Ramsey Optimal Inflation with Heterogeneous Firms

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Introduction

- Can heterogeneous *firms* models be useful for central banks?
- Golosov-Lucas (2007) started a literature recognizing the role of large *idiosyncratic shocks* for firms' price setting and inflation dynamics.
- Such models have been used widely for *positive analysis*. E.g. to infer degree of monetary non-neutrality
- *Normative analysis* in this literature is scarce; Not much is known about the optimal rate of inflation
- "Folk wisdom" may suggest that firm-level shocks do not affect the optimality of zero inflation – i.e. the standard NK logic applies

Introduction

- In a model with idiosyncratic shocks, menu costs, and a Taylor rule with ZLB Blanco (2021) finds optimal inflation of 3.5 percent, higher than the usual 2%
- We revisit the New Keynesian prescription of a zero long-run inflation target in light of firm-level heterogeneity from a normative (Ramsey) perspective.
- We show that once forward-looking pricing is combined with *mean-reverting* firm-level shocks, zero inflation is no longer optimal.
- We identify a novel mechanism by which such shocks give rise to inefficient markup dispersion, even in the absence of aggregate fluctuations.

Reset price distorsion with mean-reverting shocks

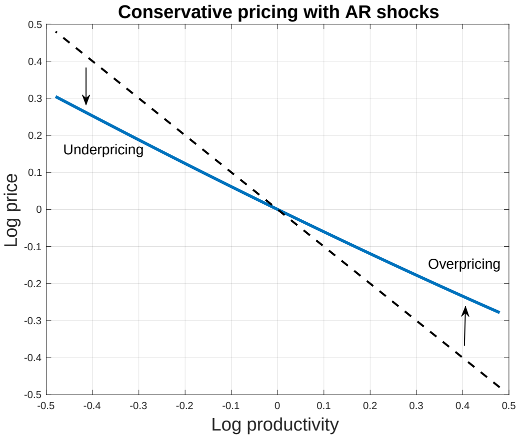


Figure: Pricing "conservatively" with mean-reverting costs

Introduction

- Firms anticipate future movements in their own productivity and set prices accordingly, resulting in inefficient pricing relative to the flex-price benchmark.
- Inflation interacts with these expectations and can be used as a policy tool to improve allocative efficiency
- *Deflation* discourages high-productivity firms from overpricing initially, while *inflation* tempers initial underpricing by low-productivity firms.
- Because high-productivity firms bear a greater share of aggregate demand, a moderate *negative inflation* rate emerges as socially optimal.

Related work

- Large literature on money non-neutrality in pricing models with firm shocks
  - Golosov-Lucas (2007): Near-neutrality of money with a fixed menu cost
  - Midrigan (2011): Fixed menu cost model matches poorly Δp histogram
  - Karadi & Reiff (2019): Large tax shocks reveal that degree of money non-neutrality is very sensitive to shape of idiosyncratic shock distribution
  - Our results rely on shocks' mean reversion – a generic feature in the literature
- Small literature on $\pi^\star$ in pricing models with idiosyncratic shocks
  - Burstein & Hellwig (2008): Sticky prices vs Friedman rule
  - Blanco (2021): Sticky prices vs ZLB
  - Adam, Gautier, Santoro & Weber (2021): Sticky prices and product lifecycles
  - We focus on sticky prices and stationary productivity shocks

NK model with firm-level shocks

- Representative household with discount rate $\beta \in (0,1)$
- Aggregate output is CES composite with substitution elasticity θ
- Firm j employs labor to produce output: $Y_{jt} = A_{jt} L_{jt}$
- A_{jt} is idiosyncratic productivity of firm j
- A_{jt} follows stationary Markov process with K states
- Firm sells output at price P_{jt} under monopolistic competition
- Firm markup

$$\mu_{jt} \equiv \frac{P_{jt}}{W_t / A_{jt}}$$

- Different price setting assumptions: flexible prices, Taylor, Calvo, menu costs

