Sticky Production and Monetary Policy

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Introduction

What drove the inflation surge?

Demand view

- Fiscal stimulus
- Loose monetary policy
- Excess savings
- Strong consumption demand

Blanchard (2023); Bernanke & Blanchard (2024); Summers (2022); Jordà et al. (2022)

Demand $>$ productive capacity $\Rightarrow$ inflation

Supply view

- Supply-chain disruptions
- Labor shortages
- Energy shocks
- Sectoral bottlenecks

Comin et al. (2023); Amiti et al. (2023); Fornaro & Wolf (2023); Guerrieri et al. (2022)

Impaired supply capacity $\Rightarrow$ inflation

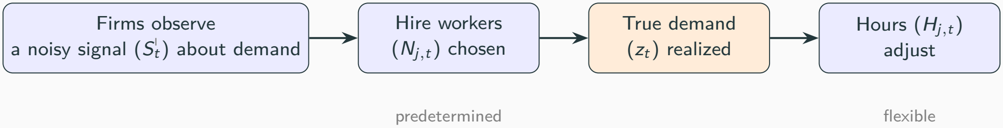
This paper: supply constraints change how demand shocks transmit

Demand and supply may not be separate forces

Flexible economy	**Capacity-constrained economy**
Demand shock	Demand shock
$\Downarrow$	$\Downarrow$
More output	Less output
$\Downarrow$	$\Downarrow$
Little inflation	More inflation

$\rightarrow$ When firms cannot expand capacity quickly, stronger demand is absorbed by prices rather than quantities.

What if firms do not observe demand perfectly?



- $\mathbb{E}_t^f$: firm expectations formed at the signal stage
- $N_{j,t}$ cannot be undone once the true shock arrives
- Hours absorb the surprise: they are the flexible margin

$\rightarrow$ Key friction: capacity is chosen before demand is known

Key idea

The effect of information frictions depends on *where* they enter the model.

Information affects production only

Information frictions

$\Downarrow$

Real rigidity

$\Downarrow$

Inflation $\uparrow$, Output $\downarrow$

Information affects production *and* pricing

Information frictions

$\Downarrow$

Nominal rigidity (dominates)

$\Downarrow$

Inflation $\downarrow$, Output $\uparrow$

$\rightarrow$ The same friction generates opposite predictions depending on which margin it relaxes.

Key results

- Supply constraints **amplify** the inflationary effect of demand shocks.
- Misperceived demand enters the Phillips curve **like a cost-push shock**. Expectation errors can look like supply disturbances.
- The effectiveness of policy communication depends on whether information frictions affect **prices or quantities**.
- Empirical evidence from IP surprises supports the **real-rigidity channel**.

$\rightarrow$ Supply constraints are not just an independent source of inflation; they change how demand shocks pass through to output and prices.

Related literature

Information frictions/price-setting/business-cycle dynamics: Woodford (2002); Mankiw & Reis (2002); Mackowiak & Wiederholt (2009); Angeletos & La'O (2013); Angeletos, Iovino & La'O (2016); Angeletos & Huo (2021)

→ Separates production and pricing channels to identify their distinct effects on inflation and output.

Real rigidities: Ball & Romer (1990); Kimball (1995); Woodford (2003)

→ Introduce an informational source of real rigidity through capacity choice.

Capacity constraints and inflation: Guerrieri et al. (2022); Fornaro & Wolf (2023); Comin & Johnson (2026)

→ Endogenise capacity constraints through imperfect information about demand.

Roadmap

1. Baseline model: information frictions as real rigidities
2. Alternative model: information frictions with real and nominal rigidities
3. Empirical evidence
4. Policy implications

Information Frictions and Real Rigidities

Model overview

The framework is a New Keynesian model with two modifications.

- First, firms choose employment **before** shocks are realized.
- Second, firms receive only a **noisy signal** about demand.

