Optimal Monetary Policy with Endogenous Entry and Product Variety.

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Question and Motivation

• Central banks in industrialized countries target short-run price stability around a long run positive average inflation rate of approximately 2 percent

• Optimal monetary policy in models with nominal rigidities (Ramsey or otherwise): Lucas and Stokey 1983; Chari, Christiano and Kehoe, 1991; Adao, Correia and Teles, 2003; Khan, King and Wolman, 2003; Woodford, 2003; Clarida, Gali and Gertler, 1999; Schmitt-Grohe and Uribe, etc.
  – long-run prediction: zero inflation is optimal, unless a monetary distortion makes Friedman rule (implying deflation) optimal.
  – short-run predictions: price stability, with some important exceptions

• Exceptions LR: zero lower bound (Billi, 2010); downward rage rigidity (Kim and Ruge-Murcia, 2009); heterogenous firms’ productivity growth (Weber, 2010)

• Exceptions SR:
  – "cost-push" shocks driving time-varying inefficiency wedges between the flexible-price equilibrium and the efficient, planner solution (Examples: sticky wages, time-varying elasticity of substitution, productivity shocks when utility is not isoelastic and/or government spending is non-zero)
  – models with search and matching in the labor market (Thomas 2008; Faia 2009)
  – models with physical capital (Levin, Lopez-Salido and Yun, 2006)
• Conclusions of literature: if anything, the opposite of what central banks actually do (i.e. zero long-run inflation, deviations from short-run price stability)

• This paper: Does endogenous entry and product variety change those conclusions?
Motivation Continued and Results

- Endogenous entry (introduction of new products) and product variety are important for business cycles
  - series of papers by Bilbiie, Ghironi and Melitz, and many others.

- In particular, possible types of distortions in the real, flexible-price model:
  - markup heterogeneity over time and across goods/states
    - example: monopolistic competition and elastic labor
    - unbalancing of consumer surplus and entry incentives

- Will the welfare costs of these distortions outweigh the welfare costs of using inflation, and hence generate optimal deviations from price stability?

- Our answers:
  - Yes, in the long run: the optimal rate of long-run inflation is nonzero under certain conditions
  - No, in the short run: central banks do not lose much by replicating price stability over the cycle.
  - These results can justify actual central banks’ policies
The Core Model with Flexible Prices - Competitive Equilibrium

- Expected Utility: $E_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} U(C_s, L_s) \right]$, $U(C_t, L_t) = \ln C_t - h(L_t)$,
  * $\varphi \equiv h_{LL}(L) L/h_L(L) \geq 0$ is the inverse Frisch elasticity of labor supply

- Symmetric homothetic preferences for consumption goods
  - Consumption index $C_t$ defined over continuum of varieties $\Omega$, with welfare-based price index $P_t$
  - Only varieties in $\Omega_t \subset \Omega$ (with measure $N_t$) are actually available.
  - Demand for variety $\omega$: $c_t(\omega) d\omega = C_t \partial P_t / \partial p_t(\omega)$, with price elasticity $-\theta(N_t), \theta' \geq 0$
  - Relative price/benefit of variety: $\rho_t \equiv p_t/P_t = \rho(N_t), \rho' > 0$
  - In elasticity form: $\epsilon(N_t) = \frac{\rho'(N_t)}{\rho(N_t)} N_t$

- Production, Entry, and the Value of Firms
  - Monopolistically competitive producers with technology: $y_t(\omega) = Z_t l_t(\omega)$
  - (Desired) Markup Function: $\mu_t \equiv \mu(N_t) = \theta(N_t) / [\theta(N_t) - 1], \mu' \leq 0$
  - Value of the firm: $v_t(\omega) = E_t \sum_{s=t+1}^{\infty} [\beta (1 - \delta)]^{s-t} [U'(C_s) / U'(C_t)] d_s(\omega)$
  - Free Entry: $v_t(\omega) = w_t f_{E,t} / Z_t$
  - Number of Producers: $N_t = (1 - \delta) (N_{t-1} + N_{E,t-1})$
Three frameworks

