

Two Illustrations of the Quantity Theory of Money Reloaded

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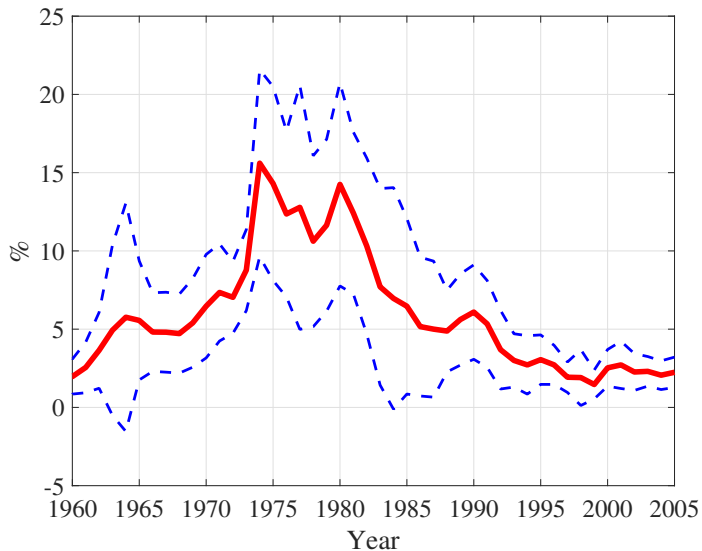
Minnesota Economics Virtual Seminar

Feb 4, 2021

Introduction

- ▶ Recent experiences: Why was inflation so low in Japan in the last twenty years ... and in Europe in the last ten?
- ▶ Scenarios:
 - ▶ What will inflation be in the USA, Japan and Europe in the next few years?
- ▶ “Inflation is always and everywhere a monetary phenomenon”.

Average Inflation for 13 OECD Countries (1960–2005)



This Paper

We argue that to understand the big picture:

1. the rise in inflation,
2. its eventual conquest,
3. and the essential role of Central Banks in the process,

it is sufficient to appeal to the **quantity theory of money**.

Old Theoretical Tradition

- ▶ David Hume (1748) and Irving Fisher (1911)
- ▶ Friedman (1959)
- ▶ Sidrauski (1967) and Lucas (1982) among many others.
- ▶ A specific model that belongs to that tradition is described below.

- ▶ The model abstract from a plethora of realistic details.
- ▶ It is tempting to disregard its lessons.
- ▶ In this paper we make a case **against** falling into temptation.
- ▶ Those details not very important in answering our questions.
- ▶ We make our case in **two steps**.

First Step – Extension of Lucas (1980)

- ▶ Derive two empirical implications in a simple flexible prices model.
- ▶ Abandon the quest to understand quarter-to-quarter movements.
- ▶ Separate the data using a statistical filter.
- ▶ Extract the “medium” run components and look at plots.

What is New?

- ▶ We have more countries and more data.
- ▶ We use the filter differently: we adopt a notion of “medium” run.

Second Step

Estimate a more general model using USA data.

- ▶ Embrace the NK view on short run fluctuations
- ▶ We add
 - ▶ Price frictions
 - ▶ Shocks to the inflation target that resemble a regime change
- ▶ Estimate the model for the USA using Bayesian methods.

Second Step

- ▶ We show
 - ▶ “Medium” term inflation is fully explained by shocks to inflation target.
 - ▶ Price frictions are not important in explaining “medium” term inflation.
- ▶ Analysis of simulations of the model strongly convalidate our filter and our definition of “medium” run:
 - ▶ Average cycle is about 3 years.

Plan

- ▶ Briefly discuss the flexible prices model.
- ▶ Discuss the filter we adopt.
- ▶ Present the evidence for the 13 OECD countries.
- ▶ Briefly present the model with price frictions and inflation target shocks.
 - ▶ Show estimation results.
 - ▶ Show simulations of counterfactuals.

A Baumol-Tobin Type Monetary Model

- ▶ Labor-only economy with uncertainty
- ▶ Representative household with preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t U(x_t).$$

▶ Technology

$$y_t = x_t = z_t l_t$$

▶ l_t is time devoted to production.

▶ Time endowment

$$1 = l_t + f(n_t)$$

▶ n_t number of 'trips to the bank'.

- ▶ Transactions require money

$$P_t x_t \leq M_t n_t$$

- ▶ In real terms

$$x_t \leq m_t n_t$$

- ▶ n_t is velocity.

- ▶ Another asset: b_t , government bond that pays i_t
- ▶ Time cost of trips to the bank

$$f(n_t) = \theta n_t \nu_t$$

- ▶ Choice of n_t is the only economically relevant decision.

- ▶ Households choose $\{x_t, m_t, b_t, n_t\}$ subject to

$$m_t + b_t \leq w_t,$$

$$x_t \leq m_t n_t$$

$$w_{t+1} \leq \frac{m_t + b_t(1 + i_t) + z_t[1 - \theta n_t \nu_t] - x_t}{\pi_{t+1}} + \tau_{t+1}$$

and

$$b_t \geq b^*.$$

- ▶ Borrowing constraint useful to address behavior at low i_t .

