Price Dispersion and Inflation Persistence

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Empirical impulse responses to a monetary policy shock

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Intrinsic or inherited inflation inertia

- The **New Keynesian Phillips Curve (NKPC)** governs inflation dynamics in sticky price models of monetary policy.

- NKPC has difficulty accounting for inflation persistence because it is purely forward-looking, so literature has incorporated lags of inflation.

- Intrinsic inflation inertia remains controversial.
  - Assumptions—rule-of-thumb price setting, price indexation—are often deemed implausible.
  - Benati (2008) finds that the degree of inflation persistence varies with the monetary policy regime across countries.

- To account for inflation persistence without resorting to intrinsic inflation inertia, NKPC must inherit persistence in driving process.
Staggered pricing model with positive trend inflation has difficulty generating inflation persistence

- Inflation dynamics in generalized NKPC depends on **relative price distortion (RPD)**, reflects productivity loss due to price dispersion.
  - Price dispersion $\rightarrow$ demand dispersion $\rightarrow$ RPD.

- Lagged RPD is an endogenous state variable, potential source of persistence.

- However, we find the inertia of RPD has a minor effect on inflation persistence, while it may generate a counterfactual decline in output per hour after an expansionary shock.

$\Rightarrow$ Dynamics of RPD creates tension between generating plausible responses of inflation and output per hour.
A “smoothed-off” kink in demand curves alters the relationship between price dispersion and RPD.

- Generalization of Dixit-Stiglitz preferences for product diversity (Kimball, 1995; Smets and Wouters, 2007).
- Kink generates strategic complementarity: large demand loss for high relative price and small demand gain for low relative price.
Responses of inflation and output per hour consistent with VAR evidence

- The kink introduces measure of **price dispersion**, distinct from RPD, which appears in NKPC.

- Lagged price dispersion is a second endogenous state variable.

- A policy shock generates a large and persistent response of price dispersion and a muted response of RPD, allowing plausible responses of both inflation and output per hour.

  ⇒ Large, persistent response of price dispersion is inherited by the response of inflation, which becomes persistent and hump-shaped.

  ⇒ Muted response of RPD prevents a counterfactual decline of output per hour.
Credible permanent disinflation

- With intrinsic inflation inertia, a permanent decline in trend inflation generates a gradual decline in inflation and a recession.
- Without the inertia inflation jumps to its new trend rate and output never deviates from its trend level.
- In our model with trend inflation and a kink in demand curves, a credible disinflation induces a gradual decline in inflation and a recession even absent intrinsic inflation inertia.
Overview

1. Model
2. Quantitative analysis
3. Conclusion
A model with trend inflation and kinked demand curves

- Representative final-good producer combines differentiated goods into a single product according to household preferences.
  - Curvature in demand curves for differentiated goods.
- Continuum of monopolistically competitive intermediate-good producers face Calvo price rigidity.
  - Fixed cost of production gives rise to increasing returns to scale.
- Monetary authority conducts interest rate policy and has positive inflation target.
- Representative household.
Following Dotsey & King (2005), demand for differentiated good $f$ is

$$Y_t(f) = \frac{Y_t}{1 + \epsilon} \left[ \left( \frac{P_t(f)}{P_t d_t} \right)^{-\theta(1+\epsilon)} + \epsilon \right].$$

Parameter $\epsilon \leq 0$ governs curvature, which is measured as $-\epsilon \theta$, and

$$d_t = \left[ \int_0^1 \left( \frac{P_t(f)}{P_t} \right)^{1-\theta(1+\epsilon)} df \right]^{\frac{1}{1-\theta(1+\epsilon)}}$$

is a measure of price dispersion.
Representative final-good firm

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The case $\epsilon = 0$ is the familiar CES case:

- Demand $Y_t(f) = Y_t \left( \frac{P_t(f)}{P_t} \right)^{-\theta}$.
- Price index $P_t = \left[ \int_0^1 \left( P_t(f) \right)^{1-\theta} df \right]^{1/(1-\theta)} \iff d_t = 1$. 
Intermediate-good firms

- Minimize production costs s.t. technology

\[ Y_t(f) = \begin{cases} 
N_t(f) - \phi & \text{if } N_t(f) \geq \phi \\
0 & \text{otherwise.} 
\end{cases} \]

- Combining production function, intermediate-good demand, and labor market clearing yields expression for output per hour

\[ \frac{Y_t}{N_t} = \left(1 - \frac{\phi}{N_t}\right) \left(\frac{s_t + \epsilon}{1 + \epsilon}\right)^{-1}. \]

- The RPD is a measure of demand dispersion:

\[ \frac{s_t + \epsilon}{1 + \epsilon} = \int_0^1 \frac{Y_t(f)}{Y_t} df. \]
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Intermediate-good firms

- Each period, a fraction $\alpha$ of firms keeps prices unchanged, while the remaining $1 - \alpha$ firms sets the price to maximize profits ($p^*$).

