case when a single firm holds almost all the market with its market share approaching one. Shouldn't a firm that holds almost all of the market simply disregard its competitors and act as a monopoly?

The answer relies on the structure of demand implied by CES preferences, where consumers reduce a higher share of their demand with respect to a 1% change in the prices of a firm's competitors when that firm holds a higher market share. Thus, while a monopolistic firm enjoys the sheer lack of competition, the mere existence of small competitors shatters the autonomy of a firm in responding to their marginal costs, especially at higher levels of market share. Therefore, while a monopolistic firm with CES demand would charge a constant markup over its marginal cost, an *almost* monopolistic firm chooses to match the average price change of their competitors with weight $1 - \eta^{-1}$.

In the other extreme, strategic complementarity disappears as $m_{j,k,t} \to 0$. This is not consistent with my findings in the empirical section of the paper, where firms with a large number of competitors and hence potentially lower market share still report high levels of strategic complementarity. This suggests that the sensitivity of markups is not the sole determinant of complementarities across firms and that other forces might be at work. I capture this in the model by introducing decreasing returns to scale in labor ($\gamma > 0$) as a second source of strategic complementarity.

Decreasing returns to scale ($\gamma > 0$) creates complementarities because relative prices affect a firm's production through demand in the equilibrium and higher production leads to higher marginal costs when $\gamma > 0$.[25] Repeating differentiation of best response but now with $\gamma > 0$, we obtain

$$\alpha^{\gamma>0}_{j,k,t} = (1-\eta^{-1})m_{j,k,t} + \big(1-(1-\eta^{-1})m_{j,k,t}\big)\left(1 - \frac{1+\gamma}{1+\gamma\eta(1-(1-\eta^{-1})m_{j,k,t})^2}\right). \quad (24)$$

Equation (24) shows that at high levels of market share, the strategic complementarity is driven mainly by the sensitivity of the markup as in the case of $\gamma = 0$. However, now when $m_{j,k,t}$ is small, strategic complementarity remains positive and converges to $\gamma(\eta - 1)/(1 + \gamma\eta)$ when $m_{j,k,t} \to 0$.

[25] This is a common approach in monetary models to generate strategic complementarities (see, e.g., Woodford 2003b).

C. *Solution Method and Incentives in Information Acquisition*

1. An Approximate Problem

I use a second-order approximation of the firms' problem to solve the model, which is a usual approach to remedy the curse of dimensionality in rational inattention models.[26] I derive this second-order approximation around the symmetric full-information equilibrium. Due to symmetry, all firms within a given sector j have the same market share under full information and charge the same markup μ_j over their marginal cost, $(1 - \bar{s}_j)Q_t$, given by equation (22):

$$P^{\text{full}}_{j,k,t} = \mu_j(1 - \bar{s}_j)Q_t = Q_t, \forall\, j \in J, k \in K_j, t \geq 0, \tag{25}$$

where the second equality follows from $\bar{s}_j = 1 - \mu_j^{-1}$ to eliminate steady-state distortions from market power. Appendix section F.2 derives a firm's approximate problem under a general demand structure as

$$\max_{\{\kappa_{j,k,t}, S_{j,k,t}, p_{j,k,t}(S^t_{j,k})\}_{t\geq 0}} - \text{rs}_j \mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t \left(\underbrace{\frac{1}{2}B_j(p_{j,k,t}(S^t_{j,k}) - p^*_{j,k,t})^2}_{\text{loss from mispricing}} + \underbrace{\omega\,\kappa_{j,k,t}}_{\text{cost of capacity}} \;\middle|\; S^{-1}_{j,k}\right)\right] \tag{26}$$

$$\text{s.t.}\quad p^*_{j,k,t} \equiv (1 - \alpha_j)q_t + \alpha_j p_{j,-k,t}(S_{j,-k,t})$$
$$\mathcal{I}(S_{j,k,t}, (q_\tau, p_{l,m,\tau}(S^\tau_{l,m}))^{(l,m)\neq(j,k)}_{\tau\leq t} | S^{t-1}_{j,k}) \leq \kappa_{j,k,t},\ S^t_{j,k} = S^{t-1}_{j,k} \cup S_{j,k,t},\ S^{-1}_{j,k} \text{ given,} \tag{27}$$

where $p_{j,k,t} \equiv \log(P_{j,k,t})$ and $p_{j,-k,t} \equiv [1/(K_j - 1)]\Sigma_{l\neq k}\log(P_{j,l,t})$. Moreover, B_j represents the curvature of firms' profit function in sector j around their optimal price. For a general demand structure, it has the form $B_j = \varepsilon^j_D/(1 - \alpha_j)$, which, in the case of the demand function assumed here, is given by

$$B_j \equiv \frac{\varepsilon^j_D}{1 - \alpha_j} = \frac{\eta + \gamma(\eta - (\eta - 1)K_j^{-1})^2}{1 + \gamma}. \tag{28}$$

Note that firms' losses from mispricing are proportional to their relative size, captured by rs_j. Thus, by assuming that the cost of capacity is also proportional to these revenue shares, the attention problem becomes homogeneous in firms' steady-state relative size, rs_j. This allows the model to consistently relate to the empirical evidence on strategic inattention, which controls for firm size.

Moreover, equation (28) shows that the attention problem of firms depends on the oligopoly parameters *only* through the demand elasticity and strategic complementarity. This is similar to Wang and Werning

[26] For a discussion, see, e.g., Maćkowiak, Matějka, and Wiederholt (2018) or Afrouzi and Yang (2019).

(2022), who find that these objects are sufficient statistics for how oligopolistic prices respond to shocks under nominal rigidities.[27] My results show that, up to a second-order approximation, these objects are also sufficient statistics for the *optimal information structure of oligopolistic firms*.

2. Information Acquisition Incentives

This approximate problem captures the trade-offs that a firm faces in information acquisition. The quadratic term models the benefits of information acquisition: more information allows firms to charge prices that are closer on average to their full-information best responses. This benefit is traded off with the cost of information processing capacity, the second term.