- ▶ If borrowing constrain is not binding

$$n_t = \left(\frac{i_t}{\theta \nu_t} \right)^{\frac{1}{2}}, \quad \text{or} \quad \frac{m_t}{x_t} = \left(\frac{\theta \nu_t}{i_t} \right)^{\frac{1}{2}}$$

- ▶ Notice that as $i_t \rightarrow 0$, $m_t \rightarrow \infty$, which implies that $b_t \rightarrow -\infty$.
- ▶ Thus, for low enough i_t , the borrowing constraint binds and

$$m_t = w_t - b^*$$

and independent of the interest rate.

- ▶ Money demand is a truncated log-log
- ▶ Precision of theory for $i_t \simeq 0$?

- ▶ The money demand in growth rates delivers the **first illustration**

$$\pi_t = \mu_t - g_t^y - \frac{1}{2}g_t^i + \varepsilon_t \quad (1)$$

- ▶ The income and interest rate elasticities pinned down by theory.
- ▶ All variables are observable.

- ▶ In addition, the Euler equation (Fisher equation) must hold

$$i_t = r_t + E_{t-1}\pi_t, \text{ so} \quad (2)$$

$$\pi_t = i_t - r_t + [\pi_t - E_{t-1}\pi_t]$$

- ▶ which relates two observables with one unobservable plus an expectational error.
- ▶ This is the **second illustration**.

- ▶ Theory delivers two equations on three variables

$$\left\{ \frac{M_{t+1}}{M_t}, \frac{P_{t+1}}{P_t}, i_t \right\}$$

- ▶ One of $\left\{ \frac{M_{t+1}}{M_t}, i_t \right\}$ is determined by policy.
- ▶ No need to take a stand on policy instrument, which may vary across countries.
- ▶ The policy instrument determines the other two.
- ▶ Central Bank responsible for evolution of the three. Rational for first mandate.

Data Analysis

1. How to deal with unobservable r_t ?
2. Which frequency to focus on?

How to deal with unobservable r_t ?

- ▶ Identifying Assumption: **Integrated Capital Markets.**
- ▶ We use data for the USA, assume that the Fisher equation holds.
- ▶ Use it to estimate a real interest rate.
- ▶ Use that interest rate to test the Fisher equation in other countries.
- ▶ Particularly problematic for first decades - financial repression.
- ▶ Two groups of countries.

Which frequency to focus on?

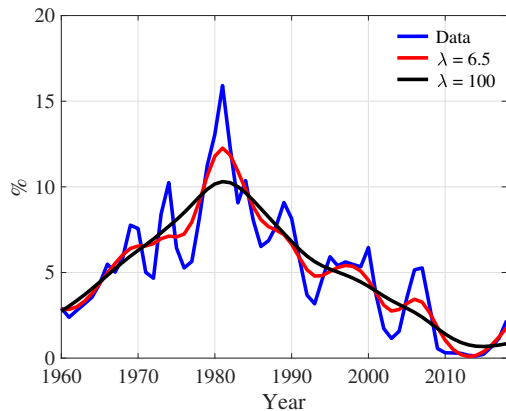
- ▶ Theory ignores realistic frictions.
- ▶ Does not apply to short term movements.
- ▶ Use Hodrick-Prescott filter, the question is which λ to use?
- ▶ Focus in USA, and on i_t .

Our Choice

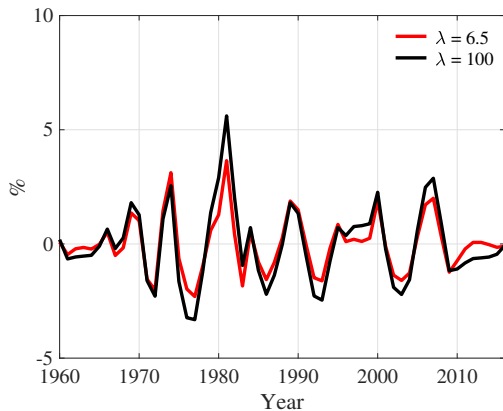
Pick lowest λ that removes “tightening cycles” (as defined by the Minneapolis Fed Research Division) from the interest rate.

1. Those are perceived as temporary changes in i_t
2. Objective to stabilize the economy around some “trend”.
3. Market frictions absent in the theory:
 - 3.1 Price rigidities
 - 3.2 Segmented markets
4. We use the “trend” around which those tightening cycles move for our illustrations.

U.S. Nominal Interest Rates



Data and HP-filtered series



Cyclical component

- ▶ We use M_1 , GDP , CPI and a short-term interest rate, from OECD database since 1960.
- ▶ Except for the USA, where we use $NewM_1$ (Lucas and Nicolini 2015).
- ▶ Filter the data using $\lambda = 100$.
- ▶ Start with the USA, and use second illustration to calibrate r_t .
- ▶ Assume r_t is common to all countries
- ▶ Stop the sample in 2005 (1990 for Japan and 1999 for Euro countries).

