State-Dependent Pricing and the Paradox of Flexibility

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Is increased price flexibility stabilizing?

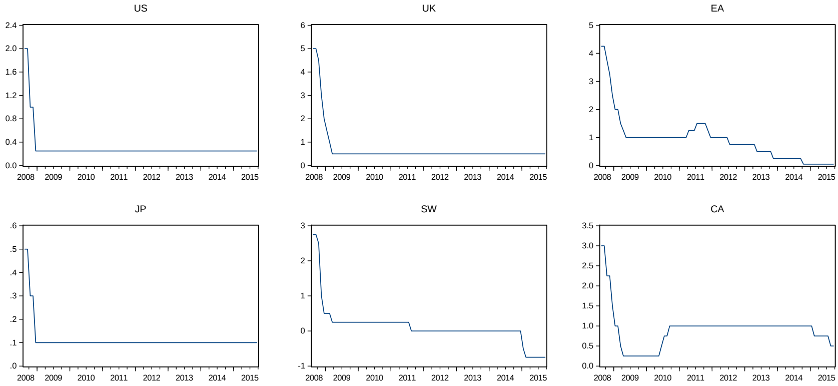
- Leading models of state-dependent pricing account well for some features of price setting at the micro level (Golosov and Lucas, 2007)
- However, in these models money is almost neutral, unlike in time-dependent pricing models (Calvo, 1983)
- Notion that increased price flexibility is stabilizing: it mutes the real effects of demand shocks

Is increased price flexibility stabilizing?

- We show here that this notion is not quite true:
  it all depends on systematic monetary policy
- If monetary policy leans sufficiently against inflation then the notion is correct
- However, if monetary policy allows for a drift in the price level, then increased price flexibility may lead to higher output volatility in response to demand shocks

Why is this interesting or relevant?

Policy nominal interest rates in six advanced economies



Growing literature

- Recent literature shows that constant interest rates may lead to the amplification of shocks:

  Woodford (2011), Christiano, Eichenbaum, Rebelo (2011), Del Negro et al. (2013), Erceg and Linde (2014), Kiley (2014)

  - A drop in the natural real rate has **larger** deflationary effects than if policy was leaning against the disinflation
  - The government spending multiplier is (much) larger than 1
  - Forward guidance is very powerful

Constant interest rates and shock amplification

- **Mechanism:**
  - Suppose $i_t = i$ for $t = 0 \ldots T$ and afterwards monetary policy follows some rule
  - Then $\hat{c}_0 = \sigma \sum_{t=1}^{T} E_0 \pi_t + \hat{c}_T \approx \sigma \left(E_0 p_T - p_0 \right)$
  - Let shock $\hat{g}_0 > 0$
  - All depends on the policy rule in place:
  - If on exit $i_{t>T} = i + \phi \pi_t$, then $p_T > p_0$ and crowding in
  - If $M_t = M$, then $p_T < p_0$ and crowding out

The paradox of flexibility

- "Paradox of flexibility": **increasing price flexibility leads to a larger drift of the price level** and **larger amplification**
- It leads to a deeper recession and deflation when hit by a deflationary shock (Eggertsson and Krugman)
- Also leads to a larger government spending multiplier (Christiano et. al., Erceg and Linde)
- The existing papers all assume exogenous flexibility (Calvo pricing)

This paper

- Looks at the effects of a shock to government spending
- Across three pricing models: Calvo, fixed menu cost, and encompassing model
- Encompassing model is "smoothly state-dependent" : adjustment probability is a smoothly increasing function
- We compare monetary policy rules that lean against inflation with ones that keep the nominal interest rate constant

Main findings

- With monetary policy that doesn't lean against inflation SDP produces even larger amplification than Calvo
- More price flexibility is destabilizing
- The paradox of flexibility is not just an artifact of Calvo pricing

Outline of the talk

1. Introduction ✓
2. Model
3. Results
4. Conclusions

Main model ingredients

- Model deviates in two ways from textbook New Keynesian model:
  - Idiosyncratic productivity shocks to firms
  - State-dependent pricing nesting Calvo and fixed menu costs
- We study monetary policy with and without drift in the price level

Model: households

- Representative household's utility

$$\frac{C_t^{1-\gamma}}{1-\gamma} - \frac{\chi N_t^{1+\psi}}{1+\psi} + \log(M_t/P_t)$$