Baseline model: prices are set *after* observing shocks, so information frictions affect production but not pricing.

Information structure

Firms observe a public signal about the demand shock:

$$S_t = z_t + \xi_t^z, \qquad z_t \sim \mathcal{N}(0, \sigma_z^2), \qquad \xi_t^z \sim \mathcal{N}(0, \sigma_{\xi^z}^2).$$

Bayesian updating gives the firm's perceived demand ($\mathbb{E}_t^f$: firm expectation conditional on S_t):

$$z_{t,t,f} \equiv \mathbb{E}[z_t \mid S_t] = \underbrace{\frac{\sigma_z^2}{\sigma_z^2 + \sigma_{\xi^z}^2}}_{\text{signal weight}} z_t + \frac{\sigma_{\xi^z}^2}{\sigma_z^2 + \sigma_{\xi^z}^2} \xi_t^z.$$

- Full information: $\sigma_{\xi^z}^2 = 0 \Rightarrow z_{t,t,f} = z_t$ (signal is perfect).
- Extreme friction: $\sigma_{\xi^z}^2 \to \infty \Rightarrow z_{t,t,f} = 0$ (signal is pure noise).

Production: one input is predetermined

Each firm produces with workers $N_{j,t}$ and hours per worker $H_{j,t}$:

$$Y_{j,t} = N_{j,t}^{\vartheta} H_{j,t}^{1-\vartheta}, \qquad 0 < \vartheta < 1.$$

- $N_{j,t}$ is chosen before shocks are realized (predetermined).
- $H_{j,t}$ adjusts after shocks are realized to meet demand (flexible).

Log-linear production:

$$\widehat{y}_t = \vartheta \widehat{n}_t + (1 - \vartheta) \widehat{h}_t.$$

→ A larger ϑ means more production depends on the predetermined input, so ex-post adjustment through hours is more difficult.

Equilibrium: marginal cost with sticky production

Employment is fixed when prices are set, so marginal cost is

$$\widehat{mc}_t = \widehat{v}_t^r + \frac{\vartheta}{1-\vartheta}\left(\widehat{y}_t - \widehat{n}_t\right).$$

With Rotemberg pricing and the one-period shock:

$$\widehat{\pi}_t = \lambda_p \left[\widehat{v}_t^r + \frac{\vartheta}{1-\vartheta}(\widehat{y}_t - \widehat{n}_t)\right].$$

Aggregate demand closes the model via the Euler equation and a Taylor rule:

$$\widehat{y}_t = -\frac{1}{\gamma}\widehat{i}_t, \qquad \widehat{i}_t = \phi_\pi \widehat{\pi}_t + \phi_y \widehat{y}_t + z_t.$$

→ Gap between realized output and planned capacity $(\widehat{y}_t - \widehat{n}_t)$ amplifies inflationary response.

Real rigidity steepens the Phillips curve

Combining household conditions, production, and marginal cost:

$$\widehat{\pi}_t = \lambda_p \left[\left(\gamma + \frac{\varphi + \vartheta}{1 - \vartheta} \right) \widehat{y}_t - (1 + \varphi) \frac{\vartheta}{1 - \vartheta} \widehat{n}_t \right].$$

Full information

$\widehat{n}_t = \widehat{y}_t$, hence

$\pi_t^{FI} = \lambda_p (\gamma + \varphi) y_t$

Information frictions

$\widehat{n}_t = 0$ for an unobserved shock, hence

$\widehat{\pi}_t^{IF} = \lambda_p \left(\gamma + \frac{\varphi + \vartheta}{1 - \vartheta} \right) \widehat{y}_t$

$\rightarrow$ Since $\vartheta > 0$, the Phillips curve is steeper under information frictions: the same change in output generates more inflation.

