

Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy

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Outline

Introduction

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Motivation

Observations in real data:

- ▶ inertial behavior of inflation
- ▶ persistence in aggregate quantities

Question :

Can models with moderate degrees of nominal rigidities generate inertial inflation and persistent output movements in response to a monetary policy shock?

Mechanism of the model

Existent explanations:

- ▶ frictions in the adjustment of financial portfolios - Alvarez, Atkenson and Kehoe(2000)
- ▶ small nominal frictions do not solve the persistence problem - Chari, Kehoe and McGratan (2001)

Here:

1. *Staggered wage contracts* and *variable capital utilization* dampens the sharp rise in marginal costs (hence prices) after an expansionary shock to monetary policy.
2. Resulting inertia in inflation and rise in nominal spending implies persistent rise in output

Final Good Firms

- ▶ At time t , a final consumption good Y_t is produced by a perfectly competitive representative firm:

$$Y_t = \left[\int_0^1 Y_{jt}^{\frac{1}{\lambda_f}} dj \right]^{\lambda_f}$$

where Y_{jt} - time t intermediate good j , $1 < \lambda_f < \infty$

- ▶ Output price P_t , and input prices P_{jt} are taken by firm as given
- ▶ By profit maximization problem, relationship between intermediate and final good is given by:

$$P_t = \left[\int_0^1 P_{jt}^{\frac{1}{1-\lambda_f}} dj \right]^{(1-\lambda_f)}$$

Intermediate Good Firms

- ▶ Intermediate good j is produced by a monopolist using following technology:

$$Y_{jt} = \begin{cases} u_t \bar{k}_{jt}^\alpha L_{jt}^{(1-\alpha)} - \phi, & u_t \bar{k}_{jt}^\alpha L_{jt}^{(1-\alpha)} \geq \phi \\ 0, & \text{otherwise;} \end{cases}$$

where $\phi > 0$ - fixed cost of production and $0 < \alpha < 1$

- ▶ No entry and exit into the production
- ▶ Firms rent capital in perfectly competitive factor markets
- ▶ Profits are distributed to households at the end of period
- ▶ Firms borrow at the beginning of the period from the financial intermediary $W_t L_{jt}$ to pay workers in advance of production
- ▶ Repayment occurs at the end of the period t at the gross rate, R_t

Intermediate Good Firms

- ▶ Firm's real marginal cost is
 $s_t = \frac{\partial S_t(Y)}{\partial Y}$, where $S_t(Y) = \min_{k,l} \{r_t^k u_t \bar{k} + \omega_t R_t l, Y\}$
- ▶ In each period, firm face constant probability, $1 - \xi_p$, of being able to reoptimize its nominal price which is independent across firms and time
- ▶ Firms reoptimize before the realization of the time t growth rate of money
- ▶ Firms that can not reoptimize, index price to lagged inflation,
 $P_{jt} = \pi_{t-1} P_{j,t-1}$

Intermediate Good Firms

- ▶ The firm reoptimize its price \tilde{P}_t by the following function

$$\max E_{t-1} \sum_{l=0}^{\infty} (\beta \xi_p)^l v_{t+l} [\tilde{P}_t X_{tl} - s_{t+l} P_{t+l}] Y_{j,t+l}$$

$$\text{where } X_{tl} = \begin{cases} \pi_t \times \pi_{t+1} \times \dots \times \pi_{t+l-1}, & \text{for } l \geq 1 \\ 1 & l = 0; \end{cases}$$

Households' Decisions

Continuum of households, indexed by $j \in (0, 1)$:

- ▶ decide upon consumption, capital accumulation, units of capital services to supply
- ▶ purchase securities whose payoffs are contingent upon whether it can reoptimize its wage decision
- ▶ set its wage rate depending on wage reoptimization ability
- ▶ receive lump-sum transfer from the monetary authority
- ▶ decide amount of its financial asset to hold in form of deposits with a financial intermediary and in the form of cash

Heterogeneity of Households

- ▶ due to idiosyncratic nature of wage reoptimization, households are *heterogenous in work load and wage rate*
- ▶ existence of state contingent securities ensure that, in equilibrium, households are *homogenous with respect to consumption and asset holdings*

