# Optimal Monetary Policy with Confounding Information*

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**Abstract**

In this paper, we study optimal monetary policy in an economy where firms' price-setting decisions are distorted by a signal-extraction problem: they cannot perfectly distinguish aggregate from idiosyncratic shocks based on noisy local information. This systematic misattribution of aggregate shocks to firm-specific factors generates an additional price response, implying that strict price stability is no longer optimal. Instead, the optimal policy fully stabilizes the output gap, which necessarily requires accommodating fluctuations in the price level. The cyclicality of the optimal price level depends on the source of firms' incomplete information: learning from local demand signals implies a procyclical price level, whereas learning from local productivity signals yields a countercyclical one.

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# 1 Introduction

In the canonical New Keynesian framework without markup shocks or idiosyncratic shocks, strict price stability is optimal and simultaneously closes the output gap—a result famously known as the "divine coincidence" (Blanchard and Galí, 2007). This prescription underpins the price-stability mandates of many modern central banks. For example, both the European Central Bank and the Bank of Japan identify price stability as a central objective of monetary policy.[1] The same principle is also reflected in the Federal Reserve's forceful response to the 2021–2022 inflation surge (Powell, 2022).

However, the theoretical optimality of strict price stability relies on assumptions that are difficult to reconcile with empirical evidence. Micro-level evidence indicates that firm-level price adjustments are largely driven by substantial idiosyncratic shocks (Hellwig and Venkateswaran, 2009; Klenow and Malin, 2010). These shocks also shape firms' informational environment. Recent survey evidence suggests that firms do not observe aggregate shocks directly; instead, they infer them from local signals that inherently confound aggregate and firm-specific shocks (Andrade et al., 2022; Dovern et al., 2023).

This paper re-examines the optimality of price stability by incorporating these empirical features into a monetary model with dispersed information. A continuum of monopolistically competitive firms set prices in response to aggregate productivity shocks and idiosyncratic demand shocks. The central friction is a confounding information structure: each firm observes only a local signal that combines these two shocks and therefore cannot distinguish between them. In contrast, the central bank has perfect information about aggregate funda-

[1] See European Central Bank, *The ECB's Monetary Policy Strategy Statement (2025)*, available at https://www.ecb.europa.eu/mopo/strategy/strategy-review/ecb.strategyreview202506_strategy_statement.en.html; and Bank of Japan, *Outline of Monetary Policy*, available at https://www.boj.or.jp/en/mopo/outline/index.htm (accessed June 10, 2026).

mentals and controls nominal spending to maximize the representative household's welfare.

The baseline model takes the confounding signal as exogenous to isolate the core mechanism. Confounding information breaks the divine coincidence when firms have incentives to respond to idiosyncratic shocks. Because firms cannot perfectly distinguish aggregate shocks from firm-specific shocks, aggregate productivity shocks generate systematic movements in firms' average beliefs about idiosyncratic demand shocks. These movements create a misattribution wedge that enters the price level and the output gap in opposite directions, so the central bank cannot simultaneously stabilize both. The optimal policy closes the output gap and minimizes relative-price distortions, but doing so requires the price level to vary with the misattribution wedge. By contrast, strict price stability is suboptimal because it translates this misattribution into output-gap volatility.

The intuition underlying the optimal policy follows from cross-sectional efficiency. Firms that perceive stronger demand for their own products should set higher relative prices. Aggregating this requirement across firms implies that the price level should move with firms' average belief about idiosyncratic demand, which underlies the misattribution wedge. The cyclicality of the optimal price level is therefore governed by the direction of firms' systematic misattribution. If firms interpret positive aggregate shocks as increases in idiosyncratic demand, the optimal price level is procyclical. If instead they interpret such shocks as lower idiosyncratic demand, the optimal price level is countercyclical.

This mechanism differs from the familiar source of monetary policy trade-offs in standard New Keynesian models. There, the divine coincidence fails when markup shocks are not offset by state-contingent subsidies, creating a trade-off between stabilizing the output gap and stabilizing inflation. In our framework, by contrast, there are no markup shocks. The failure of the divine coincidence stems instead from firms' confounding of aggregate and idiosyncratic fundamental shocks.

We provide two microfoundations for the confounding signal. First, when firms learn from local demand, the signal loading on the aggregate shock is endogenous and policy-dependent. The optimal policy then stabilizes the output gap while inducing a positive signal loading, which generates a procyclical price level. Under price stabilization, the signal loading is instead forced to zero. This minimizes relative-price distortions but prevents aggregate output from adjusting to its efficient level. Second, when firms face idiosyncratic productivity shocks and learn from their own productivity, the resulting signal structurally implies a negative loading, leading to a countercyclical optimal price level.

Finally, we examine two extensions that further clarify the scope of the mechanism. With endogenous signal precision, price stabilization remains dominated by output-gap stabilization for empirically plausible information costs, but output-gap stabilization is no longer fully optimal; the optimal policy trades off aggregate stabilization against cross-sectional efficiency. With non-fundamental sentiment shocks in firms' confounding signals, output-gap stabilization remains optimal and preserves the baseline real allocation, but nominal spending and the price level must accommodate both productivity and sentiment shocks.

**Related Literature.** This paper builds on the mechanism of Hellwig and Venkateswaran (2009), who study price adjustment when firms learn from local market signals that inherently confound aggregate and idiosyncratic shocks. They find that firms adjust prices for the "wrong" reason by misattributing aggregate shocks to idiosyncratic factors, which leads to rapid aggregate price adjustment and approximate short-run monetary neutrality. We complement this work by deriving its normative implications, showing that the same signal-extraction problem also shapes optimal monetary policy.

Our work contributes to the literature on optimal monetary policy under imperfect information. One strand of this literature largely supports standard New Keynesian prescriptions in the absence of idiosyncratic shocks.[2] Ball et al. (2005) and Adam (2007) study economies with sticky information and rational inattention, respectively, and show that complete price stabilization remains optimal for shocks that would generate efficient fluctuations under per-

[2] Nakov and Weber (2026) show that the standard zero-inflation prescription is no longer optimal with forward-looking pricing and mean-reverting firm-level idiosyncratic shocks.

fect information. Paciello and Wiederholt (2014) show that when firms choose attention elastically, the case for price stability becomes stronger: complete stabilization is optimal even for shocks that generate inefficient fluctuations under perfect information.

Another strand shows that information frictions can break the divine coincidence even without markup shocks. Lorenzoni (2010) studies an economy with dispersed information and segmented markets, where optimal policy trades off aggregate output-gap stabilization against cross-sectional efficiency. Angeletos and La'O (2020) and Angeletos et al. (2020) show that when dispersed information affects both pricing and production, optimal policy should not stabilize prices but instead "lean against the wind" by inducing a negative correlation between the price level and real activity. Related prescriptions arise in Benhima and Blengini (2020), where firms learn from market signals, and Llosa and Venkateswaran (2022), where firms acquire information endogenously and the central bank faces informational constraints.[3] Our results share the view that price stability is generally suboptimal. The difference is that the optimal price-output correlation depends on the source of firms' confounding information: productivity signals reproduce the familiar "leaning against the wind" result, whereas demand signals generate a "leaning with the wind" policy.

The study of confounding information structures has a deep tradition in macroeconomics, tracing back to Lucas (1972). In this seminal contribution, Lucas demonstrates that nominal shocks can have real effects when agents learn from local prices that confound aggregate monetary disturbances with idiosyncratic real shocks. This insight has been central to recent work by Hellwig and Venkateswaran (2009, 2025), Amador and Weill (2010), Gaballo (2018), Chahrour and Gaballo (2021), Chahrour and Ulbricht (2023), and Flynn et al. (2026). In the consumption literature, Goodfriend (1992) and Pischke (1995) find that when consumers cannot distinguish aggregate from idiosyncratic income shocks, the permanent income hypothesis holds at the individual level but fails in the aggregate. A parallel result emerges

[3] Several papers in this strand—including Lorenzoni (2010), Angeletos and La'O (2020), and Jia (2025)—generate confounding information by assuming that firms observe their own productivity, which mixes aggregate and idiosyncratic components. This corresponds to the productivity-signal microfoundation in Section 3.2.

in finance: Choi et al. (2023) show that when traders specializing in individual stocks conflate idiosyncratic and aggregate dividend shocks, the present value model is rejected for the index but not for individual firms. Finally, in a general game-theoretic framework, Bergemann et al. (2015) establish that maximal aggregate volatility arises precisely in noise-free information structures where agents confound idiosyncratic and aggregate shocks.

The remainder of the paper is organized as follows. Section 2 presents the baseline model with an exogenous confounding signal. Section 3 provides two microfoundations for this signal structure, one based on market-generated demand signals and another on productivity signals. Section 4 extends the mechanism to endogenous information acquisition and non-fundamental sentiment shocks. Section 5 concludes. All proofs are relegated to the Online Appendix.

# 2 The Baseline Model

We consider a static monetary economy with monopolistic competition and confounding information, building on Hellwig and Venkateswaran (2009). In the baseline model, the confounding information structure is taken as exogenous in order to isolate its implications for firms' beliefs, equilibrium outcomes, and the monetary policy problem.

