Competition and the Phillips Curve

Ippei Fujiwara\textsuperscript{1,3} \hspace{1em} Kiminori Matsuyama\textsuperscript{2,3}

\textsuperscript{1}Keio University and ANU
\textsuperscript{2}Northwestern University
\textsuperscript{3}CEPR

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1. Introduction

2. HSA

3. New Keynesian model under HSA

4. Competition and the Phillips curve

5. Steady state analysis

6. Dynamic analysis

7. Calvo pricing

8. Conclusion
Flattening of the Phillips curve

- Federal Reserve Vice Chair: Richard Clarida, on Sept. 26, 2019
  - “Another key development in recent decades is that price inflation appears less responsive to resource slack. That is, the short-run price Phillips curve—if not the wage Phillips curve—appears to have flattened, implying a change in the dynamic relationship between inflation and employment”

- San Francisco Fed President: Mary Daly, on Aug. 29, 2019
  - “As for the Phillips curve... most arguments today center around whether it’s dead or just gravely ill. Either way, the relationship between unemployment and inflation has become very difficult to spot”

- New York Fed President: John Williams, on Feb. 22, 2019
  - “The Phillips curve is the connective tissue between the Federal Reserve’s dual mandate goals of maximum employment and price stability. Despite regular declarations of its demise, the Phillips curve has endured. It is useful, both as an empirical basis for forecasting and for monetary policy analysis”
Market concentration

- Covarrubias, Gutierrez and Philippon (2019)
  - “After 2000, however, the evidence suggests inefficient concentration, decreasing competition and increasing barriers to entry, as leaders become more entrenched and concentration is associated with lower investment, higher prices and lower productivity growth”

- Loecker, Eeckhout and Unger (2020)
  - “In 1980, aggregate markups start to rise from 21% above marginal cost to 61% now. ... We also find an increase in the average profit rate from 1% to 8%. Although there is also an increase in overhead costs, the markup increase is in excess of overhead”

- Autor, Dorn, Katz, Patterson and Reenen (2020)
  - “sales concentration is rising across a large set of industries. ... aggregate markups have been rising”
What we do

- Argue that market concentration affects the slope of the Phillips curve and the transmission of monetary policy

- Extend the New Keynesian model under CES monopolistic competition
  - Introduce entry and exit as in Bilbiie, Ghironi and Melitz (2008) and Bilbiie, Fujiwara and Ghironi (2014)
  - Replace CES by HSA (Homothetic Single Aggregator) demand system proposed by Matsuyama and Ushchev (2017, 2020a,b, 2022a)

- HSA demand system is flexible
  - CES and Translog are special cases
  - HSA can accommodate
    - *Marshall’s second law of demand* – hereafter, the Second law: the price elasticity of demand goes up with its price
    - *The third law of demand* (Matsuyama and Ushchev, 2022a) – hereafter, the Third law: the rate of increase in the price elasticity goes down with its price
Key takeaways

- Under Rotemberg pricing, *the Second law* causes
  - Higher concentration $\Rightarrow$ lower *price elasticity* $\Rightarrow$ flattening of the Phillips curve
  - Concentration affects price setting dynamically through strategic complementarity - endogenous cost-push shock
  - Muted impacts of structural shocks on inflation rates with higher market concentration
  - Pass-through rate plays an important role in cyclicality of markup

- Under Calvo pricing, *the Third law* causes
  - Higher concentration $\Rightarrow$ lower *pass-through* $\Rightarrow$ flattening of the Phillips curve

- Under HSA, the market share function fully characterizes both the *price elasticity* and the *pass-through* rate and its single aggregator summarizes all the impacts of market concentration on the flattening of the Phillips curve
Related literature

- Competition and monetary policy
  - Wang and Werning (2020)
  - Baqaee, Farhi and Sangani (2021b)

- Business cycle model with entry and exit under monopolistic competition
  - Bilbiie, Ghironi and Melitz (2012, 2019)
  - Bilbiie, Ghironi and Melitz (2008), Bilbiie, Fujiwara and Ghironi (2014)

- HSA
  - Matsuyama and Ushchev (2017, 2020a,b, 2022a,b)
  - Kasahara and Sugita (2020)
  - Grossman, Helpman and Lhuillier (2021)
  - Baqaee, Farhi and Sangani (2021a)
Competition and monetary policy

- CES New Keynesian model, irrespective of entry and exit
  - Competition is irrelevant to the Phillips curve

Wang and Werning (2020)
- In an oligopoly model with the strategic interaction, higher concentration leads to
  - amplified real effects of monetary policy
  - the Phillips curve with inflation persistence
  - endogenous cost-push shock

Baqae, Farhi and Sangani (2021b)
- In a model with the real rigidities and the misallocation across heterogeneous firms, higher concentration leads to
  - flattening of the Phillips curve
  - endogenous cost-push shock

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- Easier to endogenize entry under HSA than Kimball
Structure of presentation

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2. HSA
3. New Keynesian model under HSA
4. Competition and the Phillips curve
5. Steady state analysis
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8. Conclusion
1. Introduction