Households' Problem

Preferences are given by

$$E_{t-1}^j \sum_{t=0}^{\infty} \beta^{l-t} [u(c_{t+l} - bc_{t+l-1}) - z(h_{j,t+l}) + v(q_{t+l})]$$

subject to asset evolution

$$M_{t+1} = R_t[M_t - Q_t + (\mu_t - 1)M_t^a] + A_{j,t} + Q_t + W_{j,t}h_{j,t} + R_t^k u_t \bar{k}_t + D_t - P_t(i_t + c_t + a(u_t)\bar{k}_t)$$

where $q_t = Q_t/P_t$ is real cash balance, $b > 0$ allows for habit formation, $(\mu_t - 1)M_t^a$ is a lump-sum payment made to HH by the monetary authority, $\bar{k}_{t+1} = (1 - \delta)\bar{k}_t + F(i_t, i_t - 1)$

Wage Decision

- ▶ Household is a monopoly supplier of a differentiated labor service, $h_{j,t}$
- ▶ Firm transfers it into an aggregate labor input, L_t , using the following technology

$$L_t = \left[\int_0^1 h_{j,t}^{\frac{1}{\lambda_\omega}} dj \right]^{\lambda_\omega}$$

- ▶ demand curve for $h_{j,t}$ is given by

$$h_{j,t} = \left(\frac{W_t}{W_{j,t}} \right)^{\frac{\lambda_\omega}{\lambda_\omega - 1}}$$

- ▶ HHs take L_t and W_t as given
- ▶ HH faces a constant probability, $1 - \xi_\omega$, of being able to reoptimize its nominal wage, otherwise indexes to lagged inflation

Monetary policy, Clearing and Equilibrium Conditions

Monetary policy is given by

$$\mu_t = \mu + \theta_0 \varepsilon_t + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2}$$

- ▶ Loan market clearing condition : $W_t L_t = \mu_t M_t - Q_t$
- ▶ Aggregate resource constraint : $c_t + i_t + a(u_t) \leq Y_t$

Following restrictions are imposed:

- ▶ $u_t = 1$ in steady state
- ▶ $a(1) = 0$

Econometric Methodology

1. Estimate the IRF of eight key macroeconomic variables to a monetary shock using VAR

$$\text{VAR vector } Y_t = [Y_{1t}, R_t, Y_{2t}]$$

$$Y_{1t} \equiv$$

{GDP, GDP deflator, real consumption, real investment, real wage, labour productivity}

$$Y_{2t} \equiv \{\text{real profits, growth rate of } M2\}$$

2. Choose six model parameters to minimize the difference between the estimated IRF and the analogous objects in the model

$$J = \min_{\gamma} (\hat{\Psi} - \Psi(\gamma))' V^{-1} (\hat{\Psi} - \Psi(\gamma))$$

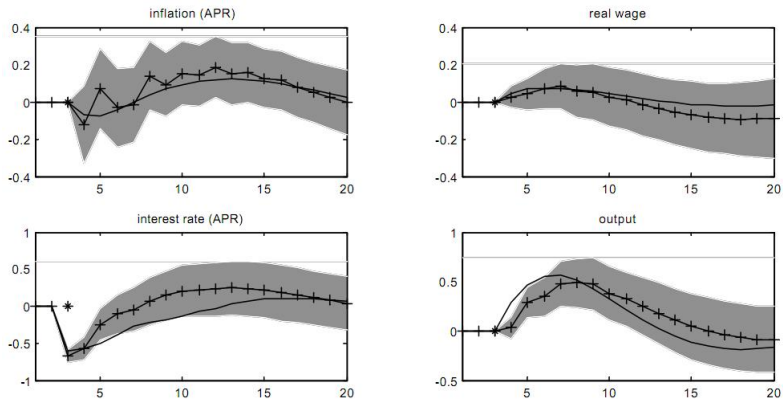
Calibration of the Parameters

PM	source	value
β	SS annualized real interest rate of 3%	$1.03^{-0.25}$
α	SS share of capital of income of 36%	0.36
δ	annual rate of depreciation on capital of 10%	0.0025
ϕ	set to ensure zero profits	
λ	robust to other perturbations in this parameter	1.05
θ_i	impulse response implied by estimated VAR $\mu_t = \tau(I - A_1L - \dots - A_4L^4)^{-1}c\epsilon_t$	