## 2.1 Setup

**Household.** The representative household chooses aggregate consumption $C$ and labor supply $\{N_i\}_{i\in[0,1]}$ to maximize

$$\max_{C,N_i} \frac{C^{1-\gamma}}{1-\gamma} - \int_0^1 \frac{N_i^{1+\epsilon}}{1+\epsilon}\mathrm{d}i, \tag{1}$$

where $N_i$ denotes labor used to produce good $i$, $\gamma > 0$ parameterizes the income elasticity of labor supply, and $\epsilon > 0$ is the inverse Frisch elasticity of labor supply. Aggregate consumption is given by a Dixit-Stiglitz aggregator,

$$C = \left( \int_0^1 \Theta_i^{\frac{1}{\rho}} C_i^{\frac{\rho-1}{\rho}} \, \mathrm{d}i \right)^{\frac{\rho}{\rho-1}}, \tag{2}$$

where $C_i$ is consumption of good $i$, $\rho > 0$ is the elasticity of substitution across goods, and $\Theta_i$ is an idiosyncratic preference shock. Letting $\vartheta_i \equiv \log \Theta_i$, we assume $\vartheta_i \sim \mathcal{N}(0, \sigma_\vartheta^2)$ independently across goods.

The household faces the budget constraint

$$\int_0^1 P_i C_i \, \mathrm{d}i \leq \int_0^1 W_i N_i \, \mathrm{d}i + \Pi + T, \tag{3}$$

where $P_i$ is the price of good $i$, $W_i$ is the nominal wage for type $i$ labor, $\Pi$ denotes aggregate nominal profits, and $T$ is a lump-sum transfer or tax from the government.

Solving the household's optimization problem yields the demand function for good $i$:[4]

$$C_i = \Theta_i \left( \frac{P_i}{P} \right)^{-\rho} C, \tag{4}$$

where the aggregate price index $P$ is defined by: $P = \left( \int_0^1 \Theta_i P_i^{1-\rho} \mathrm{d}i \right)^{1/(1-\rho)}$.

**Firms.** A continuum of monopolistically competitive firms, indexed by $i \in [0, 1]$, produce differentiated goods using

$$Y_i = A N_i^{\theta}, \tag{5}$$

where $Y_i$ is output, $N_i$ is labor input, $\theta \in (0, 1]$ is the output elasticity of labor, and $A$ is an aggregate productivity shock, with $a \equiv \log A$ following a normal distribution $\mathcal{N}(0, \sigma_a^2)$.[5]

[4] See Online Appendix A.1 for the derivation.

[5] Section 3.2 considers an extension with idiosyncratic productivity shocks.

Firm $i$ chooses its price $P_i$ to maximize expected profits,

$$\max_{P_i} \mathbb{E}_i \left[(1+\tau)P_i Y_i - W_i N_i\right], \tag{6}$$

where $\mathbb{E}_i[\,\cdot\,] \equiv \mathbb{E}[\,\cdot\,|\,\mathcal{I}_i]$ denotes the expectation conditional on the firm's information set $\mathcal{I}_i$, and $\tau$ is an output subsidy.[6] The firm's choice is subject to the demand function (4), the production technology (5), and the market-clearing condition $C_i = Y_i$ for all $i \in [0, 1]$.

Log-linearizing the firm's first-order condition yields the pricing rule

$$p_i = \mathbb{E}_i \left[p + \varphi_y y - \varphi_a a + \varphi_\vartheta \vartheta_i\right], \tag{7}$$

where

$$\varphi_y = \frac{1-\theta+\epsilon+\gamma\theta}{\theta+(1-\theta+\epsilon)\rho}, \quad \varphi_a = \frac{1+\epsilon}{\theta+(1-\theta+\epsilon)\rho}, \quad \varphi_\vartheta = \frac{1-\theta+\epsilon}{\theta+(1-\theta+\epsilon)\rho}, \tag{8}$$

and all lower-case variables denote log-deviations from the deterministic steady state.[7] The maintained parameter restrictions imply $\varphi_y, \varphi_a, \varphi_\vartheta > 0$. Equation (7) shows that firm pricing depends on expectations of the aggregate output, the price level, the productivity shock, and the idiosyncratic demand shock.

**Information Structure.** Each firm receives a confounding signal $x_i$ that is a linear combination of its idiosyncratic demand shock $\vartheta_i$ and the aggregate productivity shock $a$,

$$x_i = \lambda a + \vartheta_i + \varepsilon_i, \tag{9}$$

[6] As usual in the literature, we set $\tau = 1/(\rho-1)$ to eliminate the steady-state distortion from monopolistic competition. The government's budget constraint is $T = \tau \int_0^1 P_i Y_i \mathrm{d}i$.

[7] See Online Appendix A.2 for the derivation.

where $\lambda \neq 0$ is the common loading on the aggregate shock and $\varepsilon_i \sim \mathcal{N}(0, \sigma_\varepsilon^2)$ is idiosyncratic noise, independent of all fundamental shocks.[8] The signal is confounding because firms cannot disentangle $a$ from $\vartheta_i$, even in the noise-free limit, $\sigma_\varepsilon^2 = 0$.

Micro-level empirical evidence motivates the two ingredients of this information structure. First, idiosyncratic fundamental shocks matter for price setting. Klenow and Malin (2010) document that micro price changes are an order of magnitude larger than what is needed to keep up with aggregate inflation. As noted by Hellwig and Venkateswaran (2009), such large firm-level price fluctuations are difficult to reconcile with models relying solely on informational heterogeneity (e.g., Woodford, 2003), suggesting a role for firm-specific fundamental shocks. Second, survey evidence indicates that firms rely on local information—which may conflate these idiosyncratic fundamentals with aggregate shocks—to form aggregate expectations. For instance, Andrade et al. (2022) find that French manufacturing firms' aggregate expectations respond to industry-specific shocks that have no aggregate implications. Similarly, Dovern et al. (2023) show that German firms extrapolate from their own business situation and local economic conditions when forecasting aggregate growth. These findings suggest that the confounding signal (9) captures a realistic feature of the firms' information environment.

Section 3 shows how such a signal arises naturally from firms' market activities. When firms observe their own demand or productivity, the resulting information takes the form of (9), with $\lambda$ determined endogenously. For the baseline analysis, however, we treat $\lambda$ as an exogenous parameter to isolate the core mechanism.

**Monetary Policy.** The central bank controls nominal spending, defined as $m \equiv p + y$, to maximize the representative household's expected utility. With perfect information about

[8]We assume a common loading $\lambda$ across firms to keep the optimal monetary policy problem tractable. This signal structure is in the spirit of the confounding information framework in Bergemann et al. (2015).

aggregate conditions, the central bank commits to a linear policy rule:

$$m = \psi a, \tag{10}$$

where $\psi$ is the policy coefficient chosen by the central bank. In our framework, we assume that firms observe neither the policy instrument ($m$) itself nor any noisy signal of it.[9]

The policy objective follows from a second-order approximation to the representative household's utility.

**Lemma 1.** *The expected welfare loss of the representative household, denoted by $\mathbb{EL}$, is approximated to the second order by*

$$\mathbb{EL} = \mathrm{Var}(y - y^*) + \frac{\rho}{\varphi_y} \mathrm{Var}(\tilde{p}_i - \tilde{p}_i^*)\,, \tag{11}$$

*where $\tilde{p}_i \equiv p_i - p$ is firm $i$'s relative price, $y^* = (\varphi_a/\varphi_y)a$ is efficient output, and $\tilde{p}_i^* = \varphi_\vartheta \vartheta_i$ is the efficient relative price under perfect information.*[10]

Following Angeletos et al. (2016), the welfare loss function comprises two components: output-gap volatility, $\mathrm{Var}(y - y^*)$, and the cross-sectional dispersion of relative-price gaps, $\mathrm{Var}(\tilde{p}_i - \tilde{p}_i^*)$. The latter captures relative-price distortions and can be decomposed as:

$$\mathrm{Var}(\tilde{p}_i - \tilde{p}_i^*) = \mathrm{Var}(\tilde{p}_i) - 2\,\mathrm{Cov}(\tilde{p}_i, \tilde{p}_i^*) + \mathrm{Var}(\tilde{p}_i^*)\,. \tag{12}$$

The first term, $\mathrm{Var}(\tilde{p}_i)$, measures price dispersion, which generates welfare losses by inducing

[9]This assumption distinguishes our framework from the signaling-action literature, in which firms observe the central bank's policy action; see, e.g., Baeriswyl and Cornand (2010). If firms perfectly observed the policy instrument $m$, then, given the central bank's full information, they could infer the aggregate state $a$ whenever $\psi \neq 0$. Welfare would then be independent of the policy action, and the resulting real allocation would be second-best—the same real allocation implemented by the optimal policy in our baseline model, even though firms do not observe $m$. If firms instead observed $m$ through an exogenous noisy signal, the policy action would serve as an additional signal about the aggregate shock. Online Appendix E studies a related dual-signal environment and shows that our main conclusions remain unchanged.

[10]See Online Appendix A.3 for the detailed derivation.

cross-sectional resource misallocation.[11] The third term, $\mathrm{Var}(\tilde{p}_i^*) = \varphi_\vartheta^2 \sigma_\vartheta^2$, is constant and exogenous to policy. The key departure from textbook New Keynesian models without idiosyncratic shocks is the covariance term, $\mathrm{Cov}(\tilde{p}_i, \tilde{p}_i^*)$. With firm-specific demand shocks, efficient relative prices are not uniform: firms facing higher idiosyncratic demand should charge higher relative prices. A larger covariance between equilibrium and efficient relative prices therefore improves welfare. However, increasing this covariance may require greater price dispersion. Minimizing relative-price distortions therefore involves a trade-off between these two forces.[12]

**Timeline.** The model unfolds in four stages. First, the central bank commits to a contingent policy rule. Second, aggregate and idiosyncratic shocks are realized. Third, each firm observes a signal that confounds these shocks and sets its price. Finally, full information is revealed, the central bank implements nominal demand according to its policy rule, the household chooses consumption and labor supply, and goods and labor markets clear.