Illustrations of the U.S.

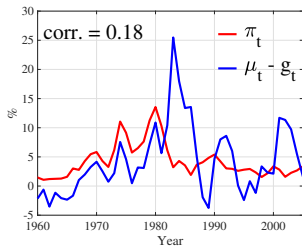


Illustration 1, raw

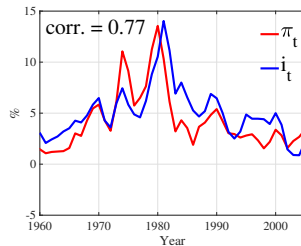


Illustration 2, raw

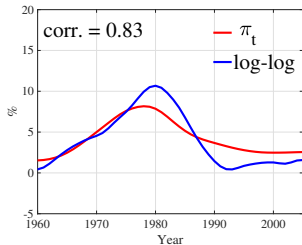


Illustration 1, filtered

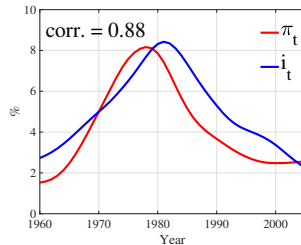
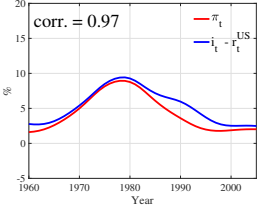
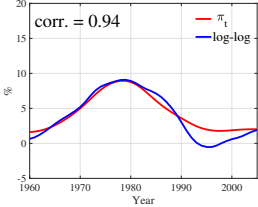
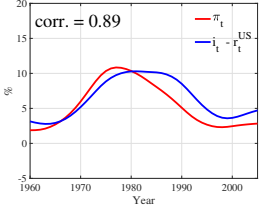
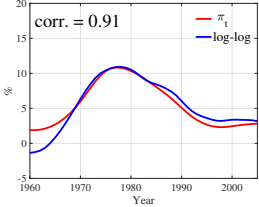
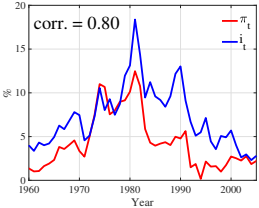
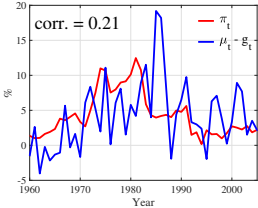
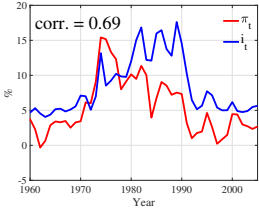
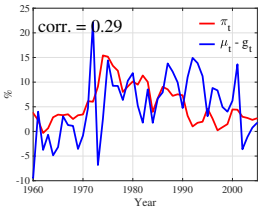


Illustration 2, filtered

Group 1 Countries (1)



(a) Illustration 1

(b) Illustration 2

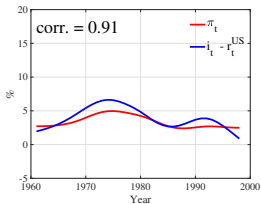
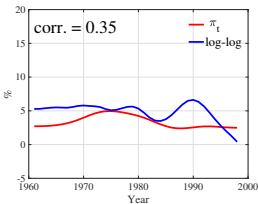
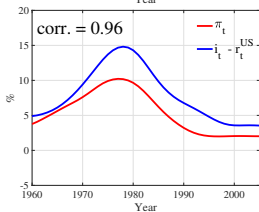
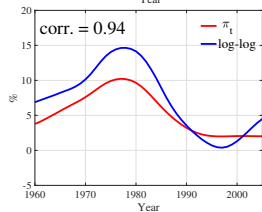
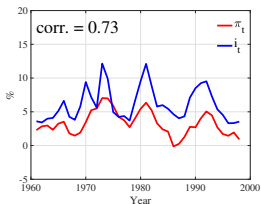
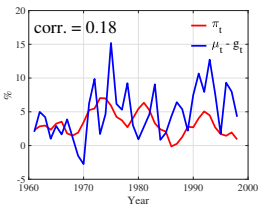
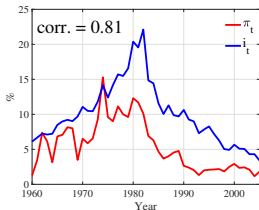
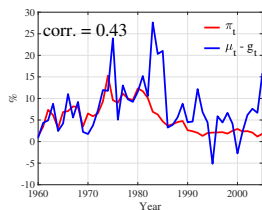
Australia

(a) Illustration 1

(b) Illustration 2

Canada

Group 1 Countries (2)