2. HSA

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HSA

- A continuum of varieties ($\omega \in \Omega$), gross substitutes and symmetry

- Market share of $\omega = \frac{p_t(\omega)c_t(\omega)}{P(p_t)C_t} = \frac{\partial \ln(P(p_t))}{\partial \ln(p_t(\omega))} = s\left(\frac{p_t(\omega)}{A(p_t)}\right)$ where $\int_{\Omega_t} s\left(\frac{p_t(\omega)}{A(p_t)}\right) d\omega \equiv 1$
  - $s : \mathbb{R}_{++} \rightarrow \mathbb{R}_+$
  - gross substitutes $\Rightarrow s(z)$ is decreasing in $z$
  - $A(p_t)$ implicitly defined by the adding-up constraint: $\int_{\Omega_t} s\left(\frac{p_t(\omega)}{A(p_t)}\right) d\omega \equiv 1$

- $A(p_t) \neq \text{constant} \times P(p_t)$
  - $A(p_t)$: single aggregator, the inverse measure of competitive pressures, fully captures cross price effects in the demand system
  - $P(p_t)$: theoretical price index, the inverse measure of TFP, captures the productivity consequences of price changes
CES as a special case of HSA: \( s \left( \frac{p_t(\omega)}{A_t} \right) = \gamma_{CES} \left( \frac{p_t(\omega)}{A_t} \right)^{1-\theta}, \theta > 1 \)

- **Production function**

\[
C_t = Z_C \left[ \int_{\Omega_t} c_t(\omega)^{1-\frac{1}{\theta}} \, d\omega \right]^{\frac{\theta}{\theta-1}}
\]

- **Hicksian demand function**

\[
c_t(\omega) = Z_C^{\theta-1} \left( \frac{p_t(\omega)}{P_t} \right)^{-\theta} C_t
\]

- **The market share function**

\[
s \left( \frac{p_t(\omega)}{A_t} \right) = \gamma_{CES} \left( \frac{p_t(\omega)}{A_t} \right)^{1-\theta} = p_t(\omega) c_t(\omega) = Z_C^{\theta-1} \left( \frac{p_t(\omega)}{P_t} \right)^{1-\theta}
\]

- \( P_t = \text{constant} \times A_t, \text{iff CES, proved by Matsuyama and Ushchev (2017)} \)
Three price indices

- $P_t$: the final goods price (CPI), which captures the productivity effects of entry – the reference price for consumers

\[ \int_{\Omega_t} \frac{p_t(\omega) c_t(\omega)}{P_tC_t} \, d\omega \equiv 1 \]

- $A_t$: the common price aggregator, which captures the competitive effects of entry – the reference price for firms

\[ \int_{\Omega_t} s \left( \frac{p_t(\omega)}{A_t} \right) \, d\omega \equiv 1 \]

- $p_t$: the average price index (PPI) – the measured price index (without entry effects)

\[ p_t := \frac{1}{N_t} \int_{\Omega_t} p_t(\omega) \, d\omega \]
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Model

- Bilbiie, Ghironi and Melitz (2008) and Bilbiie, Fujiwara and Ghironi (2014) under HSA
  - 4 agents
    1. Consumer
    2. Intermediate goods producer
    3. Final goods producer
    4. Central bank

- Symmetric equilibrium under *monopolistic competition*

- Rotemberg price adjustment cost – Calvo pricing in Section 7

- Endogenous entry but exogenous exit
Timing

- In every period, there is an unbounded mass of prospective entrants.

- One-period time-to-build lag: entrants at time $t$ only start producing at time $t + 1$.

- Exogenous destruction: all firms are subject to identical probability $\delta$ of exogenous firm destruction at the end of each period, after production and entry.
  - A proportion $\delta$ of new entrants will never produce.
Consumer

- A representative household maximizes

\[ E_0 \sum_{t=0}^{\infty} \beta^t (u(C_t) - v(L_t)) \]

subject to the budget constraint

\[ \frac{B_{t+1}}{P_t} + x_{t+1} \int_{\Omega_t + \Omega_{E,t}} \frac{V_t(\omega)}{P_t} d\omega + C_t = \frac{(1 + i_{t-1})B_t}{P_t} + x_t \int_{\Omega_t} \frac{D_t(\omega) + V_t(\omega)}{P_t} d\omega + \frac{W_t}{P_t} L_t \]

- The final good is produced with intermediate inputs under HSA technology, which leads to the HSA demand for intermediate inputs
MC intermediate inputs producers

- Intermediate inputs producer $\omega$ maximizes the value of the firm

$$\frac{V_t(\omega)}{P_t} = \mathbb{E}_0 \sum_{t=0}^{\infty} m_{t,t+1} \left( \frac{D_{t+1}(\omega)}{P_{t+1}} \right)$$

subject to the profit

$$\frac{D_t(\omega)}{P_t} = \frac{p_t(\omega)}{P_t} y_t(\omega) - \frac{W_t}{P_t} h_t(\omega) - \frac{\chi}{2} \left( \frac{p_t(\omega)}{p_{t-1}(\omega)} - 1 \right)^2 \frac{p_t(\omega)}{P_t} y_t(\omega)$$

the linear production technology

$$y_t(\omega) = Z_{P,t} l_t(\omega)$$

the HSA demand curve

$$y_t(\omega) = c_t(\omega) = s \left( \frac{p_t(\omega)}{A_t} \right) \frac{P_tC_t}{p_t(\omega)}$$
Central bank