## 2.2 Equilibrium

We conjecture a linear equilibrium in which the aggregate price level depends on the productivity shock: $p = ka$. Substituting this conjecture, the aggregate demand identity $y = m - p$, and the policy rule $m = \psi a$ into the firm's pricing rule (7), and aggregating across firms yield the price level:

$$p = \varphi_\vartheta \bar{\mathbb{E}}\left[\vartheta_i\right] + \left[\left(1-\varphi_y\right)k + \varphi_y \psi - \varphi_a\right] \bar{\mathbb{E}}\left[a\right], \tag{13}$$

where $\bar{\mathbb{E}}[\,\cdot\,] \equiv \int_0^1 \mathbb{E}_i[\,\cdot\,]\,\mathrm{d}i$ denotes the average expectation operator.

Firm $i$ observes $x_i$ and uses it to infer both aggregate and idiosyncratic shocks. By

[11] The welfare loss due to price dispersion corresponds to the welfare loss due to inflation in the textbook New Keynesian models.

[12] In the limiting case without idiosyncratic shocks, $\sigma_\vartheta^2 = 0$, efficient relative prices are uniform, $\tilde{p}_i^* = 0$. The covariance and constant terms then vanish, and the welfare loss reduces to the standard New Keynesian form, in which welfare losses arise whenever individual prices deviate from the aggregate price.

Bayesian updating, $\mathbb{E}_i[a] = \lambda\sigma_a^2/(\lambda^2\sigma_a^2+\sigma_\vartheta^2+\sigma_\varepsilon^2)\cdot x_i$ and $\mathbb{E}_i[\vartheta_i] = \sigma_\vartheta^2/(\lambda^2\sigma_a^2+\sigma_\vartheta^2+\sigma_\varepsilon^2)\cdot x_i$. Since idiosyncratic shocks and signal noise average out across firms ($\int_0^1 x_i di = \lambda a$), aggregating individual expectations leads to the average expectations:

$$\bar{\mathbb{E}}\left[a\right] = \frac{\lambda^2\sigma_a^2}{\lambda^2\sigma_a^2+\sigma_\vartheta^2+\sigma_\varepsilon^2}a, \quad \bar{\mathbb{E}}\left[\vartheta_i\right] = \frac{\lambda\sigma_\vartheta^2}{\lambda^2\sigma_a^2+\sigma_\vartheta^2+\sigma_\varepsilon^2}a. \tag{14}$$

The expression for $\bar{\mathbb{E}}[\vartheta_i]$ reveals that aggregate shocks induce a systematic bias in firms' perception of idiosyncratic conditions. Because firms cannot fully disentangle the sources of variation in $x_i$, they rationally but mistakenly attribute a portion of aggregate fluctuations to firm-specific demand. Upon aggregation, although idiosyncratic shocks average out, systematic misattribution remains, causing the average belief about idiosyncratic shocks to covary with the aggregate shock. The sign of $\lambda$ governs the direction of this misattribution: a positive (negative) $\lambda$ implies that firms partially attribute an increase in aggregate productivity $a$ to a rise (fall) in their idiosyncratic demand $\vartheta_i$.

Substituting (14) into (13) determines the equilibrium coefficient $k$. The output gap then follows from $y-y^* = m-p-(\varphi_a/\varphi_y)a$. Proposition 1 summarizes the resulting equilibrium.

**Proposition 1** (Equilibrium with exogenous confounding information)**.** *Under the linear policy rule $m = \psi a$, the equilibrium aggregate price level, output gap, and relative price are*

$$p = \left[\left(\psi - \frac{\varphi_a}{\varphi_y}\right)k_w + \lambda R(1-k_w)\right]a, \tag{15}$$

$$y - y^* = \left[\left(\psi - \frac{\varphi_a}{\varphi_y}\right)(1-k_w) - \lambda R(1-k_w)\right]a, \tag{16}$$

$$\tilde{p}_i = \left[\left(\psi - \frac{\varphi_a}{\varphi_y}\right)k_w + \lambda R(1-k_w)\right]\frac{1}{\lambda}\left(\vartheta_i + \varepsilon_i\right), \tag{17}$$

*where*

$$k_w = \frac{\varphi_y\lambda^2\sigma_a^2}{\varphi_y\lambda^2\sigma_a^2+\sigma_\vartheta^2+\sigma_\varepsilon^2}, \quad R = \varphi_\vartheta\frac{\sigma_\vartheta^2}{\sigma_\vartheta^2+\sigma_\varepsilon^2}.$$

*Proof.* See Online Appendix A.4. □

Equation (15) decomposes the response of the aggregate price to aggregate shocks into two distinct components. The first term, $(\psi - \varphi_a/\varphi_y)k_w$, arises from firms' average expectations of the aggregate shock, $\bar{\mathbb{E}}[a]$, reflecting the "right" reason for prices to respond to aggregate shocks in the sense of Hellwig and Venkateswaran (2009). The second term, $\lambda R(1-k_w)$, stems from firms' average expectations of idiosyncratic demand shocks, $\bar{\mathbb{E}}[\vartheta_i]$, and corresponds to what they term the "wrong" reason for price adjustment.[13] Equation (16) shows that the same term, $\lambda R(1-k_w)$, also distorts the equilibrium output gap. Equation (17) reveals that equilibrium relative prices are driven by the idiosyncratic components of the signal, $\vartheta_i + \varepsilon_i$, which can be interpreted as the firm's relative belief. The term in brackets is identical to the response coefficient of the aggregate price in equation (15). Finally, the term $R$ scales $\varphi_\vartheta$ by the signal-to-noise ratio of the idiosyncratic demand shock, thereby measuring the strength of firms' idiosyncratic motives for price adjustment.

This decomposition makes the policy trade-off transparent. Define the aggregate price response driven by the "wrong" reason as the misattribution wedge, $\mathcal{W} \equiv \lambda R(1-k_w)a$. The wedge originates from firms' beliefs about idiosyncratic demand and is therefore independent of the policy coefficient $\psi$. Monetary policy can offset its effect in either the price equation or the output-gap equation, but not in both. This is because $\mathcal{W}$ enters (15) and (16) with opposite signs, whereas a change in $\psi$ moves the aggregate price level and the output gap in the same direction.

Setting the bracketed terms in (15) and (16) to zero yields the policy coefficients for price stabilization and output-gap stabilization:

$$\psi^p = \frac{\varphi_a}{\varphi_y} - \lambda R \frac{1-k_w}{k_w} \quad \text{and} \quad \psi^y = \frac{\varphi_a}{\varphi_y} + \lambda R, \tag{18}$$

respectively. Under the baseline assumptions of idiosyncratic shocks ($\sigma_\vartheta^2 > 0$), confounding information ($\lambda \neq 0$), and firms' pricing response to idiosyncratic demand ($\varphi_\vartheta \neq 0$), we have

[13] In Online Appendix A.4, we provide an alternative derivation using the method of higher-order expectations and show that the coefficient $\lambda R(1-k_w)$ captures the cumulative contribution of firms' first- and higher-order average expectations regarding idiosyncratic shocks.

$\lambda R \neq 0$, so the two policy coefficients differ. Price stabilization requires the central bank to offset the misattribution wedge in the price equation, which leaves the output gap exposed to it. Stabilizing the output gap instead requires the price level to absorb the wedge. Therefore, no single policy instrument can simultaneously stabilize the price level and the output gap.

**Restoring the Divine Coincidence.** The standard divine coincidence is restored when the misattribution wedge vanishes. If idiosyncratic demand shocks are absent ($\sigma_\vartheta^2 = 0$), firms have no firm-specific demand component to misattribute aggregate shocks to. If firms do not respond to idiosyncratic demand ($\varphi_\vartheta = 0$), any such misattribution does not affect prices. If the signal is not confounding ($\lambda = 0$), it contains no aggregate component: $x_i = \vartheta_i + \varepsilon_i$, so average beliefs about idiosyncratic demand do not move with $a$. In each case, $R = 0$ or $\lambda = 0$, so $\mathcal{W} = 0$. The policy that sets $\psi = \varphi_a/\varphi_y$ then simultaneously stabilizes the price level and closes the output gap.

## 2.3 Optimal Monetary Policy

The central bank chooses the policy coefficient $\psi$ to minimize the expected welfare loss in (11). Equation (16) shows that $\psi^y$ in (18) closes the output gap. We now show that $\psi^y$ also minimizes the second component of welfare loss: the cross-sectional dispersion of relative price gaps.

Minimizing the dispersion of the relative price gap, $\mathrm{Var}(\tilde{p}_i - \tilde{p}_i^*)$, is equivalent to a signal extraction problem. Cross-sectional efficiency requires the equilibrium relative price $\tilde{p}_i$ to track its efficient counterpart, $\tilde{p}_i^* = \varphi_\vartheta \vartheta_i$. As shown in (17), $\tilde{p}_i$ is driven by the idiosyncratic component of the signal, $(\vartheta_i + \varepsilon_i)$. Due to the presence of signal noise, the best the central bank can do is to choose $\psi$ such that $\tilde{p}_i$ matches the optimal linear projection of $\tilde{p}_i^*$ onto this signal component:

$$\mathbb{E}\left[\tilde{p}_i^* | \vartheta_i + \varepsilon_i\right] = \varphi_\vartheta \frac{\sigma_\vartheta^2}{\sigma_\vartheta^2 + \sigma_\varepsilon^2}(\vartheta_i + \varepsilon_i) = R(\vartheta_i + \varepsilon_i). \tag{19}$$

Thus, the policy that minimizes relative-price distortions is the one that sets the coefficient on $(\vartheta_i + \varepsilon_i)$ in (17) equal to $R$. This condition is satisfied exactly by $\psi^y$. Hence the policy that eliminates output gap volatility also minimizes the dispersion of relative price gaps. The following proposition formalizes this result.

