Consumer Information Frictions and Monetary Non-Neutrality: A Sequential Search Approach*

By Xiaojie Liu†

Abstract

This paper proposes a model of monetary non-neutrality driven entirely by consumer-side information frictions. Consumers face search costs and imperfect information about nominal marginal costs, so after a monetary shock they partially misattribute aggregate price increases to firm-specific shocks and intensify search. This weakens strategic complementarities in pricing, leading firms to limit passthrough of aggregate shocks to deter search. I embed this mechanism in a medium-scale DSGE model estimated by impulse-response matching and find that consumer information frictions account for 30–55% of monetary non-neutrality. The mechanism also helps account for missing disinflation in Great Recession and pandemic inflation surge.

KEYWORDS: Monetary non-neutrality, price stickiness, Phillips curve, sequential search, information frictions, incomplete passthrough, higher-order beliefs.

1 Introduction

"This paper presents a theory that justifies price stickiness, namely, that firms, fearing to upset their customers, attribute a cost to price changes."

— Rotemberg (1982)

Monetary policy is widely understood to have substantial real effects in the short run. A large body of empirical literature has shown that output declines following an unexpected increase in the interest rate. Still, a fundamental question in theory persists: Why don't changes in nominal policy rates simply lead to proportional changes in nominal wages and prices, leaving real

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†Kellogg School of Management, Northwestern University. Email: xiaojie.liu@kellogg.northwestern.edu

quantities unaffected? A classic answer, dating back to Friedman (1968) and Phelps (1967), is that policy shocks are *not anticipated*.[1] Lucas (1972) shows that this unanticipated nature of shocks can be interpreted as a form of *imperfect information* under fully rational expectations.

Firms are the agents that set prices. If they are not well informed about aggregate shocks, they may fail to adjust prices accordingly. The literature has thus argued that information frictions on the firm side could rationalize non-trivial monetary non-neutrality (Woodford, 2003; Mankiw and Reis, 2002; Maćkowiak and Wiederholt, 2009). Moreover, the interaction between information frictions and standard nominal rigidities—such as Calvo or menu costs—helps account for the observed inertia and state-contingency in inflation dynamics (Angeletos and Huo, 2021; Gagliardone and Tielens, 2024).

Such a firm-centric approach, however, faces two challenges. First, it abstracts from how advances in computing and data storage are improving firms' ability to forecast demand using big data (Bajari et al., 2019; Farboodi and Veldkamp, 2021), which in turn could reduce the quantitative importance of the assumed friction. Second, and more crucially for my purposes, it abstracts from information frictions among consumers—thus also failing to account for how consumer-side frictions may influence the firms' pricing decision, even if the firms themselves had been fully informed.

By shifting the focus to such consumer-side frictions, and by studying how these frictions influence firm pricing behavior, my paper ends up echoing, and indeed micro-founds, the story told by Rotemberg (1982). He argues that sluggish adjustment of prices may arise as firms *fear* to upset consumers if they fully adjust prices (Rotemberg, 2005, 2010, 2011; Eyster et al., 2015). In my model, firms optimally choose to compress their markups and limit the passthrough of monetary shocks to prices out of fear that price increases will upset their customers and trigger them to move to a competitor. It is therefore *as if* firms face a cost from adjusting prices, but this cost is not hardwired.[2]. Furthermore, the firms' "fear" is fully rational, and so is the customers' "upsetting". Customers are likely to leave a firm if that firm raises prices, not because they get angry, but rather because they are rationally confused and hope to get a better deal elsewhere. Firms, anticipating this behavior, optimally respond in a way that makes prices appear sticky.

The model builds on standard sequential search models (Wolinsky, 1986; Anderson and Renault, 1999) where consumers decide where to buy goods and they search sequentially over firms to learn prices and their fit. Each search is associated with a cost. Consumers lack information about each firm's idiosyncratic production cost and they only receive a noisy signal about the nominal wage. As a result, they rationally confuse aggregate increase in nominal costs

[1] Friedman famously noted, "there is always a temporary trade-off between inflation and unemployment; there is no permanent trade-off. The temporary trade-off comes not from inflation per se, but from unanticipated inflation, which generally means, from a rising rate of inflation" (1968, p. 11).

[2] As is instead the case in standard models with nominal rigidity.

for all firms for a firm-specific relative price increase at the store they visit. A price increase driven by higher nominal costs may thus be mistaken for evidence of low firm productivity, prompting search rather than purchase.

This mechanism is empirically relevant because consumer search and information frictions are substantial. Across retail, automobile, finance, and housing markets, many consumers compare only a handful of options—often just one seller—even when the gains from search are large. Limited search therefore gives firms market power, raising markups, prices, and welfare losses (Kaplan and Menzio, 2015; Wildenbeest, 2011; Allen et al., 2019; Moraga-González et al., 2023). Consumers also appear imperfectly informed: they misperceive inflation (Candia et al., 2023), overweight salient prices in expectation formation (Kumar et al., 2015), anchor beliefs to recent shopping experiences and past inflation episodes (Malmendier and Nagel, 2016; D'Acunto et al., 2021b), and often attribute inflation to non-economic forces (Binetti et al., 2024a).

I begin by characterizing the full-information rational-expectations equilibrium and show that monetary policy is neutral. This result is not automatic in my setting, because search frictions also imply imperfect information at the level of individual prices. But once consumers observe the aggregate policy shock, they understand that all firms adjust prices proportionally in equilibrium. Relative prices therefore do not move, search behavior is unchanged, and monetary shocks have no real effects. The key implication is that search frictions alone cannot generate monetary non-neutrality; imperfect information about aggregate shocks is essential.

One of the contributions of this paper is to show that the equilibrium in a setting with consumer sequential search, imperfect information about policy shocks, and heterogeneous firms can be summarized by a single equation to first order, which resembles equation (2.7) in Woodford (2003) in its form,

$$\hat{p} = \Gamma \hat{mc} + (1 - \Gamma) E^c \hat{p} \tag{1}$$

where Γ is aggregate own-shock passthrough, namely passthrough of nominal marginal cost changes $\hat{mc}$, holding constant the response of other firms, and $E^c \hat{p}$ represents consumers' average expectation of price index.

In Woodford (2003), firms pass through only the component of shocks they observe. The mechanism here is different. Firms remain flexible in responding to idiosyncratic shocks because consumers correctly interpret firm-specific price changes as relative-price movements. In that case, firms optimally pass through a fraction Γ of the shock and let marginal consumers decide whether to switch. Aggregate shocks, by contrast, create a wedge between actual and perceived price indices because consumers imperfectly infer the source of price changes. The intuition is clearest when policy shocks are completely unanticipated by consumers: from their

perspective, aggregate shocks are then observationally equivalent to idiosyncratic shocks, so optimal passthrough is again Γ. This contrasts sharply with firm information-friction models, in which fully uninformed firms do not adjust prices at all. Here, firms observe the shock, but because consumers do not, firms know that consumers cannot respond to other firms' price changes through strategic complementarities.

I further show that aggregate-shock passthrough is lower for high-productivity firms. These firms respond less to idiosyncratic shocks and more to competitors' prices, so their pricing depends more on how consumers perceive prices elsewhere in the market. Passthrough also falls as search costs rise. Higher search costs increase markups, allowing firms to absorb more shocks, and weaken consumers' learning from prices by reducing the number of products they sample. I then extend the framework to supply shocks, where the same mechanism applies because consumers are also imperfectly informed about the source of price changes.

Next, I develop a DSGE model in which consumer-side frictions are the primary source of price stickiness. In the dynamic setting, consumers learn gradually about policy shocks, in the spirit of Mankiw and Reis (2002), so slower learning translates into more persistent output gaps. I embed this learning structure in sequence space following Auclert et al. (2020) and compare the model's impulse responses with those from two benchmark models: a standard New Keynesian model with Calvo pricing and a model with firm information frictions.

The comparison yields two main results. For monetary shocks, my model produces the largest initial inflation response under flexible wages, since the other two models directly attenuate passthrough from marginal costs to prices; once wage rigidity is introduced, output responses become similar across models. For technology shocks, responses are similar across models without wage rigidity, though somewhat stronger in my model, while they become much more pronounced under wage rigidity. The reason is that, even when nominal wages are slow to adjust and strategic complementarities are weakened by imperfect information, firms in my model still pass through a nontrivial share of productivity-driven cost changes into prices.

I then take the model to the data by estimating a medium-scale DSGE version with more bells and whistles. I quantify the magnitude of consumer information frictions through impulse-response matching following Christiano et al. (2005). The estimated model incorporates two additional nominal frictions: Calvo price rigidity, motivated by micro evidence on infrequent price adjustment (Bils and Klenow, 2004; Nakamura and Steinsson, 2008), and Calvo wage rigidity, which is necessary to damp the response of marginal costs and generate empirically plausible monetary dynamics. I allow consumer information frictions, price rigidity, and wage rigidity to compete as alternative sources of monetary non-neutrality. This framework lets me answer two central questions: can a model centered on consumer-side frictions, supplemented

by standard nominal rigidities, match the SVAR evidence on monetary shocks, and how much of monetary non-neutrality can those frictions explain?

I proceed in two steps. First, I estimate an external-instrument SVAR following Gertler and Karadi (2015), combining standard macroeconomic variables with household inflation expectations from the Michigan Survey of Consumers. The evidence indicates that household inflation expectations respond only weakly to monetary policy shocks. Interpreted through the model, this implies that only about 8% of consumers learn about the shock each quarter, corresponding to an average information duration of roughly 13 quarters. This estimate is close to that in Auclert et al. (2020), despite relying on different data and moments. In the structural estimation, information frictions are identified mainly from the relative responses of realized inflation and inflation expectations.

Second, I use the estimated model to decompose monetary non-neutrality across frictions. The results are stark. Information frictions account for 55% of monetary non-neutrality, compared with 38% for wage rigidity and only 7% for Calvo price rigidity. To obtain this decomposition, I first shut down both Calvo price rigidity and information frictions; the cumulative output response then falls by about 62%, implying that wage rigidity alone accounts for the remaining 38%. I next shut down only Calvo price rigidity and find that its contribution is small. Intuitively, matching the empirical impulse responses requires substantial wage rigidity and information frictions; as a result, marginal costs for price-adjusting and non-adjusting firms differ little, consistent with the findings of Christiano et al. (2005). In a specification that targets the real wage response more closely rather than the CPI response, information frictions still account for 30% of monetary non-neutrality. Thus, across specifications, consumer information frictions explain 30–55% of monetary non-neutrality.

Finally, the model helps explain both the missing disinflation during the Great Recession and the inflation surge during the pandemic. When consumers pay little attention to inflation, firms face weak discipline from marginal consumers and therefore pass through cost declines only modestly, muting disinflation. When inflation becomes salient, firms can pass through cost increases more aggressively, steepening the Phillips curve. The policy implication is state dependent: central banks should respond more aggressively when inflation is salient and place more weight on real activity when it is not.

Related Literature. This paper contributes to at least three strands of literature. First, it relates to models in which consumer reactions shape firms' pricing decisions (Rotemberg, 2005, 2010, 2011; Kleshchelski and Vincent, 2009; Nakamura and Steinsson, 2011; Eyster et al., 2015; Matějka, 2015). Unlike this work, which typically emphasizes fairness concerns or aversion to price volatility, I develop a consumer-side information-friction theory of price stickiness. In contrast to the standard imperfect-information literature, which focuses on firms' information about

aggregate shocks (Lucas, 1972; Woodford, 2003; Maćkowiak and Wiederholt, 2009; Angeletos and La'o, 2010), I show that imperfect information on the consumer side can also dampen price adjustment by weakening strategic complementarity.

Second, the paper is motivated by evidence that search frictions are quantitatively important in retail, automobile, mortgage, and housing markets (Kaplan and Menzio, 2015; Kaplan et al., 2019; Wildenbeest, 2011; Yavorsky et al., 2021; Allen et al., 2019; Agarwal et al., 2019; Moraga-González et al., 2023). It connects standard search theory (McCall, 1970; Wolinsky, 1986; Anderson and Renault, 1999) to macro price stickiness by studying how costly consumer search and imperfect information jointly shape firms' passthrough decisions. Relative to Bénabou and Gertner (1993), L'Huillier (2020), and Gaballo and Paciello (2021), my mechanism is distinct: firms are atomistic, and sluggish price adjustment arises from markup compression rather than demand reallocation to cheaper products or strategic signaling through prices. The paper is also related to the Burdett-Judd tradition (Burdett and Judd, 1983). Although Head et al. (2012) and Burdett and Menzio (2018) generate sticky prices in search-based environments, money remains neutral in their models. By contrast, consumer search and imperfect information jointly generate monetary non-neutrality in my framework.

Third, the paper helps connect recent evidence on household expectation frictions to macroeconomic dynamics. A growing literature shows that households misperceive inflation (Kumar et al., 2015; D'Acunto et al., 2021b; Candia et al., 2023), respond to the framing of Fed communication (Coibion et al., 2022), pay more attention when inflation is high (Cavallo et al., 2017; Weber et al., 2025), and often attribute inflation to non-economic forces (Binetti et al., 2024b). I provide a framework that maps these household frictions into the degree of price stickiness and, in turn, into the real effects of monetary policy. The framework also helps explain episodes such as the missing disinflation of the Great Recession and the pandemic inflation surge (Coibion and Gorodnichenko, 2015; Beaudry et al., 2024).

Outline. The rest of the paper is organized as follows. Section 2 and Section 3 presents the model setup and characterizes the equilibrium. Section 4 provides a sharp characterization of aggregate supply curve. Section 5 develops a DSGE model and studies its impulse-response properties. Section 6 estimates the degree of information frictions and quantifies their contribution to monetary transmission. Section 7 uses the framework to study two inflation puzzles. The final section concludes. Appendix A collects proofs omitted from the main text, and Appendix B contains additional details in calibration and estimation.

2 Static Partial Equilibrium Model

In this section, I develop a one-period partial-equilibrium model with three types of agents: consumers, firms, and a monetary authority. The model is presented in its general form, allowing consumers to learn from encountered prices during search. I then study two nested benchmark environments: full information and no learning. The weak-learning approximation is introduced only afterward as a tractable extension of the general setup.

Notation. For any variable Y, let $y \equiv \log Y$ denote its log level, and let $\hat{y} \equiv y - \bar{y}$ denote its log deviation from the steady-state value.

Firms. The economy is populated by a unit mass of firms indexed by $k \in [0, 1]$. Firm k produces a differentiated good using

$$Y_k = A_k L_k, \tag{2}$$

where L_k is labor input and A_k is firm-specific productivity. Productivity is i.i.d. across firms, with $\log A_k$ drawn from distribution Φ_a. The nominal wage is W, so firm k's nominal marginal cost is W/A_k. The nominal wage represents the average nominal marginal cost. Labor is supplied exogenously in partial equilibrium. Firms are monopolistic competitors and they compete on prices. The key difference of this model from models with nominal rigidity is that firms set prices flexibly.

Monetary authority. The monetary authority sets the nominal wage w. Its prior distribution is denoted by μ, with mean $\bar{w}$. Let the nominal wage shock be

$$\hat{w} \equiv w - \bar{w}. \tag{3}$$

Consumers. The economy is populated by a continuum of consumers indexed by $i \in [0, 1]$. Each consumer buys one unit of one good.[3] If consumer i buys from firm k, utility is

$$\log \frac{W_i}{P_k} + \frac{1}{\lambda}\epsilon_{ik}, \tag{4}$$

where W_i is the cash in hand for consumer i, and $\epsilon_{ik} \sim G$ is match utility between consumer i and good k, which is i.i.d across firms and consumers.[4] G is triple continuously differentiable

[3] In Appendix A, I extend the model to an environment in which each firm sells multiple products and consumers purchase a bundle of those products.

[4] The price distribution is not degenerated and the optimal prices are related to firm's idiosyncratic states, if the random utility term is match-specific. Otherwise, if it is only consumer-specific, it does not matter for search decisions. Firms compete only on price. The price distribution is degenerated to a single optimal price. If it is only good-specific, the optimal prices are not related to firm's productivity.

and its density function is g. It captures idiosyncratic consumer preferences for certain goods over others. Also, following the literature, I assume that G is *log-concave*.[5] The parameter λ controls the relative importance between two utilities. A larger λ implies more competition on prices. Since cash in hand X_i only affects the level of utility and does not change the relative utilities across goods, I define the normalized utility as follows,

$$y_{ik} = -p_k + \frac{1}{\lambda}\epsilon_{ik}. \tag{5}$$

Anderson et al. (1987) show that, absent search frictions, when G follows a Gumbel distribution, the resulting demand system is exactly CES with elasticity of substitution $\lambda + 1$. This utility is also recently studied in Mongey and Waugh (2024).

The timeline is the following. At the beginning of the period, firms post prices and commit to them. Consumers then search sequentially and randomly across firms, as in Wolinsky (1986) and Anderson and Renault (1999). Sampling a firm entails utility cost $\kappa > 0$, after which the consumer observes the posted price and match utility. Consumers do not recall previously visited firms, so once an offer is rejected it cannot be chosen later as in McCall (1970). They also do not commit to any ex ante search plan. Instead, search decisions are made sequentially, and search costs already incurred are treated as sunk.[6] Search proceeds in discrete rounds within the period. In each round, some consumers purchase and exit, while the remaining consumers continue searching. The period ends once all consumers have made a purchase.

Information and Beliefs. Consumers do not observe the nominal wage w or firm productivities $\{a_k\}_{k\in[0,1]}$. Instead, before search begins, each consumer i receives an initial private signal about w, which induces an initial posterior distribution $\Phi_x(w|x)$ over the nominal wage. Over search, consumers may learn from prices they observed. Therefore, more generally, at any point during search, consumer i's information is summarized by a posterior state x, which is a sufficient statistic for her current belief about w. Conditional on x, the consumer's posterior density over the nominal wage is denoted by $h(w \mid x)$.

Consumers are endowed with cash equal to the realized wage, but this realization is only observed at checkout after product choices are made. Hence consumers cannot infer the realized nominal wage from their cash holdings before search.

[5] Note that some commonly used distribution functions are log-concave, e.g., normal distribution, uniform distribution, Gumbel distribution. See Bagnoli and Bergstrom (2005) for a broad discussion of log-concavity.

[6] With commitment, consumers would internalize expected total search costs and optimally stop at lower match quality following unfavorable draws. In contrast, without commitment, past search costs are ignored. Burdett and Judd (1983) studies a search problem with commitment in an environment with homogeneous firms.

Given a pricing rule $p^* : \mathbb{R}^2 \to \mathbb{R}$ mapping firm states (a_k, w) into prices, the objective price distribution conditional on w is

$$F(p \mid w) = 1 - \Phi_a\Big((p^*)^{-1}(p, w)\Big), \tag{6}$$

with density $f(p \mid w)$. Conditional on posterior state x, consumers combine their beliefs about w with the perceived pricing rule to form the perceived density of a price draw:

$$q(p \mid x) = \int f(p \mid w)\, h(w \mid x)\, dw. \tag{7}$$

Consumers update their posterior beliefs after observing prices during search. Let $\Gamma(x, p)$ denote the Bayesian updating rule: if a consumer's current posterior state is x and she observes price p, then her posterior state after that observation is

$$x' = \Gamma(x, p). \tag{8}$$

Accordingly, after r observed prices, a consumer's decision in round r is made conditional on the posterior state that already incorporates the information contained in the current price.

The full-information benchmark is the special case in which the posterior state reveals the realized nominal wage, so that $h(w \mid x)$ is degenerate at the true w. The no-learning benchmark is the special case in which observed prices do not change beliefs, so that $\Gamma(x, p) = x$ for all (x, p). In this case, the posterior is only determined by the initial private signal.

Firms cannot discriminate consumers based on type and set nominal prices contingent on the state $s_f = (w,\, a_k)$:

$$p_k = p^*(s_f) \tag{9}$$

Importantly, firm's information set contains aggregate state w, which differentiates this model from models based on firm-side information frictions. Note that the optimal pricing rule p^* still relies on the exogenous productivity distribution and information structure.

Timing and consumer problem. Without recall, the consumer cannot return to previously visited firms, so the relevant state is the posterior belief about the nominal wage. At round r, the consumer enters with posterior x_{r-1}. If she continues searching, she pays the search cost $\kappa > 0$, draws a firm with posted price p_r and match shock ϵ_r, and obtains current offer value $y_r = \frac{1}{\lambda}\epsilon_r - p_r$. After observing the price, following Bayesian learning, she updates her posterior to $x_r = \Gamma(x_{r-1}, p_r)$. She then chooses whether to accept the current offer and stop, or reject it

and continue. Since there is no recall, rejecting the current offer means losing it permanently. If she rejects, the next search stage begins with posterior x_r.

Let $U(x)$ denote the continuation value of rejecting the current offer and proceeding to the next search stage with posterior x. The ex post value after observing the current offer y_r and updating to x_r is

$$\tilde{U}(y_r, x_r) = \max\{y_r, U(x_r)\}. \tag{10}$$

Hence the consumer accepts the current offer if and only if $y_r \geq U(x_r)$. The Bellman equation for the continuation value is therefore

$$U(x) = -\kappa + \iint \max\left\{\frac{\epsilon}{\lambda} - p,\ U(\Gamma(x,p))\right\} g(\epsilon)\, q(p \mid x)\, d\epsilon\, dp, \tag{11}$$

where $q(p \mid x)$ is the perceived price density. The Bellman equation is stationary because conditional on x, the search cost, match distribution, perceived price distribution, and updating rule are the same in every round. What evolves over search is not the individual decision problem, but the cross-sectional distribution of consumers across posterior states.

The individual law of motion is thus: enter the round with posterior x_{r-1}, draw (p_r, ϵ_r), update to $x_r = \Gamma(x_{r-1}, p_r)$, and either stop if $y_r \geq U(x_r)$ or continue to the next round with posterior x_r.

Search measures. To describe the cross section of active searchers, I define the measure of consumers *entering* a round of search. Let $n_r(dx)$ denote the measure of consumers who enter round r with posterior state x, before observing the round-r price. The initial entering measure is $n_1(dx) = \Phi_x(dx)$.