(a) Illustration 1

(b) Illustration 2

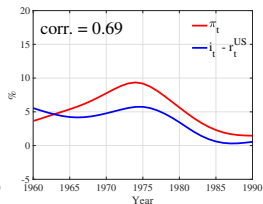
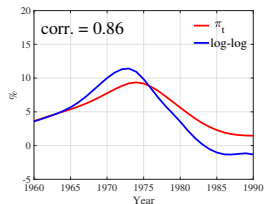
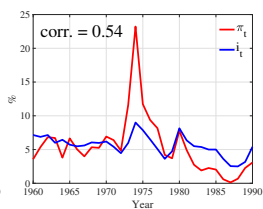
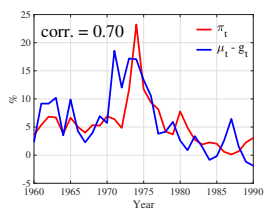
Denmark

(a) Illustration 1

(b) Illustration 2

Germany

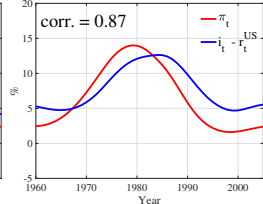
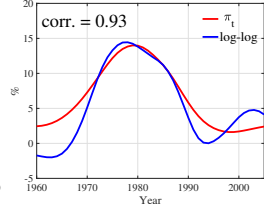
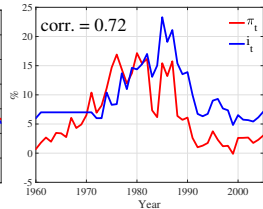
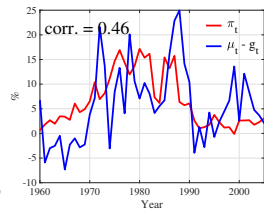
Group 1 Countries (3)



(a) Illustration 1

(b) Illustration 2

Japan

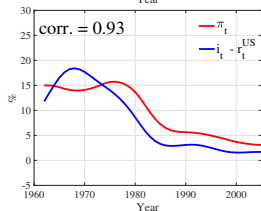
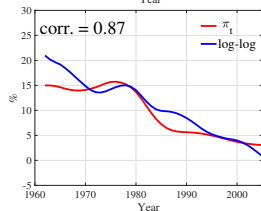
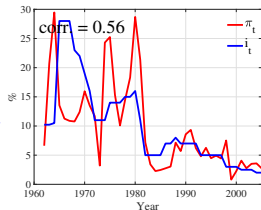
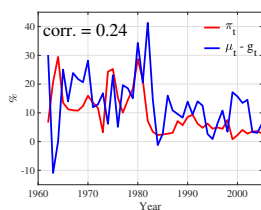


(a) Illustration 1

(b) Illustration 2

New Zealand

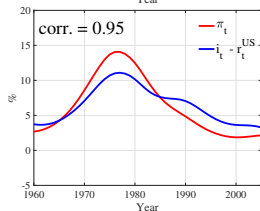
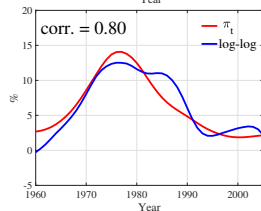
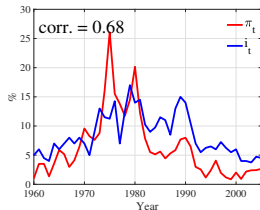
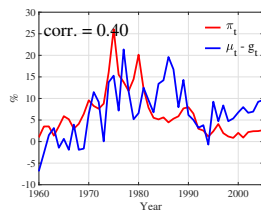
Group 1 Countries (4)



(a) Illustration 1

(b) Illustration 2

South Korea

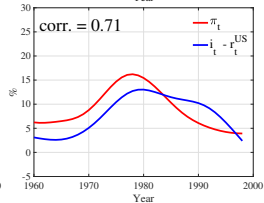
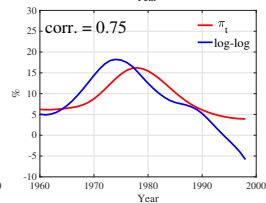
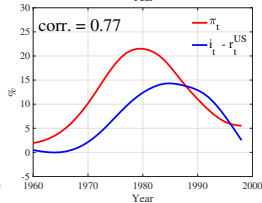
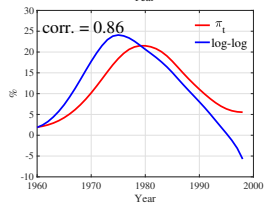
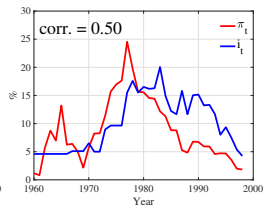
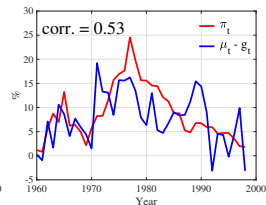
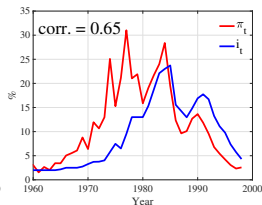
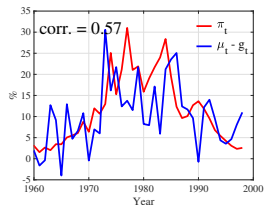