- Consumption is a CES aggregate

$$C_t = \left\{ \int_0^1 C_{it}^{\frac{\epsilon-1}{\epsilon}} di \right\}^{\frac{\epsilon}{\epsilon-1}}$$

- Nominal budget constraint

$$\int_0^1 P_{it} C_{it} di + M_t + R_t^{-1} B_t = W_t N_t + M_{t-1} + T_t + B_{t-1}$$

Model: household optimality conditions

- Household chooses C_{it}, N_t, B_t, M_t to maximize expected utility, subject to the budget constraint

- Optimal consumption across goods

$$
\begin{aligned}
C_{it} &= (P_t/P_{it})^{\epsilon} C_t \\
P_t &\equiv \left[\int_0^1 {P_{it}}^{1-\epsilon} di\right]^{\frac{1}{1-\epsilon}}
\end{aligned}
$$

- Optimal labor supply, consumption, and money use

$$
\begin{aligned}
\chi C_t^{\gamma} N_t^{\psi} &= W_t/P_t \\
1 &= \beta R_t E_t \left[P_t C_{t+1}^{-\gamma} / \left(P_{t+1} C_t^{-\gamma}\right)\right] \\
M_t/P_t &= C_t^{\gamma} R_t / (R_t - 1)
\end{aligned}
$$

Model: monopolistic competitor firms

- Firm i produces output $Y_{it} = A_{it} N_{it}$
- Productivity is **idiosyncratic**, $\log A_{it} = \rho_A \log A_{it-1} + \varepsilon^a_{it}$, $\varepsilon^a_{it} \sim N(0, \sigma^2_a)$
- Firm i faces demand from households, and the government, $Y_{it} = C_{it} + G_{it}$
- The government's consumption basket is also a CES, $G_t = \left\{ \int_0^1 G_{it}^{\frac{\epsilon-1}{\epsilon}} di \right\}^{\frac{\epsilon}{\epsilon-1}}$

Model: monopolistic competitor firms

- Demand curve, $Y_{it} = (C_t + G_t)P_t^{\epsilon} P_{it}^{-\epsilon}$
- Period profits, $U_{it} = P_{it} Y_{it} - W_t N_{it}$
- Discount rate, $Q_{t,t+1} = \beta \frac{P_t C_t^{-\gamma}}{P_{t+1} C_{t+1}^{-\gamma}}$

Model: firm value function

- Value function $V(P, A, \Omega) =$

$$U(P, A, \Omega) + \beta E \left\{ Q_{t,t'} \left[V(P, A', \Omega') + EG(P, A', \Omega') \right] \middle| A, \Omega \right\}$$

where $EG(\cdot)$ is the *expected gain* from adjustment

$$EG(P, A', \Omega') \equiv \lambda \left[\frac{D(P, A', \Omega')}{W(\Omega')} \right] D(P, A', \Omega')$$

$$D(P, A', \Omega') \equiv \max_{P} V(P, A', \Omega') - V(P, A', \Omega')$$

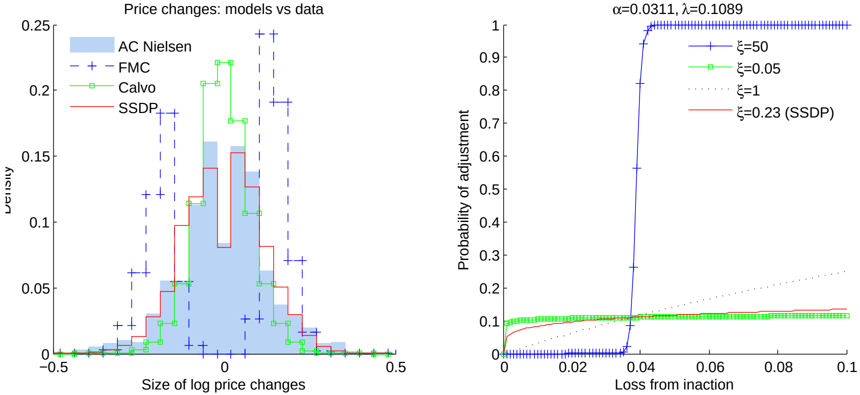
Model: adjustment function

- $\lambda(L)$ increases with the gain from adjustment L
- We postulate

$$\lambda(L) \equiv \frac{\bar{\lambda}}{(1-\bar{\lambda}) + \bar{\lambda}(\alpha/L)^{\xi}}$$