If a consumer enters round r with posterior x and visits a firm, then after observing price p the posterior becomes $\Gamma(x,p)$. The consumer rejects the current offer with probability $G(\lambda(U(x') + p))$, since rejection occurs whenever $\epsilon/\lambda - p < U(x')$, where $U(x')$ is the continuation value under x'. Hence the survival-and-transition kernel is

$$K_w(B \mid x) = \int \mathbf{1}\{\Gamma(x,p) \in B\}\, G(\lambda(U(\Gamma(x,p)) + p))\, f(p \mid w)\, dp \tag{12}$$

The entering measure for round $r+1$ thus evolves according to

$$n_{r+1}(B) = \int K_w(B \mid x) n_r(dx). \tag{13}$$

Fix a firm k. Firm k's demand is

$$D_{k,r} = \sum_{r \geq 1} \int \left(1 - G(\lambda(U(\Gamma(x, p_k)) + p_k))\right) n_r(dx) \tag{14}$$

The profit is thus

$$\pi_k = D_k \frac{W}{P_k} \left(P_k - \frac{W}{A_k} \right). \tag{15}$$

Equilibrium. The equilibrium concept is Perfect Bayesian Nash equilibrium (PBNE).[7] Formally, I define the equilibrium as follows:

Definition 1 (Equilibrium)**.** *A Perfect Bayesian Nash equilibrium consists of consumer search rules, posterior beliefs, and firm pricing rules such that:*

1. *Firms set prices to maximize profits given consumers' search behavior and beliefs.*
2. *Consumers optimize given their information and the equilibrium pricing rule.*
3. *Posterior beliefs are updated consistently with Bayes' rule on the equilibrium path.*
4. *The nominal wage is set by the monetary authority.*

Definition 2 (Full-information equilibrium)**.** *A full-information equilibrium is an equilibrium in which consumers observe the realized nominal wage w before search.*

3 Equilibrium Characterization

I characterize the equilibrium in two special but important cases that provide benchmarks for the log-linearized analysis of equilibrium with learning from prices in the next section. First, I study the full-information benchmark and establish monetary neutrality, implying that search frictions alone are not sufficient to generate non-neutrality and that information frictions are necessary. Second, I impose the no-learning restriction under sticky information, following Mankiw and Reis (2002), and show that monetary policy is exactly non-neutral.

[7] In the standard search models, prices are bounded and consumers know the range of prices. Therefore, consumers can detect the off-equilibrium prices. The literature imposes that consumers keep the same (passive) beliefs about the distribution of future prices on and off the equilibrium path. In our case, since productivity is assumed to have unbounded support, any positive price is an on-equilibrium price. The regulations on the off-equilibrium belief is not strictly needed in this model.

3.1 Full-information Benchmark

Under full information, the consumer state reduces to v and we can characterize the optimal search strategy as a threshold rule. The threshold is the same across consumers.

Proposition 1 (Full-information equilibrium characterization)**.** *In the full-information equilibrium, the optimal search strategy follows a threshold rule. There exists a reservation value $v^*(x)$ such that the consumer stops if and only if $\frac{\epsilon}{\lambda} - p > v^*(x)$. The threshold is characterized by*

$$\int \int_{\lambda(v^*(w)+p)}^{\infty} \left(\tfrac{1}{\lambda}\epsilon - p - v^*(w)\right) g(\epsilon)\, d\epsilon f(p \mid w)\, dp = \kappa. \tag{16}$$

Moreover, each firm k sets its price according to

$$P_k = \frac{e_k}{e_k - 1}\frac{W}{A_k}, \qquad e_k = 1 + \lambda \frac{g(\lambda(v^*(w) + p_k))}{1 - G(\lambda(v^*(w) + p_k))}. \tag{17}$$

The proposition implies that firm demand elasticity takes a hazard-rate form. The term $g(\lambda(v^*(w) + p_k))$ measures the mass of marginal consumers who are indifferent between purchasing from firm k and continuing to search. These are the consumers the firm loses from a marginal price increase. By contrast, $1 - G(\lambda(v^*(w) + p_k))$ measures the mass of inframarginal consumers who still purchase from the firm. The ratio of the two therefore summarizes the firm's pricing trade-off: a higher price extracts more surplus from inframarginal consumers but drives away more marginal consumers.

Log-concavity of G implies that the hazard rate $g/(1 - G)$ is increasing in its argument. It follows that demand elasticity is increasing in both the reservation value $v^*(w)$ and the firm's own price p_k. Economically, firms face more elastic demand when consumers are pickier, since a higher reservation value makes them more willing to continue searching rather than accept the current offer. This monotonicity also implies that the firm's pricing problem is well behaved and delivers a unique optimal price for each productivity level.

Next, I establish the existence of the full-information equilibrium and show the monetary neutrality.

Theorem 1 (Existence of the full-information equilibrium)**.** *There exists a unique full-information equilibrium in which consumers search actively when $\kappa < \infty$. In such equilibrium, monetary policy is neutral. Prices respond one-to-one to changes in the nominal wage.*

The existence and uniqueness of the equilibrium is proved in two steps. First, the elasticity of demand increases in price. Individual prices are uniquely determined by (17). Second, there is a unique solution to (16) for a given price distribution. One can show that the threshold

$v^*(w)$ monotonically decreases with the search cost. The equilibrium is then the fixed point of the reservation value and the price distribution. Note that there always exist a continuum of equilibria in which firms charge sufficiently high prices and consumers do not search (Diamond, 1971). However, there is only one equilibrium in which consumers search actively. The following theorem shows our first result regarding monetary neutrality.

Importantly, this theorem establishes that, under full information, firms' prices are proportional to the realized nominal wage. Although consumers do not observe individual firm prices due to search frictions, they understand in equilibrium that all firms adjust prices proportionally to the nominal wage. As a result, relative prices remain unchanged, and there is no incentive for consumers to search more or less in response to a monetary shock.

From the firms' perspective, each firm recognizes that if it and all of its competitors raise prices one-for-one with a change in the nominal wage, real demand remains unchanged. This pricing response is therefore optimal. In particular, suppose the nominal wage increases by $\hat{w}$. Then the reservation threshold $v^*(w)$ decreases by $\hat{w}$, while all log prices increase by $\hat{w}$. The resulting demand elasticity remains unchanged, implying that firms' pricing rules and consumers' search strategies are mutually consistent.

The key implication of this theorem is that search frictions alone are not sufficient to generate monetary non-neutrality. Monetary non-neutrality arises only from the interaction between search frictions and information frictions.

3.2 Equilibrium without Learning through Prices

I now impose the no-learning restriction $\Gamma(x, p) = x$. This special case is analytically convenient and provides an exact and transparent characterization of consumer search strategy and firm demand under incomplete information.

Sticky-information interpretation. A prominent microfoundation for the no-learning restriction is a sticky-information structure in the spirit of Mankiw and Reis (2002). Following an aggregate nominal shock $\hat{w}$, a fraction $\theta \in (0, 1)$ of consumers becomes informed and correctly internalizes the realized shock, while the remaining fraction $1 - \theta$ does not update and continues to believe $\hat{w} = 0$. Furthermore, the uninformed have an effectively degenerate prior around $\hat{w} = 0$, so they do not revise their belief using encountered prices, which are noisy information about nominal wage. Under this information structure, beliefs x remain fixed throughout search.

Bellman equation under no learning. Let $U(x)$ denote the continuation value prior to paying the search cost and sampling a new firm. Without recall and under i.i.d. draws, the dynamic

program is

$$U(x) = -\kappa + \int\int \max\Big\{ -p + \tfrac{1}{\lambda}\epsilon,\ U(x)\Big\}\, g(\epsilon)\, q(p \mid x)\, d\epsilon\, dp, \tag{18}$$

Proposition 2 (Optimal search strategy under no learning)**.** *Under no learning, the optimal search strategy still follows a threshold rule. The threshold is characterized by*

$$\int\int_{\lambda(v^*(x)+p)}^{\infty} \left(\frac{1}{\lambda}\epsilon - p - v^*(x)\right) g(\epsilon)\, d\epsilon\, q(p \mid x)\, dp = \kappa. \tag{19}$$

Also, the threshold $v^*(x)$ decreases in x.

The reservation threshold $v^*(x)$ is decreasing in the consumer's signal x. A higher signal about the nominal wage leads consumers to perceive higher prices on average, which lowers the expected gains from continued search and therefore reduces the reservation value.

Under no learning, a type-x consumer uses the same threshold in every round. Hence the probability of purchasing in a given visit is constant:

$$\rho(x) = \int \Big(1 - G(\lambda(v^*(x) + p))\Big)\, f(p \mid w)\, dp. \tag{20}$$

In this simple case, the search measure evolves according to

$$n_{r+1}(dx) = \big(1 - \rho(x)\big) n_r(dx). \tag{21}$$

Starting from $n_1(dx) = \Phi_x(dx)$, this yields

$$n_r(dx) = \big(1 - \rho(x)\big)^{r-1} \Phi_x(dx), \qquad r \geq 1. \tag{22}$$

Thus the number of visits by a type-x consumer is geometric, with expected value $\rho(x)^{-1}$. Aggregating across rounds, the total visit measure generated by type x is therefore $\rho(x)^{-1} d\Phi_x(x)$.

It follows that firm k's demand share is

$$D_k = \int \Big(1 - G(\lambda(v^*(x) + p_k))\Big)\, \rho(x)^{-1}\, d\Phi_x(x), \tag{23}$$

and profit is the same as (14).

The no-learning equilibrium is useful because under sticky information, it enables an exact nonlinear analysis of monetary non-neutrality without relying on first-order approximations.

Theorem 2 (Monetary non-neutrality under sticky information with no learning from prices)**.** *There exists a unique no-learning equilibrium with sticky information in which consumers search actively*

when $\kappa < \infty$. In such equilibrium, monetary policy is not neutral. In particular, equilibrium prices respond less than one-to-one to changes in the nominal wage.

Under sticky information, there are two types of consumers, informed and uninformed. Let v_i denote the reservation threshold of informed consumers and v_u that of uninformed consumers. Following a positive monetary shock, $w > \bar{w}$, informed consumers update their beliefs and lower their reservation threshold. Uninformed consumers, in contrast, do not update and continue to search as if prices were drawn from the pre-shock distribution, so that $v_i < v_u$.

This heterogeneity in reservation thresholds implies that firms face a demand elasticity that is a weighted average of elasticities with respect to informed and uninformed consumers. Firm k's elasticity is given by,

$$e_k = \alpha_{ku}\Big(1 + \lambda \frac{g(\lambda[v_u + p_k])}{1 - G(\lambda[v_u + p_k])}\Big) + (1 - \alpha_{ku})\Big(1 + \lambda \frac{g(\lambda[v_i + p_k])}{1 - G(\lambda[v_i + p_k])}\Big). \tag{24}$$

where $\alpha_{ku} \in (0, 1)$. Because $v_i < v_u$ and the hazard function is increasing, uninformed consumers are more price sensitive than informed consumers at any given price.

Two forces drive the departure from monetary neutrality. The *direct effect* arises because uninformed consumers overestimate the likelihood of encountering low prices after a positive monetary shock. As a result, they set a higher reservation threshold than informed consumers and become more price sensitive, increasing the elasticity they contribute to aggregate demand. The strength of this channel depends on the expenditure weight of uninformed consumers, α_{ku}, which is decreasing in θ. A higher θ corresponds to weaker information frictions and a smaller mass of uninformed consumers, thereby attenuating the direct effect.

The *indirect effect* operates through informed consumers. Although informed consumers observe the realized nominal wage, they understand in equilibrium that firms adjust prices less than one-for-one with the wage. Anticipating a muted response of prices, informed consumers raise their reservation threshold, which increases the elasticity of demand they contribute.

Combining both effects, the equilibrium demand elasticity exceeds the steady-state elasticity associated with $w = \bar{w}$. Firms therefore optimally absorb part of the monetary shock into markups rather than fully passing it through to prices. As a consequence, monetary policy is not neutral, and positive monetary shocks lead to an expansion in output under sticky information.

4 Log-Linearization Results

The preceding section presents the exact benchmark results. I now log-linearize the equilibrium with learning around the full-information benchmark and provide a sharp characterization of aggregate supply curve as in the models with firm information frictions (Woodford, 2003).

Gaussian environment and rational inference from prices. To obtain tractable results, I impose Gaussian assumptions on the aggregate nominal shock, firm-level productivity, and initial private information. In particular, let the monetary authority draw the nominal wage according to

$$w = \bar{w} + \hat{w}, \qquad \hat{w} \sim \mathcal{N}(0, \sigma_w^2),$$

and let firm k's productivity satisfy

$$a_k \sim \mathcal{N}(\bar{a}, \sigma_a^2),$$

independently of $\hat{w}$. Consumers receive an initial private signal summarized by $x \sim \Phi_x$, where Φ_x is Gaussian with noise σ_x^2 chosen to pin down a constant underreaction coefficient $\theta = \frac{\sigma_w^2}{\sigma_w^2+\sigma_x^2}$.

Consumers are rational in equilibrium: they know the equilibrium pricing rule $p^*(a, w)$ and, upon paying the search cost and observing a firm's posted price p, they invert p^* to recover the firm's log marginal cost

$$z \equiv w - a.$$

Under the Gaussian assumptions above, z is a Gaussian signal about w, with noise driven by idiosyncratic productivity. Hence, conditional on belief state x, one observed price generates a Gaussian Bayesian update of beliefs about w.

First-order approximation. I consider small wage shocks from the full-information equilibrium. In particular, the wage shock $\hat{w}$ is drawn from a distribution with vanishing standard deviation, so $\sigma_w \to 0$. At the same time, I impose that the informativeness of the initial private signal remains unchanged, in the sense that the ratio $\frac{\sigma_w^2}{\sigma_w^2+\sigma_x^2}$ is held fixed at θ. This is consistent with the measure of information frictions in the no-learning benchmark above.

Weak learning and the threshold rule. To first order, any individual observed price is only mildly informative about w, i.e., $\sigma_a \gg \sigma_w$. Let the signal-to-noise ratio be $\varepsilon = \frac{\sigma_w^2}{\sigma_w^2+\sigma_a^2}$, $\varepsilon \to 0$. In this case, consumers learn from prices, but only gradually.

Proposition 3 (Approximate threshold rule under weak learning)**.** *Under weak learning, the optimal search rule is approximated at first order by a threshold rule. The threshold $v^*(x)$ is characterized by equation* (19)*.*

This result implies that, to first order, the learning motive for continued search is negligible. Additional search does not materially reduce posterior uncertainty, nor does it significantly shift posterior beliefs through unusually high or low observed prices, which creates bias in posterior mean. Hence the consumer's stopping rule is locally the same as in the no-learning benchmark.

The consumer accepts the current offer if and only if $y \geq v^*(x')$. Conditional on (x', p), the probability of rejecting the current offer is $G\big(\lambda\big(v^*(x') + p\big)\big)$. Under weak learning, the

survival-and-transition kernel is thus

$$K_w(B \mid x) := \int \mathbf{1}\{\Gamma(x,p) \in B\} G\big(\lambda\big(v^*(\Gamma(x,p)) + p\big)\big)\, f(p \mid w)\, dp, \tag{25}$$

Compared with the general kernel in (12), the only difference is that the continuation value is replaced by the threshold $v^*(\Gamma(x,p))$. Then the firm k's demand can be written as

$$D_k^L = \sum_{r\geq 1} \int \Big(1 - G\big(\lambda\big(v^*(\Gamma(x,p_k)) + p_k\big)\big)\Big) n_r(dx). \tag{26}$$

Since weak learning implies $\Gamma(x,p) = x + O(\varepsilon)$, demand further admits the first-order approximation

$$D_k^L = \sum_{r\geq 1} \int \Big(1 - G(\lambda(v^*(x) + p_k))\Big)\, n_r(dx) + O(\hat{w}^2). \tag{27}$$

The FOC implies the demand elasticity is,

$$e_k = 1 + \lambda \frac{\sum_{r\geq 1} \int g(\lambda(v^*(x) + p_k))\; n_r(dx)}{\sum_{r\geq 1} \int \Big(1 - G(\lambda(v^*(x) + p_k))\Big)\, n_r(dx)} + O(\hat{w}^2) \tag{28}$$

Effective information frictions. In the no-learning benchmark, the measure of information frictions is θ. However, with learning, information frictions are expected to be reduced. To summarize the effect of learning on perceived aggregate conditions, define the learning analogue of the visit-weighted posterior mean:

$$\bar{\mu}^L \;\equiv\; \frac{\sum_{r\geq 1} \int \mu_x\, n_r(dx)}{\sum_{r\geq 1} \int n_r(dx)}, \qquad \mu_x \equiv \mathbb{E}[\hat{w} \mid x]. \tag{29}$$

Proposition 4 (Effective information frictions at first order)**.** *Fix a local sequence $\hat{w} \to 0$. To first order,*

$$\bar{\mu}^L = \theta^L \hat{w}, \tag{30}$$

where the effective information coefficient θ^L is a search measure-weighted average of round-specific Gaussian-updating coefficients. Approximation under full-information purchase probability $\bar{\rho} \in (0,1)$,

$$\theta^L = \bar{\rho} \sum_{r\geq 1} (1-\bar{\rho})^{r-1} \theta_r \in (\theta, 1), \tag{31}$$

$$\theta_r = \frac{\theta\tau_x + r\tau_a}{\tau_x + r\tau_a}, \qquad \tau_x \equiv \sigma_x^{-2},\;\; \tau_a \equiv \sigma_a^{-2}, \tag{32}$$

where τ_x is the precision of the initial signal. If $\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}}$ is small, then

$$\theta^L \approx \theta + (1-\theta)\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}}. \tag{33}$$

If $\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}} \to \infty$, then $\theta^L \to 1$.

Proposition 4 shows that search and learning jointly determine the effective information friction. When search cost is high and search is short ($\bar{\rho}$ is large), consumers observe only a few prices, so the effective information friction remains close to θ. In this case, the no-learning benchmark is a good approximation. When search lasts longer, consumers average over more price signals and become better informed about the aggregate state, so effective information frictions decline. In the limit, as search costs become arbitrarily small and search becomes arbitrarily long, effective information frictions vanish.

Price index. Let $\hat{p}_k = p_k - \bar{p}_k$ denote the log change in price in firm k from the full-information equilibrium after a wage shock. Unlike the standard demand system where an aggregate demand function is available and then the price index is naturally defined, in the model with search frictions, there is no obvious way to define a price index. However, the standard theory (Hulten, 1973, 1978) offers a simple non-parametric formula for the *log change* in price index. If preference is homothetic and stable, which is the case here, the log change in price index is the expenditure share-weighted log changes in prices of all firms[8]:

$$\hat{p} = \int \hat{p}_k \, \bar{\omega}_k dk \tag{34}$$

where $\bar{\omega}_k = \rho^{-1}\big(1 - G\big(\lambda(v^*(\bar{w}) + \bar{p}_k)\big)\big)$ is the expenditure share of firm k in the full-information equilibrium. I also normalize $\bar{p} = 0$, so that $\hat{p} = p$.

Demand Elasticity. The following proposition presents the first-order approximation to the demand elasticity in (28).

Proposition 5. *To first order, the demand elasticity is given by,*

$$e_k = \lambda \frac{g\big(\lambda(v^*(\bar{w}) + p_k - \bar{\mathbb{E}}p)\big)}{1 - G\big(\lambda(v^*(\bar{w}) + p_k - \bar{\mathbb{E}}p)\big)} + 1 \tag{35}$$

[8]Homotheticity requires that the income elasticity of demand must equal one for each good. Stability requires that consumers adjust their spending only in response to changes in income and relative prices. Baqaee and Burstein (2023) show how to generalize the standard theory to more general preferences. In our case, the demand for firm k is proportional to the aggregate income W, which implies homotheticity. In addition, there is no other factors, such as taste shocks, state of nature, other than relative prices and income, that can affect the demand. The match-specific shocks are integrated out across the population.

Under imperfect information, $\bar{\mathbb{E}}p = \theta^L p$.

This proposition establishes that to first order, demand elasticity depends on the *perceived* relative price, $p_k - \bar{\mathbb{E}}\, p$, rather than the actual relative price that appears in standard demand systems such as CES or Kimball. In those preferences, consumers observe all prices in the market and optimally allocate expenditure across goods given the full price vector. Consequently, demand depends only on actual relative prices, making it impossible for consumer information frictions to affect demand which is central to this paper.

Under imperfect information and finite search, the average expected price index responds less than the actual price index. Consumers therefore perceive current prices as high relative to the prices they expect to encounter in future search, which raises their effective reservation threshold from $v^*(\bar{w}) - p$ to $v^*(\bar{w}) - \bar{\mathbb{E}}p$. Firms thus face effectively pickier consumers who are more willing to continue searching, implying a higher demand elasticity. This mirrors Theorem 2 for the no-learning equilibrium: there the rise in elasticity is exact, while here the same result emerges from a first-order approximation of the learning equilibrium. In both cases, the mechanism is the same—information frictions leave consumers less informed about the aggregate nominal state and thereby raise demand elasticities.

4.1 Aggregate Supply Curve

To characterize the aggregate supply curve, I first define the passthrough of shocks to prices. This step is necessary because demand elasticities change following aggregate shocks, and passthrough is closely related to the superelasticity of demand (Amiti et al., 2019a). In particular, I define the passthrough of own-shock shocks as the response of firm k's price to a marginal change in its productivity at the full-information equilibrium:

$$\gamma_k \equiv (1 - \frac{d \log \mu_k}{d p_k}\Big|_{\hat{w}=0})^{-1} \tag{36}$$

I now state the results on the firm- and economy-level supply curves.

Theorem 3. *On the first order, firm supply curve writes:*

$$\hat{p}_k = \underbrace{\gamma_k \hat{w}}_{\text{pt. of own-shock shock}} + \underbrace{(1-\gamma_k)\bar{\mathbb{E}}\hat{p}}_{\text{complementarity}} \tag{37}$$

The aggregate supply curve writes,

$$\hat{p} = \Gamma \hat{w} + (1-\Gamma)\bar{\mathbb{E}}\hat{p} \tag{38}$$

where $\bar{\mathbb{E}}\hat{p} = \theta^L \hat{p}$; $\Gamma = \int \gamma_k \bar{\omega}_k dk$ *and* $\bar{\omega}_k$ *is the full-information equilibrium expenditure share of firm* k.

Firm's response of prices comes from two sources: the passthrough of wage shock as own-shock changes and strategic complementarity in other firms' price changes. This theorem establishes that the consumer information frictions only impact the price response by dampening complementarity. The result is closely related to Proposition 5. The intuition is that firms care about how their customers think about other firms' price changes. Firms are as if competing with other firms which charge lower prices. Average across firms, I achieve the aggregate supply curve, which maps the changes in real wage to changes in price index.