(a) Illustration 1

(b) Illustration 2

UK

Group 2 Countries (1)



(a) Illustration 1

(b) Illustration 2

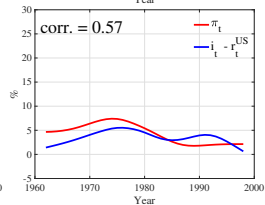
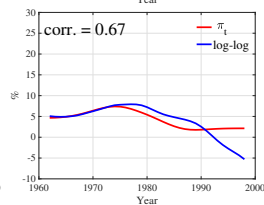
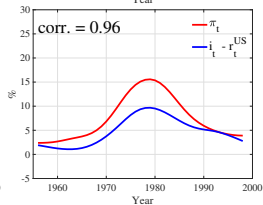
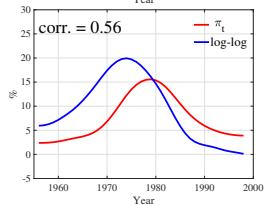
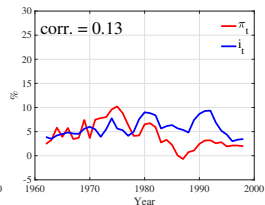
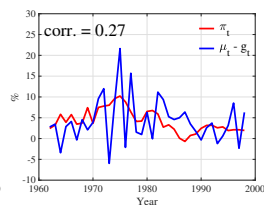
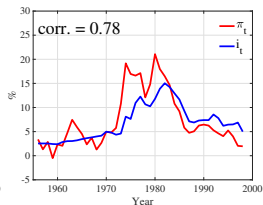
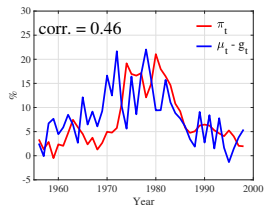
Portugal

(a) Illustration 1

(b) Illustration 2

Spain

Group 2 Countries (2)



(a) Illustration 1

(b) Illustration 2

(a) Illustration 1

(b) Illustration 2

Italy

Netherlands

Illustrations for Countries with Periods of Low Interest Rates

Illustration 1

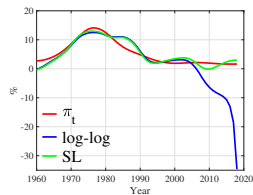
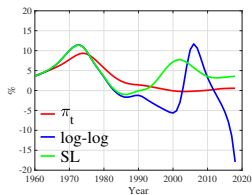
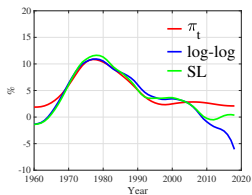
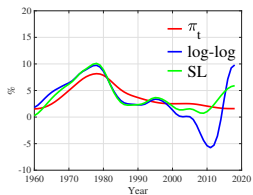
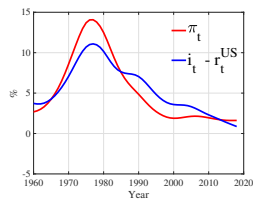
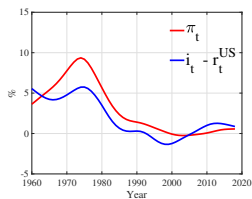
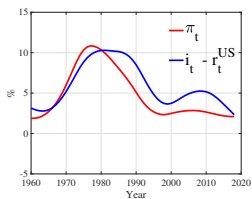
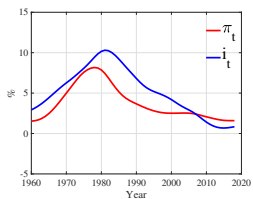


Illustration 2



USA

Australia

Japan

UK

Analysis of Simulated Data

A Standard New Keynesian Model

Model with Sticky Prices (Ireland 2004)

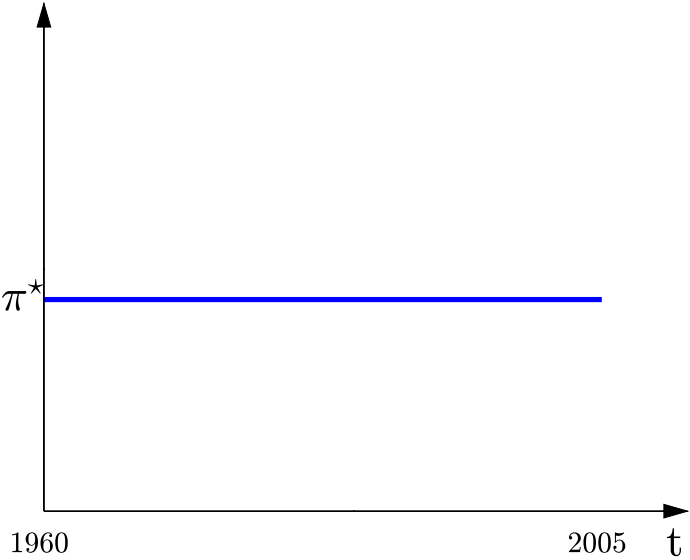
1. Add Calvo sticky prices and endogenous labor.
2. Keep the money demand!
3. Estimate using Bayesian methods.
4. Taylor rule