**Proposition 2** (Optimal policy with exogenous confounding information)**.** (i) *Under the confounding information structure, the optimal monetary policy follows a linear policy rule:*

$$m = \psi^* a, \quad \textit{with} \quad \psi^* = \psi^y = \frac{\varphi_a}{\varphi_y} + \lambda R.$$

*This policy fully closes the output gap, $y = y^*$, and minimizes the cross-sectional dispersion of relative price gaps,* $\mathrm{Var}(\tilde{p}_i - \tilde{p}_i^*)$*. The aggregate price level and relative price are given by*

$$p = \lambda R\, a, \tag{20}$$

$$\tilde{p}_i = R\left(\vartheta_i + \varepsilon_i\right). \tag{21}$$

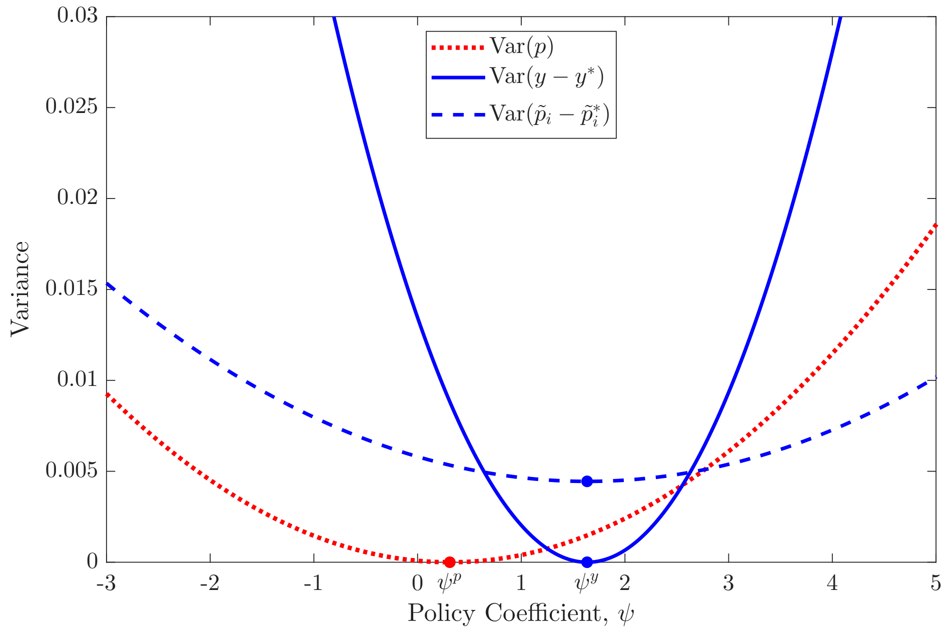
(ii) *Since $R > 0$, the price level and output are positively correlated when $\lambda > 0$ and negatively correlated when $\lambda < 0$.*

*Proof.* See Online Appendix A.5. ☐

Proposition 2 shows that the optimal policy simultaneously closes the output gap and minimizes relative-price distortions. This coincidence between aggregate and cross-sectional efficiency, however, is not implemented by price stability. Under confounding information, strict price stability forces the output gap to absorb the misattribution wedge, generating output-gap volatility. Figure 1 illustrates this result numerically.

The optimal policy neutralizes the allocative effects of the information friction regarding the aggregate shock. It replicates the allocation that would prevail if firms observed both the confounding signal $x_i$ and the aggregate state $a$. Conditional on $a$, firms can infer the

**Fig. 1:** Policy Trade-off with Exogenous Confounding Information




*Note:* The figure plots the equilibrium variances of key variables against the monetary policy coefficient, $\psi$. The red dotted line represents the aggregate price level variance, Var($p$). The blue solid and dashed lines represent the variances of the output gap, Var($y - y^*$), and the relative price gap, Var($\tilde{p}_i - \tilde{p}_i^*$), respectively. Markers on the horizontal axis denote the coefficients for price stabilization ($\psi^p$) and the optimal policy ($\psi^*$). Calibration parameters are: $\gamma = 0.2$, $\epsilon = 1$, $\theta = 0.5$, $\rho = 4$, $\lambda = 10$, $\sigma_a^2 = 0.01$, $\sigma_\vartheta^2 = 0.1$, and $\sigma_\varepsilon^2 = 0.5$.

idiosyncratic component $\vartheta_i + \varepsilon_i$ from their signal. The only remaining friction is the signal noise $\varepsilon_i$, which keeps the allocation second-best.

The cyclicality of the optimal price level is governed by the direction of firms' systematic misattribution. When $\lambda > 0$ ($\lambda < 0$), firms partially attribute an increase in aggregate productivity to higher (lower) idiosyncratic demand, generating a procyclical (countercyclical) misattribution wedge. Aggregate efficiency requires the price level to accommodate this wedge in order to close the output gap.

The same conclusion follows from cross-sectional efficiency. Equation (19) implies that firms' relative prices should covary with their relative beliefs, $\vartheta_i + \varepsilon_i$. Accordingly, firms that perceive higher idiosyncratic demand should set higher prices. Aggregating across firms, the price level should move with firms' average belief about idiosyncratic demand, $\bar{\mathbb{E}}[\vartheta_i]$, which underlies the misattribution wedge and shares its cyclicality. Thus, the optimal price level is procyclical when $\lambda > 0$ and countercyclical when $\lambda < 0$.

In the New Keynesian framework, the divine coincidence fails when markup shocks are not offset by state-contingent subsidies. Such shocks generate a trade-off between stabilizing the output gap and stabilizing inflation, and optimal policy typically implies a negative relation between the price level and real activity. In our framework, by contrast, there are no markup shocks. Instead, the failure of the divine coincidence stems from firms' confounding of aggregate and idiosyncratic fundamental shocks. The optimal policy stabilizes the output gap, while the optimal price level can be either procyclical or countercyclical depending on the sign of $\lambda$.

**An Alternative Interpretation.** The optimal policy can also be interpreted as aligning firms' full-information prices with their confounding signal.[14] The full-information target price associated with the firm's pricing rule (7) is

$$p_i^{\diamond} \equiv p + \varphi_y y - \varphi_a a + \varphi_\vartheta \vartheta_i. \tag{22}$$

This target price is a linear combination of aggregate and idiosyncratic shocks. By shaping the equilibrium outcomes $(p, y)$, monetary policy changes the relative weight of the aggregate shock in this target price.

To see the mechanism most clearly, consider the noise-free case, $\sigma_\varepsilon^2 = 0$. Under the optimal policy, $y = y^*$ and $p = \lambda \varphi_\vartheta a$, so $p_i^{\diamond} = \varphi_\vartheta(\lambda a + \vartheta_i)$, which is proportional to the firm's confounding signal $x_i = \lambda a + \vartheta_i$. Thus, even though firms cannot disentangle aggregate from idiosyncratic shocks, their confounding signal is exactly the sufficient statistic for their target price. Each firm can therefore set its price equal to its target, and the optimal policy implements the first-best allocation.[15]

This interpretation also distinguishes the optimal monetary policy studied here from cen-

[14]To sustain the full-information prices as the equilibrium pricing strategy in an incomplete-information environment, firms only need access to information sufficient to compute these full-information prices.

[15]With signal noise ($\sigma_\varepsilon^2 > 0$), the optimal policy instead sets the relative weight on the aggregate shock in $p_i^{\diamond}$ below $\lambda$, reflecting the Bayesian discounting of the noisy signal. See Online Appendix A.6.

tral bank communication. If the central bank could disclose the aggregate shock $a$ without noise and firms could fully process this information and incorporate it into their pricing decisions, the resulting allocation would coincide with that implemented by the optimal policy. Public communication policies, however, hinge on firms' attention and information-processing capacity. Recent survey evidence (e.g., Coibion et al. (2018) and Candia et al. (2024)) suggests that firm managers are largely uninformed about aggregate inflation dynamics or monetary policy. By contrast, the optimal policy here does not require firms to process additional public information. It reshapes equilibrium outcomes so that firms' existing local signals are sufficient for efficient pricing decisions.

**Comparison with Separable Information.** We contrast the baseline results with a separable information structure, with formal derivations provided in Online Appendix A.7. Suppose firms observe aggregate and idiosyncratic shocks through independent signals, $s_i^a = a + e_i^a$ and $s_i^\vartheta = \vartheta_i + e_i^\vartheta$.[16] In this case, firms do not attribute aggregate conditions to idiosyncratic demand shocks, so the misattribution wedge disappears and the divine coincidence is restored. The optimal policy is simply given by $\psi^* = \varphi_a/\varphi_y$, which simultaneously stabilizes the price level and the output gap. This comparison shows that the deviation from price stability in the baseline model is driven by the confounding nature of firms' information, rather than by dispersed information or idiosyncratic shocks alone.