Consider first a positive monetary shock, such as a 1% increase in nominal wages. In response, firms raise prices. Because consumers are imperfectly informed, an individual firm's price increase is perceived as relatively large, which induces more consumers to walk away and search. Relative to the full-information benchmark, this shifts the firm's pricing tradeoff toward retaining marginal consumers. As a result, passthrough is incomplete. This mechanism reflects Rotemberg's core intuition: firms, fearing the loss of marginal consumers, absorb part of the cost increase through lower markups.

Now consider a negative monetary shock, such as a 1% decrease in nominal wages. Firms lower prices, but consumers do not fully perceive that competing firms are also cutting prices. As a result, a given firm faces less risk of losing marginal consumers and shifts its pricing tradeoff toward extracting more surplus from infra-marginal consumers. Passthrough is again incomplete, but for the opposite reason: firms retain part of the cost reduction in higher markups because information frictions weaken competitive pressure.

Corollary 1 (MCS on Information Frictions)**.** *The passthrough of aggregate shocks increases with* θ^L. *In the limits, if* $\theta^L = 1$, *then* $\hat{p}_k = \hat{w}$; *if* $\theta^L \to 0$, *then* $\hat{p}_k \to \gamma_k \hat{w}$.

This corollary shows that, in the limit of full information, the passthrough of aggregate shocks is one for all firms. This result is consistent with Theorem 1, which establishes the exact one-for-one passthrough in the non-linear full-information equilibrium. Amiti et al. (2019a) show that aggregate-shock passthrough is unity under a broad class of preferences, including nested CES and Kimball demand systems. The present result complements their findings by emphasizing that complete information about the price index is essential for full passthrough.

In contrast, in the limit of zero consumer information, passthrough of aggregate shocks coincides with passthrough of idiosyncratic cost shocks. When consumers perceive no change in the aggregate price index, the strategic complementarity in firms' pricing decisions disappears. Aggregate shocks are then effectively treated as firm-specific shocks, so firms adjust prices only in response to their own cost movements. This highlights a sharp distinction from models with firm-side information frictions, such as Woodford (2003), where uninformed firms may fail to

adjust prices altogether. Here, firms observe the shock. Even though consumer information frictions prevent them from conditioning on competitors' price changes, they still adjust flexibly to their own cost shocks, as if those shocks were idiosyncratic.

By varying θ between 0 and 1, the model therefore spans all outcomes between the average own-shock passthrough and the full-information benchmark. In the dynamic model in Section 5, consumers learn about the shock over time. If learning converges to common knowledge of the shock, monetary policy becomes neutral in the long run.

I now solve for passthrough explicitly. Let φ_k denote the passthrough of an aggregate shock to firm k's price, so that $\hat{p}_k = \varphi_k \hat{w}$. Define the economy-level passthrough as the expenditure-weighted average, $\Phi = \int \varphi_k \bar{\omega}_k dk$, so that $\hat{p} = \Phi \hat{w}$. The following corollary provides closed-form expressions for these passthroughs.

Corollary 2 (Aggregate-Shock Passthroughs)**.** *The economy-level passthrough of aggregate shocks is given by*

$$\Phi = \frac{\Gamma}{1 - \theta^L (1 - \Gamma)}. \tag{39}$$

The firm-level passthrough of aggregate shocks is given by

$$\varphi_k = \frac{\gamma_k}{1 - \theta^L \Phi (1 - \gamma_k)}. \tag{40}$$

This result connects to Theorem 2. Recall that information frictions affect firm demand elasticities through both a direct and an indirect channel. Under linearization, the firm-level passthrough is pinned down by the economy-level passthrough: an incomplete response of the aggregate price index (a lower Φ) further dampens individual firms' passthrough. This interaction is the manifestation of the *indirect effect* in the no-learning equilibrium. Intuitively, consumers understand that firms face pickier consumers and therefore reduce price responses. Anticipating this muted adjustment of the price index, consumers become even pickier, which amplifies the increase in demand elasticity and further depresses firm-level passthrough.

I now dig deeper to show how consumer information frictions attenuate strategic complementarity in pricing through higher-order beliefs. For this purpose, I borrow heavily from game-theoretic insights as in Morris and Shin (2002) and Angeletos and Lian (2023).

Corollary 3 (Strategic Complementarity Attenuation)**.** *In rational expectations equilibrium, the change in the price index can be expressed as an infinite sum of higher-order beliefs about $\hat{w}$:*

$$\hat{p} = \Gamma \sum_{h=0}^{\infty} (1 - \Gamma)^h \, \bar{\mathbb{E}}^h \hat{w}, \tag{41}$$

where the hth-order average expectation is defined recursively by $\bar{\mathbb{E}}^h \hat{w} := \bar{\mathbb{E}}\left(\bar{\mathbb{E}}^{h-1}\hat{w}\right)$, *with* $\bar{\mathbb{E}}^0 \hat{w} := \hat{w}$.

Equation (41) follows from iterating the pricing rule in Theorem 3 forward.[9] The expression admits a natural interpretation as the response of the price index unfolding in notional rounds within a period. In the first round, when a wage shock occurs, suppose no firm has yet responded and that each firm expects other firms not to adjust. The aggregate shock then appears as an idiosyncratic cost shock to each firm, generating an initial price response of $\Gamma\hat{w}$. This belief is not the one held in rational-expectations equilibrium; rather, it is a convenient way to describe how equilibrium beliefs can be approached via iterative reasoning, consistent with the level-k thinking models (see, e.g., García-Schmidt and Woodford, 2019; Farhi and Werning, 2019).

In the second round, it becomes common knowledge among firms that the price index has increased by the first-round amount. Because price setting features strategic complementarity, firms pass an additional fraction of consumers' *perceived* increase in the price index onto their prices. Under the belief that no further price adjustment will occur, the incremental passthrough is $(1-\Gamma)\,\bar{\mathbb{E}}(\Gamma\hat{w})$. This process continues. In the $(h+1)$th round, the incremental passthrough is proportional to $(1-\Gamma)^h\,\bar{\mathbb{E}}^h\hat{w}$, and the total passthrough is the sum of these round-by-round adjustments, as in (41).

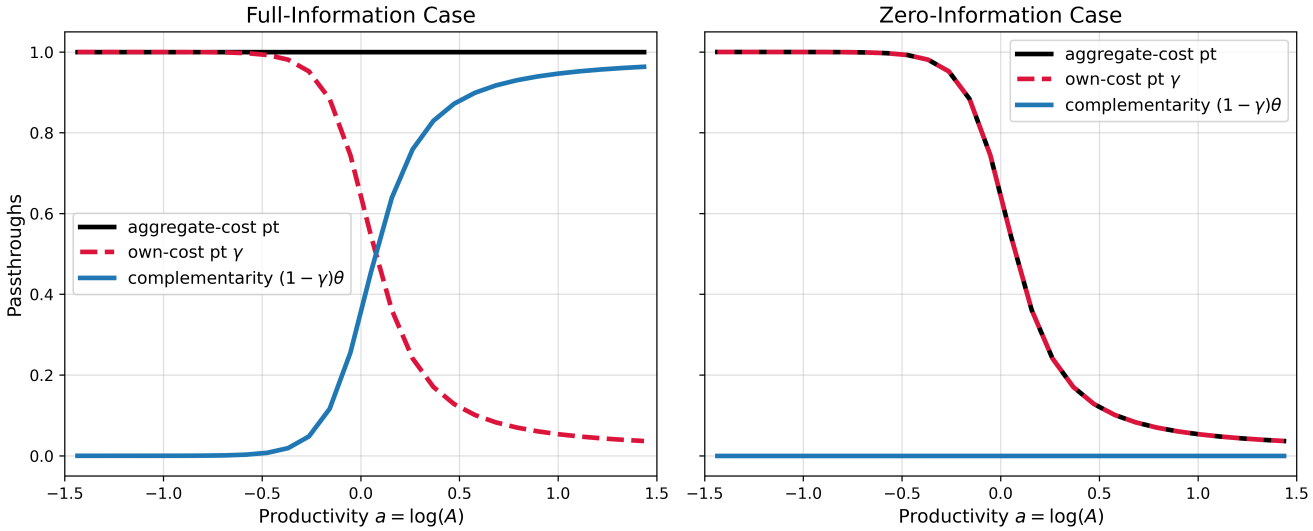
A key implication of this Corollary is that consumer information frictions attenuate higher-order strategic complementarity disproportionately: higher-order beliefs $\bar{\mathbb{E}}^h\hat{w}$ are more strongly anchored to the prior, so their contribution to (41) decays more quickly with h. Conversely, reducing information frictions increases more the contribution of higher-order beliefs and strengthens strategic complementarity.

Finally, it is important to emphasize that firms have common knowledge of the shock and of consumers' higher-order beliefs. This sharply distinguishes the mechanism here from firm-information-frictions models, in which firms must form beliefs about other firms' beliefs, creating substantial higher-order complexity (Townsend, 1983). In the present framework, the party that faces information frictions (consumers) is distinct from the party that sets prices (firms), which allows us to abstract from this complexity while preserving the central role of higher-order beliefs in aggregate passthrough.

Taken together, Theorem 3 establishes that the passthroughs of aggregate shocks are generically incomplete. Corollary 1 shows comparative statics on information frictions. Corollary 2 relates the linear result back to non-linear result in Theorem 2. Corollary 3 explains the mechanism from the perspective of higher-order beliefs.

[9] To represent the pricing game as an infinite sum of higher-order beliefs as in (41), it is sufficient that (i) firms are rational, (ii) consumers know that firms are rational, (iii) rationality is common knowledge among consumers, and (iv) firms know this common knowledge. Appendix A clarifies which rationality assumptions are invoked at each step. Rational expectations is a "super" concept that imposes all of these requirements.

Figure 1: Distribution of three types of passthroughs under incomplete and complete information



Notes: The figure plots distributions of passthroughs based on one calibration of the model. The red line represents own-shock passthrough. The blue line represents cross-price passthrough. The black line represents aggregate-shock passthrough . The left and right panels show passthroughs in the incomplete and complete information cases, respectively.

4.2 Comparative Statics

Now I characterize how passthrough varies with firm productivity. The results also depend on the distribution of match utility. To proceed, I follow the literature and assume G is the Gumbel distribution.

Proposition 6 (Passthrough Heterogeneity)**.** *Given G is Gumbel, markup $\mu(a)$ increases in productivity; own-shock passthrough $\gamma(a)$ and aggregate-shock passthrough $\varphi(a)$ decreases in productivity. Also, the following limit results hold:*

1. $\lim_{a\to\infty} \mu(a) = \infty$; $\lim_{a\to\infty} \varphi(a) = \Phi\theta^L$; $\lim_{a\to\infty} \gamma(a) = 0$
2. $\lim_{a\to-\infty} \mu(a) = \frac{\lambda+1}{\lambda}$; $\lim_{a\to-\infty} \varphi(a) = 1$; $\lim_{a\to-\infty} \gamma(a) = 1$

The proposition yields familiar implications for prices, markups, and passthrough. More productive firms charge lower prices, set higher markups, and exhibit lower own-shock passthrough. The admissible markup distribution has a lower bound pinned down by the dispersion of taste shocks and no finite upper bound. These predictions mirror standard demand systems such as oligopolistic CES and Kimball-type preferences, and are consistent with evidence that more productive firms charge higher markups and pass through less of cost shocks, including exchange-rate shocks (Amiti et al., 2014, 2019a). The contribution here is to show that a sequential-search model generates the same patterns endogenously: costly search makes relative prices affect search behavior, which in turn creates demand complementarity. As search costs vanish, the model converges to the CES benchmark and complementarity disappears.

Figure 1 illustrates heterogeneity in passthroughs. Under full information, lower own-shock passthrough for high-productivity firms is exactly offset by higher cross-price passthrough, so aggregate-shock passthrough remains one for all firms. With zero consumer information about the aggregate shock, aggregate-shock passthrough instead collapses to own-shock passthrough, because information frictions dampen the complementarity channel. This reduction is strongest for high-productivity firms, which therefore account for a disproportionate share of incomplete economy-wide passthrough. The limit results in Proposition 6 further implies that, after a positive shock, all firms face higher perceived relative prices, making consumers more likely to continue searching and demand more elastic.

I further present comparative statics of passthroughs over search cost.

Proposition 7 (MCS on Search Cost)**.** *The own-shock passthrough γ_k and aggregate-shock passthrough φ_k decrease with search cost κ for any firm k. The markup increases with search cost κ for any firm k. In the limit, $\lim_{\kappa \to 0} \gamma(a) = \varphi(a) = 1$.*

This proposition shows that higher search costs raise markups and reduce passthroughs for all firms, because higher search cost effectively increases the market power and larger markups let firms absorb more of cost shocks, which in turn amplifies the effect of information frictions. The two frictions are therefore mutually reinforcing. Moreover, by lowering the purchase hazard, higher search costs slow learning and increase effective information frictions, as shown in Proposition 4. In the limit as search costs vanish, both channels disappear: (i) $\gamma_k \to 1$ and (ii) $\theta^L \to 1$. Consequently, passthrough returns to one.

4.3 Discussions

Supply Shocks. In the model, nominal wages and aggregate productivity affect prices only through marginal costs, and the optimal pricing rule is homogeneous of degree zero in $\{W, A\}$. Hence a positive aggregate technology shock is equivalent to a proportional decline in the nominal wage. Given the information frictions about the technology shocks, one can therefore similarly define passthrough to supply shocks by $\hat{p}_k = -\varphi_k \hat{a}$, and the corresponding average aggregate-shock passthrough Φ. More generally, the pricing equation can be written as

$$\hat{p} = \Gamma \widehat{mc} + (1 - \Gamma)\theta^L \hat{p}, \tag{42}$$

where $\widehat{mc} = \hat{w} - \hat{a}$ is the log change in nominal marginal cost.

The intuition parallels that for monetary shocks. Following a negative technology shock—for example, an increase in input costs due to supply-chain disruptions—consumers with incomplete information may interpret the resulting price increases as firm-specific rather than

aggregate. This induces more intensive search across firms, which raises demand elasticities and leads firms to adjust prices less than one-for-one. As a result, passthrough of aggregate supply shocks is incomplete.

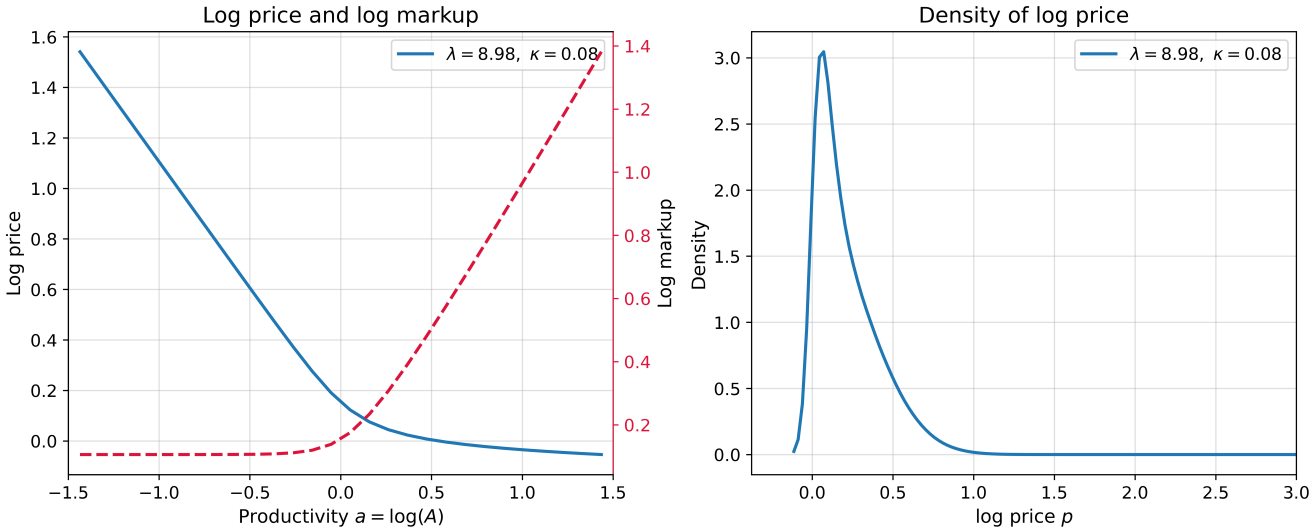
When Do Consumer Information Frictions Matter? Consumer information frictions are especially plausible for broad supply shocks—such as tariffs, oil shocks, and supply-chain disruptions—because firms observe them directly in costs, whereas consumers must infer them from posted prices. Recent tariff evidence fits this view: Cavallo et al. (2025) estimate short-run retail passthrough at only about 25 percent of the effective tariff, while Cavallo et al. (2021) find that the 2018 tariffs were only partially reflected in retail prices. At the same time, Amiti et al. (2019b) show that the 2018 tariffs were passed through fully into U.S. import prices, with the burden falling largely on U.S. firms and consumers. Together, these results suggest that firms quickly understand tariffs as cost shocks, but retail passthrough remains low and gradual. A natural interpretation is consumer information frictions: consumers may not know the size of the tariff, the origin of the goods they buy, or the extent to which imported components from multiple countries are embodied in final products.

Consumer information frictions are also natural for monetary policy shocks, since firms observe policy moves and can understand their implications for costs and pricing, whereas consumers are less likely to internalize their effects on the aggregate price level. For aggregate demand shocks, e.g., discount rate shocks, firm information frictions are more plausible initially, as firms may be uncertain whether changes in sales reflect idiosyncratic variation or a shift in aggregate demand (Woodford, 2003; Maćkowiak and Wiederholt, 2009). However, modern data technologies allow firms to learn demand conditions more quickly (Begenau et al., 2018), which weakens the case for strong firm-side information frictions. Consumer information frictions therefore complement, rather than replace, the firm-side view of demand shocks: even when firms learn demand relatively quickly, consumers may still remain imperfectly informed about whether observed price changes are aggregate or idiosyncratic, thereby causing price stickiness.

Empirical Evidence and Calibration of Search Frictions The strength of the mechanism is governed by two objects: own-cost passthrough, Γ, and effective information frictions, θ^L. The former depends purely on search frictions, namely the search cost κ and the dispersion of taste shocks λ. The latter also depends on search through purchase hazard ρ. Here, I discuss the empirical evidence on the purchase hazard ρ and the degree of strategic complementarity in pricing, $1-\Gamma$, in the literature. Then, I estimate κ and λ using these two moments.

Across markets, the evidence suggests substantial search frictions. In retail, Wildenbeest (2011) finds, using UK online grocery data, that 71% of consumers search only one store, while Liu (2025) finds that 45% of U.S. consumers purchase from only one store in large-scale retail

Figure 2: Price, Markup and Price Distribution



Notes: The right panel plots the equilibrium distribution of log prices obtained by Monte Carlo sampling. Specifically, I draw a large number of productivity realizations $a \sim \mathcal{N}(0, \sigma_a^2)$ where $\sigma_a = 0.3$, and map each draw through the deterministic equilibrium pricing rule $p(a)$ implied by the model. The resulting p samples are used to approximate the density of log prices.

data. In automobiles, Moraga-González et al. (2023) use Dutch new-car data on dealer visits and test drives to show that 47% of active searchers visit only one brand's dealer, and search frictions roughly double markups relative to full information. In finance, Allen et al. (2019) show, using Canadian mortgage data, that 45% of new home buyers visit only one lender and that the average number of quotes is fewer than three. In addition, Amiti et al. (2019a) and Gagliardone et al. (2025) estimate strategic complementary of about 0.5–0.6 using comprehensive Belgian manufacturing data.[10] Taken together, these estimates suggest a benchmark purchase hazard of $\rho = 0.5$, and own-cost passthrough $\Gamma = 0.4$.

Using these two empirical moments, taking $\sigma_a = 0.3$ from Decker et al. (2020), I estimate the search-friction parameters to be $\lambda = 8.98$ and $\kappa = 0.08$, with the associated threshold $v^* = -0.12$. Figure 5 plots the implied equilibrium objects. The left panel shows log prices and markups against productivity; the right panel shows the equilibrium distribution of log prices obtained by Monte Carlo simulation. Log markups are approximately constant on the left of threshold and then increase linearly. This asymmetry makes the price distribution concentrated on the left while generating a fatter right tail.

[10]Whether own-cost and complementarity sum to one depends on the specification. For example, Amiti et al. (2019a) find that the sum is not statistically different from one, whereas Gagliardone et al. (2025), using a specification derived from standard New Keynesian models, estimate price stickiness of about 0.7, implying that the sum is less than one.

5 DSGE Model

In this section, I present the full-fledged dynamic general equilibrium model, which completes the static model in general equilibrium and extends to dynamics over time. Then, I compare impulse responses across models and highlight the important features of this model.

Timeline. Time is discrete denoted by $t = 0, 1, 2, ...$ The household consists of a worker and a continuum of shoppers. The period is divided into morning and afternoon. In the morning, the monetary authority sets the interest rate, and the worker makes decisions on the labor supply, the bond position, and the aggregate consumption spending. In the afternoon, firms post prices, and shoppers search sequentially and decide where to buy. They are constrained by the amount of cash allocated to them. The worker has full information and shoppers have incomplete information about monetary shocks.

Monetary Authority. The monetary authority sets the nominal interest rate. It follows the Taylor rule,

$$i_t = \phi \hat{\pi}_t + v_{mt} \tag{43}$$

where v_{mt} follows,

$$v_{mt} = \rho_m v_{mt-1} + \sigma_m \varepsilon_{mt} \tag{44}$$

where ε_{mt} is the monetary shock and it follows $\varepsilon_{mt} \sim \mathcal{N}(0, 1)$.

Firm. Firm k' productivity has two components,

$$\log A_{kt} = \log A_t + \log \tilde{A}_{kt} \tag{45}$$

where $\tilde{A}_{kt}$ is idiosyncratic productivity, which is i.i.d across firms and time, and A_t is the aggregate productivity. Let $a_t = \log A_t$. It follows the AR(1) process,

$$a_t = \rho_A a_{t-1} + \varepsilon_{At} \tag{46}$$

Shoppers are imperfectly informed about supply shocks as well. Signals about different aggregate shocks are assumed to be independent.