- A simple feedback rule

\[(1 + i_t) = (1 + i_{t-1})^{\alpha_i} \left( \frac{p_t}{p_{t-1}} - 1 \right)^{(1-\alpha_i)\alpha_i} u_t\]
Aggregate conditions

- Free entry condition
  \[
  \frac{W_t}{P_t} f_{E,t} = \frac{V_t}{P_t} Z_{E,t}
  \]

- Firm dynamics
  \[
  N_t = (1 - \delta) (N_{t-1} + N_{E,t-1}) = (1 - \delta) N_{H,t-1}
  \]

- Aggregate accounting
  \[
  \frac{V_t}{P_t} N_{E,t} + C_t = \frac{D_t}{P_t} N_t + \frac{W_t}{P_t} L_t
  \]

- Adding up constraint
  \[
  s\left(\frac{p_t}{A_t}\right) = s(z_t) = \frac{1}{N_t}
  \]

- Final goods price
  \[
  \ln \left(\frac{p_t}{A_t}\right) = \ln \left(\frac{z_t}{\bar{p}_t}\right) = \bar{K} - \frac{1}{s(z_t)} \left[ \int_{z_t}^{\bar{z}} s(\xi) \frac{1}{\xi} d\xi \right]
  \]
  where
  \[
  z_t := \frac{p_t}{A_t}, \quad \bar{p}_t := \frac{p_t}{P_t}
  \]
Equilibrium

- An *equilibrium* in this economy is
  - a collection of sequence of aggregate prices \( \{P_t, A_t, W_t, i_t\} \) and the price of intermediate goods \( \{p_t\} \)
  - a collection of sequences of aggregate quantities \( \{Y_t, C_t, L_t\} \) and quantities of intermediate goods \( \{y_t, l_t\} \)
  - a collection of sequences of firm-value functions and profit \( \{V_t, D_t\} \) together with measures of operating firms and entering firms \( \{N_t, N_{E,t}\} \)

- These equilibrium objects satisfy the following conditions
  - households maximize their utility subject to their budget constraints
  - intermediate-good firms maximize the net present value of their per-period profits
  - final-good firms maximize profits
  - all of the feasibility constraints are satisfied
Preference and detrending

- Preference

\[ u(C_t) := \frac{C_t^{1-\sigma} - 1}{1 - \sigma}, \quad v(L_t) := \frac{L_t^{1+\psi}}{1 + \psi} \]

- Nominal variables are detrended

\[ w_t := \frac{W_t}{P_t}, d_t := \frac{D_t}{P_t}, v_t := \frac{V_t}{P_t}, z_t := \frac{p_t}{A_t}, \bar{p}_t := \frac{p_t}{P_t}, \pi_t := \frac{p_t}{p_{t-1}} \]
System of equations

1. Taylor rule

\[(1 + i_t) = \left(1 + i_{t-1}\right)^{\alpha_i} (\pi_t - 1) \left(1 - \alpha_i\right) \alpha \pi u_t\]

2. Euler equation for bonds

\[C_t^{-\sigma} = \beta E_t C_{t+1}^{-\sigma} \frac{1 + i_t}{\pi_{t+1}} \frac{p_{t+1}}{p_t}\]

3. New Keynesian Phillips curve (hereafter, NKPC)

\[
\left[1 - \frac{\chi}{2} (\pi_t - 1)^2\right] S' (z_t) z_t \left(\frac{z_t}{s(z_t)}\right) + \left[1 - \frac{S' (z_t) z_t}{s(z_t)}\right] L_t^\psi C_t^{-\sigma} \frac{C_{t+1}^{-\sigma}}{Z_{P,t} p_t} - \chi (\pi_t - 1) \pi_t + \beta (1 - \delta) E_t \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \chi \left(\pi_{t+1} - 1\right) \pi_{t+1} \frac{s(z_{t+1})}{s(z_t)} \frac{Y_{t+1}}{Y_t} = 0
\]

4. Euler equation for equity

\[
L_t^\psi C_t^{-\sigma} \frac{f_{E,t}}{Z_{E,t}} = \beta (1 - \delta) E_t \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \left\{ \left[1 - \frac{L_t^\psi C_{t+1}^{-\sigma}}{Z_{P,t} p_{t+1}} - \frac{\chi}{2} \left(\pi_{t+1} - 1\right)^2\right] s(z_{t+1}) Y_{t+1} + L_t^\psi C_{t+1}^{-\sigma} \frac{f_{E,t+1}}{Z_{E,t+1}} \right\}
\]

5. Firm dynamics

\[
\frac{1}{s(z_t)} = (1 - \delta) \left[\frac{1}{s(z_{t-1})} + \frac{Z_{E,t-1}}{f_{E,t-1}} \left(L_{t-1} - \frac{Y_{t-1}}{p_{t-1} Z_{t-1}}\right)\right]
\]

6. Relative price

\[
\ln \left(\frac{z_t}{p_t}\right) = \kappa - \frac{1}{s(z_t)} \left[\int_{z_t}^{z_{t-1}} \frac{s(\xi)}{\xi} d\xi\right]
\]