This cost-benefit analysis depends on the number of firms in an oligopoly through two channels. First, the extent of losses from mispricing depends on the curvature of firms' profit functions, B_j. A larger B_j amplifies losses from mispricing and increases the benefits of information acquisition.[28] As B_j itself depends partly on K_j, the extent of losses from mispricing also changes with the number of firms. Second, fixing B_j, a larger α_j amplifies firms' incentives to attend to their competitors' mistakes as discussed in the static model. Since α_j also varies with K_j, the number of firms also varies the strength of strategic incentives through this channel. Therefore, how strategic inattention varies with K_j depends on the relative importance of these two channels, which I discuss further in section V.

Finally, the persistence of q_t over time introduces a dynamic force as firms rely on their past signals to infer the current value of q_t. In the oligopoly, this leads to endogenously persistent mistakes, as firms' past mistakes feed into their current prices and motivate their competitors to pay attention to the time series of their mistakes. Thus, dynamic incentives have two potential effects on information acquisition. First, they affect the level of capacity production as firms internalize the continuation value of information. Second, they affect how firms allocate their capacity between the fundamental and others' mistakes. If mistakes are endogenously less persistent than fundamental q_t, then more patient firms will allocate a larger portion of their attention to q_t, since the continuation value of doing so would be larger.[29]

[27] Wang and Werning's (2022) sufficient statistics are in terms of elasticities and superelasticities of demand. I have derived my approximation in terms of demand elasticity and strategic complementarity, which can be written as a function of the other two, as derived in app. sec. F.2.

[28] There is evidence that supports this level effect. Coibion, Gorodnichenko, and Kumar (2018) document that firms with a higher slope in their profit function around their optimal price have more accurate expectations about inflation.

[29] For an extensive discussion of dynamic incentives of a rationally inattentive agent, see, e.g., Steiner et al. (2017); Maćkowiak, Matějka, and Wiederholt (2018); Afrouzi and Yang (2019); Miao, Wu, and Young (2022).

3. Solving for a Symmetric Stationary Equilibrium

Here I briefly discuss the outline of the algorithm for solving the model. A detailed explanation is included in appendix J, which contains the following four subsections. Appendix section J.1 extends the notion of a pure-strategy Gaussian equilibrium in definition 1 to the dynamic model. It also outlines the conditions that should hold in a symmetric stationary equilibrium, where we require pricing strategies of firms to be stationary over time and symmetric within sectors with the same number of competitors. Appendix section J.2 then shows that characterizing such an equilibrium is equivalent to finding a fixed point for the coefficients of lag polynomials that map monetary and mistake shocks to firms' equilibrium prices. Appendix section J.3 then outlines the main algorithm that I use to solve for this fixed point based on integrated moving-average (MA) approximations of equilibrium prices. Finally, appendix section J.4 outlines an alternative algorithm that uses an autoregressive MA approximation as in Maćkowiak, Matějka, and Wiederholt (2018) and shows that the two algorithms yield numerically identical solutions.

To briefly outline the solution method, the model's solution is a joint Gaussian stochastic process for all firms' prices and the nominal demand that satisfies the equilibrium conditions. Given a guess for the joint process of prices and nominal demand, I derive the implied strategy for a firm's competitors in a symmetric stationary equilibrium,[30] which then implies a stochastic process for the "ideal prices" of firms in equation (27), whose processes are inputs to firms' rational inattention problems.

I then approximate the processes for these ideal prices with an integrated MA projection on monetary shocks (where the integrated part is included to account for the unit root in nominal demand) to derive a Markov state space representation. Moreover, strategic inattention implies that the process for a firm's ideal price also depends on the nonfundamental shocks (mistakes) to their competitors' prices. With dynamics, these mistakes are persistent, and their autocovariance structure is endogenous to the equilibrium. Incorporating these requires extending the conventional solution methods for monopolistic competition rational inattention models to allow firms to pay attention to endogenous nonfundamental shocks.

[30] Here symmetry requires that all firms in sectors with K competitors have the same strategies for information acquisition and pricing decisions. Moreover, a stationary strategy is one where a firm's beliefs and prices depend on time *only* through the history of its signals. A stationary equilibrium is then a pair of initial information sets under which all firms' best responses are stationary strategies. Similar to Maćkowiak and Wiederholt (2009), one could interpret such information sets as ones where, after solving their inattention problem under the equilibrium strategy of others, all firms receive an infinitely long sequence of signals such that their own best responses are to use stationary strategies. Focusing on stationary equilibria allows us to avoid dealing with time-varying impulse response functions (IRFs) or transition dynamics of second-order moments of beliefs. See app. sec. J.1 for a precise definition and discussion of a symmetric stationary equilibrium.

To do this, I augment the state space of a firm's ideal price with the MA representation of the firm's competitors' mistakes and solve for the endogenous distribution of these mistakes over time as part of the fixed point problem described above.

With this approximated Markov state space representation of ideal prices at hand, I then use the method in Afrouzi and Yang (2019) to solve the firms' rational inattention problems, which is fast enough to make the solution of the model with $K \in \text{Supp}(\mathcal{K})$ (a total of 43 values) and several iterations of ω for calibration feasible. Given this solution, I then solve for the stochastic processes of the firms' beliefs and prices. Doing this for all K in the support of $\mathcal{K}$, I then derive the new guess for the joint stochastic process of firms' prices and iterate until convergence to the fixed point.[31]

4. A Special Case with a Closed-Form Phillips Curve

In general, the equilibrium signal structure of firms does not admit a closed-form representation. However, we can characterize optimal signals in closed form when firms are myopic in information acquisition ($\beta = 0$), which is useful for intuition.

PROPOSITION 5. Given a strategy profile for all other firms in the economy, every firm prefers to see only one signal at any given time. Moreover, if $\beta = 0$, the optimal signal of firm j,k at time t is

$$S_{j,k,t} = (1 - \alpha_j) q_t + \alpha_j p_{j,-k,t}(S^t_{j,-k}) + e_{j,k,t}.$$

This expression for optimal signals illustrates the main departure of this paper from models that assume a measure of firms. Since firms are granular in an oligopoly, mistakes propagate through the inclusion of $p_{j,-k,t}$ in firm j,k's signal and result in the excess correlation of prices beyond what is implied by shocks to q_t, as discussed in the static model. We can also derive a closed-form expression for the Phillips curve when there is no heterogeneity in the number of competitors across sectors (these assumptions are made for illustrative purposes, and I revert to the general case in the calibrated model).