Worker. Following Chahrour and Gaballo (2021), I assume that there is a representative household which consists of a single worker and a continuum of shoppers. The worker makes the labor supply and aggregate consumption spending decisions, leaving only the decisions about where to buy particular goods to the shoppers. I assume the worker has full information

about the model economy, and there is no communication between the worker and the shoppers. Under this setup, a monetary shock can shift both nominal average marginal costs (observed by firms) and nominal aggregate demand (observed by the worker) while remaining unknown to the shoppers. In particular, the worker's problem writes,

$$\max_{B_t, C_t, L_t} E_0 \sum_{t=0}^{\infty} \beta^t \left(\log(C_t - \lambda_c C_{t-1}) - \frac{L_t^{1+\eta}}{1+\eta} \right)$$
$$\text{s.t.} \quad P_t C_t + B_t = W_t L_t + R_{t-1} B_{t-1} + \Pi_t$$

where L_t is the labor effort, W_t is nominal wage, and Π_t is total nominal profits of firms. The risk-free bonds B_t is in zero net supply. The parameter λ_c measures the habit in consumption.

After determining the aggregate consumption, the worker distributes randomly the aggregate expenditure $X_t = P_t C_t$ to shoppers. Each shopper receives X_{it} and $\int \log X_{it} di = \log X_t$. Due to log utility, the level of consumption spending X_{it} does not influence the shopper's search decision, allowing the worker's and shoppers' problems to be separated.[11]

Using goods market clearing, the first-order Euler equation writes,

$$\hat{y}_t = c_1 \hat{y}_{t-1} + (1 - c_1) \hat{y}_{t+1} - c_2 (\hat{i}_t - \hat{\pi}_{t+1}) \tag{47}$$

where $c_1 = \frac{\lambda_c}{1+\lambda_c}$ and $c_2 = \frac{1-\lambda_c}{1+\lambda_c}$. Larger λ_c not only dampens the response of output to the change in the real interest rate but anchor its level to the last-period output response.

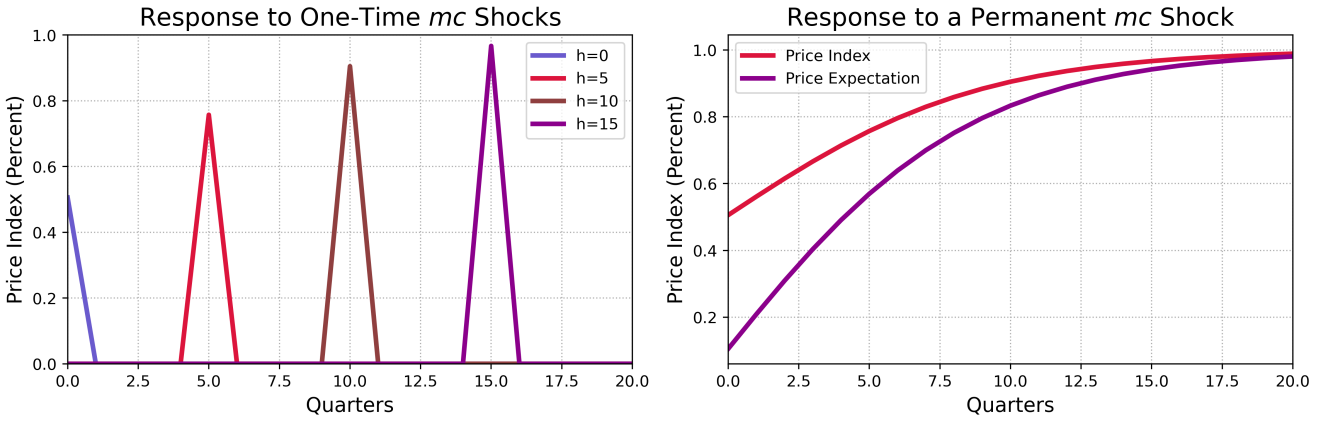
Consumer Learning. In the afternoon, each shopper receives consumption expenditure X_{it} and solves a static problem period by period. Since the equilibrium with learning is first-order equivalent to the no-learning sticky-information equilibrium given effective information frictions, I adopt a reduced-form learning protocol following Mankiw and Reis (2002). Specifically, in each period a fraction θ of shoppers becomes informed about the aggregate shock. Hence, by horizon t, the cumulative share of informed shoppers is $1 - (1 - \theta)^t$, for $t = 1, 2, 3, \ldots$.[12]

Following Auclert et al. (2020), I decompose a persistent monetary shock into a sequence of independent news shocks, and model consumer learning about these news shocks. Consider a news shock announced at time $s - 1$. Between dates 1 and s, the share of informed shoppers rises gradually, so that when the shock materializes at time s, a fraction $1 - (1 - \theta)^s$ of shoppers already knows about it.

[11] Without habit $\lambda_c = 0$, the per period utility is equivalent to the integral of shoppers' utilities. With habit, the worker's objective is different.

[12] In principle, shoppers could also extract information from X_{it}. But because X_{it} is an endogenous object, incorporating such inference would substantially complicate the model and is beyond the scope of this paper. For tractability, I set $\sigma_x \to \infty$ and focus exclusively on exogenous signals.

Figure 3: Properties of the Passthrough Matrix $\boldsymbol{\Psi}$



Notes: The figure plots the responses of price index to one-time nominal wage shocks (left panel) and a permanent nominal wage shock (right panel) when $\theta = 0.1$. In addition, the average expectation of price index is plotted in the right panel.

Stacking equation (38) over time into a vector-valued system and rearranging yields

$$\hat{\boldsymbol{p}} = \underbrace{\Gamma\big(\boldsymbol{I} - (1-\Gamma)\boldsymbol{\Theta}\big)^{-1}}_{\boldsymbol{\Psi}} (\hat{\boldsymbol{w}} - \hat{\boldsymbol{a}}), \tag{48}$$

where $\boldsymbol{\Theta}$ is the information matrix, a diagonal matrix with entries $1-(1-\theta)^j$ for $j = 1, 2, \ldots$. Following Auclert et al. (2024), I refer to Ψ as the passthrough matrix, since it characterizes the response of the price level to changes in nominal marginal costs. Importantly, this matrix embeds both information frictions through $\boldsymbol{\Theta}$ and search frictions through the parameter Γ.

The left panel of Figure 3 plots the response of the price index to a one-time nominal wage shock in the absence of Calvo frictions. The information-based Phillips curve is purely backward-looking: firms pass through the nominal wage shock only when it occurs. For shocks that materialize further in the future, shoppers have more time to become informed, implying a larger price response upon realization. However, firms do not adjust price in anticipation of future shocks. Both features mirror the firm-side information-based Phillips curve as in Mankiw and Reis (2002) and Woodford (2003). The right panel shows the responses of the price index and average price expectations to a permanent nominal wage shock. When learning is slow, the price index converges to its long-run level only gradually. Expectations initially undershoot realized prices and then converge.

Notice that it is essential for consumers to learn the aggregate price index over time. In the long run, as their expected price index converges to the actual index, their perceived relative prices also become correct. Learning only from inflation, as is often studied in New Keynesian learning models, is not sufficient.

Micro data provide strong evidence of infrequent price adjustment. For example, Bils and Klenow (2004) and Nakamura and Steinsson (2008) document average price durations of three to four quarters. In Appendix B, I further show how to incorporate the time-dependent nominal rigidities into aggregate supply curve. It becomes

$$\hat{\boldsymbol{P}} = \boldsymbol{\Gamma}\boldsymbol{\Psi}^{TD}\left(\boldsymbol{I} - (1-\boldsymbol{\Gamma})\boldsymbol{\Psi}^{TD}\boldsymbol{\Theta}\right)^{-1}(\hat{\boldsymbol{w}} - \hat{\boldsymbol{a}}) \tag{49}$$

where $\boldsymbol{\Psi}^{TD}$ denotes the passthrough matrix under purely time-dependent adjustment. This can nest standard Calvo and Taylor models. Moreover, Auclert et al. (2024) shows that on a first-order approximation, menu-cost models generate similar passthrough behavior to Calvo models, implying that focusing on Calvo pricing entails no loss of generality.

Nominal rigidity dampens price responses through two channels. First, it directly attenuates firms' responses to idiosyncratic shocks. Second, its effects are amplified by strategic complementarity, as documented extensively in the literature (e.g., Klenow and Willis, 2016). When combined with consumer search, this amplification admits a new interpretation: if consumers anticipate that many firms cannot adjust prices each period, the price distribution places greater mass on the left tail, inducing more search. Anticipating this behavior, adjusting firms optimally reduce passthrough further.

I then derive the *generalized Phillips curve* by substituting $\hat{\boldsymbol{w}} = \hat{\boldsymbol{w}}^r + \hat{\boldsymbol{p}}$, where $\hat{w}^r$ is the log-deviation of real wage, and solving the fixed point,

$$\hat{\boldsymbol{\pi}} = \underbrace{(\boldsymbol{I} - \boldsymbol{L})\boldsymbol{\Psi}\left(\boldsymbol{I} - \boldsymbol{\Psi}\right)^{-1}}_{\boldsymbol{K}}(\hat{\boldsymbol{w}}^r - \hat{\boldsymbol{a}}) \tag{50}$$

where $\boldsymbol{L}$ is the lag matrix with entries of 1 one line below the diagonal. Equation (50) maps any change in real wage $\hat{\boldsymbol{w}}$ to inflation. Matrix $\boldsymbol{K}$ represents the slope of the *generalized Phillips curve*.

Labor Union. Following Erceg et al. (2000) and Auclert et al. (2021), the worker supplies labor to unions, which differentiate the labor into types of labor services denoted by L_{jt}. A competitive labor packer aggregates these differentiated services using a Kimball aggregator (Kimball, 1995), and sells the composite labor input to firms at a nominal wage W_t. Firms use the aggregated labor service L_t in production, where aggregation satisfies:

$$\int_j G_w\left(\frac{L_{jt}}{L_t}\right)dj = 1, \tag{51}$$

with G_w denoting the Kimball aggregator. The aggregator satisfies $G_w'(x) = \exp\left\{\frac{1-x^{\frac{\zeta_w}{\varepsilon_w}}}{\zeta_w}\right\}$, where ε_w is the elasticity of substitution across labor types and ζ_w is the super-elasticity. Wages

are set by unions subject to nominal rigidities à la Calvo: with probability $1-\lambda_w$, unions can re-optimize wages in each period, while otherwise wages are indexed to past inflation.[13] Let w^r be the real wage. The union's optimization problem implies, to the first-order, the following wage Phillips curve:

$$\hat{w}_t^r = w_1(\hat{w}_{t-1}^r + \pi_{t-1}) + w_2(\mathbb{E}_t\hat{w}_{t+1}^r + \pi_{t+1}) - \pi_t - \kappa_w(\hat{w}_t^r - \eta\hat{l}_t - \hat{y}_t), \tag{52}$$

where $w_1 = \frac{1}{1+\beta}$, $w_2 = \frac{\beta}{1+\beta}$, and the slope parameter $\kappa_w = \frac{(1-\beta\lambda_w)(1-\lambda_w)}{\lambda_w}\frac{\varepsilon_w}{\varepsilon_w-1+\zeta_w}$. The slope κ_w governs the extent to which the gap between the real wage and the marginal rate of substitution between leisure and consumption is passed to the real wage.

Reallocation and Aggregate Productivity. A positive monetary shock increases search intensity under incomplete information, and stronger information frictions amplify this search response. As shoppers search more intensively, they are more likely to be drawn by high-productivity, low-price firms, expanding demand for these firms while reducing demand for low-productivity firms. This endogenous reallocation improves allocative efficiency and raises aggregate productivity (Baqaee et al., 2024). To see this formally, consider the aggregate production function:

$$\hat{y}_t = \hat{a}_t + \hat{l}_t + (\hat{v}_t - \hat{p}_t)\,, \tag{53}$$

where $\hat{v}_t = \hat{w}_t \int \bar{\alpha}_k \varphi_{kt}\, dk$, and $\bar{\alpha}_k = \frac{\omega_k \bar{\mu}_k^{-1}}{\int \omega_k \bar{\mu}_k^{-1} dk}$ denotes the labor-demand share in the full-information equilibrium. Here, $\bar{\mu}_k$ denotes the firm's markup. Because markups differ across firms, changes in aggregate productivity are in general nonzero.

To determine the sign of this effect, note that high-productivity firms have higher markups. As a result, the weight $\bar{\alpha}_k$ down-weights the incomplete passthrough coefficient φ_{kt} for high-productivity firms and up-weights it for low-productivity firms. Since φ_{kt} is lower for more productive firms, it follows that $\hat{v}_t/\hat{w}_t > \hat{p}_t/\hat{w}_t$. Thus, a positive monetary shock raises aggregate productivity through endogenous demand reallocation. The increase in productivity dampens the response of the price index and amplifies monetary non-neutrality. Using the same method as for $\hat{p}_t$, aggregate productivity satisfies

$$\hat{\boldsymbol{v}} = \underbrace{\tilde{\Gamma}\left(\boldsymbol{I} - (1-\tilde{\Gamma})\boldsymbol{\Theta}\right)^{-1}}_{\tilde{\boldsymbol{\Psi}}}(\hat{\boldsymbol{w}} - \hat{\boldsymbol{a}}), \tag{54}$$

[13] Christiano et al. (2016) derive wage inertia from their specification of how firms and workers negotiate wages. They argue that this micro-foundation outperforms a variant of the standard New Keynesian Calvo sticky wage model.

where $\tilde{\Gamma} = \int \bar{\alpha}_k \gamma_k \, dk$ and $\tilde{\Gamma} > \Gamma$. Therefore, aggregate output can be written as

$$\hat{\boldsymbol{y}} = \hat{\boldsymbol{a}} + \hat{\boldsymbol{l}} + \left(\tilde{\boldsymbol{\Psi}} - \boldsymbol{\Psi}\right)\left(\hat{\boldsymbol{w}} - \hat{\boldsymbol{a}}\right). \tag{55}$$

Equilibrium. In the limit of small monetary shock and technology shock, the equilibrium dynamics of variables $\{\hat{\pi}_t, \hat{p}_t, \hat{w}^r_t, \hat{w}_t, \hat{v}_t, \hat{c}_t, \hat{i}_t\}$ is governed by equations , (43),(47), (50), (52), (54), (55) and two equations that connect nominal and real variables: $\hat{w}_t = \hat{w}^r_t + \hat{p}_t$ and $\hat{\pi}_t = \hat{p}_t - \hat{p}_{t-1}$.

Comparison of IRFs Across Models. I shut down habit formation and compare the model's implications with those of two other models: a Calvo pricing model and a firm-information model in which the aggregate supply curve is given by

$$\hat{p} = \Gamma \bar{E}^f \widehat{mc} + (1 - \Gamma)\bar{E}^f \hat{p}. \tag{56}$$

Suppose firms and consumers face the same degree of information friction. Then the only distinction between the two information-friction models is that, in the firm-information model, imperfectly informed firms adjust only partially to changes in marginal costs, whereas in my model firms respond fully to marginal costs despite selling to imperfectly informed consumers.

I compare the implications of these models under two cases, with and without nominal wage rigidity. In the Calvo model, I set the Calvo parameter to 0.75. For comparability across models, I set the effective information friction to $\theta^L = 0.25$ in both information-friction models, which also facilitates comparison with the Calvo model. Shock persistence is set to 0.8, and the degree of nominal wage rigidity is also set to 0.8. All other parameters are as in Table 1.

Figure 4 plots the impulse responses to a monetary shock. Without wage rigidity, the firm-frictions models generate similar dynamics, while my model delivers the largest impact response of inflation because the other two models directly damp passthrough from marginal costs to prices: through infrequent repricing in the Calvo model and through imperfect information about cost changes in the firm-information model. The resulting sharp rise in inflation also increases the real interest rate under the Taylor rule, producing a hump-shaped output response. With nominal wage rigidity, inflation becomes more hump-shaped in both information-friction models. In the Calvo model, adjusting firms anticipate future increases in real wages and therefore set higher prices today, leading to front-loading and a more pronounced initial inflation response (Werning, 2023). Importantly, the output response in my model is close to that in the other two models, consistent with the view that nominal wage rigidity is essential for generating empirically plausible impulse responses to monetary shocks (Christiano et al., 2005).

Figure 5 shows the impulse responses to a negative technology shock. Without wage rigidity, the firm-side frictions models generate fairly similar responses, while my model delivers

Figure 4: Impulse Responses of Three Models to A Monetary Shock

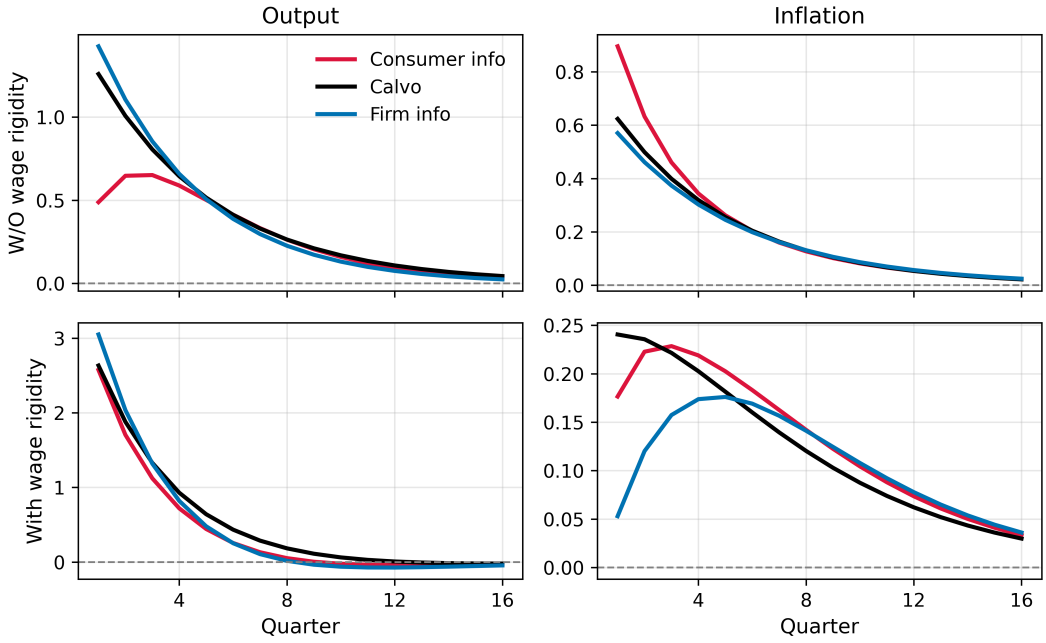
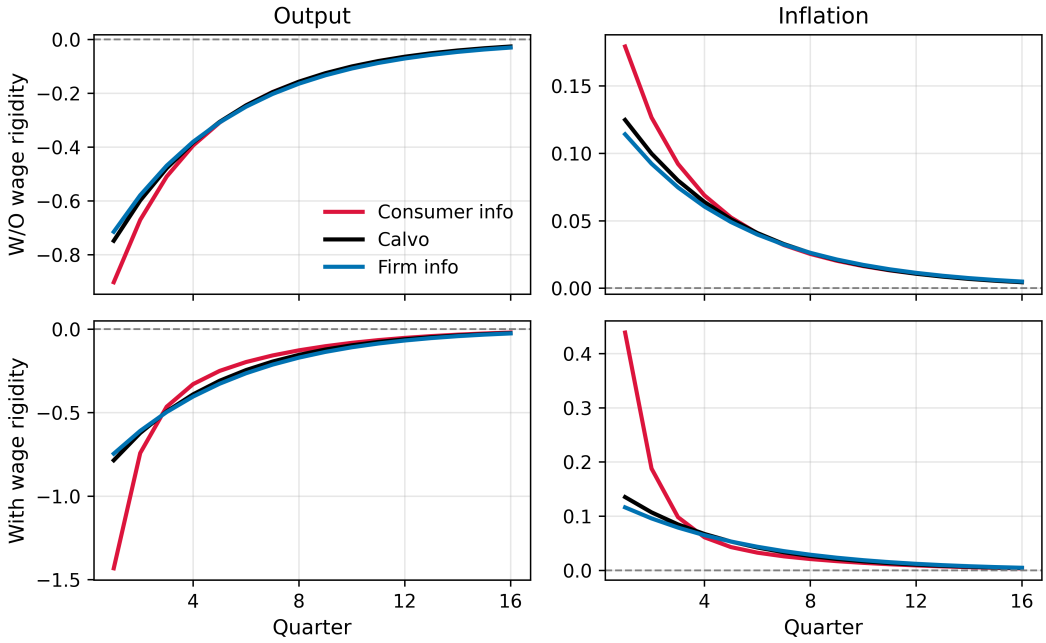


Figure 5: Impulse Responses of Three Models to A technology shock



noticeably larger movements, especially in inflation. With nominal wage rigidity, the responses in the firm-side frictions models change only modestly relative to the no-wage-rigidity case, because nominal wages move little on impact—the decline in real wages is largely offset by higher inflation—and adjust only gradually thereafter, so wage rigidity has limited bite. In my

model, by contrast, flexible nominal wages fall much more on impact, absorbing part of the productivity decline.

Once wages are rigid, that adjustment channel disappears. A fall in productivity then translates into a sharper rise in firms' marginal costs on impact. Since firms in my model pass through at least 40% of the resulting cost increase into prices, inflation rises markedly, monetary policy tightens more, and output contracts more, with hours falling on impact rather than rising as in the other models. The amplification is temporary, however, because the nominal wage wedge—the gap between the real wage and the marginal rate of substitution—shrinks quickly once nominal wages begin to adjust. Inflation therefore returns relatively quickly toward the flexible-wage path.

Overall, the model generates large inflation responses to supply shocks, addressing a common shortcoming of standard sticky-price models, which often struggle to produce sufficiently strong inflation responses to supply shocks under empirically plausible pricing frictions. Moreover, the short-lived inflation spike is consistent with the serially uncorrelated transitory component in inflation highlighted by Stock and Watson (2007).

6 Quantification

I first introduce data and present the empirical findings. Then, I incorporate nominal price rigidities, nominal wage rigidity, and consumer information frictions into the model and let them compete for explaining the monetary non-neutrality. Next, I use impulse response matching to estimate the information frictions and other key parameters. Finally, I dissect mechanisms of how each channel contributes to non-neutrality.

Data and Method. The sample spans 1978m1–2019m12 and includes six monthly variables: industrial production; average hourly earnings of private production employees deflated by core CPI[14]; headline CPI; consumer inflation expectations from the Michigan Survey of Consumers; the excess bond premium; and the one-year government bond rate. Because households rely heavily on food and energy prices when forming inflation expectations (Kumar et al., 2015; D'Acunto et al., 2021a), it is important to include these components in the inflation measure. I therefore use headline CPI to align realized inflation with the prices households observe when forming expectations.