Output and inflation: full information vs. information frictions

Full information

$$\widehat{y}_t^{FI} = -\frac{1}{\gamma}\frac{z_t}{1+\frac{\phi_\pi \lambda_p(\gamma+\varphi)+\phi_y}{\gamma}}$$

Information frictions

$$\widehat{y}_t^{IF} = -\frac{1}{\gamma}\frac{z_t}{1+\frac{\phi_\pi \lambda_p\left(\gamma+\frac{\varphi+\vartheta}{1-\vartheta}\right)+\phi_y}{\gamma}}$$

The denominator is larger under information frictions (steeper Phillips curve ⇒ stronger policy response).

→ Information frictions dampen output and amplify inflation: demand is absorbed by prices rather than quantities.

Natural output depends on expected demand

Under flexible prices, $\widehat{mc}_t = 0$. Solving the supply side yields

$$\widehat{y}_t^n = \frac{\vartheta(1+\varphi)}{\vartheta + (1-\vartheta)\gamma + \varphi}\widehat{n}_t.$$

Since employment is expectation-driven,

$$\widehat{y}_t^n = -\frac{1}{\gamma}\frac{\vartheta(1+\varphi)}{\vartheta + (1-\vartheta)\gamma + \varphi}\frac{1}{1 + \frac{1}{\gamma}\phi_\pi \lambda_p(\gamma+\varphi) + \frac{1}{\gamma}\phi_y} z_{t,t,f}.$$

$\rightarrow$ Misperceived demand changes the natural level of output even if fundamentals do not move.

Expectation shocks look like cost-push shocks

The Phillips curve in output-gap form:

$$\widehat{\pi}_t = \lambda_p \frac{\vartheta + (1-\vartheta)\gamma + \varphi}{1-\vartheta} \widetilde{y}_t, \qquad \widetilde{y}_t \equiv \widehat{y}_t - \widehat{y}_t^n.$$

Substituting for $\widehat{y}_t^n$ reveals an additional term:

$$\widehat{\pi}_t = \lambda_p \frac{\vartheta + (1-\vartheta)\gamma + \varphi}{1-\vartheta} \widehat{y}_t + \underbrace{\lambda_p \frac{1}{\gamma} \frac{\vartheta(1+\varphi)}{1-\vartheta} \frac{z_{t,t,f}}{1 + \frac{1}{\gamma}\phi_\pi \lambda_p (\gamma + \varphi) + \frac{1}{\gamma}\phi_y}}_{\text{expectation-driven cost-push term}}.$$

→ Demand expectations enter the Phillips curve like a cost-push shock. A policymaker who ignores information frictions will misread the source of inflation.

Information Frictions with Real and Nominal Rigidities

When information also affects pricing

Now firms choose prices under the same imperfect information. The pricing condition becomes

$$\widehat{p}_{j,t} = \mathbb{E}\left[\widehat{mc}_{j,t} + \widehat{p}_t \mid S_{j,t}\right].$$

This yields

$$\widehat{\pi}_t = \vartheta \widehat{w}^r_{t,t,f} + (1-\vartheta)\widehat{v}^r_{t,t,f} - \widehat{a}_{t,t,f} + \widehat{\pi}_{t,t,f}.$$

→ Information frictions now make prices sticky as well. Demand shocks move quantities more because prices do not fully adjust.

Equilibrium with real and nominal information frictions

When information frictions affect both production and pricing:

$$\widehat{y}_t = -\frac{1}{\gamma + \phi_y}\left(z_t - z_{t,t,f}\right),$$

$$\widehat{\pi}_t = -\frac{1}{\phi_\pi} z_{t,t,f}.$$

Full information: $z_{t,t,f} = z_t$

$$\widehat{y}_t^{FI} = 0, \quad \widehat{\pi}_t^{FI} = -\frac{1}{\phi_\pi} z_t.$$

No information: $z_{t,t,f} = 0$

$$\widehat{y}_t^{IF} = -\frac{z_t}{\gamma + \phi_y}, \quad \widehat{\pi}_t^{IF} = 0.$$

→ The result reverses: less information means less price adjustment, so inflation reacts *less* and output reacts *more*.