7. Resource constraint

\[C_t = \left[1 - \frac{\chi}{2} (\pi_t - 1)^2\right] Y_t\]
Steady state

1. Taylor rule
   \[ \pi = 1 \]

2. Euler equation for bonds
   \[ i = \frac{1 - \beta}{\beta} \]

3. NKPC
   \[ L^\psi Y^\sigma = \frac{\bar{p}}{1 - \frac{s(z)}{s'(z)z}} Z_P \]

4. Euler equation for equity
   \[ L = \frac{1}{1 - \delta} \frac{f_E}{Z_E} \left[ \delta - \frac{1 - \beta (1 - \delta)}{\beta} \frac{s'(z)z}{s(z)} \right] \frac{1}{s(z)} \]

5. Firm dynamics
   \[ Y = -\frac{1 - \beta (1 - \delta)}{\beta (1 - \delta)} Z_P \frac{f_E}{Z_E} \frac{s'(z)z}{s(z)} \frac{z}{s(z)} \exp \left( \tilde{K} - \int^z_{\tilde{z}} \frac{s(\xi)}{s(z)} d\tilde{\xi} \right) \]

6. Relative price
   \[ \bar{p} = \frac{z}{\exp \left( \tilde{K} - \int^z_{\tilde{z}} \frac{s(\xi)}{s(z)} d\tilde{\xi} \right)} \]
Linearized system of equations

1. **Taylor rule**
   \[ i_t = \alpha_i i_{t-1} + (1 - \alpha_i) \alpha \pi \hat{\pi}_t + u_t \]

2. **Euler equation for bonds**
   \[
   \hat{Y}_t = \mathbb{E}_t \hat{Y}_{t+1} - \frac{1}{\sigma} \left[ i_t - (\hat{\beta}_t - \mathbb{E}_t \hat{\beta}_{t+1}) - \mathbb{E}_t \hat{\pi}_{t+1} \right]
   \]

3. **NKPC**
   \[
   \hat{\pi}_t = \frac{1}{\chi} \left[ -\frac{s'(z)}{s(z)} \right] \left( \psi \hat{L}_t + \sigma \hat{Y}_t - \hat{Z}_{P,t} - \hat{\beta}_t \right) + \frac{1}{\chi} \left[ \frac{s'(z)}{s(z)} - \frac{s''(z)}{s'(z)} \right] \hat{z}_t + \beta (1 - \delta) \mathbb{E}_t \hat{\pi}_{t+1}
   \]

4. **Euler equation for equity**
   \[
   \psi \hat{L}_t = \left\{ [1 - \beta (1 - \delta)] \frac{s'(z)}{s(z)} + \beta (1 - \delta) \right\} \psi \mathbb{E}_t \hat{L}_{t+1} + [1 - \beta (1 - \delta)] \left[ \sigma \frac{s'(z)}{s(z)} + (1 - \sigma) \right] \mathbb{E}_t \hat{Y}_{t+1}
   \]
   \[ - \left( \hat{f}_{E,t} - \hat{Z}_{E,t} \right) + \beta (1 - \delta) \mathbb{E}_t \left( \hat{f}_{E,t+1} - \hat{Z}_{E,t+1} \right) - [1 - \beta (1 - \delta)] \frac{s'(z)}{s(z)} \mathbb{E}_t \hat{Z}_{P,t+1}
   \]

5. **Firm dynamics**
   \[
   \hat{z}_t = (1 - \delta) \hat{z}_{t-1} - \left\{ \delta \frac{s(z)}{s'(z)} - \frac{1 - \beta (1 - \delta)}{\beta} \right\} \hat{L}_t - \hat{Y}_t + \hat{\beta}_t + \hat{Z}_{P,t} + \delta \frac{s(z)}{s'(z)} \left( \hat{f}_{E,t} - \hat{Z}_{E,t} \right)
   \]

6. **Relative price**
   \[
   \hat{p}_t = - \frac{1}{s(z)} \int_{\hat{z}}^{\hat{z}_t} \frac{s(\xi)}{s'(\xi)} d\xi \frac{s'(z)}{s(z)} \hat{z}_t
   \]
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How does market concentration affect the slope of the Phillips curve?

How does the entry cost $f_E$ affect the number of firms $N$ in the steady state, and then the slope of NKPC?

\[
\hat{\pi}_t = \beta (1 - \delta) \mathbb{E}_t \hat{\pi}_{t+1} + \frac{1}{\chi} \left[ - \frac{s'(z) z}{s(z)} \right] \left( \hat{W}_t - \hat{Z}_{P,t} - \hat{p}_t \right) + \frac{1}{\chi} \left[ \frac{s'(z) z}{s(z)} - \frac{s''(z) z}{s'(z) s(z)} \right] \left[ - \frac{s'(z) z}{s(z)} \right] \hat{z}_t
\]

\[
= \beta (1 - \delta) \mathbb{E}_t \hat{\pi}_{t+1} + \frac{1}{\chi} \left( \hat{W}_t - \hat{Z}_{P,t} - \hat{p}_t \right) - \frac{1}{\chi} \frac{1 - \rho(z)}{\rho(z)} \hat{N}_t
\]

- Price elasticity

\[
\zeta(z) := - \frac{\partial \ln (c_t (\omega))}{\partial \ln (p_t)} = 1 - \frac{s'(z) z}{s(z)} > 1
\]