I have argued that the economy returns to long-run neutrality only when consumers eventually learn the true price level. To construct the expected price index, in Appendix

[14]I deflate nominal wages by core CPI because wage contracts respond primarily to core inflation rather than transitory energy and food price shocks. Core CPI therefore better captures expected inflation at the time wages are set, especially in a model with wage stickiness.

B, I show that when consumers learn the price index from a Gaussian signal, the consensus expected price index follows

$$p_{t|t} = p_{t-1|t-1} + \pi_{t|t-1} + \lambda(\pi_{t|t} - \pi_{t|t-1}), \tag{57}$$

where λ is the Kalman gain. The intuition is that the current forecast of the price index equals the predicted price index based on past information, $p_{t-1|t-1} + \pi_{t|t-1}$, plus a revision term that reflects new information about price index which is reflected in the forecast revision, $\pi_{t|t} - \pi_{t|t-1}$. I compute the one-month-ahead inflation forecast $\pi_{t|t-1}$ by dividing the one-year-ahead consumer inflation forecast by 12 from the Michigan Survey. Because the survey does not provide an inflation nowcast, I approximate $\pi_{t|t}$ using $\pi_{t+1|t}/\hat{\rho}$, where $\hat{\rho}$ is the estimated persistence of inflation expectations (about 0.952).

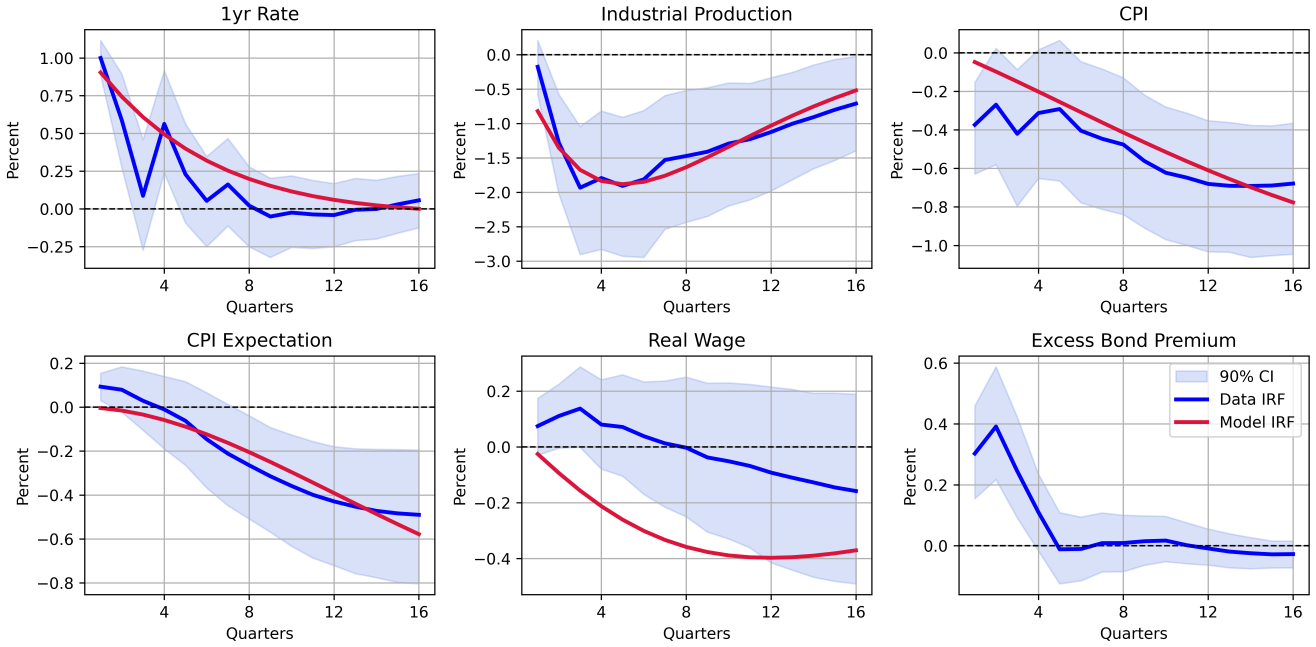
To estimate λ, I use the Survey of Professional Forecasters, which reports forecasts at multiple horizons. In Appendix B, I estimates $\lambda = 1.55$. I further conduct robustness checks to assess the sensitivity of the results to λ. The SVAR results are largely unaffected over a wide range of values because forecast revisions are centered near zero and typically one-magnitude smaller than one-month-ahead inflation forecast.

I begin by estimating the reduced form of a monthly six-variable VAR, using twelve lags for each variable. The six reduced-form residuals are modeled as linear combinations of six underlying structural shocks. The goal is to identify how the structural shocks to monetary policy affect the contemporaneous reduced-form residuals. Once these shocks are identified, the VAR can be used to trace out their dynamic effects on the macroeconomic variables. To identify exogenous variation for the monetary shocks, I employ external instruments for the government bond rate based on high-frequency surprises in futures market prices around FOMC announcements following the approach in Gertler and Karadi (2015) and Bauer and Swanson (2023). I use the monetary policy shock series provided by Bauer and Swanson (2023).

Empirical Findings. Figure 6 presents the main results. The blue lines depict the empirical impulse responses of macroeconomic variables following a 100 basis point increase in the one-year government bond rate. Industrial production exhibits a hump-shaped response, declining by about 200 bps in one year. Headline CPI falls on impact by about 35 bps and continues to decline, reaching a total reduction of 70 bps in 4 years. In contrast, price-index expectation increases a little on impact, then gradually declines, falling by about 50 bps over the same horizon.[15] Real wage is extremely sticky and barely move. These empirical patterns have two key implications. First, inflation expectations systematically undershoot realized inflation,

[15]The initial rise in inflation expectations is noteworthy and somewhat puzzling, though a full explanation lies beyond the scope of this paper.

Figure 6: Empirical and Baseline Model Impulse Responses



Notes: The figure plots the impulse responses for 6 variables following a 100 bp shock on the 1-year government bond rate. The sample period is 1978M1–2019M12. The blue lines represent the empirical impulse responses and the red lines represent the model counterparts. The shaded areas are 90% confidence intervals derived from wild bootstrap. The red line represents the model impulse responses. The x-axis denotes quarters from the shock, starting at 0. The y-axis denotes percent.

supporting the core assumption of the model—namely, that consumers possess incomplete information about monetary shocks. Second, consumer learning appears remarkably slow: even after three years, consumers have internalized only about 65% of the total decline in CPI. If we just focus on the relative responses of CPI and CPI expectation, a simple back-of-the-envelope calculation shows: $1-(1-\theta)^{16}=5/7$, which yields $\theta=0.075$, implying an average duration about 13 quarters. I will show in what follows that this provides a useful reference point for the structural estimate of θ obtained through impulse response matching.

Impulse Response Matching. Following Christiano et al. (2005), I use impulse response matching to estimate 4 parameters: nominal wage rigidity λ_w, shoppers' average information frictions θ, worker's habit λ_c, and persistence of monetary shock ρ_m. Collecting them in the vector $\mathbf{\Lambda}=\{\lambda_w,\lambda_c,\theta,\rho_m\}$. Let $\mathbf{J},\widehat{\mathbf{J}}$ denote model and empirical impulse responses. The estimator $\hat{\Lambda}$ solves,

$$\min_{\mathbf{\Lambda}}\left(\mathbf{J}(\mathbf{\Lambda})-\widehat{\mathbf{J}}\right)'\mathbf{\Sigma}^{-1}\left(\mathbf{J}(\mathbf{\Lambda})-\widehat{\mathbf{J}}\right)$$

Table 1: Calibrated and Estimated Parameters.

Panel A: Calibrated parameters			Panel B: Estimated parameters			
Param.	**Description**	**Value**	**Param.**	**Description**	**Value**	**S.E.**
σ	EIS	1	θ	Information frictions	0.084	(0.012)
η	Frisch elasticity of labor	0.5	λ_c	Habit formation	0.832	(0.007)
β	Discount factor	0.99	λ_w	Calvo wage stickiness	0.949	(0.005)
ϕ	Taylor rule coefficient	2	ρ_m	Persistence of monetary shock	0.845	(0.004)
ε_w	Elasticity across labor types	3				
ζ_w	Superelasticity across labor types	10				
λ_p	Calvo price stickiness	0.75				
Γ	Aggregate own-shock passthrough	0.4				
$\tilde{\Gamma}$	Demand reallocation	0.52				

$\mathbf{\Sigma}$ is a diagonal matrix that has confidence interval of empirical impulse responses in its entries. I also compute an estimator $\hat{\mathbf{V}}$ for the asymptotic covariance matrix of $\hat{\mathbf{\Lambda}}$ as

$$\hat{\mathbf{V}} = \left(\left(\frac{\partial \mathbf{J}}{\partial \mathbf{\Lambda}}(\hat{\mathbf{\Lambda}}) \right)' \mathbf{\Sigma}^{-1} \frac{\partial \mathbf{J}}{\partial \mathbf{\Lambda}}(\hat{\mathbf{\Lambda}}) \right)^{-1}$$

where the derivative is the Jacobian of $\mathbf{J}(\mathbf{\Lambda})$ at $\hat{\mathbf{\Lambda}}$.

Estimation Strategy. Shock persistence and habit formation are identified primarily from the output response. I incorporate Calvo price adjustment into the pricing rule as in equation (49) and fix the Calvo parameter at $\lambda_p = 0.75$, consistent with micro price evidence (Nakamura and Steinsson, 2008). By contrast, there is little micro evidence on wage stickiness and consumer information frictions, so I estimate these parameters by targeting the impulse responses of the real wage and consumer CPI expectations. This strategy generates over-identification restrictions: if the model matches the responses of the real wage and consumer CPI expectations, then the CPI response is implied rather than directly targeted; conversely, if it matches the responses of CPI and CPI expectations, then the real wage response is implied. This provides a useful test of the model's ability to reconcile the key features of the data.

Results. Table 1 summarizes the calibrated parameters. As discussed in Section 4.3, I calibrate the aggregate own-shock passthrough to 40%. Using the estimated search frictions, I then infer the inverse-markup-weighted passthrough in equation (54), which captures the demand-reallocation effect and equals about 52%. This suggests that demand reallocation is quantitatively sizable, consistent with Gaballo and Paciello (2021) and Baqaee et al. (2024). I also follow Smets and Wouters (2007) by setting the wage markup to 1.5, implying an elasticity of substitution across labor types of 3, and the Kimball superelasticity to $\zeta_w = 10$.

Figure 6 plots the model-implied impulse responses at the estimated parameters in red. The model matches the empirical responses closely. The estimated consumer information-friction parameter, $\theta = 0.084$, implies an average duration of incomplete information of 12 quarters. This estimate is consistent with the earlier back-of-the-envelope calculation and suggests that θ is identified mainly from the relative responses of CPI and CPI inflation expectations. It is also close to the estimate in Auclert et al. (2020), who find an average duration of about 15 quarters in a HANK model. While their identification relies on matching the hump-shaped output response to Romer and Romer (2004) shocks, mine relies directly on the response of inflation expectations.

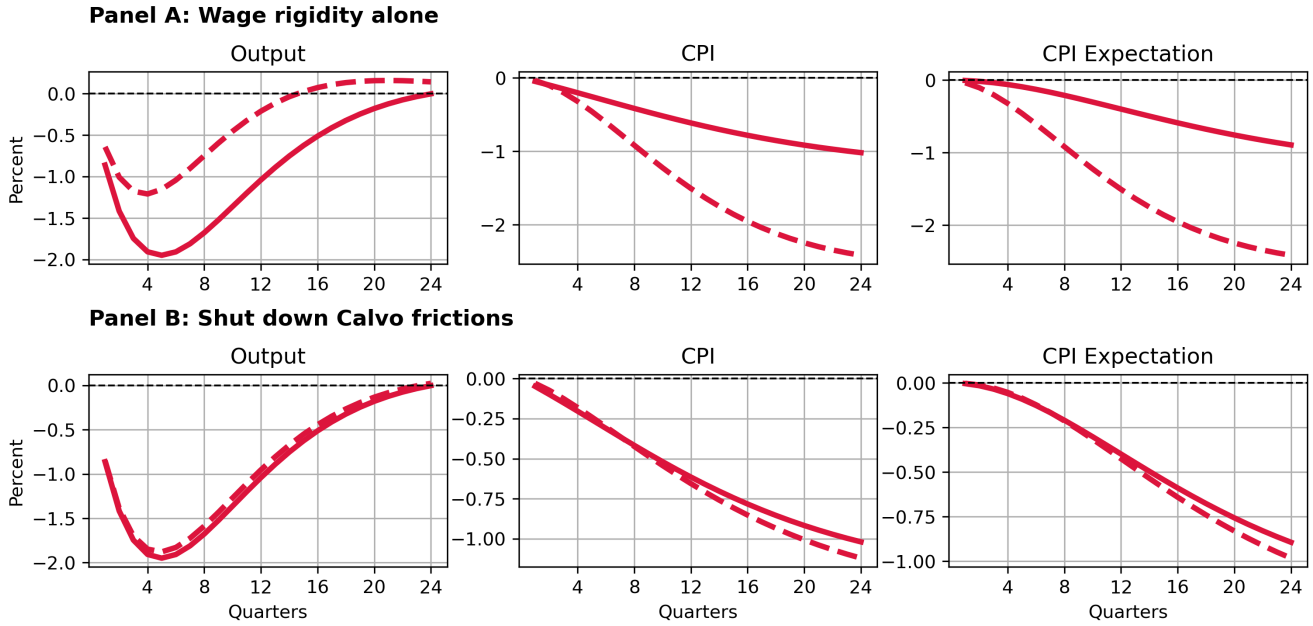
The estimated degree of wage rigidity reported in Table 1 is $\lambda_w = 0.949$, which is close to the value of about 0.9 used by Auclert et al. (2020) in a related model with household information frictions and asset heterogeneity. Even so, the model still slightly over-predicts the real wage response relative to the empirical counterpart. This reflects the fact that the estimation places more weight on matching the responses of CPI and CPI expectations, leaving the real wage response largely implied rather than directly targeted.

This trade-off is informative. Increasing λ_w would improve the fit for real wages, but only at the cost of dampening the responses of CPI and CPI expectations and thereby worsening the overall fit. The source of the trade-off is that labor is the model's only production input, so wage rigidity directly governs both real wage dynamics and firms' marginal costs. In richer environments with multiple inputs, especially inputs with more flexible prices such as commodities, this tension may be weaker. Consistent with this interpretation, Appendix B reports an alternative estimation that places five times more weight on the real wage response. In that case, the estimated wage rigidity rises to $\lambda_w = 0.965$, and the model-implied real wage response becomes much more muted and closer to the data. However, the CPI response also becomes dampened relative to the data. Because CPI expectations remain closely matched, the estimated information-friction parameter falls to $\theta = 0.866$, implying an average duration of incomplete information of 7.5 quarters, about 40% lower than in the baseline estimation.

In sum, the relative responses of CPI and CPI expectation discipline the degree of information frictions; wage rigidity is largely implied; the persistence of the monetary shock determines both the duration and magnitude of responses; and habit formation is crucial for generating the hump-shaped output response;

Comparison with No-Information-Friction DSGE Model. Following Christiano et al. (2005), Appendix B estimates a DSGE model in which information frictions are shut down ($\theta = 1$) and the Calvo price-adjustment parameter λ_p is allowed to vary to match the empirical impulse responses, while all other parameters are fixed at the values in Table 1. In this specification, identification is exact: wage stickiness is disciplined by the real wage response, and price stickiness by the CPI response. The resulting estimates are $\lambda_w = 0.97$ and $\lambda_p = 0.83$.

Figure 7: Decomposing the Transmission Channels of Monetary Policy



Notes: For both panels, the solid line plots the baseline impulse responses at the estimated parameters in Table 1 as the benchmark. In Panel A, dashed lines represent the case with $\lambda_p = 0$, holding all other parameters at their estimated values. Panel B shows the case when $\lambda_p = 0$ and $\theta = 1$.

Figure B.3 shows that this model provides a reasonable fit for standard macroeconomic variables, but fails to match the dynamics of inflation expectations. This is unsurprising, since under full information expectations move one-for-one with realized inflation, so this model cannot generate the observed wedge between actual and expected inflation. By contrast, in my calibration I set price stickiness to be consistent with micro price evidence, and the model is able to match both series jointly, highlighting the empirical relevance of the proposed mechanism.

Monetary Policy Transmission Channels I now examine the transmission channels of monetary policy. In particular, monetary non-neutrality arises from three forces: consumer information frictions, Calvo price stickiness, and nominal wage rigidity. The counterfactual experiments reported in Figure 7 isolate the contribution of each mechanism.

Panel A further shuts down both information frictions and Calvo pricing. The solid line plots the impulse responses from the baseline model, while the dashed line shows the responses in this counterfactual economy. As expected, the CPI now declines by more than twice as much as in the baseline model, and the response of CPI expectation is no longer dampened. Monetary non-neutrality is substantially reduced: the cumulative output response falls by roughly 62%, and the peak output response declines about 100 bps.[16] Information frictions account for a large share of monetary non-neutrality for two reasons. First, they dampen firms' price responses to

[16]The cumulative output response is computed as the discounted sum of output responses over 500 periods, weighted by β^t for $t = 0, 1, 2, \ldots$.

changes in other firms' prices. Second, because monetary shocks are much less persistent than information frictions, perceived CPI lags behind actual CPI even after the shock has dissipated, generating persistent output effects. This counterfactual also implies that nominal wage rigidity alone accounts for approximately 38% of monetary non-neutrality. Wage rigidity is therefore crucial in dampening marginal-cost movements and generating realistic inflation dynamics in the model, as discussed in Section 5.

Panel B shuts down Calvo price rigidity while holding all other parameters at their estimated values. Prices rise only marginally, and the output response is largely unchanged, with the cumulative output response declining by about 7%. Conditional on information frictions and wage rigidity, Calvo pricing therefore accounts for only a small share of overall monetary non-neutrality. The intuition is as follows. When wages are highly sticky, marginal costs respond little, implying that the price gap between adjusting and non-adjusting firms remains small, as emphasized by Christiano et al. (2005). With strategic complementarities, price rigidity can further dampen the price adjustments of re-optimizing firms, as firms fear consumer substitution toward firms that have not adjusted. However, sizable information frictions already weaken these complementarities, rendering this mechanism largely ineffective. As a result, price rigidity plays only a minor role once both wage rigidity and information frictions are present.

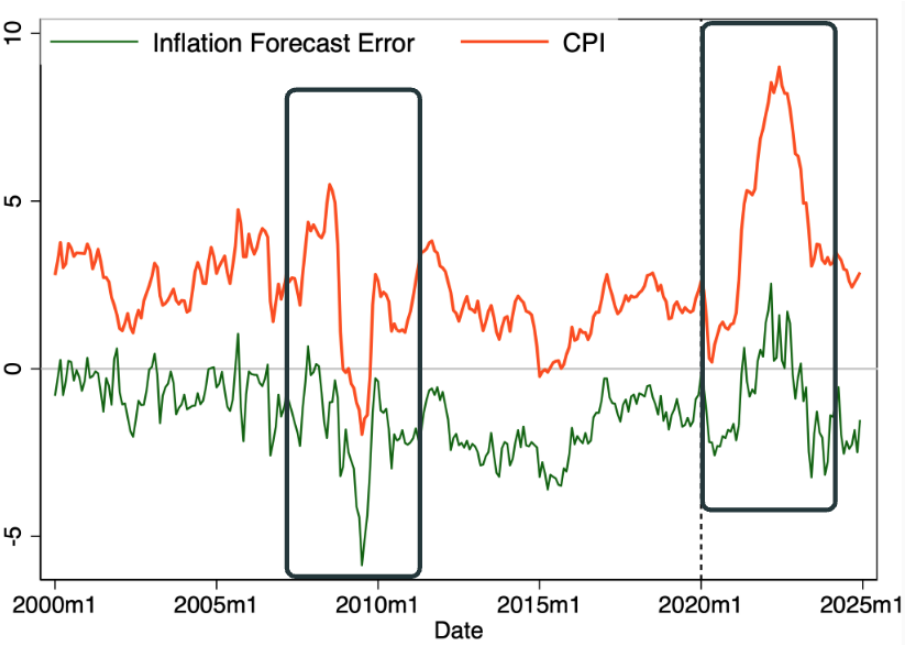
Taken together, the counterfactual analysis implies that information frictions account for about 55% of monetary non-neutrality, nominal wage rigidity for about 38%, and Calvo price rigidity for the remaining 7%. To further isolate the role of demand reallocation, I consider a counterfactual that shuts it down by setting $\tilde{\Gamma} = \Gamma = 0.4$. The cumulative output response then falls by 7%, an effect comparable in size to that of Calvo pricing frictions and equal to about 13% of the total contribution of information frictions. This suggests that the effect of demand reallocation is quantitatively sizable for impulse responses.

As a robustness check, Appendix B repeats the same decomposition using the alternative estimation that places greater weight on the real wage response. In that case, information frictions account for 31% of monetary non-neutrality, nominal wage rigidity for 55%, and Calvo price rigidity for the remaining 14%. Overall, these exercises suggest that information frictions account for roughly 30–55% of monetary non-neutrality, depending on the estimation strategy.

7 Resolving Two Inflation Puzzles

I now use the model to address two well-known puzzles. The first is the "missing disinflation" during the Great Recession: standard New Keynesian models predict substantial disinflation at the zero lower bound, yet inflation barely turned negative. Coibion and Gorodnichenko (2015) argue that elevated household inflation expectations helped sustain inflation during

Figure 8: Inflation and Inflation Forecast error



Notes: The figure plots headline CPI inflation and inflation forecast error. The inflation forecast error is defined as the difference between realized inflation and the lagged one-month-ahead forecast: $\pi_t - \bar{E}_{t-1}\pi_t$.

this episode. The second is the post-COVID inflation surge: inflation, likely triggered by supply disruptions, rose quickly and remained persistently high, despite the flat Phillips curve estimated from pre-COVID data (Hazell et al., 2022). Existing explanations emphasize nonlinear Phillips-curve effects (Benigno and Eggertsson, 2023), cost shocks (Blanchard and Bernanke, 2023), and unfunded fiscal expansions (Bianchi et al., 2023).