PROPOSITION 6. Suppose that $\beta = 0$ and $K_j = K,\ \forall j \in J$ for some $K \in \mathbb{N}$. Then, $\alpha_j = \alpha,\ \forall j \in J$ and in the stationary equilibrium $\kappa_{j,k,t} = \kappa > 0,\ \forall j \in J,\ k \in K$. Moreover, the Phillips curve of this economy is

[31] In contrast to the static model, which had multiple equilibria with both zero and positive capacity, the dynamic model cannot have any equilibria with zero capacity. This is because the process for q_t has a unit root, meaning that given a strategy with zero capacity, the variance of any given firm's ideal price grows unboundedly as long as $\alpha < 1$ (see the proof of proposition 6 for a more formal argument in that case). This implies that at some point, this variance would be large enough for the firm to deviate from this strategy, regardless of what its competitors do. As a result, firms must choose a positive capacity in the stationary equilibrium of the game, which is similar to the unique equilibrium in the static model when ω/B is small relative to the unconditional variance of q (normalized to one).

$$\pi_t = (1-\alpha)\overline{\mathbb{E}_{t-1}^{j,k}[\Delta q_t]} + \alpha\overline{\mathbb{E}_{t-1}^{j,k}[\pi_{j,-k,t}]} + (1-\alpha)(e^{2\kappa}-1)y_t,$$

where $\overline{\mathbb{E}_{t-1}^{j,k}[\Delta q_t]}$ represents the average expected growth of nominal demand at $t-1$, $\overline{\mathbb{E}_{t-1}^{j,k}[\pi_{j,-k,t}]}$ represents the average expectation across firms of their competitors' price changes, and y_t represents the output gap.

This Phillips curve indicates that in economies with large strategic complementarities, the main driver of inflation is firms' expectations of their competitors' prices. As proposition 5 shows, a larger α means that firms learn more about their competitors' prices relative to aggregate demand. Therefore, when α is large, not only are firms' expectations of their competitors' prices the main driver of inflation but these expectations are also formed under information sets that are more informative of those prices.

Additionally, the slope of the Phillips curve shows how these strategic complementarities and the capacity for processing information interact in affecting monetary nonneutrality in this economy. The higher capacity of processing information makes the Phillips curve steeper, such that in the limit when $\kappa \to \infty$ (which arises endogenously when $\omega \to 0$), the Phillips curve is vertical. In contrast, higher strategic complementarity makes the Phillips curve flatter since firms' higher-order beliefs become more important in their pricing decisions (Woodford 2003a). Thus, to understand how the number of competitors, K, affects the slope of the Phillips curve, we need to investigate how α and κ jointly change with K, which I come back to in detail in section V.C.

D. Calibration

The model is calibrated to the firm-level survey data from New Zealand at a quarterly frequency, with a discount factor $\beta = 0.96^{1/4}$. A calibration to US data might be desirable, but a main objective of quantifying the model is to examine whether it fits the relationship between competition and firms' expectations about aggregate inflation, the evidence for which comes from the New Zealand survey data.[32] The key and new parameters are the distribution of competitors, $\mathcal{K}$, and the cost of attention, ω. Other parameters are externally calibrated, as presented in table 3 and discussed in more detail in appendix section I.1. In particular, based on equation (24), I choose γ to match the degree of strategic complementarity measured from the survey data in table A.1. Moreover, for the distribution of K_j,

[32] In addition, to calibrate the model to the US data, one needs microdata on firms' expectations about inflation to calibrate the cost of attention in the United States as well as data on how many competitors firms *directly* face to calibrate the distribution of the number of competitors, none of which are available for the United States to the best of my knowledge.

TABLE 3
Calibration Summary

Parameter	Description	Value	Moment Matched
$\mathcal{K}$	Distribution of K	$\sim\hat{\mathcal{K}}$	Empirical distribution (fig. A.1)
ω	Cost of attention	.037	Weight on prior in inflation forecasts
η	Elasticity of substitution	12	Elasticity of markups to $1/(1-K_j^{-1})$
$1/(1+\gamma)$	Curvature of production	.514	Average strategic complementarity
ρ	Persistence of Δq	.707	Persistence of NGDP growth in New Zealand
σ_u	Standard deviation of shock to Δq	.011	Standard deviation of NGDP growth in New Zealand

Note.—This table reports the calibrated values of the parameters for the dynamic model.

denoted by $\mathcal{K}$, I choose it to match the empirical distribution of the number of competitors in the survey data (fig. A.1).[33]

To calibrate ω, I target the weight that firms put on their priors in their inflation forecasts, as in Wiederholt (2015). This approach identifies ω because, with larger ω, firms' signals in the model are less accurate, leading firms to rely more on their priors in their forecasts. The fourth wave of the New Zealand survey asks firms about their yearly inflation forecasts and their inflation nowcasts for the previous year in waves 1 and 4. These waves were conducted 12 months apart (2013:Q4 to 2014:Q4), allowing for the comparison of ex ante and ex post beliefs for the subset of firms present in both waves. Using these data, I run the following regression for this calibration:

$$\mathbb{E}_{i,t}[\pi_t] = \text{constant} + \delta\mathbb{E}_{i,t-4}[\pi_t] + \text{error}, \tag{29}$$

where δ is the coefficient of interest.

Column 1 of table A.2 reports the baseline estimates for this specification, while column 2 controls for firms' different beliefs about long-run inflation rates (Patton and Timmermann 2010).[34] I calibrate by targeting the coefficient in column 2 using the same regression on simulated data, resulting in $\omega = 0.037$. Figure A.3 shows that ω is identified as the regression coefficient δ increases with ω within the model.