Why the result reverses

When firms receive more information, which adjustment margin becomes more responsive?

Model	More information mainly affects	Effect of a demand shock
Real rigidity only	Production capacity (indirect, via costs)	Inflation $\downarrow$, Output $\uparrow$
Nominal rigidity only	Price adjustment (direct)	Inflation $\uparrow$, Output $\downarrow$
Real + nominal	Price adjustment (dominant margin)	Inflation $\uparrow$, Output $\downarrow$

Monetary policy communication

Forward guidance as expectation alignment

Suppose firms mistakenly expect weaker future demand.

Forward guidance aligns firms' expectations with the central bank's intended policy path.

How do firms respond?

- **Real-rigidity channel:** Better information encourages firms to expand capacity in advance.
  $\Rightarrow$ more output, lower inflation
- **Nominal-rigidity channel:** Better information allows firms to adjust prices more aggressively.
  $\Rightarrow$ less output, higher inflation

Implication: The effects of communication depend on whether expectations primarily affect capacity choices or pricing decisions.

Empirical evidence

Which mechanism fits the data?

The two models generate opposite predictions after a positive demand surprise:

	Inflation	Output
Real rigidities only	$\downarrow$	$\uparrow$
Real + nominal rigidities	$\uparrow$	$\downarrow$

Use industrial production (IP) surprises to distinguish between the two.

Constructing demand-driven IP surprises

Construction

1. Take IP release minus Bloomberg consensus forecast (monthly data: January 2010 – April 2025)
2. Regress on same-month PPI, WTI oil, commodity index
3. Residual $\hat{u}_t$ = demand-driven surprise

Motivation

- First stage strips out supply-side co-movement
- Firms learn about aggregate demand from IP releases
- Positive residual: upward revision to demand expectations

Local projection specification

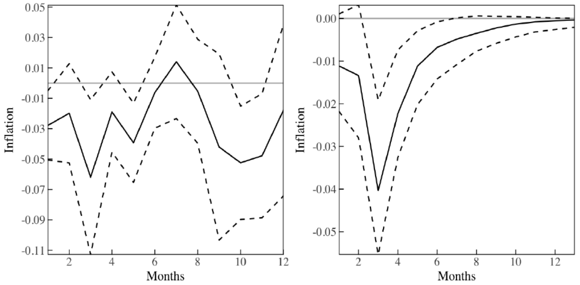
For horizon h:

$$y_{t+h} = \alpha_h + \theta_h \cdot shock_t + \sum_{j=1}^{p} \beta_{h,j} y_{t-j} + \sum_{j=0}^{q} \gamma_{h,j} x_{t-j} + \varepsilon_{t+h}.$$

- y_{t+h}: core monthly inflation at horizon h
- x_{t-j}: seasonally adjusted monthly IP growth
- p selected by AIC; $q = 6$
- Standard errors: Newey-West HAC with pre-whitening

$\rightarrow$ θ_h measures the inflation response to a one-percentage-point demand-driven IP surprise.

A positive demand surprise is followed by lower inflation



Notes: Confidence intervals are constructed at the 90% level using Newey-West heteroskedasticity and autocorrelation-consistent standard errors with pre-whitening. Cumulative impulse responses are computed as $\text{IRF}_h = \sum_{j=1}^{h} \theta_j$. The right panel shows the IRFs obtained from a VAR specification.

- Inflation falls persistently after a positive demand signal
- Local projections and VARs give the same qualitative sign

$\rightarrow$ Consistent with real-rigidities: firms expand capacity rather than raising prices.