- Markup rate under flexible price: $\mu^f(z) = \zeta(z) / (\zeta(z) - 1)$

- Pass-through rate

\[
\rho(z) := \frac{\partial \ln (p_t)}{\partial \ln (W_t / Z_{P,t})} = \left[ 1 - d \ln \left( \frac{\zeta(z)}{\zeta(z) - 1} \right) d \ln (z) \right]^{-1}
\]
NKPC under CES

- Under CES
  \[ s(z) = \gamma_{CES} z^{1-\theta} \]

- No effect from competition – the entry cost \( f_{E,t} \) – on parameters in NKPC
  \[ \hat{\pi}_t = \beta (1 - \delta) \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\theta - 1}{\chi} (\hat{W}_t - \hat{Z}_{P,t} - \hat{p}_t) \]

- Due to constant price elasticity under CES
  - no effect to the slope of the Phillips curve
  - no dynamic effect of competition
Price elasticity in the slope of NKPC/Rotemberg

- Even though HSA endogenizes the price elasticity, the reason why the slope depends on the price elasticity is the same as under CES

- The optimal price setting condition under the symmetric equilibrium

\[(1 - \theta) + \theta mc_t - \chi (\pi_t - 1)^2 \pi_t + E_t m_{t+1} \chi (\pi_{t+1} - 1) \pi_{t+1} \frac{Y_{t+1}}{Y_t} = 0\]

- In response to higher TFP
  - The 2nd term shows how much costs decline \(\propto\) price elasticity
  - The 3rd and 4th terms represent losses and gains from price adjustments (inflation rates)
  - ↑ price elasticity ⇒ ↑ decline in the demand ⇒ ↑ impact of the marginal cost on inflation rates

- With an exogenous change in the real marginal cost, the incentive to set the price closer to the optimal level (the price without nominal rigidities) becomes stronger with higher price elasticity ⇔ state dependent pricing
  - This motive is absent in Calvo pricing
Implications of the Second law $\zeta' (z) > 0$

\[ \hat{\pi}_t = \beta (1 - \delta) \mathbb{E}_t \hat{\pi}_{t+1} + \frac{\zeta(z) - 1}{\chi} (\hat{W}_t - \hat{Z}_{P,t} - \hat{p}_t) - \frac{1}{\chi} \frac{1 - \rho(z)}{\rho(z)} \hat{N}_t \]

1. **Steady-state effect of competition - flattening of the Phillips curve**
   - More concentration $\Leftrightarrow$ higher market share, $s(z) \uparrow \Leftrightarrow z \downarrow$
   - $\zeta' (z) > 0 \Rightarrow \zeta(z) \downarrow$, flattening of the Phillips curve

2. **Dynamic effect of competition - endogenous cost-push shock**
   \[
   \hat{\mu}_t^f = - \frac{1 - \rho(z)}{\rho(z)} \hat{z}_t = - \frac{1 - \rho(z)}{\rho(z)} (\hat{p}_t - \hat{A}_t)
   \]
   - $\zeta' (z) > 0 \Leftrightarrow$ incomplete pass-through: $\rho(z) < 1 \Leftrightarrow$ strategic complementarity
     - The firm reduces its price and markup rate in response to more competitive pressure, a lower $A_t$, when other firms reduce their prices
     - If $\hat{\mu}_t^f = - (\hat{W}_t - \hat{Z}_{P,t} - \hat{p}_t)$ and $\hat{z}_t$ move to the opposite directions (same direction) to a structural shock, its impact on inflation is muted (amplified)
Cyclicality of markup to the technology shock

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<td>The Second law</td>
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- In a flexible price equilibrium under CES, constant
- In a sticky price equilibrium under CES, procyclical
  - The marginal cost decreases but the price does not change
- In a flexible price equilibrium under the Second law, countercyclical
  - A positive technology shock increases the number of firms, which causes the markup rate to decline
- In a sticky price equilibrium under the Second law, generally ambiguous and depends on the tension between nominal rigidities and the pass-through rate

\[
\hat{\mu}_t = \frac{\chi}{\zeta(z) - 1} \left[ \beta (1 - \delta) E_t \hat{\pi}_{t+1} - \pi_t \right] - \frac{1 - \rho(z)}{\rho(z)} \hat{z}_t
\]
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## Parametric families of HSA

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<th>Pass-through $\rho(z)$</th>
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<tr>
<td>CES</td>
<td>$s(z) = \gamma_{\text{CES}} z^{1-\theta}$</td>
<td>$\zeta(z) = \theta$</td>
<td>$\rho(z) = 1$</td>
</tr>
<tr>
<td>Translog</td>
<td>$s(z) = \gamma_{\text{TL}} \ln \left( \frac{\bar{z}}{z} \right)$</td>
<td>$\zeta(z) = 1 + \frac{1}{\ln \left( \frac{\bar{z}}{z} \right)}$</td>
<td>$\rho(z) = \frac{1+\ln \left( \frac{\bar{z}}{z} \right)}{2+\ln \left( \frac{\bar{z}}{z} \right)}$</td>
</tr>
<tr>
<td>Co-PaTh</td>
<td>$s(z) = \gamma_{\text{CP}} \theta^{1-\rho} \left[ 1 - \left( \frac{\bar{z}}{z} \right)^{\frac{1-\rho}{\rho}} \right]^{\frac{\rho}{1-\rho}}$</td>
<td>$\zeta(z) = \frac{1}{1 - \left( \frac{\bar{z}}{z} \right)^{\frac{1-\rho}{\rho}}}$</td>
<td>$\rho(z) = \rho &lt; 1$</td>
</tr>
</tbody>
</table>