- Under staggered price setting lags of price dispersion and RPD are endogenous state variables

$$
(d_t)^{1-\theta(1+\epsilon)} = (1 - \alpha) \left( p^*_t \right)^{1-\theta(1+\epsilon)} + \alpha \left( \frac{d_{t-1}}{\pi_t} \right)^{1-\theta(1+\epsilon)}
$$

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\]
Monetary authority and household

- Monetary authority sets the short-term interest rate according to a Taylor-type rule with interest rate smoothing:

\[
\log i_t = (1 - \rho) \left[ \log i + \phi_\pi (\log \pi_t - \log \pi) \right] + \rho \log i_{t-1} + \varepsilon_t.
\]

- Representative household chooses final-good consumption, labor supply, and riskless bonds to maximize utility

\[
E_0 \sum_{t=0}^{\infty} \beta^t \left( \log C_t - \frac{N_t^{1+\sigma_n}}{1 + \sigma_n} \right)
\]

subject to budget constraint.
Generalizing the NKPC

- At the zero trend inflation rate or, equivalently, with full indexation to the trend inflation rate,

\[ \hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - \alpha)(1 - \alpha \beta)}{\alpha} \hat{m}_c_t. \]
Generalizing the NKPC

- At the zero trend inflation rate or, equivalently, with full indexation to the trend inflation rate,

\[ \hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - \alpha)(1 - \alpha\beta)}{\alpha} \hat{m}_t. \]

- At a positive trend inflation rate without price indexation, the NKPC generalizes as

\[ \hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - \alpha\pi^{\theta-1})(1 - \alpha\beta\pi^\theta)}{\alpha\pi^{\theta-1}} \hat{m}_t + \varphi_t \]

where \( \varphi_t = \alpha\beta\pi^\theta E_t \varphi_{t+1} \)

\[ + \beta(\pi - 1)(1 - \alpha\pi^{\theta-1}) \left[ \theta E_t \hat{\pi}_{t+1} + (1 - \alpha\beta\pi^\theta) E_t \hat{m}_c_{t+1} \right]. \]
Adding a kink in demand, inflation inherits inertia from price dispersion in generalized NKPC

\[ \hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - \alpha \pi \gamma^{-1})(1 - \alpha \beta \pi \gamma)}{\alpha \pi \gamma^{-1}[1 - \tilde{\epsilon} \gamma/(\gamma - 1 - \tilde{\epsilon})]} \hat{m}_c_t + \varphi_t + \psi_t \]

\[ - \gamma(1 - \alpha \pi \gamma^{-1})[\alpha \beta \pi \gamma^{-1}(\pi - 1)(\gamma - 1) + \tilde{\epsilon}(1 - \alpha \beta \pi \gamma)] \hat{d}_t \]

\[ + \left(E_t \hat{d}_{t+1} - \frac{1}{\alpha \pi \gamma^{-1} \hat{d}_t}\right) - \alpha \beta \pi \gamma^{-1} \left(\hat{d}_t - \frac{1}{\alpha \pi \gamma^{-1} \hat{d}_{t-1}}\right) \]

using shorthand \( \gamma = \theta(1 + \epsilon) \) and \( \tilde{\epsilon} = f(\epsilon, \alpha, \beta, \theta, \pi) \).
Adding a kink in demand, inflation inherits inertia from price dispersion in generalized NKPC