$$i_t = i_t^* + \phi_\pi(\pi_t - \pi_t^*) + \phi_y(y_t - y^*) + \varepsilon_t^i,$$

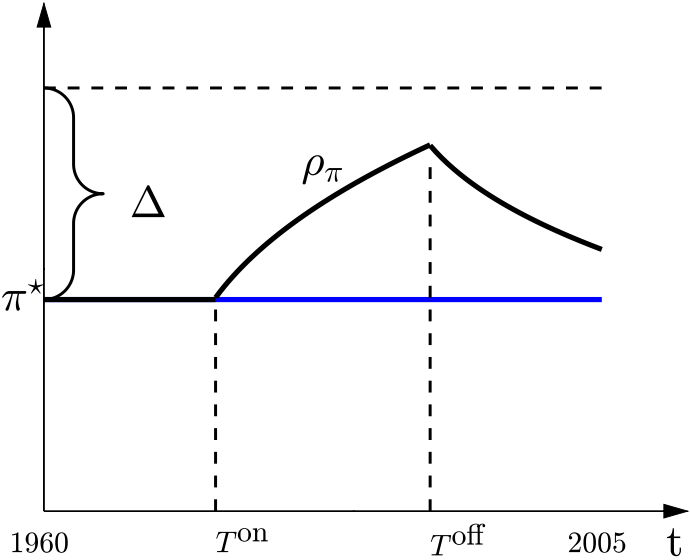
5. Allow for an inflation target shock π_t^* .

$$i_t^* = r^* + \pi_t^*$$

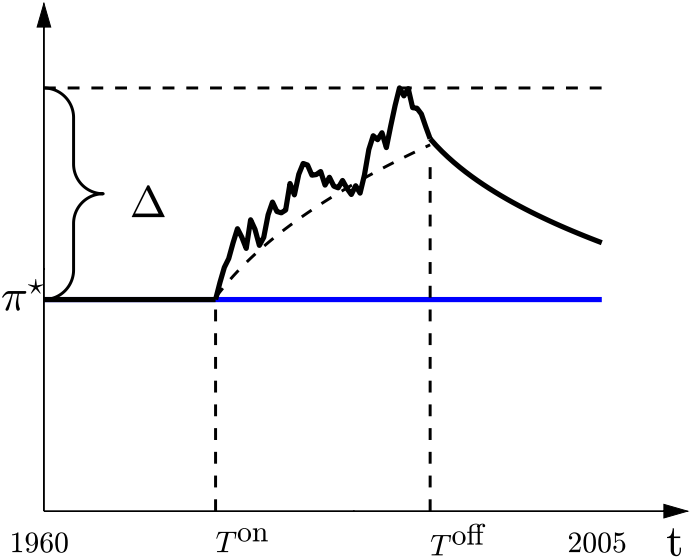
Usual NK Assumption



The Increase in Long-run Target Shock



Additional Stochastic Component



6.

$$\begin{aligned}i_t &= r^* + \pi_t^* + \phi_\pi(\pi_t - \pi_t^*) + \phi_y(y_t - y^*) + \varepsilon_t^i, \\ \pi_t^* &= (1 - \rho_\pi)\pi^s(\mathbb{I}^s) + \rho_\pi\pi_{t-1}^* + \mathbb{I}^s\varepsilon_{\pi,t}\end{aligned}$$

- Start from year 1960:

$$\pi_{1960}^* = 2\%$$

- Indicator of phases:

$$\mathbb{I}^s = \begin{cases} 0 & \text{for } t \in [1960, T^{\text{on}}) \text{ and } t \in [T^{\text{off}}, \infty) \\ 1 & \text{for } t \in [T^{\text{on}}, T^{\text{off}}) \end{cases}$$

- Long-run inflation target:

$$\pi^s(0) = 2\%$$

$$\pi^s(1) = 2\% + \Delta$$

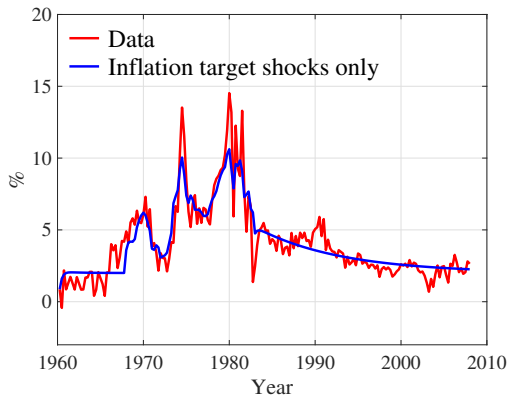
7. The parameters $\{T^{\text{on}}, T^{\text{off}}, \rho_\pi, \Delta\}$ are all estimated.