- $\bar{z} := \inf \{ z > 0 | s(z) = 0 \}$: if $\bar{z} < \infty$, $\bar{z}A_t$ is the choke price

\[
\bar{z} = \left( \frac{\theta}{\theta - 1} \right) \frac{\rho}{1-\rho}
\]
**Calibration**

<table>
<thead>
<tr>
<th>parameter</th>
<th>definition</th>
<th>value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta$</td>
<td>subjective discount factor</td>
<td>0.99</td>
</tr>
<tr>
<td>$\sigma$</td>
<td>relative risk aversion</td>
<td>1</td>
</tr>
<tr>
<td>$\delta$</td>
<td>exit rate</td>
<td>0.025</td>
</tr>
<tr>
<td>$\psi$</td>
<td>inverse of labor supply elasticity</td>
<td>1</td>
</tr>
<tr>
<td>$f_{E,Z_E,Z_P}$</td>
<td>technologies</td>
<td>1</td>
</tr>
<tr>
<td>$\theta$</td>
<td>price elasticity under CES</td>
<td>3.8</td>
</tr>
<tr>
<td>$\chi$</td>
<td>Rotemberg adj. cost</td>
<td>77</td>
</tr>
<tr>
<td>$\alpha_i$</td>
<td>policy inertia</td>
<td>0.9</td>
</tr>
<tr>
<td>$\alpha_\pi$</td>
<td>policy reaction to $\pi$</td>
<td>1.5 or $\infty$</td>
</tr>
<tr>
<td>$\rho$</td>
<td>pass-through rate</td>
<td>1, 0.9 or 0.5</td>
</tr>
</tbody>
</table>

- Most are taken from Bilbiie, Fujiwara and Ghironi (2014)
Entry cost and the slope of NKPC

- CES: $\rho = 1.0$
- Co–PaTh: $\rho = 0.9$
- Translog
- Co–PaTh: $\rho = 0.5$
Concentration and the slope of NKPC

- The slope of NKPC: \( \frac{\zeta(z) - 1}{\chi} \), where \( \frac{dz}{dN} > 0 \),
- The Second law

\[
\frac{d\ln \left( \frac{\zeta(z)}{\zeta(z) - 1} \right)}{d\ln (z)} = 1 - \frac{1}{\rho(z)} < 0
\]
SS with varying entry cost

- Increasing barriers to entry: higher entry cost
  - Market concentration: fewer number of firms
    - More concentration $\iff$ high market share (concentration), $s(z) \uparrow \iff z \downarrow$
    - The Second law: $\zeta'(z) > 0 \Rightarrow \zeta(z) \downarrow$
  - Higher markup, $\mu(z) = \frac{\zeta(z)}{\zeta(z) - 1} \uparrow$: higher profit
1. Introduction

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3. New Keynesian model under HSA

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5. Steady state analysis

6. Dynamic analysis

7. Calvo pricing

8. Conclusion
Impulse responses

- Two shocks
  1. Technology shock: $Z_{P,t}, Z_{E,t}$
  2. Monetary policy shock: $u_t$

- Two scenarios
  1. Around the same steady state markup
  2. Around the different market concentration reflecting difference in the entry cost
    - Two countries
    - Two regulatory regimes
Technology shock

- Higher return $\Rightarrow C_t = Y_t \uparrow$ and $N_{E,t} \uparrow$ for intertemporal smoothing, but gradual increase in $N_t \Rightarrow z_t \uparrow \Rightarrow y_t \downarrow \Rightarrow d_t \downarrow$

Sticky vs Flex
- Countercyclical (procyclical) markup under flexible (sticky) price
- Cyclicality of markup depends on the pass-through and nominal rigidities
- The dynamic effect of competition $\Rightarrow$ deflation with small $\rho(z)$

Different pass-through
- Closer substitutes $\Rightarrow$ lower markup & profits
- Weaker incentive for creation, and muted increase in $N_t$ and $z_t$
Concentration and transmission of shocks

- Higher market concentration
  - Response of $\pi_t$ becomes smaller
    - The Second law $\Rightarrow$ flatter NKPC
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NKPC under Calvo pricing

\[ \hat{\pi}_t = \beta (1 - \delta) E_t \hat{\pi}_{t+1} + \frac{(1 - \psi) [1 - \psi \beta (1 - \delta)]}{\psi} \left[ \rho (\tilde{z}) (\hat{W}_t - \hat{Z}_{p,t} - \hat{p}^*_t) - \frac{1 - \rho (\tilde{z})}{\zeta (\tilde{z}) - 1} \hat{N}_t \right] \]

where \( \hat{\pi}_t := \hat{p}_t / \hat{p}_{t-1} \), \( \tilde{z}_t := \hat{p}_t / A_t \) and \( \hat{p}_t \) is implicitly given by

\[ \int_{\Omega} s (p_t (\omega) / A_t) \, d \omega = 1 = N_t s (\hat{p}_t / A_t) \]