The basic mechanism

- Two period Taylor contracts, discrete realizations of idiosyncratic productivity
- In an efficient allocation, although idiosyncratic productivity varies over time, the *flex price markup remains constant*
- *Sticky price markup* co-moves with A_k over price spell: A_k high, marginal costs low, markup high (given constant price)
- At reset dates,

$$\mu_k^\star = \frac{P_{kt}^\star}{W_t} A_k \tag{1}$$

- At non-reset dates, firm's *expected* markup is,

$$\mu_k^\circ = \frac{P_{kt}^\star}{W_{t+1}} A^\circ \tag{2}$$

The basic mechanism

- Since firm's price remains unchanged and wage growth equals inflation,

$$\frac{\mu_k^\star}{\mu_k^\circ} = \frac{P_{t+1}}{P_t}\frac{A_k}{A^\circ} \tag{3}$$

- Markup dispersion drives a wedge between relative prices and relative productivities leading to an inefficient allocation of resources
- No markup dispersion, $\mu_k^\star = \mu_k^\circ$, requires k-specific inflation

$$\frac{P_{t+1}}{P_t} = \frac{A^\circ}{A_k} \tag{4}$$

- Negative inflation for productive firms anticipating lower productivity in the future, $A^\circ < A_k$
- Lower W_{t+1} partly offsets the expected decline in productivity A°

Formula for Ramsey Inflation

Proposition 2. Ramsey Inflation Formula *In the limit with $\beta \to 1$, the gross inflation rate Π^R that solves the steady-state of the Ramsey problem is given by*

$$\Pi^R = \sum_k \omega_k \cdot (A^\circ / A_k), \tag{5}$$

with $k = 1, 2$. The weights depend on Π and are given by the output shares

$$\omega_k = \frac{\left(\mu_k^\star / A_k\right)^{-\theta}}{\sum_i \left(\mu_i^\star / A_i\right)^{-\theta}}, \tag{6}$$

where $i = 1, 2$ and $\sum_k \omega_k = 1$

Ramsey Inflation is Negative

Proposition 3. *The net Ramsey inflation in equation (5) is negative,* $\Pi^R - 1 < 0$*, whenever* $A_1 \neq A_2$*. The Ramsey inflation rate is zero,* $\Pi^R - 1 = 0$*, in the case without idiosyncratic shocks,* $A_1 = A_2 = A^\circ$

Ramsey inflation and idiosyncratic productivity

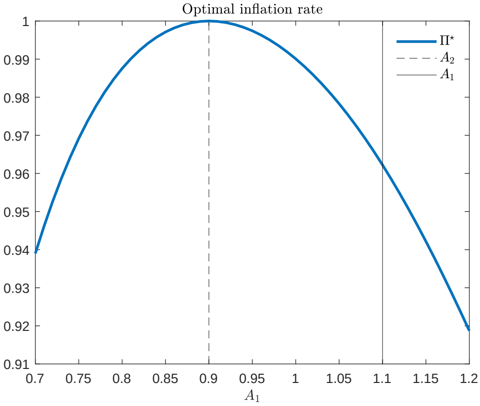


Figure: Ramsey inflation and idiosyncratic productivity

Ramsey problem with 2-period Taylor contracts

$$\max \sum_{t=0}^{\infty} \beta^t U\left(\frac{A_t}{\mu_t}, \frac{1}{\mu_t}\right) \tag{7}$$

subject to:

$$\frac{1}{\vartheta} = s_{t,t+1}\frac{1}{\mu^{\star}_{kt}} + (1 - s_{t,t+1})\frac{1}{\mu^{\circ}_{kt+1}} \tag{8}$$

$$s_{t,t+1} = \frac{(P^{\star}_{kt}/P_t)^{1-\theta}}{(P^{\star}_{kt}/P_t)^{1-\theta} + \beta(P^{\star}_{kt}/P_{t+1})^{1-\theta}} = (1 + \beta\Pi^{\theta-1}_{t+1})^{-1} \tag{9}$$

$$\frac{\mu^{\star}_{kt}}{\mu_t}\frac{A_t}{A_k} = \Pi_{t+1} \cdot \left(\frac{\mu^{\circ}_{kt+1}}{\mu_{t+1}}\frac{A_{t+1}}{A^{\circ}}\right) \tag{10}$$

$$\frac{1}{\mu_t} = \sum_{k=1,2}\left[\frac{1}{4}\left(\frac{\mu^{\star}_{kt}}{\mu_t}\frac{A_t}{A_k}\right)^{1-\theta}\frac{1}{\mu^{\star}_{kt}} + \frac{1}{4}\left(\frac{\mu^{\circ}_{kt}}{\mu_t}\frac{A_t}{A^{\circ}}\right)^{1-\theta}\frac{1}{\mu^{\circ}_{kt}}\right] \tag{11}$$

$$1 = \sum_{k=1,2}\left[\frac{1}{4}\left(\frac{\mu^{\star}_{kt}}{\mu_t}\frac{A_t}{A_k}\right)^{1-\theta} + \frac{1}{4}\left(\frac{\mu^{\circ}_{kt}}{\mu_t}\frac{A_t}{A^{\circ}}\right)^{1-\theta}\right] \tag{12}$$