8. As a first step, we treat \mathbb{I}^s as unanticipated.

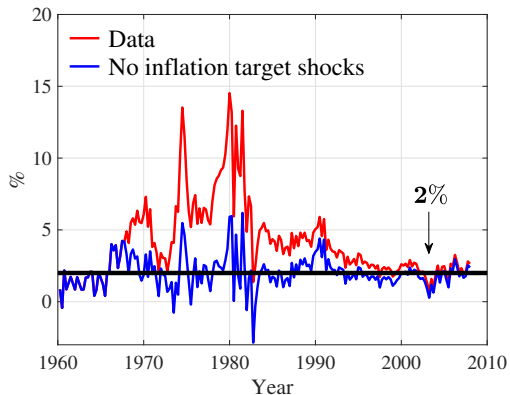
Estimates of Key Parameters

	Mode
ρ_π	0.97
$100 \times \Delta$	4.1
T^{on}	1968Q1
T^{off}	1983Q1

Result 1: Role of Inflation Target Shock on Inflation

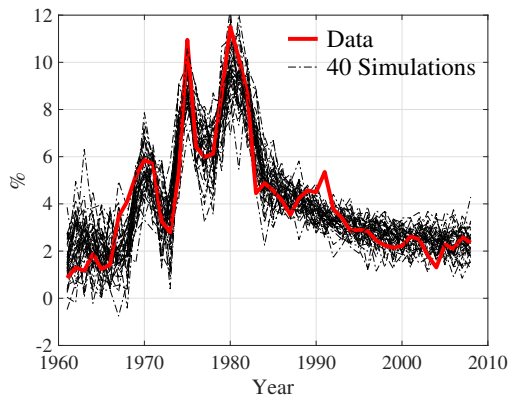


Inflation target shocks only

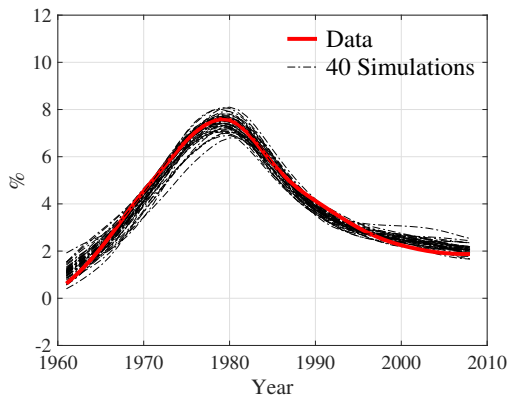


All shocks but inflation target shocks

Result 2: Model Fitness of Inflation Rates



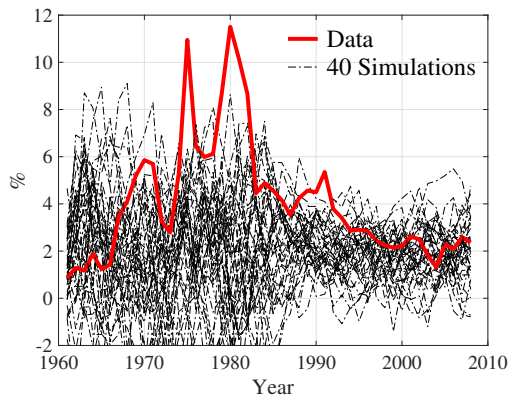
Raw



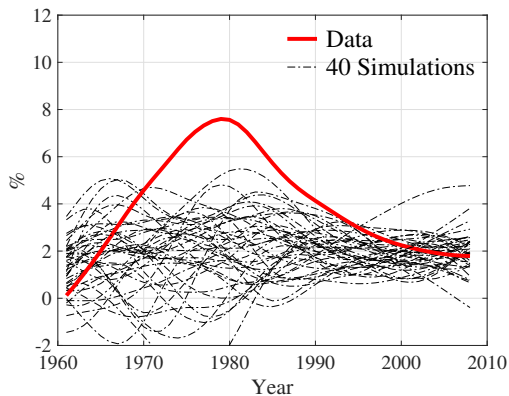
Filtered

Estimation **with** inflation target shocks

Result 2: Model Fitness of Inflation Rates



Raw

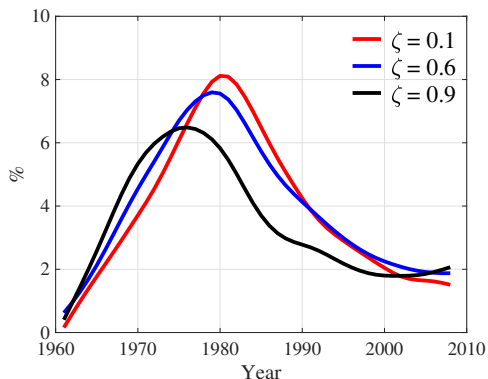


Filtered

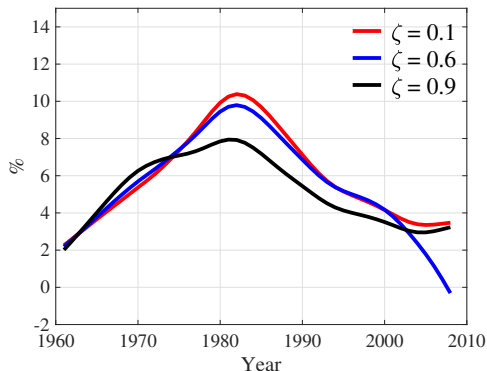
Estimation **without** inflation target shocks