<table>
<thead>
<tr>
<th>C.E.S.-DS</th>
<th>C.E.S.-Benassy</th>
<th>Translog</th>
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<tbody>
<tr>
<td>$\mu_t = \mu = \frac{\theta}{\theta - 1}$</td>
<td>$\mu_t = \mu = \frac{\theta}{\theta - 1}$</td>
<td>$\mu (N_t) = 1 + \frac{1}{\sigma N_t}$</td>
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<tr>
<td>$\rho(N_t) = (N_t)^{\frac{1}{\theta - 1}}$</td>
<td>$\rho(N_t) = (N_t)^{\gamma}$</td>
<td>$\rho(N_t) = e^{-\frac{N-N_t}{2\sigma N_t}}$, $\tilde{N} \equiv Mass(\Omega)$</td>
</tr>
<tr>
<td>$\epsilon(N_t) = \mu - 1$</td>
<td>$\epsilon(N_t) = \epsilon$</td>
<td>$\epsilon(N_t) = \frac{1}{2\sigma N_t} = \frac{1}{2}(\mu(N_t) - 1)$</td>
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Budget Constraint:

$$v_t (N_t + N_{E,t}) x_{t+1} + C_t = (d_t + v_t) N_t x_t + w_t L_t$$

Euler Equation

$$v_t = \beta (1 - \delta) E_t \left[ \frac{U''(C_{t+1})}{U'(C_t)} (v_{t+1} + d_{t+1}) \right].$$

Labor optimality:

$$MRS_{C,L} = Z_t \rho(N_t) / \mu(N_t).$$ (1)

Aggregate Accounting:

$$Y_t \equiv C_t + N_{E,t} v_t = w_t L_t + N_t d_t$$

• Existence: $\mu'(.) \leq 0$
Planner Equilibrium

• Given $f_{E,t}$ and $Z_t$, planner solves:

$$\max_{\{L_s^C, L_s\}_{s=t}^{\infty}} E_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} U \left( Z_s \rho (N_s) L_s^C, L_s \right) \right],$$

subject to $N_{t+1} = (1 - \delta) N_t + (1 - \delta) \frac{(L - L_t^C) Z_t}{f_{E,t}}$.

• Existence: $\epsilon'(\cdot) \leq 0$

• Euler Equation PO:

$$U'(C_t) \rho (N_t) f_{E,t} = \beta (1 - \delta) E_t \left\{ U'(C_{t+1}) \left[ f_{E,t+1} \rho (N_{t+1}) + \frac{C_{t+1}}{N_{t+1}} \epsilon (N_{t+1}) \right] \right\}. \quad (2)$$

Compare with CE:

$$U'(C_t) \rho (N_t) f_{E,t} = \beta (1 - \delta) E_t \left\{ U'(C_{t+1}) \left[ f_{E,t+1} \rho (N_{t+1}) \frac{\mu (N_t)}{\mu (N_{t+1})} + \frac{C_{t+1}}{N_{t+1}} \mu (N_t) \left( 1 - \frac{1}{\mu (N_{t+1})} \right) \right] \right\}. \quad (3)$$

Planner’s labor allocation:

$$MRS_{C,L} = Z_t \rho (N_t). \quad (4)$$
Distortions with Flexible Prices

• **Theorem:** The competitive equilibrium is efficient if and only if:
  
  – Inelastic labor:
    
    – (i) \( \mu(N_t) = \mu(N_{t+1}) = \mu \)
    
    – (ii) The variety benefit and markup functions are such that \( \varepsilon(x) = \mu(x) - 1 \)

\( \iff \) **C.E.S.** Dixit Stiglitz

• **Intuition:**
  
  (i) Markup synchronization over time/across states (not only across goods):