Productivity maximization gives upper bound on Π^R

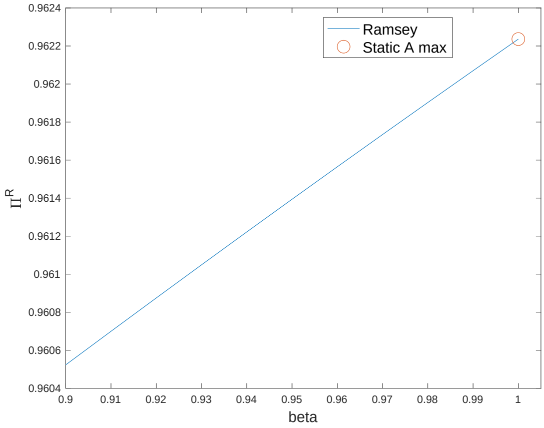


Figure: Ramsey inflation and household discount factor

Calvo model with persistent firm level shocks

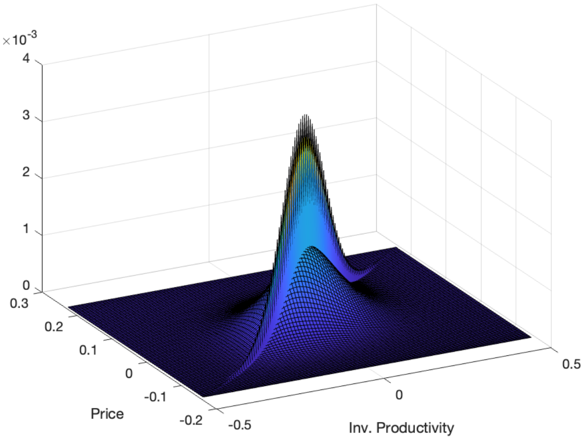
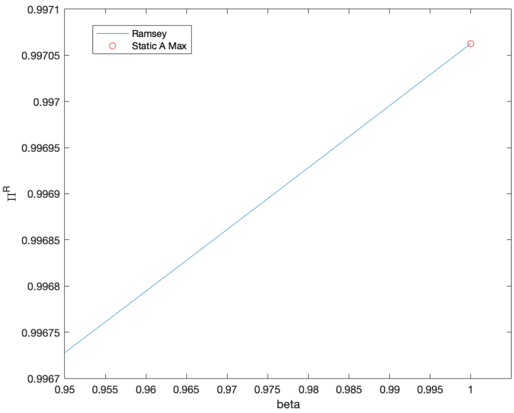


Figure: Stationary distribution of firms

Calvo model with persistent firm level shocks



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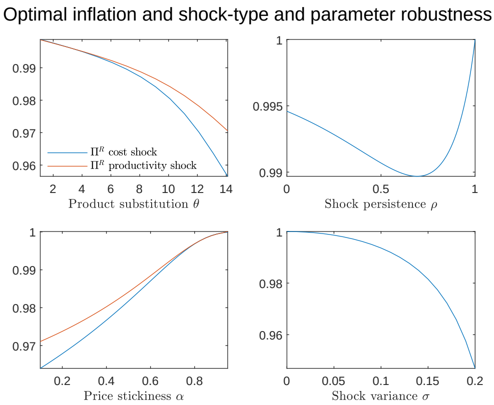

Figure: Sensitivity

A state-dependent pricing model

Random menu costs *iid* uniform over $[0, \bar{\xi}]$ as in Boar et al (2025).