[33] As far as I know, there are no data available on how many competitors firms directly face in their market for the United States. It is important to note that the value of K in this model corresponds to direct competitors of a firm that are only a small subset of all the firms that operate in a single Standard Industrial Classification (SIC) code. Market segmentation, such as spatial constraints for consumers, make the number of firms within a single SIC code not suitable for calibrating this model.

[34] The exact question about long-run inflation is, "What annual percentage rate of change in overall prices do you think the Reserve Bank of New Zealand is trying to achieve?" Matching the coefficient that controls for this response is the model consistent approach because in the model all firms have the same long-run inflation forecast. Also, this is the more conservative calibration of ω, as matching the coefficient in col. 1 would imply a larger value for the cost of attention.

To see how this value compares with the estimates of information rigidity in the literature, we can compare the implied Kalman gain of firms in the model with the documented values in the literature for professional forecasters. The average firm in this model has a Kalman gain of 0.49 as seen in figure A.4, higher than the estimated value of 0.45 for professional forecasters in the United States (Coibion and Gorodnichenko 2015). This suggests that firms in the model are more informed about their optimal prices than professional forecasters are about aggregate inflation, but they exhibit large degrees of information rigidity in inflation forecasts because their optimal signals are less informative of inflation than of their optimal prices.

E. Examining Nontargeted Moments: Subjective Uncertainty in the Model

Can the calibrated model replicate the strategic inattention of firms observed in the data? Table 1 shows that firms' uncertainty about aggregate inflation decreases with the number of their competitors. This relationship is not consistent with benchmark models without rational inattention and oligopolistic competition but emerges endogenously in this model with strategic inattention incentives.

Figure 1 shows this relationship in both the model (solid line) and the data (binned scatterplot).[35] The model accurately reproduces the decrease in subjective uncertainty with the number of competitors. Both the heterogeneity in the number of competitors and endogenous information acquisition are key for this relationship: the former creates the differential incentives for information acquisition, and the latter is essential for the endogenous variation in information acquisition. Figure A.4 shows the equilibrium level of firms' information acquisition and their implied Kalman gains as a function of the number of firms' competitors. More competitive firms (1) produce a higher capacity for processing information and (2) allocate more capacity toward aggregate shocks. As a result, more competitive firms have more accurate posteriors about aggregate variables.

V. Macroeconomic Implications

In this section, I investigate the *aggregate* and *reallocative* implications of strategic inattention for the propagation of monetary shocks to inflation and output. To do so, I consider three measures. To measure monetary nonneutrality, following Nakamura and Steinsson (2010), I use the variance

[35] I have normalized average uncertainty in both the data and the model to one.

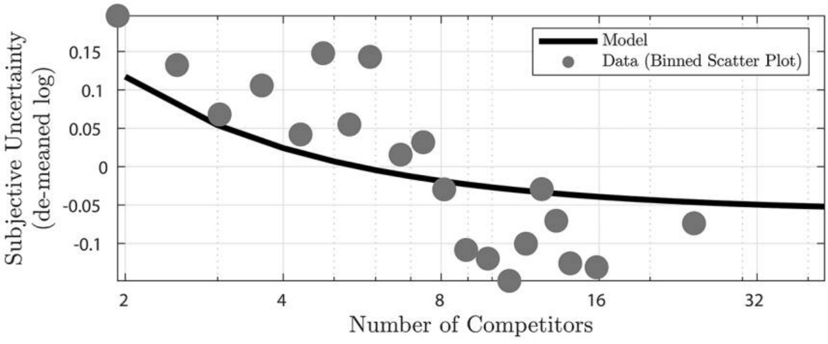

FIG. 1.—Subjective uncertainty about inflation: model versus data. This figure presents the fit of the model for the relationship between firms' (log) subjective uncertainty about aggregate inflation and the number of their competitors. Filled circles show the binned scatterplot of the log standard deviation of firms' subjective beliefs of the 12-month-ahead forecast of aggregate inflation against the number of competitors in data (table 1). The curved line depicts this relationship in the calibrated model. Subjective uncertainty in the model is calculated as the standard deviation of firms' beliefs about the full-information rational expectations 12-month-ahead forecast of inflation. The average subjective uncertainty is normalized to one in both the data and the model. This relationship was not targeted in the calibration of the model.

of output (normalized by its natural level).[36] To measure the persistent effects of monetary shocks, I use the cumulative half-life of output and inflation responses (time until the area under the impulse response reaches half of its full cumulative response). Finally, to compare reallocative effects of policy across sectors, I use the cumulative response of output (see, e.g., Alvarez, Le Bihan, and Lippi 2016), defined as the area under the output IRF of sectors with different numbers of competitors.

A. *Aggregate Effects: Monopolistic versus Oligopolistic Competition*

I start by comparing the calibrated model with a monopolistic competition model, nested when $K_j \to \infty$. To define the proper monopolistic competition benchmark, it is important to ensure that it has the same level of strategic complementarity as the calibrated model so that the only difference between the two models is firms' strategic inattention—that is, the *only* difference in impulse responses comes from the different signals that firms choose in the two models.[37] This is because we know from previous research

[36] Up to a second-order approximation to the household's utility, the variance of output normalized by its natural level is proportional to her welfare loss in consumption-equivalent units (Lucas 2003): $\mathbb{E}[\log(Y_t/\bar{Y})] \approx -(1/2)\text{var}(Y_t/\bar{Y})$.