My framework offers a unified explanation. During the Great Recession, household attention to inflation was low. When marginal consumers did not perceive that other firms had also lowered prices, firms could keep prices relatively high and continue extracting surplus from infra-marginal consumers without inducing additional search. This mechanism is related to Gilchrist et al. (2017), but here limited passthrough arises from consumer information frictions rather than reduction in firm discount rates in recession. During the pandemic, by contrast, household attention to inflation rose sharply, increasing passthrough of positive cost shocks and amplifying inflation.

Figure 8 supports this interpretation. Over most of the sample, inflation forecast errors comove closely with headline CPI, especially during the Great Recession, when expectations moved little and declines in inflation translated almost one-for-one into forecast errors. The pandemic period looks very different. Headline inflation rose above 8%, but the forecast error increased by only about 1.5%, implying much greater passthrough from realized inflation into

expectations. This pattern is consistent with evidence that household attention rises sharply once inflation exceeds roughly 3–4% (Korenok et al., 2023; Pfäuti, 2024), and with findings that households become more attentive and informed in high-inflation environments (Cavallo et al., 2017; Weber et al., 2025). During the pandemic, this heightened attention was plausibly reinforced by exceptional media coverage and public discussion of supply disruptions and inflation.

My theory provides a joint explanation for both puzzles. During the Great Recession, when consumers paid little attention to inflation, firms passed through negative marginal cost shocks less aggressively: with inattentive marginal consumers who did not believe other firms had lowered prices, higher prices could extract more surplus from infra-marginal consumers without triggering search. Gilchrist et al. (2017) present a mechanism related to consumer base based on higher firm discount rates during periods of elevated exit risk; here, limited passthrough arises instead from information frictions. By contrast, during the pandemic inflation surge, greater attention increased the passthrough of positive marginal cost shocks, amplifying inflation. Beaudry et al. (2024) find that household inflation expectations were a dominant driver of the surge; my framework explains why those expectations matter for realized inflation.

The broader policy implication is that the slope of the Phillips curve is endogenous to the consumer information environment. Shocks that make inflation salient—through media coverage, public debate, or policy communication—raise household attention and steepen the Phillips curve, making prices more responsive and calling for a more aggressive monetary response. When inflation is less salient, the Phillips curve is flatter, and monetary policy should place greater weight on real activities within the dual mandate.

8 Conclusion

This paper develops a new framework for understanding monetary non-neutrality, driven entirely by consumer-side frictions. At the heart of the model is the information asymmetry about nominal marginal costs between consumers and firms. Specifically, the framework integrates a heterogeneous firm block and incomplete consumer information into a standard sequential search model. I further embed this aggregate supply curve derived from the log-linearized model into a full-fledged DSGE model and discuss the properties of the impulse responses. Finally, I estimate a quantitative model that incorporates both Calvo price and wage rigidity. To match the extremely gradual adjustment in household inflation expectations observed in the data, the estimated model features significant information frictions. It accounts for about 30-55% of the total monetary non-neutrality, depending on estimation strategy.

Several directions remain for future research. First, although the paper focuses on final-goods markets, the framework could be extended to other markets with many buyers and sellers, such as upstream and downstream firms in production networks. Second, applying the model to the labor market may be fruitful, since workers' incomplete information about posted wages could shape job-search behavior. Finally, an analysis of optimal monetary policy in this environment would help clarify the model's policy implications.

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Online Appendix to *Consumer Information Frictions and Monetary Non-Neutrality: A Sequential Search Approach*

Xiaojie Liu

[Not for publication]

A Proofs 49

B Additional Details on Calibration and Estimation 63

A Proofs

Proof of Proposition 1 and 2:

Proof. Assume that $E_\psi(y \mid x) > \kappa$, so consumers strictly prefer to participate in the market. Without recall, if the consumer rejects the current offer v, that offer is lost permanently. Under no learning, the belief state remains x, so the continuation problem after rejection is independent of the current realized offer v. Define the continuation value

$$C(x) := -\kappa + \int_{-\infty}^{\infty} \tilde{U}(y \mid x)\psi(y \mid x)\, dy. \tag{A.1}$$

where $\psi(y)$ is the density of value of a good. Then the Bellman equation is

$$\tilde{U}(v \mid x) = \max\{v, U(x)\}. \tag{A.2}$$

Since $U(x)$ does not depend on v, the continuation value is constant across all current offers. Hence there exists a cutoff $v^*(x)$ such that

$$v^*(x) = U(x), \tag{A.3}$$

and therefore

$$\tilde{U}(v \mid x) = \max\{v, v^*(x)\}. \tag{A.4}$$

It follows immediately that the consumer accepts the current offer if and only if $v \geq v^*(x)$. Thus the optimal search strategy follows a threshold rule.

At the cutoff $v^*(x)$, value matching implies

$$v^*(x) = -\kappa + \int_{-\infty}^{\infty} \max\{y, v^*(x)\}\psi(y \mid x)\, dy. \tag{A.5}$$

Splitting the integral at $v^*(x)$ gives

$$v^*(x) = -\kappa + v^*(x)\Psi(v^*(x) \mid x) + \int_{v^*(x)}^{\infty} y\, \psi(y \mid x)\, dy. \tag{A.6}$$

Rearranging,

$$\kappa = \int_{v^*(x)}^{\infty} (y - v^*(x))\psi(y \mid x)\, dy. \tag{A.7}$$

Substituting the definition of $\psi(y \mid x)$ induced by the perceived price density $q(p \mid x)$ and the match distribution $g(\epsilon)$, and changing variables to $\epsilon = \lambda(y + p)$, yields

$$\int\int_{\lambda(v^*(x)+p)}^{\infty} \left(\frac{1}{\lambda}\epsilon - p - v^*(x)\right) g(\epsilon)\, d\epsilon\, q(p \mid x)\, dp = \kappa. \tag{A.8}$$

This proves the result. □

Proof of Theorem 1: I first prove a lemma that is useful for proving Theorem 1.

Lemma A.1. *Fix w. Let $p^*(a; v)$ denote the full-information optimal (log) price of a firm with productivity a when the reservation value is v, and let*

$$\psi(s) \;\equiv\; \int_{\lambda s}^{\infty} \left(\tfrac{1}{\lambda}\epsilon - s\right) g(\epsilon)\, d\epsilon, \qquad \mathcal{S}(v; w) \;\equiv\; \int \psi\big(v + p^*(a; v)\big)\, \phi_a(a)\, da.$$

If G is log-concave, then $\mathcal{S}(v; w)$ is strictly decreasing in v. Hence the full-information reservation value $v^*(w)$ solving $\mathcal{S}(v^*(w); w) = \kappa$ is strictly decreasing in κ.

Proof. Under full information, $P_k = \mu_k W / A_k$ with $\mu_k = e_k/(e_k - 1)$ and $e_k = 1 + \lambda h(z_k)$, where $h(z) \equiv g(z)/(1 - G(z))$ and $z_k = \lambda(v + p_k)$. Holding (w, a_k) fixed implies W/A_k does not depend on v, hence $p_k'(v) = \frac{d}{dv} \log \mu_k(v)$. Moreover $\partial e_k / \partial p_k = \lambda^2 h'(z_k)$, and log-concavity of G implies h is increasing (IHR), so $h'(z_k) \geq 0$ and

$$\Lambda_k \;\equiv\; -\frac{d \log \mu_k}{dp_k} = \frac{1}{e_k(e_k - 1)} \frac{\partial e_k}{\partial p_k} \;>\; 0.$$

Using $\frac{d}{de} \log\left(\frac{e}{e-1}\right) = -\frac{1}{e(e-1)}$ and $\frac{\partial e_k}{\partial v} = \lambda^2 h'(z_k)\,(1 + p_k'(v))$ yields

$$p_k'(v) = \frac{d \log \mu_k}{dv} = -\frac{1}{e_k(e_k - 1)} \frac{\partial e_k}{\partial v} = -\Lambda_k\,(1 + p_k'(v)),$$

so $p_k'(v) = -\Lambda_k/(1 + \Lambda_k) \in (-1, 0)$ and thus $1 + p_k'(v) \in (0, 1)$ for all a. Since $\psi'(s) < 0$ for all s and $\phi_a(a) \geq 0$,

$$\frac{\partial \mathcal{S}(v; w)}{\partial v} = \int \psi'\big(v + p^*(a; v)\big)\, \big(1 + \partial_v p^*(a; v)\big)\, \phi_a(a)\, da \;<\; 0,$$

hence $\mathcal{S}(\cdot; w)$ is strictly decreasing. Therefore the solution to $\mathcal{S}(v; w) = \kappa$ is unique and strictly decreasing in κ. □

Now, I prove the theorem. I first prove the existence and uniqueness of the full-information equilibrium. For finite $\mathbb{E}\varepsilon$ is finite and any $\infty > \kappa > 0$ there exists a unique full-information reservation value $v^*(w) \in \mathbb{R}$ solving (16). Given $v^*(w)$, firms' pricing rule (16) pins down a unique price function $p^*(a; v^*(w))$ and hence a unique price distribution $f(p \mid w)$.

Proof. Define $\mathcal{S}(v; w) = \int \psi(v + p^*(a; v))\, \phi_a(a)\, da$ as in Lemma A.1, so that (16) is $\mathcal{S}(v; w) = \kappa$. By Lemma A.1, $\mathcal{S}(\cdot; w)$ is continuous and strictly decreasing on $\mathbb{R}$.

For boundary behavior, $\psi(s) \geq 0$ and $\psi(s) \to 0$ as $s \to +\infty$, so $\lim_{v \to +\infty} \mathcal{S}(v; w) = 0$. As $s \to -\infty$, the truncation vanishes and

$$\psi(s) = \int_{-\infty}^{\infty} \left(\tfrac{1}{\lambda}\epsilon - s\right) g(\epsilon)\, d\epsilon = \frac{1}{\lambda}\mathbb{E}[\epsilon] - s \;\to\; +\infty,$$

hence $\lim_{v \to -\infty} \mathcal{S}(v; w) = +\infty$. Therefore $\mathcal{S}(\cdot; w)$ spans $(0, +\infty)$ and is strictly decreasing, so for any $\kappa > 0$ there exists a unique $v^*(w)$ solving (16).

Since the LHS of firms' optimal pricing rule is increasing in price and RHS is decreasing, given $v^*(w)$, it uniquely determines $p^*(a; v^*(w))$ and thus the induced $f(p \mid w)$. □

Now I prove the monetary neutrality under full-information equilibrium.

Proof. Suppose the nominal wage changes from w to w'. We guess that all the optimal prices increase proportionally, i.e., $p'_k = p_k + \hat{w}$. Then the price distribution $f(p|w)$ shifts to the right and becomes $f(p - \hat{w}|w')$. The threshold is determined by,

$$\int \int_{\lambda(v^*(w')+p)}^{\infty} \left(\frac{1}{\lambda}\epsilon - p - v^*(w')\right) g(\epsilon) d\epsilon f(p - \hat{w}|w') dp = \kappa \tag{A.9}$$

This implies that $v^*(w') = v^*(w) - \hat{w}$. The elasticity of demand is given by,

$$\begin{aligned} e'_k &= \lambda \frac{g\big(\lambda(v^*(w') + p'_k)\big)}{1 - G\big(\lambda(v^*(w') + p'_k)\big)} + 1 \\ &= \lambda \frac{g\big(\lambda(v^*(w) - \hat{w} + p_k + \hat{w})\big)}{1 - G\big(\lambda(v^*(w) - \hat{w} + p_k + \hat{w})\big)} + 1 = e_k \end{aligned}$$

Since the demand elasticity does not change, the optimal price does increase by $\hat{w}$. Therefore, we verify the guess that the optimal prices increase proportionally with the nominal wage. Based on the uniqueness of the equilibrium, the above constructed equilibrium is the only equilibrium when the nominal wage is w'. □

Remarks on Computation of the Full-information Equilibrium:

Remark 1 (Remark on Computing Steady-State Equilibrium)**.** *The proof of Theorem 1 provides insights on the computational method for the full-information equilibrium.*

1. *First guess a $v^*(w)$*
2. *Calculate the optimal price distribution given $v^*(w)$*
3. *Plug guessed $v^*(w)$ and derived price distribution and plug it into (16) and check if LHS is equal to the given search cost κ.*

4. *Increases guessed $v^*(w)$ if LHS is larger than search cost. Vice versa.*

5. *Loop the procedure 1-4 until the difference between the LHS and the RHS of (16) is smaller than the given tolerance*

Proof of Theorem 2: I first prove the existence and uniqueness of the equilibrium.

Proof. Let

$$F_I(v_I, v_U) \equiv \mathcal{S}_I(v_I; v_U) - \kappa, \quad F_U(v_I, v_U) \equiv \mathcal{S}_U(v_U; v_I) - \kappa, \tag{A.10}$$

so equilibrium thresholds solve

$$F_I(v_I, v_U) = 0, \quad F_U(v_I, v_U) = 0. \tag{A.11}$$

By the implicit function theorem,

$$R_I'(v_U) = -\frac{F_{I,v_U}}{F_{I,v_I}}, \qquad R_U'(v_I) = -\frac{F_{U,v_I}}{F_{U,v_U}}. \tag{A.12}$$

Fix (v_I, v_U). Let $e(p; v_I, v_U)$ denote the firm's demand elasticity and define

$$\chi(p; v_I, v_U) \equiv \frac{1}{e(e-1)} > 0. \tag{A.13}$$

Since e depends on (p, v_I, v_U) only through $\lambda(v_I + p)$ and $\lambda(v_U + p)$,

$$e_p = e_{v_I} + e_{v_U}. \tag{A.14}$$

Because $e_{v_I}, e_{v_U} > 0$, let $\alpha \equiv \frac{e_{v_I}}{e_p} \in (0,1)$. Differentiating the pricing equation with respect to $v_j \in \{v_I, v_U\}$ yields

$$p_{v_j} = -\frac{\chi\, e_{v_j}}{1 + \chi e_p}, \quad p_{v_I} = -\frac{\alpha \chi e_p}{1 + \chi e_p} \in (-1, 0), \quad p_{v_U} = -\frac{(1-\alpha)\chi e_p}{1 + \chi e_p} \in (-1, 0), \tag{A.15}$$

Now

$$F_{I,v_I} = \int \psi'(v_I + p^*(a)) \left(1 + p^*_{v_I}(a)\right) \phi_a(a)\, da, \quad F_{I,v_U} = \int \psi'(v_I + p^*(a))\, p^*_{v_U}(a) \phi_a(a)\, da. \tag{A.16}$$

Since $\psi' < 0$,

$$|R_I'(v_U)| = \frac{\int |\psi'|\, |p^*_{v_U}(a)|\, \phi_a(a)\, da}{\int |\psi'| \left(1 + p^*_{v_I}(a)\right) \phi_a(a)\, da}. \tag{A.17}$$

Moreover,

$$|p_{v_U}| = \frac{(1-\alpha)\chi e_p}{1 + \chi e_p} < \frac{1 + (1-\alpha)\chi e_p}{1 + \chi e_p} = 1 + p_{v_I}, \tag{A.18}$$

so $|R_I'(v_U)| < 1$. By symmetry, $|R_U'(v_I)| < 1$. Therefore

$$\left|(R_I \circ R_U)'(v_I)\right| = |R_I'(v_U)R_U'(v_I)| < 1 \tag{A.19}$$

uniformly, so $R_I \circ R_U$ is a contraction and has a unique fixed point v_I^*. Then $v_U^* = R_U(v_I^*)$ is uniquely determined. Since the firm pricing problem is uniquely solved given (v_I^*, v_U^*), the equilibrium is unique. □

Now I prove the monetary non-neutrality under sticky-information no-learning equilibrium.

Proof. In the two-type no-learning equilibrium, let $t \in \{I, U\}$ denote informed and partially informed consumers, with reservation values v_t, visit probabilities ρ_t, and visit weights

$$\omega_{k,t} \equiv \frac{(1 - G(z_{k,t}))\rho_t^{-1}\lambda_t}{\sum_{s\in\{I,U\}}(1 - G(z_{k,s}))\rho_s^{-1}\lambda_s}, \tag{A.20}$$

where $\lambda_I = \theta$, $\lambda_U = 1 - \theta$, and

$$z_{k,t} \equiv \lambda(v_t + p_k). \tag{A.21}$$

Then firm k's demand elasticity is

$$e_k = \sum_{t\in\{I,U\}} \omega_{k,t}\, e_{k,t}, \qquad e_{k,t} \equiv 1 + \lambda\frac{g(z_{k,t})}{1 - G(z_{k,t})}. \tag{A.22}$$

We first consider the benchmark in which a nominal-wage shock $\hat{w}$ is publicly understood by both types, so that both types correctly internalize the shift in the nominal price distribution. Assume complete passthrough, i.e.

$$f_1(p \mid w) = f_0(p - \hat{w} \mid w), \qquad p_{k,1} = p_{k,0} + \hat{w}. \tag{A.23}$$

For each type t, the threshold condition is

$$\int \psi(v_t + p)\, f_t(p)\, dp = \kappa. \tag{A.24}$$

The same change-of-variables argument as in the full-information case implies

$$v_{t,1} = v_{t,0} - \hat{w}, \qquad t \in \{I, U\}. \tag{A.25}$$

Hence

$$z_{k,t,1} = \lambda(v_{t,1} + p_{k,1}) = \lambda(v_{t,0} + p_{k,0}) = z_{k,t,0}, \tag{A.26}$$

so $e_{k,t,1} = e_{k,t,0}$ for both types, and therefore $e_{k,1} = e_{k,0}$. Thus, if all consumers fully internalize the aggregate nominal shock, complete passthrough is consistent with unchanged elasticity.

Now turn to the two-type no-learning equilibrium. After a positive nominal-wage shock $w' = \bar{w} + \hat{w}$, informed consumers correctly perceive the shift, while partially informed consumers perceive only $w + \gamma\hat{w}$ with $\gamma \in (0, 1)$. Under the maintained hypothesis of complete

passthrough,

$$p_{k,1} = p_{k,0} + \hat{w}. \tag{A.27}$$

For informed consumers, the same argument as above gives

$$v_{I,1} = v_{I,0} - \hat{w}, \qquad z_{k,I,1} = z_{k,I,0}, \qquad e_{k,I,1} = e_{k,I,0}. \tag{A.28}$$

For partially informed consumers, the perceived price distribution shifts only by $\gamma\hat{w}$, so the threshold condition implies

$$v_{U,1} = v_{U,0} - \gamma\hat{w}. \tag{A.29}$$

Therefore

$$\begin{aligned} z_{k,U,1} &= \lambda(v_{U,1} + p_{k,1}) = \lambda(v_{U,0} - \gamma\hat{w} + p_{k,0} + \hat{w}) \\ &= z_{k,U,0} + \lambda(1-\gamma)\hat{w} > z_{k,U,0}. \end{aligned} \tag{A.30}$$

Since G is log-concave, its hazard rate $g/(1-G)$ is increasing, so

$$e_{k,U,1} > e_{k,U,0}. \tag{A.31}$$

Thus, under complete passthrough, the partially informed type becomes strictly more price sensitive, while the informed type's elasticity is unchanged.

Finally, from (A.22), the aggregate elasticity e_k is a convex combination of the two type-specific elasticities. Its lower bound is therefore the smaller of the two type elasticities. Since

$$e_{k,I,1} = e_k^{FI} \qquad \text{and} \qquad e_{k,U,1} > e_k^{FI}, \tag{A.32}$$

it follows that

$$e_{k,1} > e_k^{FI} \tag{A.33}$$

for every firm k, regardless of the expenditure weights. Hence complete passthrough cannot be an equilibrium. The only way to restore firms' optimality is for prices to respond less than one-to-one to the nominal-wage shock. Therefore, equilibrium passthrough is incomplete. □

Proof of Proposition 3:

Proof. By definition,

$$\tilde{U}(y,x) = \max\{y, U(x)\}, \qquad y = \frac{\epsilon}{\lambda} - p. \tag{A.34}$$

The Bellman equation is

$$U(x) = -\kappa + \int\!\!\int \tilde{U}\Big(\frac{\epsilon}{\lambda} - p, \Gamma(x,p)\Big)\, g(\epsilon)\, q(p \mid x)\, d\epsilon\, dp. \tag{A.35}$$

Under weak learning, one observed price is only weakly informative, so

$$\Gamma(x, p) = x + O(\varepsilon). \tag{A.36}$$

Hence

$$U(x) = -\kappa + \iint \tilde{U}\Big(\frac{\epsilon}{\lambda} - p, x\Big)\, g(\epsilon)\, q(p \mid x)\, d\epsilon\, dp + O(\varepsilon). \tag{A.37}$$

Substituting $\tilde{U}(y, x) = \max\{y, U(x)\}$ gives

$$U(x) = -\kappa + \iint \max\Big\{\frac{\epsilon}{\lambda} - p,\, U(x)\Big\}\, g(\epsilon)\, q(p \mid x)\, d\epsilon\, dp + O(\varepsilon). \tag{A.38}$$

Thus, conditional on x, the problem is the fixed-belief no-recall problem up to an $O(\varepsilon)$ perturbation. Therefore

$$U(x) = v^*(x) + O(\varepsilon), \tag{A.39}$$

□

Proof of Proposition 4:

Proof. Let

$$M_r \equiv \int m_r(dx), \qquad \bar{\mu}_r \equiv \frac{\int \mu_x\, m_r(dx)}{M_r}, \tag{A.40}$$

so that

$$\bar{\mu}^L = \frac{\sum_{r\geq 1} M_r \bar{\mu}_r}{\sum_{r\geq 1} M_r}. \tag{A.41}$$

We proceed in five steps.