  • Just like differences in markups across goods imply inefficiency (more resources should be allocated to production of high markup goods), differences in markups over time/across states also imply inefficiency (more resources should be allocated to production in high markup periods/states)

  (ii) Balancing of profit incentives for entry (via markup) with consumer benefit of additional product variety:

  • This happens only for C.E.S. and is violated if the preference function has an elasticity different from the markup function; If \( \theta \) is ‘low’, then:

    • markups and profits are ‘high’, so incentives for more entry

    • ... and love for variety is also ‘high’ as goods are more differentiated

• (In)efficiency with endogenous labor

  – Price of consumption goods relative to leisure is distorted by markup.
Ramsey Optimal Monetary Policy

- Sticky prices à la Rotemberg (BGM NBER Macro Annual) → extra distortion; firms pay adjustment cost to reset prices
  \[ pac_t (\omega) \equiv \frac{\kappa}{2} \left( \frac{p_t(\omega)}{p_{t-1}(\omega)} - 1 \right)^2 \frac{p_t(\omega)}{P_t} y_t^D (\omega), \quad \kappa \geq 0. \]

- Pricing equation becomes:
  \[ \mu_t = \frac{\theta (N_t)}{\left[ \theta(N_t) - 1 \right] \left( 1 - \frac{\kappa}{2} \pi_t^2 \right) + \kappa \left( (1 + \pi_t) \pi_t - \beta (1 - \delta) E_t \left[ \frac{1 - \frac{\kappa}{2} \pi_t^2}{1 - \frac{\kappa}{2} \pi_{t+1}^2} N_t \right] (1 + \pi_{t+1}) \pi_{t+1} \right]} \]. \tag{5}

- Second-best environment, Primal approach:
  \[ \max_{L_t, \pi_t, L_{C,t}, N_{t+1}} E_0 \sum_{t=0}^{\infty} \beta^t U \left[ \left( 1 - \frac{\kappa}{2} \pi_t^2 \right) Z_t \rho \left( N_t \right) L_{C,t}, L_t \right] \]
  \[ s.t. \ CE \ equilibrium \ conditions, \ including \ Phillips \ curve \]

- Benchmark NK model with no entry, fixed variety (no other distortions):
  – zero inflation in the long run and over the cycle. Novel analytical proof.
  – with cost-push shocks: zero inflation in the long run but significant deviations from price stability over the cycle

- With entry and variety: trade off cost of inflation with potential benefits.
Long-run results

- With entry and variety: zero long-run inflation optimal if and only if $\epsilon(x) = \mu(x) - 1$ (regardless of labor elasticity).

- Otherwise, incentives to use inflation to affect markup, and so the wedge between $\epsilon$ and $\mu - 1$.

- $\epsilon(x) < \mu(x) - 1 \rightarrow$ too much entry, use inflation to decrease average markup and provide less entry incentives.

- Optimal policy balances the benefit of this with the resource cost of price changes.
Figure 1: The steady-state net markup as a function of steady-state inflation.
• Quantitative results, baseline calibration

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\theta$</th>
<th>$\beta$</th>
<th>$\delta$</th>
<th>$\varphi$</th>
<th>$\kappa$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>3.8</td>
<td>0.99</td>
<td>0.025</td>
<td>0.25</td>
<td>77</td>
</tr>
</tbody>
</table>

Figure 2: Optimal long-run inflation rate as a function of benefit of variety, benchmark calibration.
• Long-run policy implications hinge crucially upon the welfare benefit of new products $\epsilon$. How large is it?

• Direct aggregate measure is not available, and “probably not feasible” (Bils and Klenow, 2001). "Calibrate" under CES:

$$\frac{1 + \pi_t}{1 + \pi^C_t} = \frac{\rho_t}{\rho_{t-1}} = \left(\frac{N_t}{N_{t-1}}\right)^\epsilon,$$

Take logs allowing for long-run growth in $N_t$:

$$\epsilon = \frac{\pi - \pi^C}{g_N} = \frac{\pi - \hat{\pi}^C + bias}{g_N},$$

where $\hat{\pi}^C$ is data, measured CPI inflation (Boskin et al, 1996, Broda and Weinstein, 2010).