- where L is the relevant state
- With $\xi \to 0$, $\lambda(L) = \bar{\lambda}$ Calvo
- With $\xi \to \infty$, $\lambda(L) = \mathbf{1}\{L \geq \alpha\}$ Fixed menu cost

Model: adjustment function and histogram fit



Model: monetary policy and government spending

- Monetary policy is:

$$i_{t\leq T} = i^{ss}$$

$$i_{t>T} = i^{ss} + \phi_\pi \pi_t$$

- Government spending, $g_t = \frac{G_t - G^{ss}}{Y^{ss}}$:

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g$$

with $\varepsilon_t^g \sim N(0, \sigma_g^2)$

Calibration

Discount factor	$\beta^{-12} = 1.04$	Golosov-Lucas (2007)
CRRA	$\gamma = 2$	Ibid.
Goods elast. of subst.	$\epsilon = 7$	Ibid.
Labor supply elast.	$\psi = 1$	Common value
Inflation target	$\Pi^* = 1$	AC Nielsen inflation
Inflation reaction	$\phi_\pi = 2$	Common value
Length of CIR period	$T = \{24, 36\}$	Erceg and Linde (2014)
Persistence of G_t	$\rho_G = 0.9$	Ibid.
Persistence of A_{it}	$\rho_A = 0.9$	Costain-Nakov (2011)
Std. dev. of A_{it}	$\sigma_A = 0.1$	Ibid.
State dependence	$\xi = \{0, 0.23, 1\}$	Ibid.
Fixed menu cost	$\alpha = 0.04$	Ibid.
Calvo frequency	$\bar{\lambda} = 0.1$	Nakamura-Steinsson (2008)

Preliminaries: textbook Calvo model

- The flexible price multiplier is (Woodford, 2011)

$$\Gamma = \frac{\gamma}{\gamma + \psi} \leq 1$$

- Log-linearized consumption Euler equation

$$y_t - g_t \quad = \quad E_t\left(y_{t+1} - g_{t+1}\right) - \gamma^{-1}\left(i_t - E_t \pi_{t+1} - \bar{r}\right)$$

- Phillips curve

$$\pi_t \quad = \quad \beta E_t\left(\pi_{t+1}\right) + \kappa(y_t - \Gamma g_t),$$

where $\kappa = \frac{(1-\alpha)(1-\alpha\beta)}{\alpha}(\gamma + \psi)$

Calvo model with active Taylor rule

- Let ρ be the persistence of the demand shock
- Solution under a Taylor rule

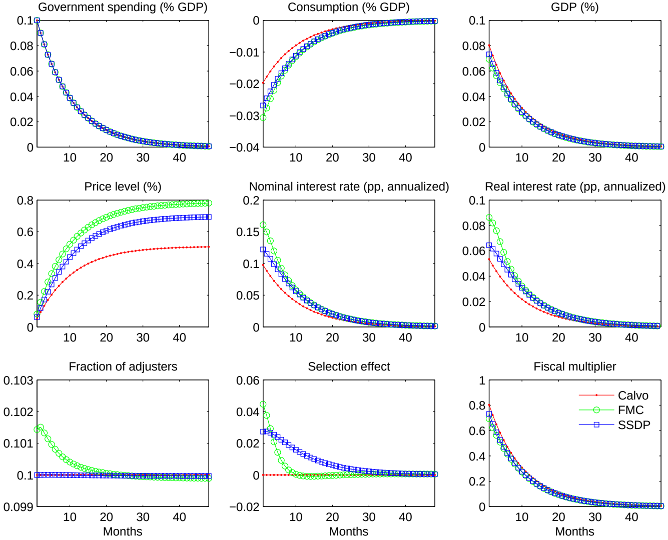
$$\mu^{TR} = 1 - \frac{\left(\frac{\phi_\pi - \rho}{1 - \beta\rho}\kappa + \phi_C\right)(1 - \Gamma)}{(1-\rho)\gamma + \left(\frac{\phi_\pi - \rho}{1 - \beta\rho}\kappa + \phi_C\right)} < 1$$