## 2.4 Welfare Analysis

We now compare the welfare implications of price stabilization and the optimal policy. The unique policy coefficient that implements strict price stability is $\psi^p$ in (18). Under this policy, firms no longer condition individual prices on their confounding information, so individual prices are stabilized, $p_i = p = 0$. Price stabilization therefore eliminates price dispersion,

[16]Such separable information structures are common in the rational-inattention literature; see, e.g., Maćkowiak and Wiederholt (2009), Pasten and Schoenle (2016), and Gondhi (2023).

but forces the output gap to absorb the misattribution wedge:

$$y - y^* = -\frac{\varphi_\vartheta}{\varphi_y}\frac{\sigma_\vartheta^2}{\lambda\sigma_a^2}a. \tag{23}$$

The expected welfare losses under the optimal policy, $\mathbb{EL}^*$, and under price stabilization, $\mathbb{EL}^p$, are

$$\mathbb{EL}^* = \frac{\rho\varphi_\vartheta^2}{\varphi_y}\frac{\sigma_\vartheta^2\sigma_\varepsilon^2}{\sigma_\vartheta^2+\sigma_\varepsilon^2}, \qquad \mathbb{EL}^p = \frac{\rho\varphi_\vartheta^2}{\varphi_y}\sigma_\vartheta^2 + \frac{\varphi_\vartheta^2}{\varphi_y^2}\frac{(\sigma_\vartheta^2)^2}{\lambda^2\sigma_a^2}.$$

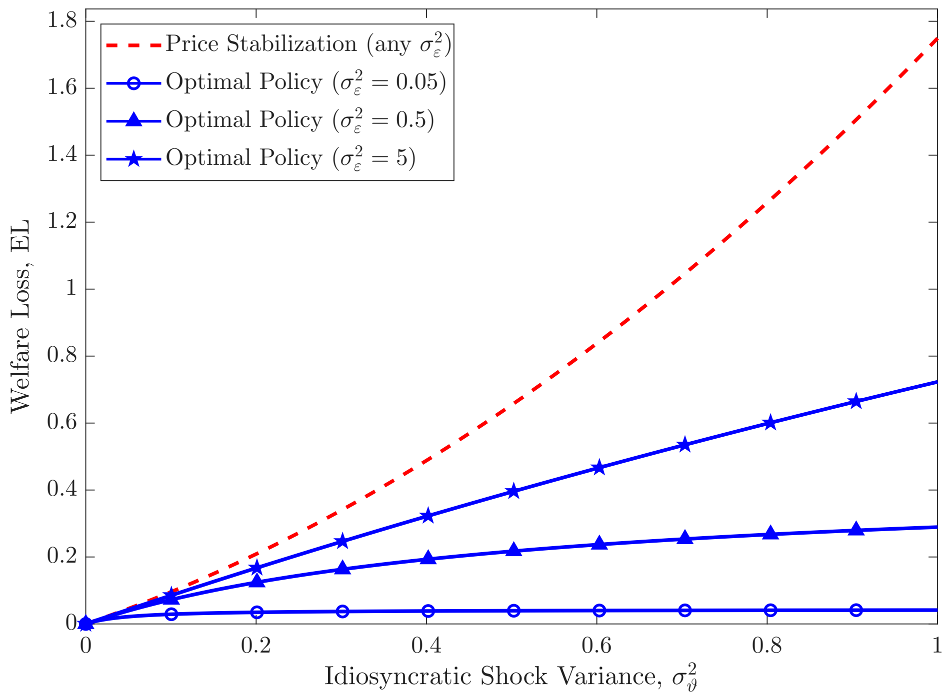
Because the optimal policy closes the output gap and minimizes relative-price distortions, its welfare loss reflects only residual distortions due to signal noise. By contrast, price stabilization generates larger relative-price distortions, as reflected in the first term of $\mathbb{EL}^p$. Although this policy eliminates price dispersion, it also prevents equilibrium relative prices from adjusting to their efficient counterparts, implying $\text{Cov}(\tilde{p}_i, \tilde{p}_i^*) = 0$. The resulting misalignment more than offsets the welfare gain from eliminating price dispersion. The second term in $\mathbb{EL}^p$ reflects aggregate inefficiency from the output-gap volatility in (23). Hence, price stabilization is suboptimal in this environment.

Figure 2 shows that the welfare gap between price stabilization and the optimal policy widens with the variance of idiosyncratic demand shocks, $\sigma_\vartheta^2$, reflecting the growing cost of suppressing firms' responses to their confounding information. For the same reason, welfare losses under price stabilization are invariant to the noise variance, $\sigma_\varepsilon^2$. Under the optimal policy, by contrast, a higher $\sigma_\varepsilon^2$ reduces the informativeness of $x_i$ about $\vartheta_i$, increasing relative-price distortions. The welfare gap therefore narrows as the noise variance increases.

# 3 Microfoundations for Confounding Signals

The baseline model takes the signal loading $\lambda$, which governs the direction of firms' misattribution, as exogenous. This section derives $\lambda$ from two information environments. When firms learn from local demand, $\lambda$ is endogenous and policy-dependent: output-gap stabilization

**Fig. 2:** Welfare Losses vs. Idiosyncratic Shock Variance




*Note:* The figure plots expected welfare losses against the idiosyncratic shock variance, $\sigma_\vartheta^2$. The red dashed line represents price stabilization, whose welfare loss is invariant to signal noise. The solid blue lines correspond to the optimal policy for the three noise variances $\sigma_\varepsilon^2 \in \{0.05, 0.5, 5\}$. Calibration parameters are: $\gamma = 0.2$, $\epsilon = 1$, $\theta = 0.5$, $\rho = 4$, $\sigma_a^2 = 0.01$, and $\lambda^2 = 100$.

implies $\lambda > 0$, while price stabilization implies $\lambda = 0$. When firms learn from productivity, the signal structure implies $\lambda < 0$.

## 3.1 Learning from Market Demand

We first consider an environment in which firms learn from local market interactions. When firm $i$ sets its price $p_i$, it observes the demand for its own good, $y_i$, but cannot directly observe aggregate output $y$ or the price level $p$.

Log-linearizing the household demand schedule (4) yields the demand curve faced by firm $i$:

$$y_i = (\rho p + y + \vartheta_i) - \rho p_i.$$

Firm $i$ observes its demand with idiosyncratic noise $\varepsilon_i$. Combining this noisy observation with its own price, the firm constructs the demand signal:

$$x_i = (y_i + \varepsilon_i) + \rho p_i = \rho p + y + \vartheta_i + \varepsilon_i. \tag{24}$$

The signal combines the idiosyncratic demand shock $\vartheta_i$ with the aggregate term $\rho p + y$, so firm $i$ cannot disentangle these two components, even in the absence of signal noise. Local demand therefore naturally generates a confounding signal.

We conjecture a linear equilibrium in which the aggregate component of the demand signal satisfies $\rho p + y = \lambda a$. Under this conjecture, (24) takes the same form as the baseline signal in (9). In contrast to the baseline model, however, $\lambda$ is endogenous: it is both the loading of the aggregate shock in firms' signals and the equilibrium response of the aggregate signal component to that shock. It is therefore determined by the monetary policy regime.

**Optimal Monetary Policy.** The following proposition characterizes the optimal monetary policy under this microfounded information structure.

**Proposition 3** (Optimal policy with demand signals)**.** (i) *When firms observe the demand signal $x_i$, there exists a unique optimal monetary policy: $m = \psi^* a$, where*

$$\psi^* = \psi^y = \frac{\varphi_a}{\varphi_y} + \lambda R, \quad \textit{with} \quad \lambda = \frac{\sigma_\vartheta^2 + \sigma_\varepsilon^2}{(1 - \rho\varphi_\vartheta)\,\sigma_\vartheta^2 + \sigma_\varepsilon^2}\frac{\varphi_a}{\varphi_y}.$$

*Under this policy, the equilibrium allocation features a closed output gap, $y = y^*$, and the aggregate price level and relative price satisfy:*

$$p = \lambda R a, \quad \tilde{p}_i = R(\vartheta_i + \varepsilon_i).$$

(ii) *Since $1 - \rho\varphi_\vartheta > 0$, the signal loading $\lambda$ is strictly positive. The optimal policy therefore induces a positive correlation between the price level and output.*

*Proof.* See Online Appendix B.1. □

Proposition 3 shows that, when firms' information arises endogenously from local demand, the optimal policy implements the same real allocation as in the baseline: it fully stabilizes the output gap and minimizes relative-price distortions. The main difference is that the signal loading is no longer primitive. It is determined in equilibrium by monetary policy and structural parameters. Under the optimal policy, this endogenous loading is strictly positive, so the aggregate price level moves procyclically with output. This endogeneity gives monetary policy a dual role. It shapes both how firms' target prices respond to aggregate shocks and how their demand signals load on aggregate shocks. The optimal policy aligns target prices with demand signals, making these signals sufficient for efficient pricing.

**Welfare Analysis.** We next compare the welfare implications of price stabilization and the optimal policy in the demand-signal specification. Under the sufficient conditions stated in Online Appendix B.2, the unique policy coefficient that implements strict price stability is $\psi = 0$.[17] The resulting allocation features a stable price level and stable output, $p = y = 0$. The demand signal then reduces to $x_i = \vartheta_i + \varepsilon_i$, so firms' information is purely idiosyncratic. Since $p = 0$, relative prices equal posted prices and satisfy $\tilde{p}_i = p_i = R(\vartheta_i + \varepsilon_i)$, the optimal linear projection of efficient relative prices. Thus, unlike in the baseline model, price stabilization minimizes relative-price distortions and achieves cross-sectional efficiency. It does so, however, at the cost of aggregate inefficiency: output is fixed at $y = 0$, whereas the efficient level $y^* = (\varphi_a/\varphi_y)a$ varies with aggregate shocks.