• Bias due to not accounting for new goods: 0.6 pp/year (Boskin report, 1996) to 0.8 pp (Broda and Weinstein, 2010).

• $\pi - \hat{\pi}^C$ is at least $-0.5$ percentage points (and at most $-0.8$) across a wide range of indexes.

• $g_N = 2$ percent (Bils and Klenow, 2001)

• Benefit of variety parameter $\epsilon$ lies between 0.05 and 0.15, and it is in any case not very far from zero $\rightarrow$ optimal LR inflation.
Short-run results: Impulse responses and inflation volatilities

- Dixit-Stiglitz CES: no deviations from zero inflation.

- Non-DS CES: in principle, could expect deviations from short-run price stability because SS distortion is 'large'
  - quantitatively, not relevant; allocation very close to flexible-price equilibrium (with trend inflation).
  - impulse responses and optimal inflation volatilities

Figure: Optimal inflation volatility as a function of $\theta$, for $\epsilon = 0.1$. 
Figure: Optimal inflation volatility as a function of $\theta$, for $\epsilon = 1$. 
Figure 3: CESDS

- Number of Firms
- Consumption
- Hours
- Nominal Interest Rates
- Real Interest Rates
- Price Level
- Inflation
Figure 4: CES, epsilon=0.1

- Number of Firms
- Consumption
- Hours
- Nominal Interest Rates
- Real Interest Rates
- Price Level
- Inflation
Figure 5: CES, epsilon=1

- Number of Firms
- Consumption
- Hours
- Nominal Interest Rates
- Real Interest Rates
- Price Level
- Inflation

Lines represent different models:
- blue: flex
- red: ramsey
• Translog
  – in principle, use inflation over the cycle to correct for intertemporal misalignment of markups (endogenous cost-push shocks)
  – but: also quantitatively negligible

Figure: Optimal inflation volatility as a function of $\sigma$, translog preferences.
Figure 3: \( \sigma = 0.1 \)

- **Number of Firms**
- **Consumption**
- **Hours**
- **Nominal Interest Rates**
- **Real Interest Rates**
- **Price Level**
- **Inflation**
Welfare cost of short-run price stability

• Lucas (1987) exercise: percentage points of SS consumption that we need to give the household to make it indifferent between a policy that stabilizes producer prices around zero inflation and Ramsey optimal policy.

Figure: Total welfare loss (in steady-state consumption units) of replicating price stability around zero inflation, relative to Ramsey-optimal policy, for CES preferences.
Figure: Total welfare loss (in steady-state consumption units) of replicating price stability around zero inflation, relative to Ramsey-optimal policy, for translog preference

- decompose in static and dynamic loss: the cost of replicating short-run price stability around the Ramsey-optimal long-run inflation rate
Figure: "Dynamic" welfare loss (in steady-state consumption units) of replicating price stability around Ramsey-optimal long-run (steady-state) inflation, relative to full Ramsey-optimal policy, for CES preferences.
Figure: "Dynamic" welfare loss (in steady-state consumption units) of replicating price stability around Ramsey-optimal long-run (steady-state) inflation, relative to full Ramsey-optimal policy, for translog preferences.
Conclusions

• LR: inflation target different from zero justified on welfare grounds
  – it can correct entry incentives for producers when they are not aligned with consumers’ surplus from new varieties.

• Short-run price stability around the long-run trend is close to optimal
  – stark contrast with models of exogenously-varying desired markups, models with physical capital, and search and matching models.

• Novel argument for potentially significant deviations from long-run price stability, but need more empirical investigation into the nature of preferences for variety.