- More price flexibility (higher κ) leads to a smaller multiplier

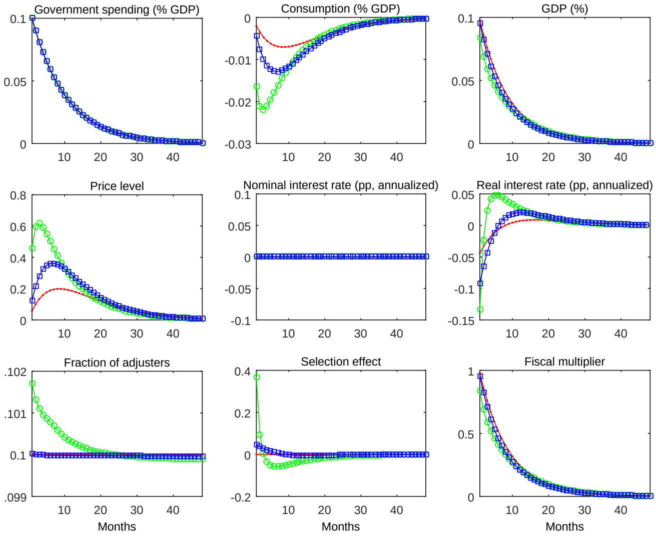
Results under state dependent pricing

1. Under an active Taylor rule more price flexibility leads to a smaller multiplier.

Taylor rule: the multiplier is smaller under SDP (< 1)



Constant money: the multiplier is also less than 1



Calvo with constant interest rate of stochastic duration: Woodford's case

- General solution

$$y_t - g_t = \frac{\kappa(1-\Gamma)\rho}{(1-\rho)(1-\beta\rho)\gamma - \kappa\rho} g_t + a_1\lambda_1^t + a_2\lambda_2^t$$

- When denominator $\Delta > 0$ then $\lambda_1, \lambda_2 > 1$ and so setting $a_1, a_2 = 0$ ensures a unique bounded solution:

$$y_t = g_t + \frac{\kappa(1-\Gamma)\rho}{\Delta} g_t = \mu^{ZLB} g_t$$

- Paradox of flexibility: as $\kappa \uparrow$, then $\Delta \to 0^+$ and $\mu^{ZLB} \to +\infty$

- Ohanian: paradox is limited to $\Delta > 0$, otherwise μ^{ZLB} is not well defined due to multiplicity of equilibria

Werning's perfect foresight solution: deterministic T

- Difference equations valid only up to T; thereafter CB follows its policy rule which determines equilibrium upon liftoff:

$$
\begin{aligned}
y_t \;&=\; \mu^{ZLB} g_t - \frac{\kappa\,(1-\Gamma)\,\rho}{\Delta}\,\frac{1-\rho\beta\lambda_1}{1-\beta\lambda_1^2}\left(\frac{\rho}{\lambda_1}\right)^{T-t} g_t + \\
&\qquad \frac{\pi_{T+1} + (1-\beta\lambda_1)\,\gamma\,(y_{T+1} - g_{T+1})}{\left(1-\beta\lambda_1^2\right)\gamma\lambda_1^{T-t}},
\end{aligned}
$$

- When T sufficiently large and κ such that $\Delta \to 0^+$, then $\rho < \lambda_1 < 1$ and solution close to μ^{ZLB}

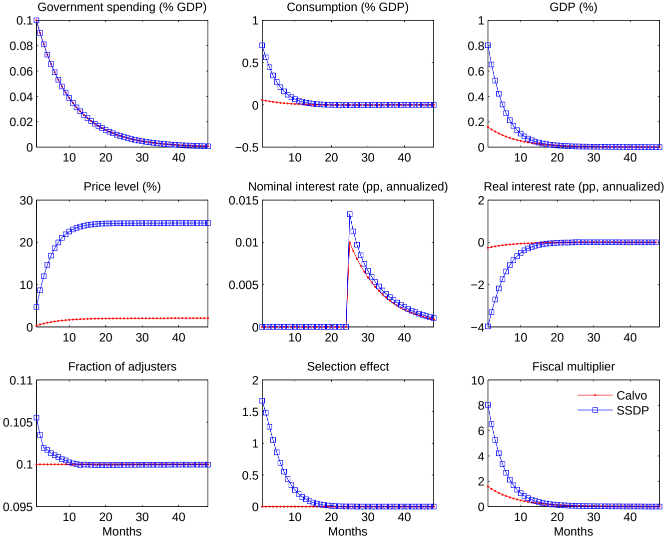
- For κ larger, such that $\Delta < 0$, $\rho/\lambda_1 > 1$, backward explosion