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\hat{\pi}_t = \beta E_t \hat{\pi}_{t+1} + \frac{(1 - \alpha \pi \gamma^{-1})(1 - \alpha \beta \pi \gamma)}{\alpha \pi \gamma^{-1}[1 - \tilde{\epsilon} \gamma/(\gamma - 1 - \tilde{\epsilon})]} \hat{m}_c_t + \varphi_t + \psi_t
\]

\[
- \frac{\gamma(1 - \alpha \pi \gamma^{-1})[\alpha \beta \pi \gamma^{-1}(\pi - 1)(\gamma - 1) + \tilde{\epsilon}(1 - \alpha \beta \pi \gamma)]}{\alpha \pi \gamma^{-1}[\gamma - 1 - \tilde{\epsilon}(\gamma + 1)]} \hat{d}_t
\]

\[
+ \left( E_t \hat{d}_{t+1} - \frac{1}{\alpha \pi \gamma^{-1}} \hat{d}_t \right) - \alpha \beta \pi \gamma^{-1} \left( \hat{d}_t - \frac{1}{\alpha \pi \gamma^{-1}} \hat{d}_{t-1} \right)
\]

using shorthand \( \gamma = \theta(1 + \epsilon) \) and \( \tilde{\epsilon} = f(\epsilon, \alpha, \beta, \theta, \pi) \).
Effects of RPD on the dynamics of inflation and output per hour

- RPD can increase inflation persistence through real marginal cost:

\[ \hat{mc}_t = \left( 1 + \frac{\sigma_n}{1 + \frac{\phi}{Y} \frac{1+\epsilon}{s+\epsilon}} \right) \hat{Y}_t + \frac{\sigma_n \frac{s}{s+\epsilon}}{1 + \frac{\phi}{Y} \frac{1+\epsilon}{s+\epsilon}} \hat{s}_t. \]

- RPD can change the sign of response of output per hour:

\[
\hat{Y}_t - \hat{N}_t = \left( \frac{\phi}{Y} \frac{1+\epsilon}{s+\epsilon} \right) \hat{N}_t - \frac{s}{s+\epsilon} \hat{s}_t. \quad (1)
\]
## Quarterly calibration

<table>
<thead>
<tr>
<th>Preferences and technology</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>$\beta$  Subjective discount factor</td>
<td>0.99</td>
</tr>
<tr>
<td>$\sigma_n$ Inverse of the elasticity of labor supply</td>
<td>0.5</td>
</tr>
<tr>
<td>$\alpha$ Probability of no price change</td>
<td>0.75</td>
</tr>
<tr>
<td>$\theta$ Parameter governing the price elasticity of demand</td>
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</tr>
<tr>
<td>$\epsilon$ Degree of strategic complementarity</td>
<td>$-9, 0$</td>
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<table>
<thead>
<tr>
<th>Monetary policy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi_\pi$ Policy response to inflation</td>
<td>1.5</td>
</tr>
<tr>
<td>$\rho$ Policy response to lag of interest rate</td>
<td>0.9</td>
</tr>
<tr>
<td>$\bar{\pi}$ Annualized trend inflation rate</td>
<td>2.5%</td>
</tr>
</tbody>
</table>
Impulse responses to a monetary policy shock in the case of no kink in demand curves

- Federal Funds Rate
- Annualized Inflation Rate
- Output
- Output Per Hour

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Trend inflation has minor influence on inflation persistence but major influence on output per hour.
Kink gives rise to persistent and hump-shaped response of inflation and positive response of output per hour.
Persistent rise in price dispersion with muted response of RPD
Effect of the kink in demand curves on the slope of the (generalized) NKPC

![Graph showing the effect of kink in demand curves on the slope of the NKPC]

- Blue line: Trend inflation rate = 2.5%
- Gray line: Trend inflation rate = 0

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Effects of a credible permanent decline in trend inflation

- Volcker disinflation in early 1980s: gradual decline in inflation and recession.

- NKPC generates a gradual decline in inflation and a temporary decline in output, provided the model contains intrinsic inflation inertia.

- Generalized NKPC generates similar responses, provided the model contains a kink in demand curves.
A one percentage point decline in trend inflation: NKPC with full price indexation to past inflation

- Inflation
  - $\epsilon = 0$, indexation

- Output

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A one percentage point decline in trend inflation: Generalized NKPC but no kink in demand.
A one percentage point decline in trend inflation: Generalized NKPC and a kink in demand
Models of the monetary transmission mechanism have difficulty accounting for observed inflation inertia without assuming it is intrinsic.

A positive trend inflation rate has a minor influence on inflation persistence and can induce a counterfactual response of productivity to a policy shock.

Combination of positive trend inflation, kink in demand curves, and fixed cost in production can generate responses of inflation and productivity in line with empirical evidence.

Model improves responses to a transitory policy shock and a permanent disinflation.