Step 1: Round-r posterior mean under Gaussian updating. After the initial private signal and r price signals, Gaussian updating implies that the posterior mean loads on the true nominal wage with coefficient

$$\theta_r = \frac{\theta\tau_x + r\tau_a}{\tau_x + r\tau_a}. \tag{A.42}$$

Hence, absent endogenous selection,

$$\mathbb{E}[\mu_x \mid r \text{ signals}] = \theta_r \hat{w}. \tag{A.43}$$

Step 2: Endogenous selection affects the round-r mean only at second order. Let the survival probability at x until round r be $s_r(x)$. The round-r selected mean can be written as

$$\bar{\mu}_r = \frac{\mathbb{E}[\mu_x s_r(x)]}{\mathbb{E}[s_r(x)]}. \tag{A.44}$$

Write

$$\mu_x = \theta_r \hat{w} + \delta_x, \qquad \mathbb{E}[\delta_x] = 0, \qquad \delta_x = O(\hat{w}). \tag{A.45}$$

Because the purchase hazard is smooth in posterior beliefs, survival is also smooth in x, so around the round-r average posterior,

$$s_r(x) = \bar{s}_r + O(\delta_x). \tag{A.46}$$

Therefore

$$\begin{aligned} \mathbb{E}[\mu_x s_r(x)] &= \mathbb{E}\big[(\theta_r \hat{w} + \delta_x)(\bar{s}_r + O(\delta_x))\big] \\ &= \theta_r \hat{w}\, \bar{s}_r + O(\hat{w}^2), \end{aligned} \tag{A.47}$$

since $\mathbb{E}[\delta_x] = 0$ and $\delta_x^2 = O(\hat{w}^2)$. Similarly,

$$\mathbb{E}[s_r(x)] = \bar{s}_r + O(\hat{w}^2). \tag{A.48}$$

Dividing gives

$$\bar{\mu}_r = \theta_r \hat{w} + O(\hat{w}^2). \tag{A.49}$$

Step 3: Aggregate across rounds. Substituting the previous result into the visit-weighted average,

$$\bar{\mu}^L = \frac{\sum_{r\geq 1} M_r \bar{\mu}_r}{\sum_{r\geq 1} M_r} = \frac{\sum_{r\geq 1} M_r \theta_r}{\sum_{r\geq 1} M_r} \hat{w} + O(\hat{w}^2). \tag{A.50}$$

Thus the first-order coefficient is

$$\theta^L = \lim_{\hat{w}\to 0} \frac{\sum_{r\geq 1} M_r \theta_r}{\sum_{r\geq 1} M_r}. \tag{A.51}$$

Step 4: Approximate the search measure by a geometric law. Under weak learning, the stopping rule is approximated by the fixed-belief threshold rule, so the round masses are geometric to first order:

$$M_r = (1-\bar{\rho})^{r-1}\big(1 + O(\hat{w})\big), \qquad r \geq 1, \tag{A.52}$$

where $\bar{\rho} \in (0,1)$ is the benchmark purchase probability. Hence

$$\theta^L = \frac{\sum_{r\geq 1}(1-\bar{\rho})^{r-1}\theta_r}{\sum_{r\geq 1}(1-\bar{\rho})^{r-1}} = \bar{\rho} \sum_{r\geq 1} (1-\bar{\rho})^{r-1}\theta_r. \tag{A.53}$$

Because θ_r satisfies $\theta < \theta_r < 1 \qquad (r \geq 1,\ \tau_a > 0)$, their geometric average also satisfies $\theta < \theta^L < 1$.

Step 5: Two limiting regimes. If $\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}}$ is small, then

$$\theta^L = \bar{\rho}\sum_{r\geq 1}(1-\bar{\rho})^{r-1}\left[\theta + (1-\theta)\frac{r\tau_a}{\tau_x}\right] + o\left(\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}}\right). \tag{A.54}$$

Then

$$\theta^L \approx \theta + (1-\theta)\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}}. \tag{A.55}$$

If instead $\frac{\tau_a}{\tau_x}\frac{1}{\bar{\rho}} \to \infty$, then $\theta^L \to 1$. □

Proof of Proposition ??:

Proof. I first prove an approximation in threshold. The threshold $v^*(x)$ solves

$$\int \psi\big(v^*(x) + p(a,w)\big)\, h(w \mid x)\, \phi_a(a)\, dw\, da = \kappa + O(\hat{w}^2), \tag{A.56}$$

where

$$\psi(s) \equiv \int_{\lambda s}^{\infty} \Big(\tfrac{1}{\lambda}\epsilon - s\Big) g(\epsilon)\, d\epsilon. \tag{A.57}$$

By assumption,

$$p(a,w) = p_0(a) + \varphi(a)\hat{w}, \qquad \mu_x \equiv \mathbb{E}[\hat{w} \mid x] = O(\hat{w}), \qquad Var(\hat{w} \mid x) = O(\hat{w}^2). \tag{A.58}$$

Hence, conditional on x,

$$\int p(a,w)\, h(w \mid x)\, dw = p_0(a) + \varphi(a)\mu_x + O(\hat{w}^2). \tag{A.59}$$

Using the local concentration of posteriors, (A.56) becomes

$$\int \psi\big(v^*(x) + p_0(a) + \varphi(a)\mu_x\big)\phi_a(a)\, da = \kappa + O(\hat{w}^2). \tag{A.60}$$

Let $\bar{v}$ denote the full-information threshold, defined by

$$\int \psi\big(v^*(\bar{w}) + \bar{p}(a)\big)\phi_a(a)\, da = \kappa. \tag{A.61}$$

Write $v^*(x) = v^*(\bar{w}) + \Delta_v(x)$, $\Delta_v(x) = O(\hat{w})$. A first-order expansion of (A.60) around $(v^*(\bar{w}), \mu_x) = (v^*(\bar{w}), 0)$ yields

$$0 = \int \psi'\big(v^*(\bar{w}) + \bar{p}(a)\big)\big(\Delta_v(x) + \varphi(a)\mu_x\big)\phi_a(a)\, da + O(\hat{w}^2). \tag{A.62}$$

Since $\psi'(s) = -\bar{G}(\lambda s), \qquad \bar{G} \equiv 1 - G$, we obtain

$$\Delta_v(x) = -\mu_x \frac{\int \bar{G}(\lambda(v^*(\bar{w}) + \bar{p}(a)))\, \varphi(a)\, \phi_a(a)\, da}{\int \bar{G}(\lambda(v^*(\bar{w}) + \bar{p}(a)))\, \phi_a(a)\, da} + O(\hat{w}^2). \tag{A.63}$$

Therefore

$$v^*(x) = v^*(\bar{w}) - \Phi\, \mu_x + O(\hat{w}^2), \tag{A.64}$$

where $\Phi \equiv \int \bar{\omega}_k \varphi_k dk$.

Now let $\nu(dx) \equiv \sum_{r \geq 1} m_r(dx)$. Then the elasticity in (28) can be written as

$$e_k = 1 + \lambda \frac{\int g(\lambda(v^*(x) + p_k))\, \nu(dx)}{\int \bar{G}(\lambda(v^*(x) + p_k))\, \nu(dx)} + o(\hat{w}). \tag{A.65}$$

Using part (1),

$$v^*(x) = v_0 - \Phi \mu_x + O(\hat{w}^2). \tag{A.66}$$

Define the search-measure-weighted mean expected price by

$$\overline{\mathbb{E}}\hat{p} = \theta^L \hat{w} \equiv \Phi \frac{\int \mu_x\, \nu(dx)}{\int \nu(dx)}. \tag{A.67}$$

Write $\mu_x = \bar{\mu} + \delta_x$, $\int \delta_x\, \nu(dx) = 0$. Then

$$\lambda(v^*(x) + p_k) = \lambda\big(v_0 + p_k - \overline{\mathbb{E}}\hat{p}\big) - \lambda \Phi\, \delta_x + O(\hat{w}^2). \tag{A.68}$$

A first-order Taylor expansion of both numerator and denominator around

$$z_k \equiv \lambda\big(v_0 + p_k - \overline{\mathbb{E}}\hat{p}\big) \tag{A.69}$$

shows that the linear terms in δ_x vanish after integration, by construction of $\overline{\mathbb{E}}\hat{p}$. Hence

$$\int g(\lambda(v^*(x) + p_k))\, \nu(dx) = g(z_k) \int \nu(dx) + o(\hat{w}), \tag{A.70}$$

$$\int \bar{G}(\lambda(v^*(x) + p_k))\, \nu(dx) = \bar{G}(z_k) \int \nu(dx) + o(\hat{w}). \tag{A.71}$$

Therefore

$$e_k = 1 + \lambda\, \frac{g\Big(\lambda\big(v^*(w) + p_k - \overline{\mathbb{E}}\hat{p}\big)\Big)}{1 - G\Big(\lambda\big(v^*(w) + p_k - \overline{\mathbb{E}}\hat{p}\big)\Big)} + o(\hat{w}). \tag{A.72}$$

□

Proof of Theorem 3:

Proof. Start from the firm's pricing rule

$$p_k = \log \mu_k + w - a_k, \qquad \mu_k = \frac{e_k}{e_k - 1}. \tag{A.73}$$

Taking a first-order expansion around $\hat{w} = 0$ gives

$$\hat{p}_k = \hat{w} + d \log \mu_k. \tag{A.74}$$

By Proposition 5, to first order the elasticity e_k depends on p_k and $\bar{\mathbb{E}}\hat{p}$ only through the difference

$$p_k - \bar{\mathbb{E}}\hat{p}. \tag{A.75}$$

Hence the markup μ_k also depends only on $p_k - \bar{\mathbb{E}}\hat{p}$, so

$$d \log \mu_k = \frac{d \log \mu_k}{d p_k} \left(d p_k - d\bar{\mathbb{E}}\hat{p} \right). \tag{A.76}$$

Substituting into (A.74) yields

$$\left(1 - \frac{d \log \mu_k}{d p_k}\right) \hat{p}_k = \hat{w} - \frac{d \log \mu_k}{d p_k} \bar{\mathbb{E}}\hat{p}. \tag{A.77}$$

Define

$$\gamma_k \equiv \left(1 - \frac{d \log \mu_k}{d p_k}\Big|_{\hat{w}=0}\right)^{-1}. \tag{A.78}$$

Then

$$\hat{p}_k = \gamma_k \hat{w} + (1 - \gamma_k) \bar{\mathbb{E}}\hat{p}, \tag{A.79}$$

which proves the firm supply curve.

Aggregating across firms using full-information expenditure weights $\bar{\omega}_k$,

$$\hat{p} = \Gamma \hat{w} + (1 - \Gamma) \bar{\mathbb{E}}\hat{p}. \tag{A.80}$$

Finally, using $\bar{\mathbb{E}}\hat{p} = \theta^L \hat{p}$ yields the aggregate supply curve in (38). This proves the theorem. □

Proof of Corollary 3:

Proof. The aggregation in (38) requires every firm is individually rational, so they know individual firm's pricing rule. Suppose every consumer believe that firms and other consumers are rational. Then every consumer believes (38) holds. Consumers' average expectation of $\hat{p}$ satisfies,

$$\bar{E}\hat{p} = \Gamma \bar{E}\hat{w} + (1 - \Gamma) \bar{E}^2 \hat{p} \tag{A.81}$$

where $\bar{E}^2[\cdot] = \bar{E}[\bar{E}[\cdot]]$ denotes the second-order belief. Iterating ad infinitum, the change in the actual price index $\hat{p}$ can be expressed in terms of the higher-order beliefs of $\hat{w}$:

$$\hat{p} = \Gamma \sum_{h=0}^{\infty} (1-\Gamma)^h \bar{E}^h \hat{w} \tag{A.82}$$

"Iterating ad infinitum" amounts to imposing common knowledge of rationality. The first iteration requires that consumers know that firms and other consumers are rational, the second iteration requires that consumers know that others know they are rational and firms are rational, and so on. □

Proof of Proposition 6 and 7: Before proving Proposition 6 and 7, I first state and prove the following lemma.

Lemma A.2. *Let* $\Lambda_k = -\frac{d \log \mu_k}{d p_k}\Big|_{\hat{w}=0}$ *denote the steady-state markup elasticity. When G is Gumbel distribution, it has the following property,*

$$\frac{d\Lambda(y)}{dy} < 0$$

In addition, $\Lambda(y) \to 0$ *as* $y \to \infty$ *and* $\Lambda(y) \to \infty$ *as* $y \to -\infty$.

Proof. To simplify notation, I denote $y_k = \lambda(v^*(\bar{w}) + \bar{p}_k)$. I assume that G follows standard type-I extreme-value distribution, i.e., $G(y) = \exp(-\exp(-y))$, $g(y) = \exp(-y - \exp(-y))$. It also follows that $\frac{g'}{g} = e^{-y} - 1$.

First, since G is log-concave, g is also log-concave. This implies the following property,

$$(\frac{g'}{g})' < 0; \quad (\frac{1-G}{g})' < 0$$

Additionally, using G is Gumbel, I have $\frac{1-G}{g} \to 1$ as $y \to \infty$ and therefore $\frac{1-G}{g} > 1$.

Second, we write out markup elasticity,

$$\Lambda = \frac{\frac{g'}{g}\frac{1-G}{g} + 1}{\frac{1}{\lambda}\frac{1-G}{g} + 1} \tag{A.83}$$

Then the derivative of markup elasticity w.r.t y is given by,

$$\begin{aligned}
\frac{d\Lambda(y)}{dy} &= \left(\frac{g'}{g}\right)' \left(\frac{1-G}{g}\right)^2 \frac{1}{\lambda} - \left(\frac{1-G}{g}\right)' \frac{1}{\lambda} + \left(\frac{g'}{g}\frac{1-G}{g}\right)' \\
&= -e^{-y}\left(\frac{1-G}{g}\right)^2 \frac{1}{\lambda} + \frac{1}{\lambda}\left(1 + \frac{g'}{g}\frac{1-G}{g}\right) + \left(\frac{g'}{g}\frac{1-G}{g}\right)' \\
&< -e^{-y}\left(\frac{1-G}{g}\right)\frac{1}{\lambda} + \frac{1}{\lambda}\left(1 + (e^{-y}-1)\frac{1-G}{g}\right) + \left(\frac{g'}{g}\frac{1-G}{g}\right)' \\
&= \frac{1}{\lambda}\left(1 - \frac{1-G}{g}\right) + \left(\frac{g'}{g}\frac{1-G}{g}\right)'
\end{aligned}$$

The inequality is due to $\frac{1-G}{g} > 1$. The first term of the last equation is negative. We need to deal with the second term. Notice that

$$\left(\frac{g'}{g}\frac{1-G}{g}\right)' = \left(\frac{g'}{g}\right)'\left(\frac{1-G}{g}\right) + \left(\frac{g'}{g}\right)\left(\frac{1-G}{g}\right)'$$

It is straightforward that when $y < 0$, $\frac{g'}{g} = e^{-y} - 1 > 0$. Then, $\left(\frac{g'}{g}\frac{1-G}{g}\right)' < 0$. We now focus on the case where $y > 0$.

$$\begin{aligned}\left(\frac{g'}{g}\frac{1-G}{g}\right)' &= -e^{-y}\frac{1-G}{g} + (1-e^{-y}) - (1-e^{-y})^2\frac{1-G}{g} \\ &< -e^{-y}\frac{1-G}{g} + (1-e^{-y}) - (1-e^{-y})\frac{1-G}{g} \\ &= (1-e^{-y}) - \frac{1-G}{g} < 0\end{aligned}$$

The first inequality is due to $1 - e^{-y} \in (0,1)$ when $y > 0$. The second inequality is due to $\frac{1-G}{g} > 1$. Combine all together, we have $\Lambda'(y) < 0$.

For limit results, first recall $\frac{1-G}{g} \to 1$ as $y \to \infty$. Plug into (A.83), we get $\Lambda \to 0$ when $y \to \infty$. Second, since $\frac{1-G}{g} \to \infty$ when $y \to -\infty$, $\Lambda \approx \lambda g'/g \to \infty$ since $g'/g \to \infty$. □

Next, we turn to the result on comparative statics.

Proof of Proposition 6: First, notice that to show φ_k decreases in a_k, it is sufficient to show that γ_k decreases in a_k. From the definition of γ_k, $\gamma_k = (1+\Lambda_k)^{-1}$. Since Λ_k decreases in P_k based on Lemma A.2, it implies γ_k increases in P_k. Since P_k decreases in a_k, it implies γ_k decreases in a_k.

Since the markup μ_k decreases in p_k, it increases in a_k. It is easy to show that $\lim_{a\to-\infty} e_k = 1 - \lambda\frac{g'}{g} = 1 + \lambda$ and $\lim_{a\to\infty} e_k = 1$. Then, $\lim_{a\to-\infty} \mu_k = \frac{\lambda+1}{\lambda}$ and $\lim_{a\to\infty} \mu_k = \infty$.

Also, we know $\xi_k = \theta(1-\gamma_k)$, so ξ_k increases in a_k. Also, in the limit when $a \to \infty$, $p \to -\infty$. Then $\Lambda \to \infty$ and $\gamma \to 0$, $\xi \to \theta$. In the opposite limit, $p \to \infty$, and $\Lambda \to 0$, implying $\gamma \to 1$ and $\xi \to 0$. □

Proof of Proposition 7: I first consider the comparative statics on κ. From Lemma A.1, an increase in the search cost κ implies lower threshold $v^*(\bar{w})$. Since the steady-state markup elasticity decreases in $v^*(\bar{w})$, γ_k decreases for all k. As a result, φ_k decreases in κ for all k. When $\kappa \to 0$, $v^*(\bar{w}) \to \infty$ and therefore $\Lambda_k \to 0$, resulting in $\gamma_k \to 1$ for any k. This implies $\varphi_k = 1$ for any k. When $\kappa \to \infty$, $v^*(\bar{w}) \to -\infty$, and therefore $\Lambda_k \to \infty$, resulting in $\gamma_k \to 0$ for any k. This implies $\varphi_k = 0$ for any k. Then, I consider the comparative statics on θ. An increase in the information friction, which means a decrease in θ, induces lower φ_k. When $\theta \to 0$, $\Phi = \Gamma$. When $\theta \to 1$, $\varphi_k = 1$. □

Extension to Multiple Goods and Passthrough. The baseline model assumes that each firm sells a single good and each consumer buys one good from one firm. I now extend the model to allow each firm to sell multiple goods. Firm k produces product j with productivity

$$\log A_{kj} = \log A + a_k + a_{kj},$$

where a_{kj} is an i.i.d. product-specific productivity component. I assume there are no search frictions within the firm: consumers draw a taste shock at the firm level, choose which firm to patronize, and then purchase a CES bundle of that firm's products. Let P_k denote firm k's CES price index. The following result obtains.

Proposition A.1. *Each firm charges the same markup across all products it sells:*

$$\mu_{kj} = \frac{e_k}{e_k - 1}; \quad e_k = 1 + \lambda \frac{\sum_{r\geq 1} \int g(\lambda(v^*(x) + p_k))\, m_r(dx)}{\sum_{r\geq 1} \int \Big(1 - G(\lambda(v^*(x) + p_k))\Big) m_r(dx)}. \tag{A.84}$$

with P_k the CES price index over $\{P_{kj}\}_j$ and $p_k = \log P_k$. Moreover, passthrough of product-level productivity shocks a_{kj} converges to one as the number of products grows.

This extension connects to the empirical literature on exchange-rate passthrough to retail prices. Goldberg and Hellerstein (2013) and Nakamura and Zerom (2010), for example, find nearly complete passthrough of wholesale costs to retail prices for beer and coffee sold in retail stores. The proposition provides a simple rationale: when a store sells many goods, product-specific idiosyncratic shocks pass through almost one-for-one into product prices. By contrast, passthrough of aggregate shocks and firm-level shocks need not be complete.

Proof. The profit of a firm that has N products indexed by j is given by,

$$\pi_k = \frac{1}{\rho} \sum_{j=1}^{N} \int \big(1 - G\big(\lambda(v^*(x) + p_k)\big)\big) d\nu(x) \frac{1}{P_{jk}} (P_{jk} - \frac{W}{A_{jk}}) (\frac{P_{jk}}{P_k})^{-\sigma} \tag{A.85}$$

where $P_k = (\sum_{j=1}^{N} P_{jk}^{1-\sigma})^{\frac{1}{1-\sigma}}$. Denote the total expenditure share on firm k as $\omega_k = \omega(P_k)$, then,

$$\pi_k = \frac{1}{\rho} \sum_{j=1}^{N} \omega(P_k) \frac{1}{P_{jk}} (P_{jk} - \frac{W}{A_{jk}}) (\frac{P_{jk}}{P_k})^{-\sigma} \tag{A.86}$$

Firm k will internalize the effect of change in P_{jk} on overall price index P_k of the firm. The first-order condition w.r.t. P_{jk} is given by,

$$P_{jk} = \mu_k \frac{W}{A_{jk}} = \frac{\sigma}{\sigma - 1 - P_k^{-1} \tilde{\pi}_k (e_k - 1 + \sigma - 1)} \frac{W}{A_{jk}} \tag{A.87}$$

Notice that the markup is the same across all the products within the firm. Also, we have $\tilde{\pi}_k = (1 - \mu_k) P_k$. Plug in the above equation, we have,

$$\mu_k = \frac{e_k}{e_k - 1} \tag{A.88}$$

The passthrough of productivity shock to a given product j is proportional to the expenditure share of this product over all products on the market.

$$\gamma_{jk} = \frac{\omega_{jk}}{\omega_k} \gamma_k \tag{A.89}$$

Therefore, when $N = 1$, $\gamma_{jk} = \gamma_k$; when $N \to \infty$, $\gamma_{jk} \to 0$. □

B Additional Details on Calibration and Estimation

B.1 Aggregate supply curve with time-dependent nominal rigidities

Proposition B.1. *With time-dependent nominal rigidities, the pricing rule becomes,*

$$\hat{P} = \Gamma \Psi^{TD} (I - (1-\Gamma)\Psi^{TD})^{-1} \widehat{MC} \tag{B.1}$$

Proof. In time-dependent (TD) pricing models, price adjustments are governed by an exogenous *survival function* Φ_s, which represents the fraction of firms that have not yet adjusted their price after s periods. The function is weakly decreasing in s, i.e., $\Phi_s \in [0,1]$ and $\Phi_0 = 1$.

Each period, firms get opportunities to reset their prices based on the survival function and the time since the last adjustment. The optimal reset price is given by:

$$x_t^* = \arg\min_x \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \Phi_s \frac{1}{2} \left(x - \gamma \sum_{r=1}^{s} \epsilon_{it+r} - \gamma \log MC_{t+s} - (1-\gamma) E_{t+s}^c \log P_{t+s} \right)^2 \tag{B.2}$$

where $x - \gamma \sum_{r=1}^{s} \epsilon_{it+r}$ is the price gap of firm i at date $t+s$ if it starts with a price gap of x at date t and does not adjust between t and $t+s$. $E_t^c \log P_{t+s}$ is the consumers' average expectation of price index at date $t+s$. The adjustment hazard at horizon s is defined as: $\lambda_s = \frac{\Phi_{s-1} - \Phi_s}{\Phi_{s-1}}$, $\lambda_s \in [0,1]$ when $\Phi_{s-1} = 0$, we set $\lambda_s = 1$. The law of motion for individual price gaps follows:

$$x_{it} = \begin{cases} x_t^* & \text{with probability } \lambda_s \\ x_{it-1} - \epsilon_{it} & \text{otherwise} \end{cases} \tag{B.3}$$

Denote by a_s the share of prices that last adjusted s periods ago, that is, the share of prices with age s. The age distribution of prices in the steady state is given by,

$$a_s = \frac{\Phi_s}{\sum_{r=0}^{\infty} \Phi_r} \tag{B.4}$$

The reset price gap x_t^* satisfies the FOC of the problem in (B.2),

$$x_t^* = \Gamma \frac{\sum_{s \geq 0} \beta^s \Phi_s \widehat{MC}_{t+s}}{\sum_{s \geq 0} \beta^s \Phi_s} + (1-\Gamma) \frac{\sum_{s \geq 0} \beta^s \Phi_s E_{t+s}^c \widehat{P}_{t+s}}{\sum_{s \geq 0} \beta^s \Phi_s} \tag{B.5}$$

Equation (B.5) shows that, with strategic complementarity, the optimal reset price gap is a weighted average of future nominal marginal cost shocks and price index changes. In addition, due to the information friction, consumers' average expectation of price index changes is typically dampened compared to the actual changes, which leads to dampened response of reset price gap.