The adjustment probability function takes the following form:

$$\lambda(p, a) = \bar{\lambda} + (1 - \bar{\lambda}) \min \left(\frac{EG(p, a)}{\bar{\xi} w_t}, 1 \right) \tag{13}$$

where

$$EG(p, a) = V^{adj}(a) - V^{nadj}(p, a) \tag{14}$$

is the expected gain from adjustment; p is the log relative price and a is log productivity, evolving according to

$$a_{jt} \quad = \quad \rho a_{jt-1} + \sigma \epsilon_t, \quad \epsilon_t \sim \mathrm{N}(0, 1)$$

The continuous shock process is discretized into a finite-state Markov process.

Exogenous parameters

Table: Exogenous parameters

Parameter	Description	Value	Source
β	Monthly discount factor	0.9984	Annual real interest of 2%
γ	Intertemporal elasticity of subst.	2	Golosov and Lucas (2007)
χ	Coefficient on disutility of labor	6	Ibid
θ	Elasticity of subst. across varieties	7	Ibid
$\bar{\pi}$	Inflation target	2%	ECB target
ρ	Persistence of productivity	0.8662	$\rho = 0.65^{1/3}$

Calibrated parameters, targeted and matched moments

Table: Calibrated parameters

Description	Parameter	Value
Maximum menu cost	$\bar{\xi}$	0.6605
Probability of free change	λ	0.0604
Std dev of productivity shock	σ	0.0965

Table: Targeted moments in euro area data and model

Moment	Data	Model
Frequency Δp (%)	9.5	9.5
Size Δp (%)	9.3	9.3
Kurtosis Δp	3.2	3.2

Source: Karadi et al (2023) (Euro Area 4)

Adjustment probability function

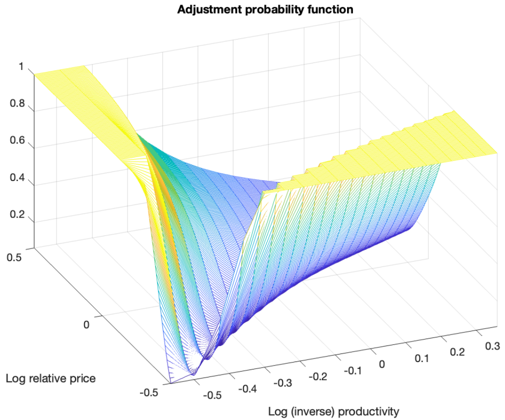

Figure: Hazard function in SDP model

Reset price distorsion with mean-reverting shocks

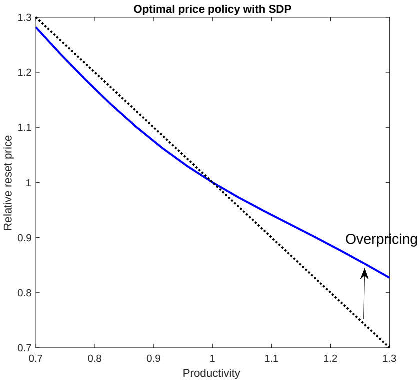

Figure: Pricing “conservatively” with mean-reverting costs

Productivity maximizing inflation

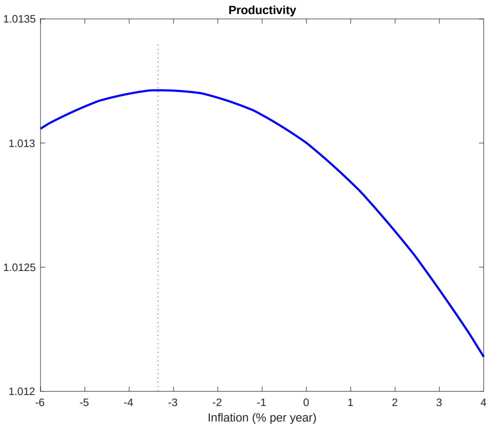

Figure: Optimal inflation in SDP model

Conclusions

- Models consistent with observed price change heterogeneity imply sizeable misallocation at zero inflation and a role for monetary policy to reduce it.
- Stickiness coupled with idiosyncratic productivity shocks distorts relative markups thereby reducing aggregate productivity.
- This distortion provides a new motive for choosing lower (even negative) $\pi^{\star}$.
- We abstract from other known motives for positive inflation targets—such as ZLB, downward wage rigidity, or trends in firms' efficient relative prices.
- Future research can explore how this mechanism interacts with other frictions and constraints faced by CBs, and assess the extent to which our insight can be integrated into broader frameworks used for inflation targeting.