[37] Firms in the oligopolistic model pay direct attention to the mistakes of their competitors, but firms in the monopolistic competition model, similar to Woodford (2003a), pay

TABLE 4
OUTPUT AND MONETARY NONNEUTRALITY ACROSS MODELS

	VARIANCE		PERSISTENCE	
MODEL	$\text{var}(Y)^{\times 10^4}$ (1)	Amplification Factor (2)	Half-Life$^{\text{qtrs}}$ (3)	Amplification Factor (4)
Monopolistic competition	3.17	1.00	3.40	1.00
Benchmark ($K \sim \mathcal{K}$)	4.07	1.28	3.72	1.09
Two competitors ($K = 2$)	4.69	1.48	4.14	1.22
Four competitors ($K = 4$)	4.14	1.30	3.78	1.11
Eight competitors ($K = 8$)	3.99	1.26	3.65	1.07
16 competitors ($K = 16$)	3.94	1.24	3.60	1.06
32 competitors ($K = 32$)	3.91	1.23	3.57	1.05
Infinite competitors ($K \to \infty$)	3.89	1.23	3.55	1.04

NOTE.—This table presents statistics for monetary nonneutrality across models with different numbers of competitors at the micro level. "var(Y)" denotes the variance of output conditional on monetary shocks multiplied by 10^4. "Half-Life" denotes the length of time that it takes for output to live half of its cumulative response in quarters. "Amplification Factor" denotes the factor by which the relevant statistic is larger in the corresponding model relative to the model with monopolistic competition.

that higher strategic complementarities amplify monetary nonneutrality (see, e.g., Ball and Romer 1990); section V.C discusses this in more detail. To generate the same strategic complementarity in the monopolistic competition model, I replace the within-sector CES aggregator of the oligopolistic model with a Kimball aggregator, which introduces a new parameter that allows me to calibrate the two models to the same strategic complementarity while keeping other parameters the same (see app. sec. I.2).

The first two rows in columns 1 and 2 of table 4 report the absolute and relative variance of output across the two models, respectively.[38] Output is 28% more volatile in the benchmark model, indicating that firms in the monopolistic competition model are more informed about aggregates due to the lack of strategic inattention motives. Column 4 shows that output response is also 9% more persistent in the benchmark model: as reported in column 3, it takes 3.72 quarters for output to reach its half-life in the benchmark model as opposed to 3.40 quarters in the monopolistic competition model.

The first two rows of table 5 compare the behavior of inflation across these models. Inflation is smaller and more persistent in the model with strategic inattention. Columns 1 and 2 show that inflation is 6% less volatile compared with the model with monopolistic competition. Column 3 shows that it takes inflation 4.42 quarters to reach its cumulative half-life

attention only to the fundamental shocks. However, there is a difference between the shape of signals in the monopolistic competition here and those in Woodford (2003a), which assumes that $S_{j,k,t} = q_t$ + noise. Here signals under monopolistic competition are linear functions of innovations to q_t (plus noise), but the exact linear combination is an endogenous object that is solved for as a fixed point.

[38] Magnitudes in col. 1 are small since the variance of innovations to nominal GDP (NGDP) growth is small. The same is true for the United States (Nakamura and Steinsson 2010).

TABLE 5
INFLATION ACROSS MODELS

	VARIANCE		PERSISTENCE	
MODEL	$\text{var}(\pi)^{\times 10^4}$ (1)	Dampening Factor (2)	Half-Life$^{\text{qtrs}}$ (3)	Amplification Factor (4)
Monopolistic competition	1.47	1.00	4.42	1.00
Benchmark ($K \sim \mathcal{K}$)	1.37	.94	4.66	1.05
Two competitors ($K = 2$)	1.28	.87	4.83	1.09
Four competitors ($K = 4$)	1.36	.93	4.68	1.06
Eight competitors ($K = 8$)	1.39	.95	4.64	1.05
16 competitors ($K = 16$)	1.40	.95	4.62	1.05
32 competitors ($K = 32$)	1.41	.96	4.62	1.05
Infinite competitors ($K \to \infty$)	1.41	.96	4.61	1.04

NOTE.—This table presents statistics for inflation response across models with different numbers of competitors at the micro level. "$\text{var}(\pi)$" denotes the variance of inflation conditional on monetary shocks multiplied by 10^4. "Half-Life" denotes the length of time that it takes for inflation to live half of its cumulative response in quarters. "Dampening Factor" ("Amplification Factor") denotes the factor by which the relevant statistic is smaller (larger) in the corresponding model relative to the model with monopolistic competition.

in the monopolistic competition model compared with 4.66 quarters in the benchmark model, a 5% increase as reported in column 4. Figure A.5 also presents the IRFs of output and inflation in the two models along with those of a duopoly model, showing how monetary nonneutrality is amplified and inflation response is dampened with strategic inattention.

B. *Reallocative Effects and Concentration Multipliers*

I continue my analysis by investigating the differences in inflation and output responses across sectors with different numbers of competitors. To do so, I conduct two analyses. First, I compare the output volatility of sectors with different numbers of competitors to the same monopolistic competition model as before. Second, I compare the output response of different sectors to the response of aggregate output in the same model, focusing on the relative differences within the same economy.

Output volatility conditional on number of competitors.—How do output and inflation responses differ across sectors for different values of K? Table 4 reports output volatility and amplification factors relative to the model with monopolistic competition. Monetary nonneutrality is larger, and output response is more persistent in sectors with fewer competitors. For instance, in the duopoly model, output volatility is 48% larger and the cumulative half-life of output is 22% longer. Table 5 reports the equivalent results for inflation. Inflation response is more muted, and its half-life is longer in sectors with fewer competitors. In the duopoly case, for instance, the variance of inflation is 13% smaller than the model with monopolistic competition, and its cumulative half-life is 9% longer.

Concentration multipliers.—As prices are less responsive to aggregate shocks in sectors with fewer competitors, monetary shocks also have reallocative effects across sectors. A natural exercise to measure the magnitude of these distortions is to calculate what share of the total output response is driven by the firms with fewer competitors. Formally, let $\mathcal{Y}_k$ denote the average cumulative impulse response of log output to a 1 standard deviation monetary policy shock in sectors with k competitors, and let $\mathcal{Y}$ denote the cumulative impulse response of aggregate output:

$$\mathcal{Y}_k \equiv \mathbb{E}^j\left[\frac{\partial}{\partial u_0}\sum_{t=0}^{\infty}\log(Y_{j,t})|K_j = k\right], \quad \mathcal{Y} \equiv \frac{\partial}{\partial u_0}\sum_{t=0}^{\infty}\log(Y_t). \quad (30)$$

It is then straightforward to derive the relationship between these aggregate and sectoral responses as $\mathcal{Y} \equiv \Sigma_{k=2}^{\infty} s_k \mathcal{Y}_k$, where s_k represents the steady-state market share of sectors with k competitors. We can now define the *concentration multiplier* of sectors with k competitors as the ratio $\mathcal{M}_k \equiv \mathcal{Y}_k/\mathcal{Y}$. These concentration multipliers capture reallocative effects because they would be equal to one for all k if there was no heterogeneity in output response. However, with heterogeneity, it measures the share of the cumulative response of output in sectors with k competitors *relative* to the aggregate output response.