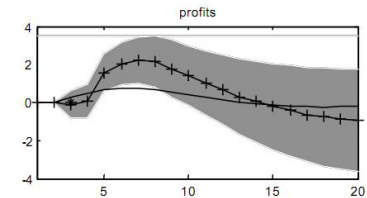
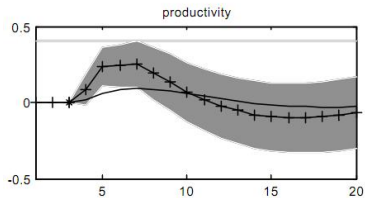
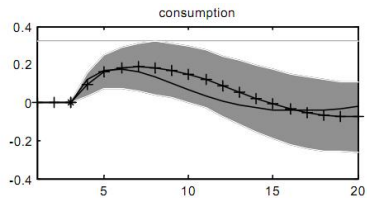
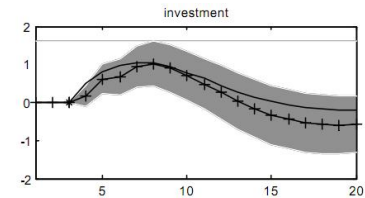
$\gamma \equiv (\lambda_f, \xi_\omega, \xi_p, \sigma_q, \varkappa, b, \sigma_a)$ is estimated by minimizing a measure of distance between the model and empirical impulse response functions

Empirical Results

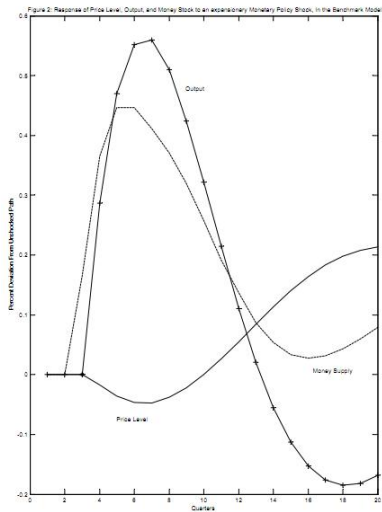
Figure 1: Model- and VAR-Based Impulse Responses



Empirical Results



Empirical Results



Why persistent output and inertial inflation process?

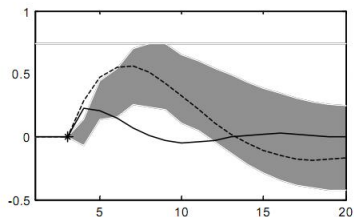
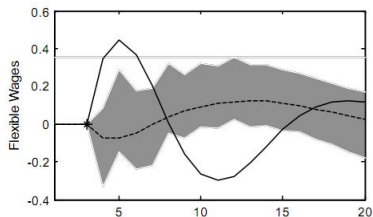
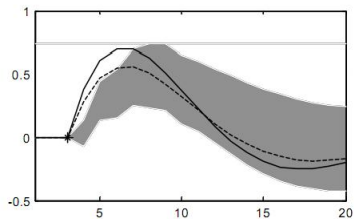
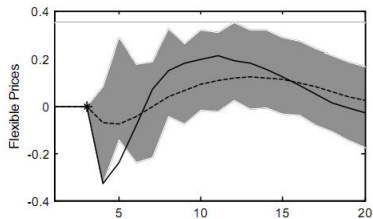
HHs' FOC condition for cash balances: $v'(q_t) + \phi_t = \phi_t R_t$

Loan market clearing condition : $W_t L_t = \mu_t M_t - Q_t$

From price optimization problem:

$$\hat{\pi}_t - \hat{\pi}_{t-1} = \frac{(1-\beta\xi_p)(1-\xi_p)}{\xi_p} E_{t-1} \sum_{j=0}^{\infty} \beta^j \hat{s}_{t+j}$$

Variants of the Benchmark Model



Conclusion

- ▶ Built a model embodying moderate amounts of nominal rigidities, which accounts well the dynamic response of the US economy to a monetary policy shock
- ▶ Model generates persistent output and inertial inflation observed in data
- ▶ Stickiness in nominal wages is crucial for the model relative to stickiness in prices