Conclusions

- Information frictions can create **real rigidities** by making productive capacity slow to adjust.
- Real rigidities steepen the Phillips curve: demand shocks generate **more inflation and less output**.
- When information also affects pricing, nominal-rigidity effects dominate and the predictions reverse.
- Demand expectations can enter the Phillips curve like a cost-push shock, making expectation errors look like supply disturbances.
- Communication can improve firms' capacity choices by aligning expectations with intended policy.
- Evidence from IP surprises supports the **real-rigidity mechanism**.

Appendix

Appendix: compact model summary

$$
\begin{aligned}
\widehat{w}_t^r &= \gamma \widehat{y}_t + \varphi \widehat{n}_t, \\
\widehat{n}_t &= \widehat{v}_{t,t,f}^r - \widehat{w}_{t,t,f}^r + \widehat{h}_{t,t,f}, \\
\widehat{\pi}_t &= \lambda_p \left[\widehat{v}_t^r + \frac{\vartheta}{1-\vartheta} (\widehat{y}_t - \widehat{n}_t) \right], \\
\widehat{i}_t &= \phi_\pi \widehat{\pi}_t + \phi_y \widehat{y}_t + z_t.
\end{aligned}
$$

$$
\begin{aligned}
\widehat{v}_t^r &= \gamma \widehat{y}_t + \varphi \widehat{h}_t, \\
\widehat{y}_t &= \vartheta \widehat{n}_t + (1-\vartheta) \widehat{h}_t, \\
\widehat{y}_t &= -\frac{1}{\gamma} \widehat{i}_t,
\end{aligned}
$$

Appendix: one-line comparison of slopes

The real-information model can be summarized as a change in the Phillips curve slope:

$$\kappa^{FI} = \lambda_p(\gamma + \varphi), \qquad \kappa^{IF} = \lambda_p \left(\gamma + \frac{\varphi + \vartheta}{1 - \vartheta}\right).$$

Since

$$\kappa^{IF} - \kappa^{FI} = \lambda_p \left[\frac{\varphi + \vartheta}{1 - \vartheta} - \varphi\right] = \lambda_p \frac{\vartheta(1 + \varphi)}{1 - \vartheta} > 0,$$

information frictions make inflation more sensitive to output.

Appendix: markups still reveal real rigidity

Although output and inflation responses are identical across cases when nominal frictions dominate, markups differ.

Both real and nominal frictions

$$\widehat{\mu}_t = -\frac{\gamma + \frac{\varphi+\vartheta}{1-\vartheta}}{\gamma + \phi_y}(z_t - z_{t,t,f}).$$

Nominal frictions only

$$\widehat{\mu}_t = -\frac{\gamma + \varphi}{\gamma + \phi_y}(z_t - z_{t,t,f}).$$

For $\vartheta > 0$, unexpected demand shocks move marginal cost and markups more when input adjustment is constrained. Markup data can distinguish the two models even when inflation and output cannot.

Appendix: input choice under imperfect information

The firm chooses $N_{j,t}$ by minimizing expected input costs conditional on S_t. The log-linear labor demand condition is

$$\widehat{n}_t = \widehat{v}^r_{t,t,f} - \widehat{w}^r_{t,t,f} + \widehat{h}_{t,t,f}.$$

Household labor supply for the two margins is

$$\widehat{w}^r_t = \gamma\widehat{y}_t + \varphi\widehat{n}_t,$$
$$\widehat{v}^r_t = \gamma\widehat{y}_t + \varphi\widehat{h}_t.$$

$\rightarrow$ Employment reacts to expected demand, not realized demand. Hours absorb the surprise component.

Example

Normal day

- More customers arrive
- The restaurant hires more staff
- The kitchen serves more meals

$\Rightarrow$ Demand $\uparrow$, Output $\uparrow$, Prices stable

Capacity constrained

- Kitchen is already full
- Staff cannot be hired in time
- Queues lengthen, prices rise

$\Rightarrow$ Demand $\uparrow$, Output $\approx$, Prices $\uparrow$

$\rightarrow$ Why can't firms expand capacity in time? **They do not see the demand shock coming.**