The expected welfare losses under the optimal policy, $\mathbb{EL}^*$, and under price stabilization, $\mathbb{EL}^p$, are

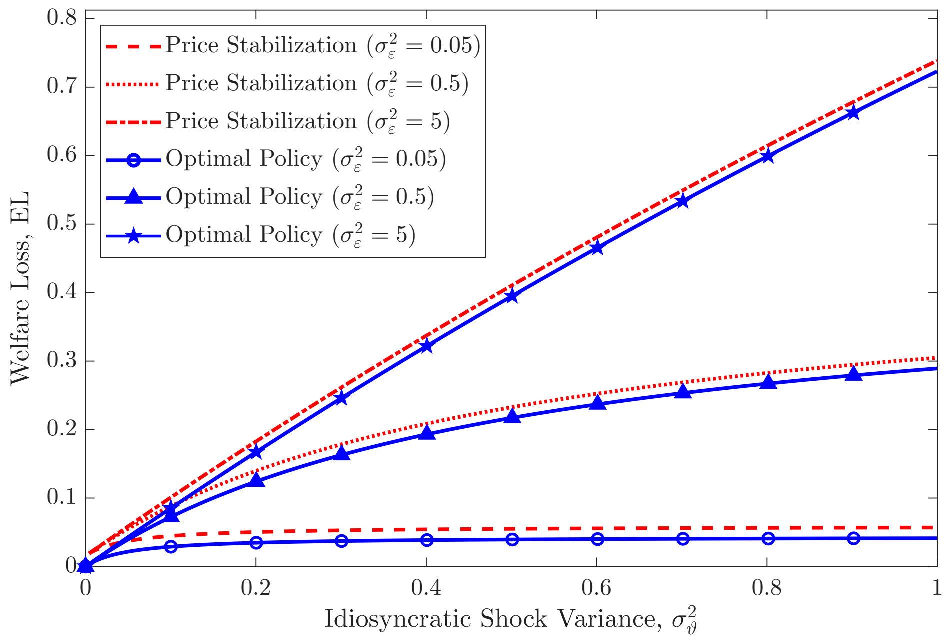
$$\mathbb{EL}^* = \frac{\rho\varphi_\vartheta^2}{\varphi_y}\frac{\sigma_\vartheta^2\sigma_\varepsilon^2}{\sigma_\vartheta^2+\sigma_\varepsilon^2}, \qquad \mathbb{EL}^p = \frac{\rho\varphi_\vartheta^2}{\varphi_y}\frac{\sigma_\vartheta^2\sigma_\varepsilon^2}{\sigma_\vartheta^2+\sigma_\varepsilon^2} + \frac{\varphi_a^2}{\varphi_y^2}\sigma_a^2.$$

Since the optimal policy implements the same real allocation as in the baseline model, $\mathbb{EL}^*$ remains unchanged. Under price stabilization, the first term of $\mathbb{EL}^p$ coincides with $\mathbb{EL}^*$ because this policy minimizes relative-price distortions. The second term reflects the

[17] These conditions require a sufficiently large idiosyncratic-to-aggregate shock variance ratio, $\sigma_\vartheta^2/\sigma_a^2$, consistent with micro-price evidence that firm-level fluctuations are much larger than aggregate fluctuations.

output-gap volatility from fixing output at $y = 0$. Hence, the welfare gap depends only on the variance of aggregate shocks and is independent of $\sigma_\vartheta^2$ and $\sigma_\varepsilon^2$, as illustrated in Figure 3.

**Fig. 3:** Welfare Losses vs. Idiosyncratic Shock Variance (Demand Signals)




*Note:* The figure plots the expected welfare losses against the idiosyncratic shock variance, $\sigma_\vartheta^2$, under the demand-signal specification. The red dashed lines represent the price stabilization, plotted only for the range where the policy existence condition holds ($\sigma_\vartheta^2 > 0.0042$). The blue solid lines represent the optimal policy. The different line styles correspond to varying levels of signal noise variance, $\sigma_\varepsilon^2 \in \{0.05, 0.5, 5\}$. Calibration parameters are set to: $\gamma = 0.2$, $\epsilon = 1$, $\theta = 0.5$, $\rho = 4$, and $\sigma_a^2 = 0.01$.

**Relation to Literature.** Our demand-signal framework is related to Benhima and Blengini (2020), where firms also learn from endogenous market outcomes. The key difference lies in the nature of the informational friction and, consequently, in the role of monetary policy. Their model abstracts from idiosyncratic fundamental shocks, and firms' demand signals confound real and nominal aggregate shocks. The central bank seeks to make demand signals more informative about real aggregate shocks. In our model, by contrast, firms' demand signals confound aggregate productivity with idiosyncratic demand. The role of monetary policy is not to maximize the informativeness of signals about a particular shock, but to induce an efficient weighting of aggregate and idiosyncratic components in firms' signals.

Models in which agents learn from endogenous market signals often involve fixed-point problems that give rise to multiple rational expectation equilibria (e.g., Benhabib et al. (2017); Chahrour and Gaballo (2021)). Our demand-signal framework also features this possibility: solving for the equilibrium price response yields a cubic equation whose number of real roots depends on the monetary policy coefficient (see Online Appendix B.1). Proposition 3 shows that the optimal policy selects a unique equilibrium. This differs from Chahrour and Gaballo (2021), where multiplicity depends on structural parameters such as the labor share in construction.

## 3.2 Learning from Productivity

This subsection examines an alternative microfoundation based on productivity signals. To isolate this mechanism, we abstract from idiosyncratic demand shocks (setting $\sigma_\vartheta^2 = 0$) and instead introduce firm-specific productivity shocks. Firms operate with the production technology, $Y_i = A_i N_i^\theta$, where $A_i$ denotes firm-specific productivity. Let $a_i \equiv \log A_i$ denote firm $i$'s log productivity, which consists of an aggregate and an idiosyncratic component:

$$a_i = a + \xi_i, \tag{25}$$

where $\xi_i \sim \mathcal{N}(0, \sigma_\xi^2)$ is an idiosyncratic productivity shock that is independent of $a$ and i.i.d. across firms. The rest of the model follows the baseline setup.

Log-linearizing the firm's optimal pricing condition gives

$$p_i = \mathbb{E}_i \left[ p + \varphi_y y - \varphi_a a - \varphi_a \xi_i \right]. \tag{26}$$

This expression mirrors the baseline pricing rule (7), with the idiosyncratic demand term $\varphi_\vartheta \vartheta_i$ replaced by the idiosyncratic productivity term $-\varphi_a \xi_i$. As shown in Online Appendix A.3, this structural change leaves the form of the welfare loss function (11) and the efficient aggregate output $y^*$ unchanged. However, the efficient relative price is now driven by firm-specific productivity:

$$\tilde{p}_i^* = -\varphi_a \xi_i.$$

Intuitively, a firm with higher idiosyncratic productivity has lower marginal cost and therefore requires a lower relative price in the efficient allocation.

Firm $i$ observes its own productivity $a_i$ with noise $\varepsilon_i$.[18] Given that the efficient relative price is decreasing in $\xi_i$, we define the firm's productivity signal $x_i$ as the negative of its observed productivity, plus noise:

$$x_i = -a_i + \varepsilon_i = -a - \xi_i + \varepsilon_i. \tag{27}$$

Both the signal and the efficient relative price are decreasing in $\xi_i$, preserving the same qualitative mapping as in the baseline model. This formulation microfounds a negative signal loading on the aggregate shock, $\lambda = -1$.

**Optimal Monetary Policy.** The productivity-signal economy is isomorphic to the baseline framework under the mapping $\vartheta_i \mapsto -\xi_i$, $\varphi_\vartheta \mapsto \varphi_a$, $\sigma_\vartheta^2 \mapsto \sigma_\xi^2$, and $\lambda = -1$. The optimal policy therefore follows directly from Proposition 2.

**Proposition 4** (Optimal policy with productivity signals)**.** *When firms face idiosyncratic productivity shocks and learn from their own productivity, the unique optimal monetary policy coefficient is*

$$\psi^* = \frac{\varphi_a}{\varphi_y} - \varphi_a \frac{\sigma_\xi^2}{\sigma_\xi^2 + \sigma_\varepsilon^2}.$$

*This policy fully closes the output gap, $y = y^*$, and minimizes the cross-sectional dispersion of relative price gaps,* $\mathrm{Var}(\tilde{p}_i - \tilde{p}_i^*)$*. The aggregate price level and relative price are given by*

$$p = -\varphi_a \frac{\sigma_\xi^2}{\sigma_\xi^2 + \sigma_\varepsilon^2} a, \qquad \tilde{p}_i = \varphi_a \frac{\sigma_\xi^2}{\sigma_\xi^2 + \sigma_\varepsilon^2} \left(-\xi_i + \varepsilon_i\right).$$

[18] The assumption that agents observe noisy signals of their own fundamentals is common in models with uncertain heterogeneous valuations; see, e.g., Angeletos and Pavan (2009), Vives (2011), and Rostek and Weretka (2012).