Figure 2 plots these multipliers for different numbers of competitors and shows that less competitive sectors respond more strongly to monetary shocks in their output. For instance, duopolies have a 17% larger output response to monetary policy shocks relative to the aggregate output response.

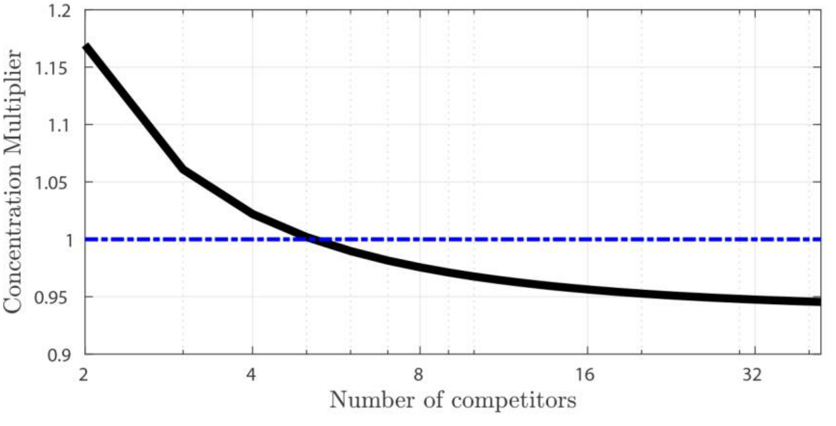

FIG. 2.—Concentration multipliers. This figure shows the *concentration multiplier* as a function of the number of competitors. A concentration multiplier of k is defined as the cumulative response of output coming from sectors with k competitors relative to the aggregate cumulative response of output. Less competitive sectors are responsible for a larger share of output response relative to their steady-state market share.

Thus, expansionary monetary policy *concentrates* production among *less* competitive firms, increasing the impact of such firms on the economy.[39] It is important to note that more competitive firms contribute less to output response despite having higher strategic complementarities. Conventional models with exogenous information rigidity, such as Woodford (2003b), show that higher strategic complementarities lead to higher monetary nonneutrality. The results here show that endogenous information acquisition *reverses* this result in a calibrated model through strategic inattention. The following section explains and decomposes the roles of each of these forces in the model.

C. *Inspecting the Mechanism: Strategic Inattention versus Strategic Complementarities*

The number of competitors affects both the degree of strategic complementarity and the amount of capacity produced by firms. Thus, the degree of monetary nonneutrality across sectors with different K is the sum of two separate forces: (1) the well-known *real rigidity* channel that alters monetary nonneutrality through the degree of strategic complementarity and (2) the new *strategic inattention* channel that alters monetary nonneutrality through information acquisition and utilization.

In the calibrated model, these two forces work in opposite directions. On the one hand, as discussed in section IV.E, firms with more competitors allocate a greater amount of attention to aggregates, and their prices move more swiftly in response to monetary shocks, which dampens their output response as a result. Hence, monetary nonneutrality decreases with competition through the strategic inattention channel.

On the other hand, the degree of strategic complementarity in equation (24) increases with the number of competitors in the calibrated model, which is depicted in figure A.6. Therefore, by fixing the capacity of processing information, a larger number of competitors increases monetary nonneutrality through higher strategic complementarities. Specifically, higher strategic complementarity amplifies nonneutrality by putting a larger weight on firms' higher-order beliefs, whose responses to shocks are more rigid (see, e.g., Woodford 2003a; Nimark 2008; Maćkowiak,

[39] More competitive firms have more flexible prices, so in response to expansionary (contractionary) monetary shocks they adjust their prices faster and their output falls (increases) relative to less competitive firms. Thus, in response to contractionary shocks, prices (markups) of more competitive firms fall relative to those of less competitive firms, which in relative terms reallocates labor toward more competitive firms (which are the firms with lower steady-state markups in the model). This is consistent with the evidence presented in Baqaee, Farhi, and Sangani (2024). Using Compustat data, they find that "a contractionary shock leads high-markup firms to increase their markups relative to low-markup firms; the result … is a reallocation of resources away from high-markup firms and toward low-markup firms" (Baqaee, Farhi, and Sangani 2024, 1104).

Matějka, and Wiederholt 2018). To verify this mechanism within the model, figure A.7 shows the IRFs of firms' higher-order beliefs to a 1% increase in nominal demand for three different values of K. With larger K, the responses of higher-order beliefs are smaller and more persistent, indicating that monetary nonneutrality increases with the number of competitors through the real rigidity channel.

To better understand the separate roles of these two channels, below I present three complementary analyses. First, I decompose the effects of these channels on the variance of output and inflation and show that, while both channels are significant, the strategic inattention channel dominates. Second, given the microfoundations of this section, I revisit the static model where I can derive analytical expressions for these channels, which provide further insight into their relative importance. Third, I redo the quantitative analysis of the model under an alternative specification where strategic complementarities decrease with K and find that while the strategic inattention channel is mitigated in this case, it continues to amplify monetary nonneutrality with lower K.