The price index is a weighted average of past reset price gaps, with the age distribution as weights,

$$\hat{P}_t = \int x_{it} di = \sum_{s \geq 0} a_s x_{t-s}^* = \frac{\sum_{s \geq 0} \Phi_s x_{t-s}^*}{\sum_{s \geq 0} \Phi_s} \tag{B.6}$$

Both SD and TD models describe a mapping between nominal marginal cost $\{MC_t\}$ and the aggregate price level $\{P_t\}$. This can be expressed as:

$$P_t = \mathcal{P}_t(\{MC_s\}) \tag{B.7}$$

which, when log-linearized around steady state, gives:

$$\hat{P}_t = \sum_{s=0}^{\infty} \frac{\partial \log P_t}{\partial \log MC_s} \hat{MC}_s \tag{B.8}$$

Defining the pass-through matrix $\Psi_{t,s}$ as:

$$\Psi_{t,s} = \frac{\partial \log P_t}{\partial \log MC_s} \tag{B.9}$$

we can express the aggregate price level response as:

$$\hat{P} = \Psi \hat{MC} \tag{B.10}$$

We denote by $\Psi^{TD}_{\Phi_s}$ the canonical pass-through matrix when the strategic complementarity and the information friction are absent. It takes the form as equation (12) in Auclert et al. (2024).

$$\Psi^{TD} \equiv \frac{1}{(\sum_{s\geq 0}\Phi_s)(\sum_{s\geq 0}\beta^s\Phi_s)} \begin{pmatrix} \Phi_0 & 0 & 0 & \cdots \\ \Phi_1 & \Phi_0 & 0 & \cdots \\ \Phi_2 & \Phi_1 & \Phi_0 & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix} \begin{pmatrix} \Phi_0 & \beta\Phi_1 & \beta^2\Phi_2 & \cdots \\ 0 & \Phi_0 & \beta\Phi_1 & \cdots \\ 0 & 0 & \Phi_0 & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{pmatrix}$$

Combining the policy function (B.5) and the law of motion (B.6), I obtain the pass-through matrix for a TD model with both strategic complementarity and information friction as:

$$\hat{P} = \Gamma\Psi^{TD}(I - (1-\Gamma)\Psi^{TD})^{-1}\widehat{MC} \tag{B.11}$$

where M is a diagonal matrix that captures both strategic complementarity and information friction.

□

B.2 Learning from signals about the price index

Let the log price level evolve as the cumulated inflation rate, with inflation following an AR(1). Each period, agents observe a noisy Gaussian signal of the price level.

Define the state vector

$$x_t \equiv \begin{bmatrix} p_t \\ \pi_t \end{bmatrix},$$

with transition equation

$$x_t = Fx_{t-1} + w_t, \qquad F = \begin{bmatrix} 1 & \rho \\ 0 & \rho \end{bmatrix}, \qquad w_t = \begin{bmatrix} 1 \\ 1 \end{bmatrix} \epsilon_t,$$

where $w_t \sim \mathcal{N}(0, Q)$ and

$$Q = \begin{bmatrix} \sigma_\epsilon^2 & \sigma_\epsilon^2 \\ \sigma_\epsilon^2 & \sigma_\epsilon^2 \end{bmatrix}.$$

Agents observe

$$y_t = Hx_t + \eta_t, \qquad H = \begin{bmatrix} 1 & 0 \end{bmatrix}, \qquad \eta_t \sim \mathcal{N}(0, \sigma_\eta^2).$$

The Kalman filter is standard. The prediction step is

$$x_{t|t-1} = Fx_{t-1|t-1}, \qquad P_{t|t-1} = FP_{t-1|t-1}F^\top + Q,$$

where in steady state

$$P = \begin{bmatrix} \sigma_p^2 & \sigma_{p\pi} \\ \sigma_{p\pi} & \sigma_\pi^2 \end{bmatrix}.$$

The Kalman gain is

$$K = PH^\top (HPH^\top + \sigma_\eta^2)^{-1} = \begin{bmatrix} K_p \\ K_\pi \end{bmatrix},$$

with

$$K_p = \frac{\sigma_p^2}{\sigma_p^2 + \sigma_\eta^2}, \qquad K_\pi = \frac{\sigma_{p\pi}}{\sigma_p^2 + \sigma_\eta^2}.$$

Hence the posterior updates are

$$p_{t|t} = p_{t|t-1} + K_p(y_t - p_{t|t-1}), \qquad \pi_{t|t} = \pi_{t|t-1} + K_\pi(y_t - p_{t|t-1}).$$

Combine these two equations, the price update can be written as

$$p_{t|t} = p_{t|t-1} + \frac{K_p}{K_\pi}(\pi_{t|t} - \pi_{t|t-1}).$$

Since $p_{t|t-1} = p_{t-1|t-1} + \pi_{t|t-1}$, it follows that

$$p_{t|t} = p_{t-1|t-1} + \pi_{t|t-1} + \frac{K_p}{K_\pi}(\pi_{t|t} - \pi_{t|t-1}). \tag{B.12}$$

Estimates from SPF I use the Survey of Professional forecasters to estimate $\lambda = \frac{K_p}{K_\pi}$. For price index , I use PDGP. I conduct the estimation on different horizons,

$$p_{t+j|t+j} = \gamma p_{t+j-1|t+j-1} + \alpha \pi_{t+j|t+j-1} + \beta(\pi_{t+j|t+j} - \pi_{t+j|t+j-1}), \quad \forall j = 0, 1, 2, 3 \tag{B.13}$$

Table B.1 shows that the coefficients increase over the horizon of the forecast and the statistical significance also increases. I adjust coefficients such that they are consistent with (B.12): $\lambda = \frac{\beta}{\alpha}$. Following the literature, I take the 3 quarter-ahead forecast as the main result. Therefore, $\lambda = 1.55$.

It is easy to show that since K_p is related to the variance of p and $K_{p\pi}$ is related to the covariance between p and π. Given positive covariance, the variance of p must be larger than the covariance. Therefore, we should expect that λ is at least one. I therefore consider the robustness check for $\lambda = 1$ and a larger value $\lambda = 5$.

Table B.1: Estimation of Learning from the Price Index Using SPF

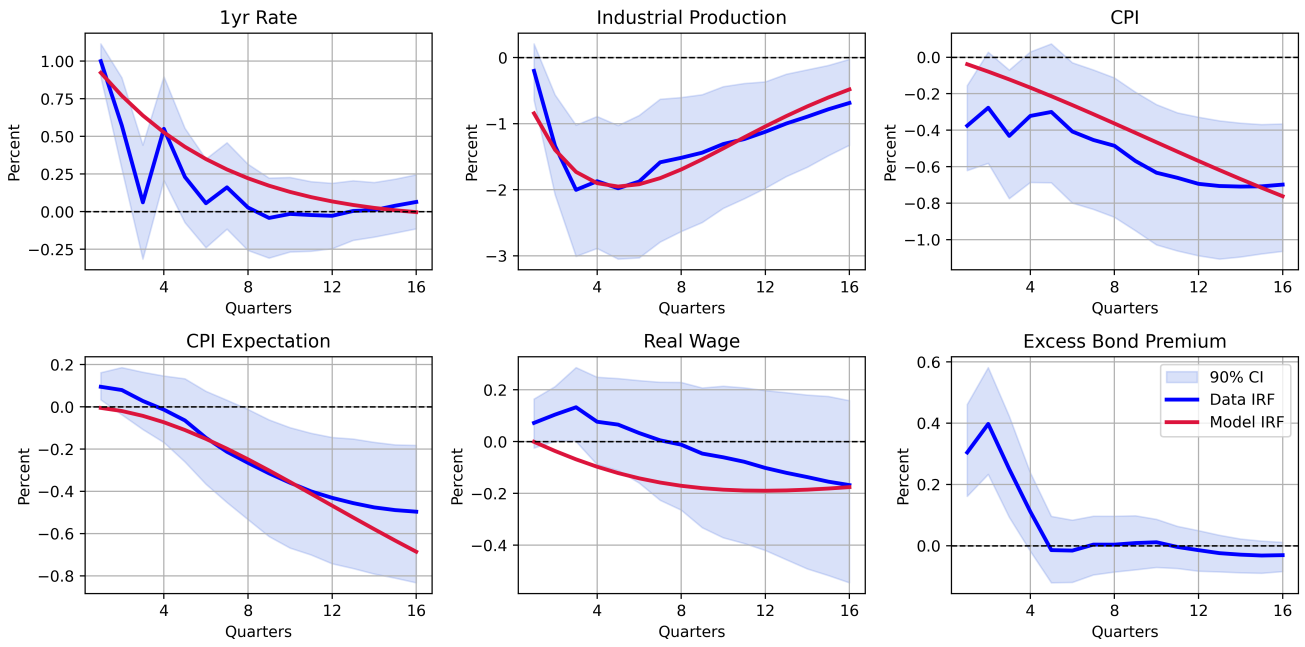
	(1)	(2)	(3)	(4)
Dependent variable	$pgdp_0$	$pgdp_1$	$pgdp_2$	$pgdp_3$
$L.pgdp_j$	0.886***	0.876***	0.877***	0.877***
	(0.030)	(0.031)	(0.032)	(0.032)
$L.CPI_{j+1}$	1.415***	1.822***	1.844***	1.824***
	(0.503)	(0.552)	(0.574)	(0.586)
$CPI_j - L.CPI_{j+1}$	0.128	1.520	2.563*	2.823*
	(0.409)	(1.063)	(1.528)	(1.539)
Observations	177	177	177	177
R^2	0.915	0.918	0.920	0.921

Notes: Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

B.3 Estimation with more weight on real wage

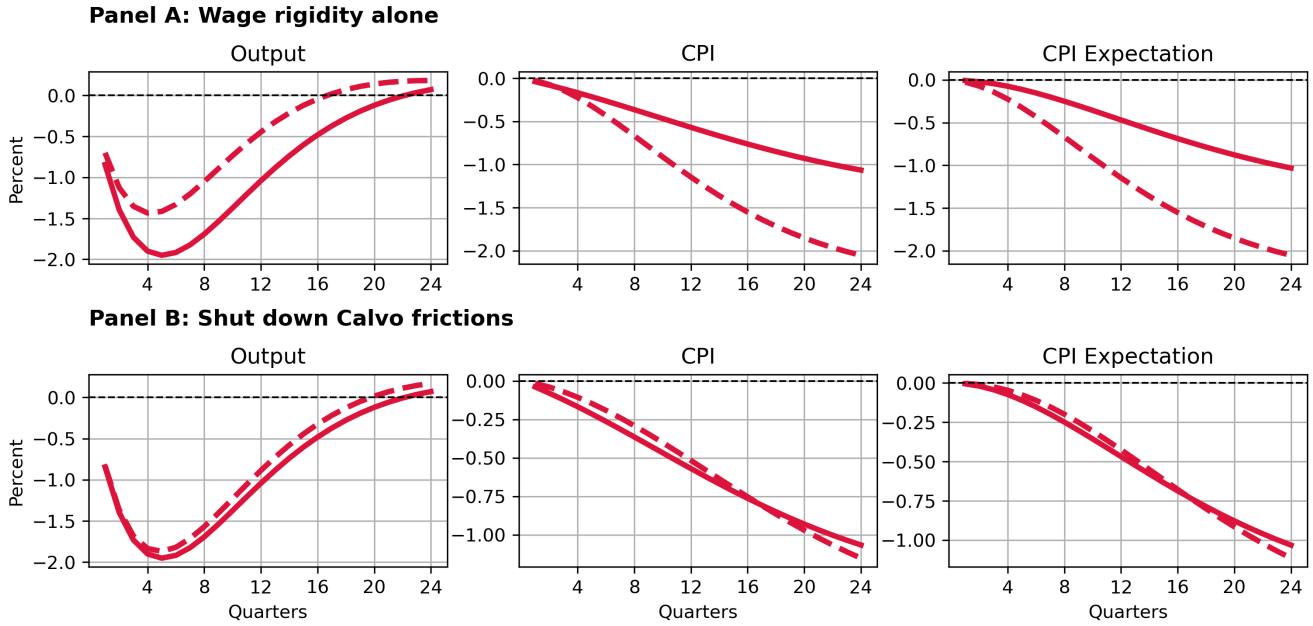
I present an alternative estimation where I assign 5 times more weight to real wage response compared to the baseline estimation. The model yields close fit on real wage responses but more dampened response on CPI.

Figure B.1: Empirical and Model Impulse Responses with Alternative Estimation



I further conduct the counterfactual analysis as in the baseline model. The results are shown in Figure B.2.

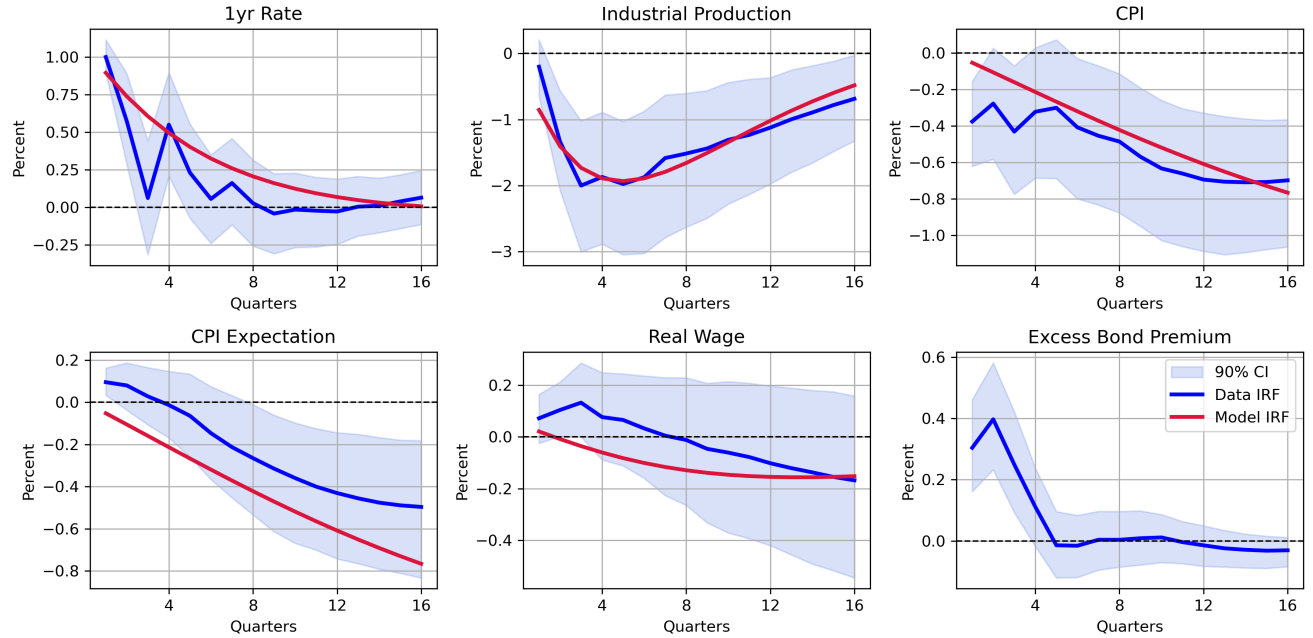
Figure B.2: Counterfactual Analysis in Alternative Estimated Model



B.4 Estimated no-information-friction model

I present the estimated no-information-friction model. The resulting estimates are $\lambda_w = 0.97$ and $\lambda_p = 0.83$. Figure B.3 shows the result. The model yields a good fit for the inflation and output responses. However, it fails to capture the response of inflation expectations.

Figure B.3: Empirical and Calvo Model Impulse Responses



B.5 Robustness checks with different λ

Figure B.4 shows that the inflation forecast revision is one-magnitude smaller than the inflation forecast. Therefore, for reasonable λ, the expected price index is not largely affected.

Figure B.4: Household Inflation Forecast Revision

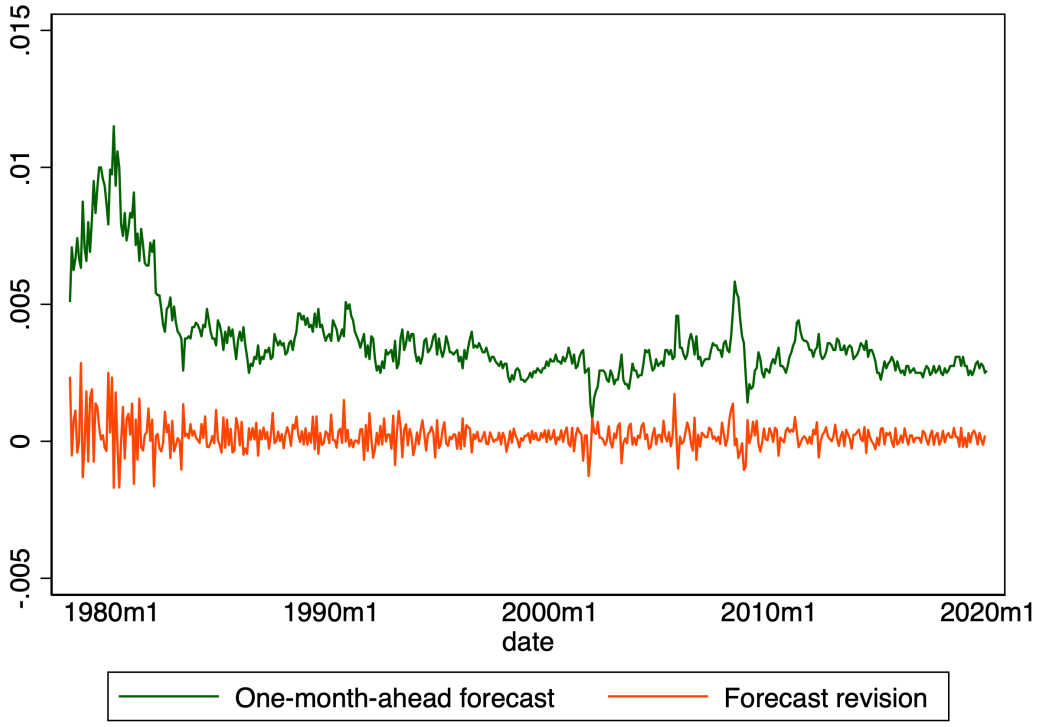


Figure B.5 shows the first robustness check where $\lambda = 1$. Figure B.6 shows the first robustness check where $\lambda = 5$. The estimated θ is 0.102 and 0.1 respectively, implying robustness of our main results.

Figure B.5: Robustness: $\lambda = 1$

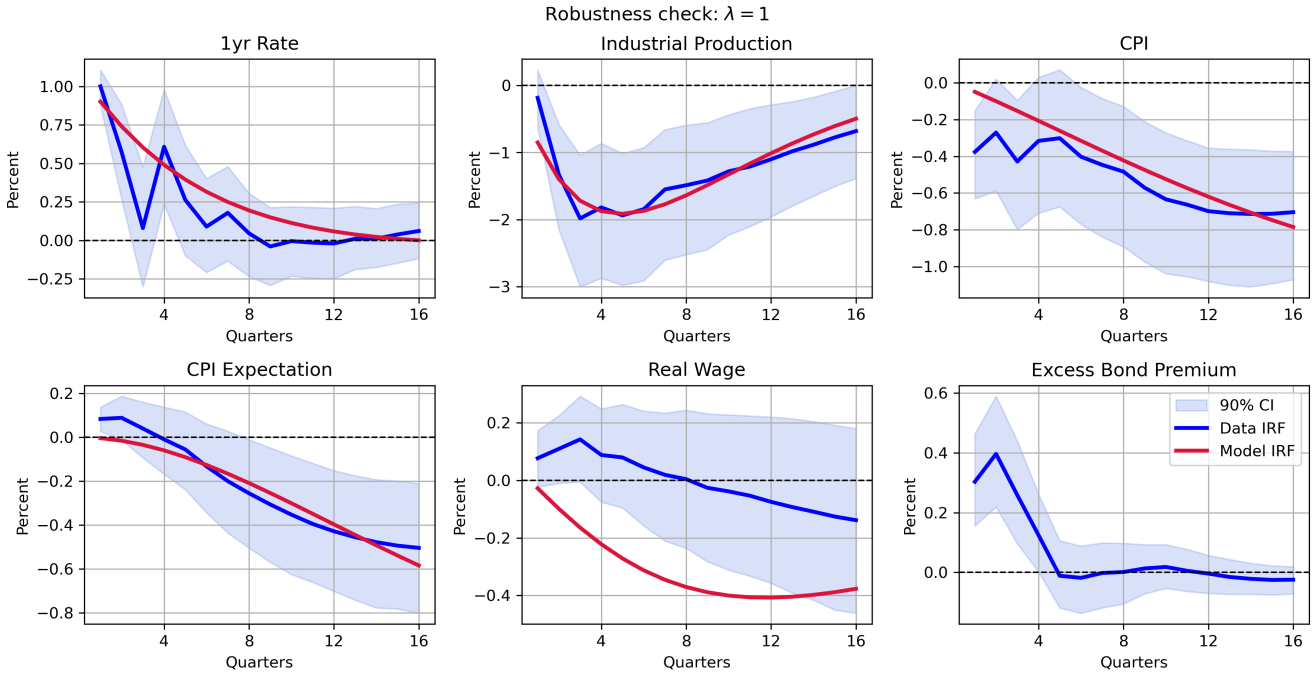


Figure B.6: Robustness: $\lambda = 5$