*Hence, the optimal price level is countercyclical.*

Proposition 4 shows that the optimal policy in the productivity-signal economy again stabilizes the output gap and minimizes relative-price distortions. Since the direction of misattribution is negative, $\lambda = -1 < 0$, the optimal price level is countercyclical. Online Appendix F.3 shows that price stability generates quantitatively large welfare losses, as the smaller signal loading, $\lambda^2 = 1$ rather than $\lambda^2 = 100$ in the baseline calibration of Figure 2, amplifies output-gap volatility.

**Relation to Literature.** Several studies on optimal monetary policy under information frictions consider settings in which firms observe their own productivity, including Lorenzoni (2010), Angeletos and La'O (2020), and Jia (2025).[19] These settings correspond to the noise-free limit of our productivity-signal environment, $\sigma_\varepsilon^2 = 0$. As Proposition 4 shows, the optimal policy then stabilizes the output gap, replicates the first-best allocation, and implies a countercyclical price level.

Our analysis is related to these papers, but differs in emphasis. Lorenzoni (2010) also identifies the optimality of output-gap stabilization in a related environment, although his analysis does not examine whether this requires a deviation from price stability.[20] Angeletos and La'O (2020, Section VII) provide an example in which the optimal policy targets a negative correlation between the price level and output. Their example, however, combines two distinct mechanisms that can generate this result: informational friction in production decisions, which they emphasize, and confounding information in price-setting decisions, which this paper isolates.[21] Jia (2025) considers productivity signals in firms' pricing decisions, but does not characterize output-gap stabilization as optimal.

[19] This assumption is also common in the incomplete-information business-cycle literature; see, e.g., Lorenzoni (2009), Angeletos and La'O (2010), and Nimark (2014).

[20] The main model in Lorenzoni (2010) features segmented goods markets, which makes output-gap stabilization suboptimal. The result cited here applies to a version of his model without market segmentation.

[21] The main model in Angeletos and La'O (2020) focuses on informational frictions in production and abstracts from idiosyncratic fundamental shocks and confounding information. A specification incorporating both mechanisms appears in their illustrative example in Section VII.

Taken together, these papers help rationalize a countercyclical price level—or "leaning against the wind"—when firms learn from productivity. Our contribution is to show that the cyclicality of the optimal price level depends on the direction of firms' misattribution. The optimal price level is countercyclical when $\lambda < 0$, as in the productivity-signal case, but procyclical—or "leans with the wind"—when $\lambda > 0$.

# 4 Extensions

This section considers two extensions of the baseline information structure: endogenous information acquisition and non-fundamental sentiment shocks.

## 4.1 Elastic Attention

In the baseline model, signal noise $\varepsilon_i$ is exogenous. We now allow firms to choose how much attention they devote to processing relevant information.[22] As in the rational inattention literature (e.g., Sims (2010), Paciello and Wiederholt (2014), and Luo et al. (2017)), agents face a trade-off: greater attention improves signal precision but entails a cognitive cost.

**The Firm's Attention Problem.** Before observing any shocks, firm $i$ chooses how much attention it devotes to the confounding bundle $(\lambda a + \vartheta_i)$ to maximize its expected profit net of information costs. The firm then receives a signal $x_i = \lambda a + \vartheta_i + \varepsilon_i$ with the chosen precision and sets its price.[23]

As shown in Online Appendix C.1, the firm's problem is equivalent to minimizing the

[22] If attention were exogenously fixed, monetary policy would not affect signal precision. Propositions 1 and 2 from the baseline model would continue to hold.

[23] Unlike benchmark rational-inattention models, where agents flexibly choose signal structures (e.g., Miao et al. (2022)), firms here take the confounding bundle as given and choose only signal precision. Maćkowiak and Wiederholt (2009, Section VII) note that if firms could freely pay attention to any linear combination of aggregate and idiosyncratic conditions, the optimal signal would be the profit-maximizing price, $p_i^\diamond$, plus noise. They argue, however, that such information structures are likely to be very special.

expected profit loss from pricing errors plus information-processing costs:

$$\min_{\kappa_i \geq 0} \quad \mathbb{E}\left[\frac{\omega}{2}(p_i - p_i^{\diamond})^2\right] + f(\kappa_i), \tag{28}$$
$$\text{subject to: } \mathcal{H}(\lambda a + \vartheta_i) - \mathcal{H}(\lambda a + \vartheta_i | x_i) = \kappa_i.$$

Here, $\kappa_i$ denotes the amount of information acquired by firm $i$, $p_i^{\diamond}$ is the full-information target price in (22), $\mathcal{H}(\cdot)$ is the entropy function, and $\omega \equiv \rho\bar{Y}[1 + (1-\theta)\rho/\theta]$, with $\bar{Y} = \theta^{1/(\gamma-1+(1+\epsilon)/\theta)}$ denoting steady-state output. Following Paciello and Wiederholt (2014), we assume an exponential attention cost, $f(\kappa_i) = \mu \exp(2\kappa_i)$, where $\mu > 0$ governs the marginal cost of information processing.[24]

**Equilibrium.** We focus on a symmetric equilibrium in which all firms choose the same attention level, $\kappa_i = \kappa$. Online Appendix C.2 shows that equilibrium attention depends on the monetary policy coefficient $\psi$. In particular, there exists an inattention interval, $[\psi^-, \psi^+]$, over which firms optimally choose not to acquire information.[25] For $\psi \in [\psi^-, \psi^+]$, the aggregate component of the target price $p_i^{\diamond}$ is not sufficiently volatile to incentivize firms to pay attention: the marginal benefit of attention at $\kappa = 0$ is below its marginal cost. Firms therefore choose $\kappa = 0$, and the aggregate price level is stable, $p = 0$. This interval also characterizes the set of price-stabilization policies. For $\psi \notin [\psi^-, \psi^+]$, the aggregate component of $p_i^{\diamond}$ is sufficiently volatile to induce attention. Firms then choose $\kappa > 0$ and condition prices on their signals $x_i$, so the aggregate price level responds to aggregate shocks.

The divine coincidence fails when output-gap stabilization induces firms to acquire infor-

[24]Online Appendix C.2 considers a general attention cost function and derives sufficient conditions for equilibrium uniqueness. The exponential specification adopted here satisfies these conditions.

[25]The endpoints of the inattention interval are

$$\psi^{\pm} \equiv \frac{\varphi_a}{\varphi_y} - \frac{\varphi_\vartheta}{\varphi_y}\frac{\sigma_\vartheta^2}{\lambda\sigma_a^2} \pm \frac{1}{\varphi_y}\sqrt{\frac{2\mu(\lambda^2\sigma_a^2 + \sigma_\vartheta^2)}{\omega\lambda^2\sigma_a^4}}.$$

mation, which occurs if

$$\underbrace{\omega\frac{\varphi_{\vartheta}^{2}\sigma_{\vartheta}^{4}}{\lambda^{2}\sigma_{a}^{2}+\sigma_{\vartheta}^{2}}}_{\text{Marginal Benefit}} > \underbrace{2\mu}_{\text{Marginal Cost}} . \tag{29}$$

This condition compares the marginal benefit and marginal cost of information acquisition at $\kappa = 0$ under output-gap stabilization. When this condition holds, the unique output-gap-stabilization policy lies outside the inattention interval and is given by

$$\psi^{y} = \frac{\varphi_{a}}{\varphi_{y}} + \lambda\varphi_{\vartheta} - \lambda\sqrt{\frac{2\mu\left(\lambda^{2}\sigma_{a}^{2}+\sigma_{\vartheta}^{2}\right)}{\omega\sigma_{\vartheta}^{4}}}.$$

Under this policy, firms acquire information, $\kappa > 0$, the output gap is fully stabilized, and the aggregate price level fluctuates. As in the baseline model, the cyclicality of the price level depends on the sign of $\lambda$. Online Appendix C.3 shows that output-gap stabilization dominates price stabilization in this regime.

If $\omega\varphi_{\vartheta}^{2}\sigma_{\vartheta}^{4}/(\lambda^{2}\sigma_{a}^{2}+\sigma_{\vartheta}^{2}) \leq 2\mu$, the unique policy coefficient that stabilizes the output gap is $\psi_{0}^{y} = \varphi_{a}/\varphi_{y}$, which lies inside the inattention interval. Under this policy, firms remain inattentive, $\kappa = 0$, and both the output gap and the aggregate price level are fully stabilized. The divine coincidence is therefore restored.