1. Quantitative Decomposition in the Calibrated Model

To decompose the effects of these two opposing forces in the calibrated model, let us define $\alpha(K)$ as the degree of strategic complementarity in a model where all sectors have K competitors, and all the other parameters are fixed at their calibrated values. Moreover, let $\sigma_y^2(\alpha(K), K)$ denote the output variance in the model where every sector has K competitors. The first argument captures the effect of the number of competitors on the weight that higher-order beliefs receive in the model (the real rigidity channel), and the second argument captures the effect of the number of competitors on the attention allocation of firms (strategic inattention channel). Then, we can decompose the difference in monetary nonneutrality of the two extreme models ($K = 2$ vs. $K \to \infty$) as

$$\underbrace{\lim_{K\to\infty} \log\left(\frac{\sigma_y^2(\alpha(2), 2)}{\sigma_y^2(\alpha(K), K)}\right)}_{\substack{\text{total}\\ \text{percentage change}}} = \underbrace{\lim_{K\to\infty} \log\left(\frac{\sigma_y^2(\alpha(2), 2)}{\sigma_y^2(\alpha(2), K)}\right)}_{\substack{\text{percentage change due to}\\ \text{strategic inattention}}} + \underbrace{\lim_{K\to\infty} \log\left(\frac{\sigma_y^2(\alpha(2), K)}{\sigma_y^2(\alpha(K), K)}\right)}_{\substack{\text{percentage change due to}\\ \text{real rigidities}}}. \tag{31}$$

Column 1 of table 6 shows the results of this decomposition. Output variance is 18.6% larger with $K = 2$ relative to $K \to \infty$ (percentage difference here is calculated as the log difference from table 4). Once decomposed to its two contributing factors, decreasing the number of competitors from $K \to \infty$ to $K = 2$ increases monetary nonneutrality by 78.5 percentage

TABLE 6
DECOMPOSITION: STRATEGIC INATTENTION VERSUS REAL RIGIDITIES

	PERCENTAGE CHANGE IN VARIANCE OF:	
	Output (1)	Inflation (2)
Total change (%)	18.6	−9.7
Due to strategic inattention (ppt)	78.5	−19.8
Due to real rigidities (ppt)	−60.0	10.1

NOTE.—This table shows the decomposition of the effects of the strategic inattention and real rigidity channels for the change in volatility of output (monetary nonneutrality) and inflation conditional on monetary shocks, as derived in eq. (31).

points due to the strategic inattention channel and decreases it by 60.0 percentage points through the real rigidity channel. As for inflation, column 2 of table 6 shows that decreasing the number of competitors from $K \to \infty$ to $K = 2$ decreases the variance of inflation by 19.8 percentage points through the strategic inattention channel and increases it by 10.1 percentage points through the real rigidity channel.

2. Analytical Decomposition in the Static Model

To further examine the relative importance of these two channels, here I revisit monetary nonneutrality in the static model of section II.D using the microfoundations derived in this section. The detailed derivations can be found in appendix K.

To begin, let us denote the average price of oligopolies with K competitors as p_K and their average output as the difference between nominal demand and their average price, $y_K = q - p_K$. It then follows from equation (5) that the response of output to a monetary shock is given by $\partial y_K/\partial q = 1 - \delta_K$. Moreover, the variance of output is also related to this object as $\mathbb{V}\text{ar}(y_K) = (1 - \delta_K)^2\, \mathbb{V}\text{ar}(q)$. Thus, differentiating this response with respect to K, we can formalize the role of these two channels on how monetary nonneutrality changes with the number of competitors:

$$\partial_K(\partial y_K/\partial q) = \partial_K(1 - \delta_K) = \underbrace{\frac{(1 - \lambda_K)\lambda_K}{(1 - \alpha_K\lambda_K)^2}\partial_K\alpha_K}_{\text{channel A: real rigidity}} - \underbrace{\frac{1 - \alpha_K}{(1 - \alpha_K\lambda_K)^2}\partial_K\lambda_K}_{\text{channel B: strategic inattention}}, \quad (32)$$

where we have indexed α_K, λ_K with K to note that both of these objects vary with K. The first term in the expression above captures the real rigidity channel: holding information processing capacity fixed, higher strategic complementarity increases monetary nonneutrality. The second term captures the strategic inattention channel: holding strategic complementarity fixed, higher information processing capacity decreases monetary nonneutrality. Since λ_K is itself an endogenous object, the question of how the two channels interact condenses to how λ_K varies with K. To answer this question, recall from equation (10) that in an equilibrium with positive capacity, $\lambda_K = 1 - [\omega/(B_K V_K^*)]$, where V_K^* represents the variance of firms' desired prices and B_K represents the curvature of a firm's profit function in an oligopoly with K competitors, respectively. Moreover, as shown in equation (28) and derived for a generally specified profit function, the curvature B_K is itself a function of firms' demand elasticities ε_D^K and strategic complementarity α_K: $B_K = \varepsilon_D^K/(1 - \alpha_K)$. Thus, the second term in equation (32) can be further decomposed as

$$\partial_K \lambda_K = (1 - \lambda_K)\left(\underbrace{\partial_K \ln(\varepsilon_D^K)}_{\text{change in } B_K \text{ through elasticity}} + \underbrace{\frac{1}{1 - \alpha_K}\partial_K \alpha_K}_{\text{change in } B_K \text{ through } \alpha_K} + \underbrace{\partial_K \ln(V_K^*)}_{\text{change in variance}}\right). \quad (33)$$

Taken together, equations (32) and (33) show that changes in α_K have two effects in monetary nonneutrality. First, directly, they increase monetary nonneutrality through the real rigidity channel. Second, indirectly, they decrease monetary nonneutrality by increasing the curvature of firms' profit functions, which in turn increases the information processing capacity of firms.

To further simplify the expressions above, let us consider the first-order Taylor expansion of the equilibrium of the static model in section II.D around the full-information benchmark ($\omega = 0$), as derived in appendix section C.8. Rewriting equation (32) with this approximation, we obtain

$$\partial_K(\partial y_K/\partial q) = \underbrace{\frac{\omega}{\varepsilon_D^K(1-\alpha_K)}\partial_K \alpha_K}_{\text{channel A (first-order effects of } \omega)} - \underbrace{\overbrace{\frac{\omega}{\varepsilon_D^K(1-\alpha_K)}\partial_K \alpha_K}^{\text{pass-through on } B_K} - \frac{\omega}{\varepsilon_D^K}\overbrace{\partial_K \ln(\varepsilon_D^K)}^{\text{elasticity on } B_K}}_{\text{channel B (first-order effects of } \omega)} + \mathcal{O}\left(\left\|\frac{\omega}{B_K}\right\|^2\right).$$