- The multiplier grows with T, and the Paradox of Flexibility holds for any κ

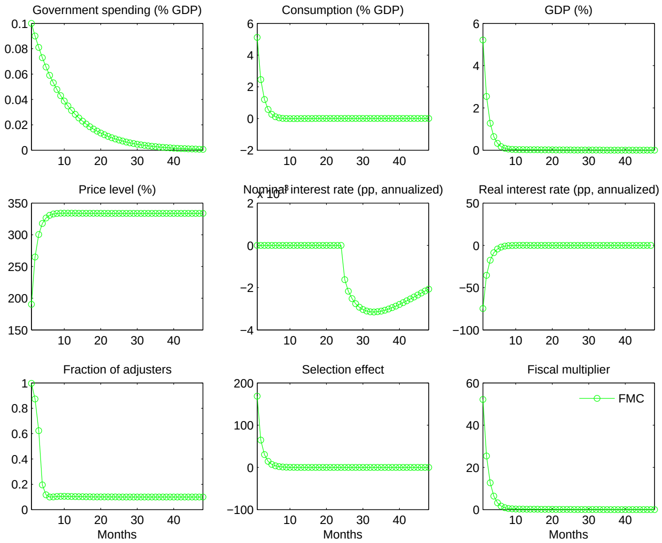
Results under state dependent pricing

2. Under monetary policy that allows a drift in prices: much larger amplification under SDP.

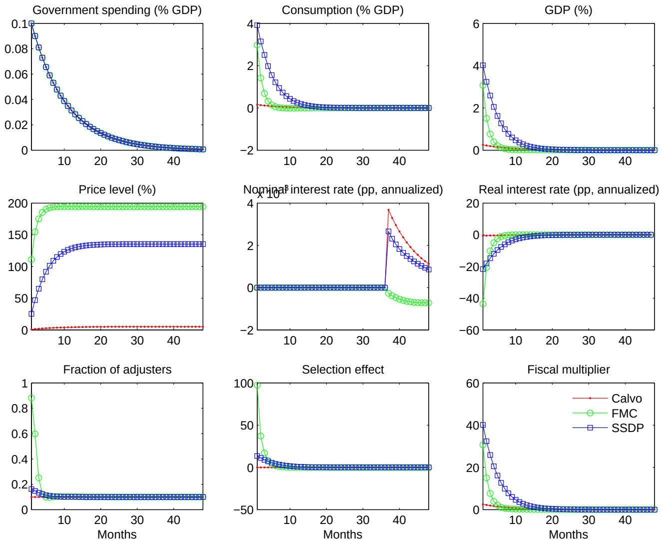
With monetary policy that does not stabilize the price level – much larger amplification under SDP



Largest amplification in Golosov-Lucas FMC case



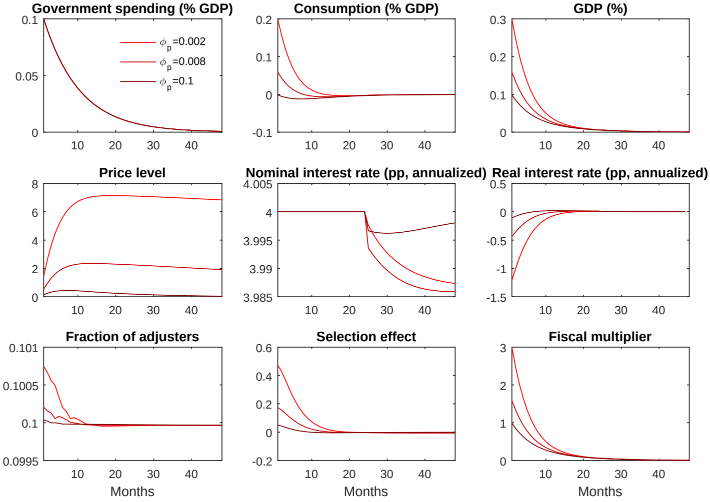
With $T = 36$ amplification is larger under SSDP



Conclusions

- With monetary policy that leans against inflation under SDP the fiscal multiplier is close to flexible-prices (< 1)
- But with a rule that does not stabilize the price level there is a much larger amplification of demand shocks under SDP ($>> 1$)
- The largest amplification is in the Golosov-Lucas (2007) model

Taylor rule reacting to the price level as well: SSDP



Responses to a TFP shock under constant money