**Quantitative Exploration.** We numerically evaluate the plausibility of condition (29). We use the productivity-signal microfoundation from Section 3.2, which implies the mappings $\varphi_{\vartheta} \mapsto \varphi_{a}$, $\sigma_{\vartheta}^{2} \mapsto \sigma_{\xi}^{2}$, and $\lambda = -1$. We set $\gamma = 0.2$, $\epsilon = 1$, $\theta = 0.5$, $\rho = 4$, and $\sigma_{\xi} = 0.15$, and impose $\sigma_{a}^{2}/\sigma_{\xi}^{2} = 0.01$, consistent with micro-price evidence that idiosyncratic volatility is an order of magnitude larger than aggregate volatility. Under this calibration, condition (29) reduces to $\mu < 0.017$. Information costs are typically estimated to be small in the rational inattention literature.[26] These values comfortably satisfy condition (29). Using $\mu = 0.003$, firms acquire $\kappa^{y} \approx 0.436$ nats of information under output-gap stabilization and a slightly

[26] Maćkowiak and Wiederholt (2015) solve a DSGE model with rational inattention and show that values of $\mu/\omega$ between $1 \times 10^{-4}$ and $2 \times 10^{-4}$ match various empirical impulse responses of prices to shocks. With $\omega \approx 16.1$ in our calibration, this implies $\mu \in [0.0016, 0.0032]$.

larger amount under the optimal policy ($\kappa^* \approx 0.437$ nats), whereas under price stabilization firms optimally choose not to acquire any information.[27]

**Optimal Monetary Policy.** We solve for the optimal policy coefficient $\psi^*$ that minimizes the welfare loss.

**Proposition 5** (Optimal policy under rational inattention)**.** *The optimal policy is characterized by the following two regimes:*

(i) *Incentivizing attention regime: If the model parameters satisfy*

$$\omega \frac{\varphi_\vartheta^2 \sigma_\vartheta^4}{\lambda^2 \sigma_a^2 + \sigma_\vartheta^2} \mathcal{B}^2 > 2\mu, \tag{30}$$

*where* $\mathcal{B} \equiv 2\sqrt{\sigma_\vartheta^2 + \rho\varphi_y \lambda^2 \sigma_a^2} / (\sqrt{\sigma_\vartheta^2 + \rho\varphi_y \lambda^2 \sigma_a^2} + \sigma_\vartheta)$*, the optimal policy coefficient is*

$$\psi^* = \frac{\varphi_a}{\varphi_y} + \lambda\varphi_\vartheta - \lambda\sqrt{\frac{2\mu\left(\lambda^2\sigma_a^2 + \sigma_\vartheta^2\right)}{\omega\sigma_\vartheta^4}}\left(1 - \frac{\rho}{2}\frac{\varphi_y\lambda^2\sigma_a^2 + \sigma_\vartheta^2}{\rho\varphi_y\lambda^2\sigma_a^2 + \sigma_\vartheta^2}\right).$$

*This policy induces positive attention,* $\kappa > 0$*, and entails both aggregate price and output gap fluctuations,* $p \neq 0$ *and* $y \neq y^*$*.*

(ii) *Divine coincidence regime: If* $\omega\varphi_\vartheta^2\sigma_\vartheta^4\mathcal{B}^2/(\lambda^2\sigma_a^2 + \sigma_\vartheta^2) \leq 2\mu$*, the optimal policy is* $\psi^* = \psi_0^y = \varphi_a/\varphi_y$*. Firms then remain inattentive,* $\kappa = 0$*, and both the aggregate price level and the output gap are fully stabilized,* $p = 0$ *and* $y = y^*$*.*

*Proof.* See Online Appendix C.4. □

Proposition 5 shows that the optimal monetary policy depends on the relative size of the information cost $\mu$. Only when information costs are sufficiently high does the optimal policy coincide with output-gap stabilization and achieve price stability. For empirically plausible

[27] Direct evidence on firm managers' attention to macroeconomic conditions is scarce. Coibion and Gorodnichenko (2015) provide a relatively model-independent estimate of learning capacity and show that a Kalman gain of 0.5 fits a range of forecast and survey data, which corresponds to $\kappa \approx 0.347$ nats in our framework.

values of the information cost,[28] price stabilization is dominated by output-gap stabilization, as in the baseline model. Unlike in the baseline model, however, output-gap stabilization is no longer optimal. In this low cost regime, the central bank optimally deviates from output-gap stabilization to make the aggregate component of firms' target prices more volatile. The resulting output-gap volatility is costly, but it raises firms' incentive to pay attention to the confounding bundle $(\lambda a + \vartheta_i)$. This improves the precision of firms' information about idiosyncratic shocks and reduces relative-price distortions. Condition (30) is precisely the requirement that the welfare gain from improved cross-sectional efficiency outweighs the welfare cost of the induced output-gap volatility. The optimal monetary policy therefore balances aggregate stabilization against cross-sectional efficiency.

## 4.2 Sentiment Shock

The baseline model considers confounding signals in which the aggregate component is driven solely by fundamental shocks. We now incorporate non-fundamental common noise, often interpreted as sentiment shocks (Angeletos and La'O, 2013; Benhabib et al., 2016), while keeping all other aspects of the baseline model unchanged.[29]

Specifically, firm $i$ observes a confounding signal augmented with a common noise:

$$x_i = \lambda a + \vartheta_i + \varepsilon_i + \eta, \tag{31}$$

where $\eta \sim \mathcal{N}(0, \sigma_\eta^2)$ is an aggregate sentiment shock, orthogonal to all other shocks.[30] Due to the confounding nature of $x_i$, the sentiment shock $\eta$ induces systematic misattribution analogous to that caused by the aggregate productivity shock. Aggregating firms' beliefs

[28] The quantitative exploration suggests that condition (29) holds for empirically plausible information costs. Since $\mathcal{B}^2 > 1$, this implies that condition (30) also holds.

[29] We model sentiment as exogenous common noise, in contrast to Benhabib et al. (2015), where sentiments are self-fulfilling expectations of aggregate income.

[30] For confounding information with common noise, see Vives (2014) and Bergemann et al. (2015).

yields the following average expectation of idiosyncratic demand:

$$\bar{\mathbb{E}}[\vartheta_i] = \frac{\sigma_\vartheta^2}{\lambda^2\sigma_a^2 + \sigma_\eta^2 + \sigma_\vartheta^2 + \sigma_\varepsilon^2}(\lambda a + \eta). \tag{32}$$

Because firms cannot distinguish the sources of variation in their signal, they attribute part of aggregate fluctuations—whether fundamental ($a$) or non-fundamental ($\eta$)—to their own idiosyncratic demand ($\vartheta_i$). As a result, sentiment shocks generate comovement in firms' beliefs and pricing decisions, even though they are orthogonal to fundamentals.[31]

**Optimal Monetary Policy.** We allow the central bank to respond separately to fundamental and non-fundamental aggregate shocks:

$$m = \psi_a a + \psi_\eta \eta, \tag{33}$$

where $\psi_a$ and $\psi_\eta$ denote the policy responses to productivity and sentiment shocks, respectively. The next proposition characterizes the optimal policy.

**Proposition 6** (Optimal policy with sentiment shocks)**.** *In the presence of sentiment shocks, the unique optimal monetary policy is implemented by*

$$\psi_a^* = \frac{\varphi_a}{\varphi_y} + \lambda R, \qquad \psi_\eta^* = R,$$

*where* $R = \varphi_\vartheta \sigma_\vartheta^2/(\sigma_\vartheta^2 + \sigma_\varepsilon^2)$*. This policy has the following properties:*

(i) *The output gap is fully stabilized,* $y = y^*$*, and relative-price distortions are minimized:*

$$\tilde{p}_i = R(\vartheta_i + \varepsilon_i).$$

(ii) *The aggregate price level responds to both the aggregate productivity shock and the*

[31] The full derivation of the equilibrium is provided in Online Appendix D.1.

*sentiment shock:*

$$p = R(\lambda a + \eta). \tag{34}$$

*Proof.* See Online Appendix D.2. $\square$

Proposition 6 shows that sentiment shocks do not alter the real allocation under the optimal policy: the output gap remains fully stabilized, and relative prices are equal to the optimal linear projection of efficient relative prices. The nominal implication, however, differs from the baseline. Under the optimal policy, nominal spending and the price level must accommodate not only the fundamental shock $a$, but also the non-fundamental sentiment shock $\eta$. The intuition parallels the baseline mechanism. Cross-sectional efficiency requires firms' relative prices to covary with their relative beliefs about idiosyncratic demand. Aggregating across firms then requires the price level to track the average belief (32), which now reflects both productivity and sentiment shocks.

**Price Stabilization.** Online Appendix D.3 characterizes price-stabilization policies in the sentiment-shock extension. Because strict price stability imposes only one linear restriction on two policy coefficients, there is a continuum of such policies. First, all of them are dominated by the output-gap stabilization policy. Second, within this continuum, there exists a unique welfare-maximizing price-stabilization policy, which requires nominal spending to respond to both productivity and sentiment shocks. Thus, even under a strict price-stability mandate, ignoring sentiment shocks is suboptimal.

**Sentiment Shock in a Non-Confounding Signal.** Online Appendix E extends the analysis to a dual-signal environment. Firms observe both $x_i$ in (31) and a non-confounding signal, $s_i^a = a+u+e_i^a$, where $u$ is common noise and $e_i^a$ is idiosyncratic noise. Output-gap stabilization remains optimal and implements the same real allocation. The source of common noise, however, matters for nominal variables. The optimal price level accommodates the sentiment shock $\eta$ in the confounding signal $x_i$, but is invariant to $u$ in the non-confounding signal $s_i^a$. This distinction refines the principle in Angeletos and La'O (2020) that price stability is optimal with respect to shocks that do not affect the efficient allocation. The principle applies when the sentiment shock appears in a non-confounding signal, but not when it is embedded in a confounding signal.

# 5 Conclusion

This article studies optimal monetary policy in an economy where price-setting firms cannot perfectly distinguish between aggregate and idiosyncratic shocks. Even without markup shocks, firms' misattribution of aggregate shocks to idiosyncratic fundamentals breaks the standard divine coincidence and makes strict price stability suboptimal. In the baseline model, the optimal policy fully stabilizes the output gap and minimizes relative-price distortions by allowing the price level to move with firms' systematic misattribution. The cyclicality of the optimal price level depends on the direction of firms' misattribution. Learning from local demand implies a procyclical price level, whereas learning from local productivity implies a countercyclical one. The extensions show that endogenous attention introduces a further trade-off between aggregate stabilization and cross-sectional efficiency, while sentiment shocks change the required nominal response without changing the optimal real allocation.

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