A key observation is that up to this first-order approximation, the direct and indirect effects of how strategic complementarity changes with K ($\partial_K \alpha_K$) fully offset each other. In other words, while a higher α_K increases monetary nonneutrality through the real rigidity channel, this effect is offset up to the first order of ω through the higher information acquisition of firms as α_K increases the curvature of their profit functions. Thus, the only relevant first-order factor is how ε_D^K changes with K:

$$\partial_K(\partial y_K/\partial q) = -\frac{\omega}{\varepsilon_D^K}\overbrace{\partial_K \ln(\varepsilon_D^K)}^{\geq 0} + \mathcal{O}\left(\left\|\frac{\omega}{B_K}\right\|^2\right). \quad (35)$$

Since more competitive firms have higher demand elasticities and lower markups, as shown in equation (22), the total first-order effect is negative and monetary nonneutrality decreases with K.[40]

Finally, it is useful to note that while the sign and magnitude of $\partial_K \alpha_K$ do not matter for how K affects monetary nonneutrality up to first order, they do matter for the contribution of the strategic inattention channel. In particular, a negative $\partial_K \alpha_K$ decreases the contribution of the strategic inattention channel to the decline of monetary nonneutrality with K by reducing the curvature of firms' profit functions to K and dampening the sensitivity of firms' information acquisition to K. My next exercise is to illustrate this by solving the dynamic model when α_K decreases with K.

3. Alternative Specification of Strategic Complementarities

While the analytical results from the static model give us insight into how the real rigidity and strategic inattention channels interact and change with the sign of $\partial_K \alpha_K$, they do not provide a quantitative assessment of the relative importance of these channels when strategic complementarities decrease with K—especially since we considered only the first-order effects of ω / B_K. It is possible that the interactions may be more complex in the dynamic model or that higher-order effects of ω / B_K may be important. To address this concern, I solve the dynamic model when α_K decreases with K with Atkeson and Burstein (2008) preferences.

This exercise is described in detail in appendix L. In summary, its results confirm the intuition developed from the analytical decomposition of the two channels in the static model. First, table L.2 shows that despite the negative sign of $\partial_K \alpha_K$, monetary nonneutrality still decreases with K, consistent with equation (34) and the increasing demand elasticities with K in this model. Second, as expected from equation (33), a negative $\partial_K \alpha_K$ reduces the curvature of firms' profit functions as K increases, dampening the strength of the strategic inattention channel. However, this effect is not strong enough to fully counteract the effect of changes in demand elasticity on firms' capacity production. As shown in figure L.1, capacity still increases with K, albeit with a small slope. Finally, table L.3 presents the decomposition of equation (31) in this case and shows that both channels work in the same direction to decrease the degree of monetary nonneutrality with a negative $\partial_K \alpha_K$.

[40] For recent empirical evidence on how demand elasticities decrease with market share ($1/K$ in the model), see, e.g., Burstein, Carvalho, and Grassi (2020) and Burya and Mishra (2023).

D. Additional Robustness Exercises

Before concluding, I briefly mention four additional robustness exercises that are explored in more detail in the appendixes. I solved the model by approximating firms' problems in equation (26) around a symmetric equilibrium, and my solution method relies on the symmetries implied by this approach. Appendix section M.1 discusses and speculates on the role of asymmetric market shares. In appendix section M.2, I examine whether the persistence of the growth rate of nominal demand affects the results by re-solving the model for $\rho = 0.23$ and find results similar to the benchmark calibration. Appendix section M.3 investigates the interaction of dynamic and strategic incentives in information acquisition by calibrating the model to a lower discount factor and finding that strategic motives become stronger when firms are more myopic. Finally, appendix section M.4 discusses how sector- or firm-level idiosyncratic shocks may impact the results of the model and solves a numerical example with sector-level shocks.

VI. Concluding Remarks

This paper develops a new model to study how imperfect competition affects firms' information acquisition and expectations. The interaction of these two frictions creates an endogenous correlation between the accuracy of firms' beliefs and the number of their competitors. Oligopolistic firms find it optimal to acquire information about and pay direct attention to the beliefs of their competitors, an incentive that is stronger when they have fewer competitors or higher strategic complementarities in pricing.

The model's implications for monetary nonneutrality and inflation dynamics speak to recently documented trends in rising concentration and market power. These results suggest that with more concentration, monetary policy is more potent and its real effects are stronger. Furthermore, the reallocative effects of strategic inattention imply that this change in potency is not uniform across all firms. These heterogeneous effects introduce new distortions to relative prices that might lead to new sources of misallocation and, more broadly, to efficiency loss, which should be of interest for future research.

Moreover, in tracking their competitors' beliefs, firms ignore aggregate shocks, and as a result their beliefs about aggregate variables are more inaccurate and noisy than the beliefs that feed into their prices. Thus, firms' expectations about aggregate variables are no longer the appropriate measures for their decisions with oligopolies. These results are informative for surveys that aim to connect firms' expectations to their decisions: under oligopolistic competition, there is a wedge between firms' relevant expectations for their prices and their aggregate inflation expectations.

These expectations are relatively unimportant for firms and do not have much impact on their pricing decisions.

Furthermore, the results in this paper have implications for policies that target expectations. In particular, they provide a new perspective on why managing inflation expectations might be less effective than what a model with monopolistic competition would suggest. Oligopolistic firms do not directly care about aggregate inflation and are concerned mainly with how their competitors' prices respond to shocks. Thus, any communication about aggregate variables will be discounted accordingly.

Nevertheless, this result does not necessarily rule out policies that target expectations but rather provides a new view on how those policies should be framed and *which* expectations they should target. An important takeaway from this paper is that for such a policy to be successful, it has to communicate the course of monetary policy to price-setters not in terms of how it will steer the overall prices but in terms of how it will affect their own industry prices. In other words, framing policy in terms of the aggregate variables will not gain as much attention and response from firms as it would if the news about the policy were to reach firms in terms of how their competitors would be affected. How policy can achieve these ends remains a question that deserves more investigation.

Data Availability

Code replicating the tables and figures in this article can be found in the Harvard Dataverse, https://doi.org/10.7910/DVN/AO6C85 (Afrouzi 2024).

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