- Concentration leads to flattening of NKPC under the Third law (Matsuyama and Ushchev, 2022b)
  - A higher price leads to a smaller rate of change in the price elasticity
  - A higher entry cost leads to less competitive pressures and lowers the pass-through rate
  - Translog cannot accommodate Marshall’s third law of demand

- Strategic complementarity: \( \uparrow \) concentration \( \Rightarrow \) \( \downarrow \) pass-through
  - \( \uparrow \) flattening of NKPC
  - \( \uparrow \) the dynamic effect of competition
Pass-through in the slope of NKPC/Calvo

- The optimal price setting condition

\[ \mathbb{E}_0 \sum_{i=0}^{\infty} [\psi \beta (1 - \delta)]^i u' (C_{t+i}) Y_{t+i} s \left( \frac{p_t^*}{A_{t+i}} \right) \left[ 1 - \zeta \left( \frac{p_t^*}{A_{t+i}} \right) \right] \left[ p_t^* - \frac{\zeta \left( \frac{p_t^*}{A_{t+i}} \right)}{\zeta \left( \frac{p_t^*}{A_{t+i}} \right) - 1} \frac{W_{t+i}}{Z_{P,t+i}} \right] = 0 \]

- The reset price can be replaced by inflation rates under Calvo pricing

- Impact of the marginal cost on inflation rates depends on how markup changes with the reset price, which is pinned down by the pass-through

\[ \frac{d \ln \left( \frac{\zeta(z)}{\zeta(z)-1} \right)}{d \ln (z)} = 1 - \frac{1}{\rho(z)} \]

- Strategic complementarity under HSA
- Constant markup under CES
Power elasticity of markup rate

- Power Elasticity of Markup rate (hereafter, PEM) proposed by Matsuyama and Ushchev (2022b) accommodates the third law
- The market share function: either $\bar{z} = 0$ and $c \leq 1$ or $\bar{z} < 0$ and $c = 1$, $\kappa > 0$ and $\lambda > 0 \Rightarrow$ the Second law and the strong Third law

$$s(z) = \exp \left[ \int_{z_0}^{z} \frac{c}{c - \exp \left( -\frac{\kappa\bar{z} - \lambda}{\lambda} \right) \exp \left( \frac{\kappa\zeta - \lambda}{\lambda} \right)} \frac{d\zeta}{\zeta} \right]$$

- Price elasticity

$$\zeta(z) = \frac{1}{1 - c \exp \left( \frac{\kappa\bar{z} - \lambda}{\lambda} \right) \exp \left( -\frac{\kappa\bar{z} - \lambda}{\lambda} \right)}$$

- Pass-through

$$\rho(z) = \frac{1}{1 + \kappa\bar{z} - \lambda}$$

- PEM collapses to
  - CES with $\kappa = 0$, $c = 1 - 1/\theta$ and $\bar{z} = \infty$
  - Co-PaTh with $\lambda = 0$, $\kappa = (1 - \rho) / \rho$, $c = 1$ and $\bar{z} < \infty$
The markup rate and the slope of NKPC under Calvo

The graph shows the relationship between the markup rate and the slope of NKPC for different values of the parameters $\kappa$ and $\lambda$. The graph includes lines for $\kappa=0.1, \lambda=0.1$, $\kappa=0.1, \lambda=0.5$, $\kappa=0.1, \lambda=1.0$, $\kappa=0.1, \lambda=1.5$, $\kappa=0.1, \lambda=2.0$, and $\kappa=0.1, \lambda=4.0$. The CES model is represented by a solid black line.
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Key takeaways

- Under Rotemberg pricing, the Second law implies
  - Higher concentration $\Rightarrow$ higher markup $\Rightarrow$ flattening of the Phillips curve
  - Concentration affects price setting dynamically through strategic complementarity - endogenous cost-push shock
  - Muted impacts of structural shocks on inflation rates with higher market concentration
  - Pass-through rate plays an important role in cyclicality of markup

- Under Calvo pricing, the Third law causes
  - Higher concentration $\Rightarrow$ lower pass-through $\Rightarrow$ flattening of the Phillips curve

- Under HSA, the market share function fully characterizes both the price elasticity and the pass-through rate and its single aggregator summarizes all the impacts of market concentration on the flattening of the Phillips curve
Future studies

- Future studies include
  - Optimal policy
  - Wage Phillips curve
  - Menu cost model
  - Heterogeneous firm
  - Reference price gap \((P \text{ vs } A)\)
  - Empirical investigation


Computation of $z$


\( P(p_t) vs A(p_t) \)

- **Under HSA**
  \[
  \frac{\partial P(p_t) / \partial p_t(\omega)}{P(p_t) / p_t(\omega)} = s\left( \frac{p_t(\omega)}{A(p_t)} \right) \Rightarrow \frac{\partial (P(p_t) / A(p_t))}{P(p_t) / A(p_t)} = \frac{s(z_t(\omega))}{z_t(\omega)} \partial z_t(\omega)
  \]

- **By integrating**
  \[
  \ln \left( \frac{P(p_t)}{A(p_t)} \right) = \bar{K} - \int_{\Omega_t} \left[ \int_{p_t(\omega)}^{\bar{z}(\omega)} \frac{s(\xi)}{\xi} d\xi \right] d\omega
  \]
  \[\bar{z} := \inf \{ z > 0 | s(z) = 0 \} \text{ if } \bar{z} < \infty, \bar{z}A_t \text{ is the choke price}\]
  \[\bar{K} \text{ a constant}\]

- **\( P(p_t) = \text{constant} \times A(p_t) \iff \text{CES, because, by differentiating the adding-up constraint}**
  \[
  \frac{\partial \ln (A(p_t))}{\partial \ln (p_t(\omega))} = \frac{\frac{p_t(\omega)}{A(p_t)} s' \left( \frac{p_t(\omega)}{A(p_t)} \right)}{\int_{\Omega_t} \frac{p_t(\omega')}{A(p_t)} s' \left( \frac{p_t(\omega')}{A(p_t)} \right) d\omega'} \neq s\left( \frac{p_t(\omega)}{A(p_t)} \right) = \frac{\partial \ln (P(p_t))}{\partial \ln (p_t(\omega))}
  \]
  unless \( s(z) \) is a power function
9. $P(p_t) \text{ vs } A(p_t)$

10. Computation of $z$
Computation of $z$

- Steady state of $z$ is pinned down by
  
  1. Pricing formula: $f(L(z), Y(z), z) = 0$

  \[
  \frac{\text{MRS}}{L(z)^\psi Y(z)^\sigma} = \frac{w}{\text{markup}} = \frac{z}{\text{MPL}} = \frac{\exp \left( \text{const.} - \int_z^{\bar{z}} \frac{s(\xi)}{s(z)} d\xi \right)}{Z_P}
  \]

  - Firm dynamics: $Y = Y(z)$

  \[
  Y(z) = -\frac{1 - \beta (1 - \delta)}{\beta (1 - \delta)} Z_P \frac{f_E}{Z_E} \frac{\frac{s'(z)z}{z}}{\frac{s(z)}{s(z)}} \exp \left( \text{const.} - \int_z^{\bar{z}} \frac{s(\xi)}{s(z)} d\xi \right)
  \]

  - Value of the firm: $L = L(z)$

  \[
  L(z) = \frac{1}{1 - \delta} \frac{f_E}{Z_E} \left[ \delta - \frac{1 - \beta (1 - \delta)}{\beta} \frac{s'(z)z}{s(z)} \right] \frac{1}{s(z)}
  \]
Computation of $z$ under CES

- Steady state of $z$ is pinned down by
  - Pricing formula: $f(L(z), Y(z)) = \text{constant}$

\[
\frac{MRS}{L(z)^\psi Y(z)^\sigma} = \frac{w}{\frac{\theta - 1}{\theta} Z_P}
\]

- Firm dynamics: $Y = Y(z)$: $\frac{\partial Y}{\partial z} > 0$, $\frac{\partial^2 Y}{\partial z \partial f_E} > 0$

\[
Y(z) = \frac{1 - \beta (1 - \delta)}{\beta (1 - \delta)} Z_P \frac{f_E}{Z_E} (\theta - 1) z^{\theta - 1}
\]

- Value of the firm: $L = L(z)$: $\frac{\partial L}{\partial z} > 0$, $\frac{\partial^2 L}{\partial z \partial f_E} > 0$

\[
L(z) = \frac{1}{1 - \delta} \frac{f_E}{Z_E} \left[ \delta + \frac{1 - \beta (1 - \delta)}{\beta} (\theta - 1) \right] z^{\theta - 1}
\]
Labor market equilibrium with $f_E$: Co-PaTh, $\rho = 0.9$
Calibration of $\bar{K}$

- $\bar{K}$ is calibrated so that under CES
  \[ \frac{p_t}{A_t} = z_t = \bar{p}_t = \frac{p_t}{P_t} \]

- Under CES, where $\bar{z} = \infty$
  \[
  \ln \left( \frac{z_t}{\bar{p}_t} \right) = \bar{K} - \frac{1}{\gamma_{C\text{ES}} \left( \frac{z_t}{\bar{p}} \right)^{1-\theta}} \left[ \int_{z_t}^{\bar{z}} \frac{\gamma_{C\text{ES}} \left( \frac{z}{\bar{p}} \right)^{1-\theta}}{\xi} d\xi \right] = \bar{K} + \frac{1}{1-\theta} = 0
  \]

  \[ \therefore \bar{K} = \frac{1}{\theta - 1} \]
Analytical integration

- We need to solve the integral in

\[
\bar{p} = \frac{z}{\exp\left(\tilde{K} - \int_\bar{z}^z \frac{s(\xi)}{s(z)} d\xi\right)}
\]

- Under Co-PaTh, the integral is given analytically by the hypergeometric function

\[
\int \left[1 - \left(\frac{\xi}{\bar{z}}\right)^{1/\nu}\right]^{1+\nu} \frac{d\xi}{\bar{z}} = \frac{\nu}{1+\nu} \sum_{n=0}^{\infty} \frac{(1)_n (1+\nu)_n}{(2+\nu)_n n!} \left[1 - \left(\frac{\xi}{\bar{z}}\right)^{1/\nu}\right]^n
\]

- Under Translog

\[
\int \frac{\gamma_{TL} \ln\left(\frac{\bar{z}}{\xi}\right)}{\bar{z}} d\xi = -\frac{\gamma_{TL}}{2} \left[\ln\left(\frac{\bar{z}}{\xi}\right)\right]^2
\]