Result 3: Sensitivity to Price Stickiness

Calvo parameter ζ : fraction of sticky firms



Inflation rates, filtered

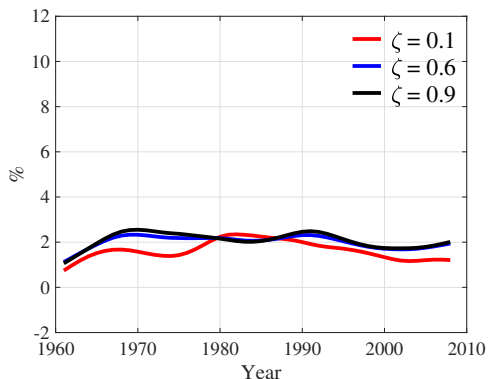


Nominal interest rates, filtered

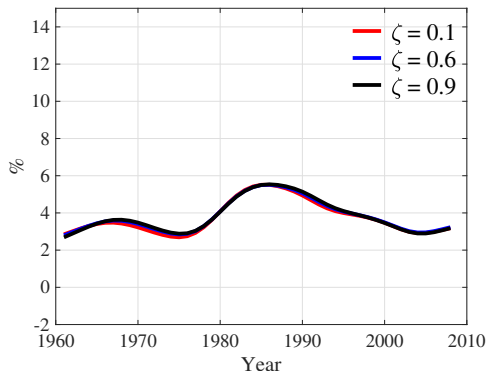
Simulation **with** inflation target shocks

Result 3: Sensitivity to Price Stickiness

Calvo parameter ζ : fraction of sticky firms



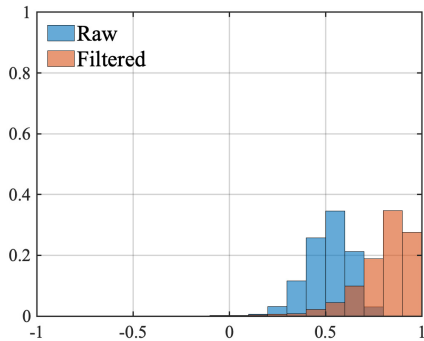
Inflation rates, filtered



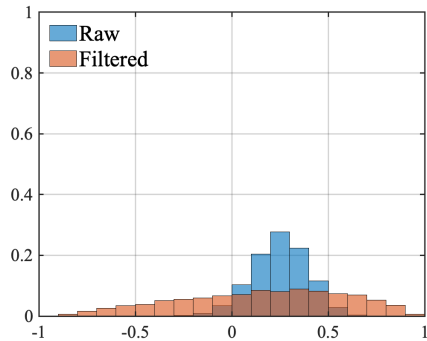
Nominal interest rates, filtered

Simulation **without** inflation target shocks

Result 4: Correlations of Series in Simulated Data



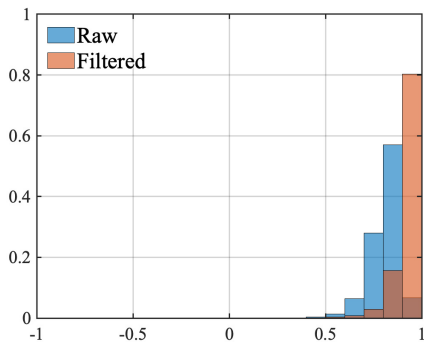
Benchmark



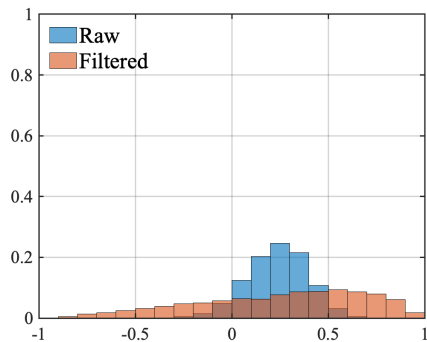
Without inflation target shocks

Illustration 1

Results 4: Correlations of Series in Simulated Data



Benchmark



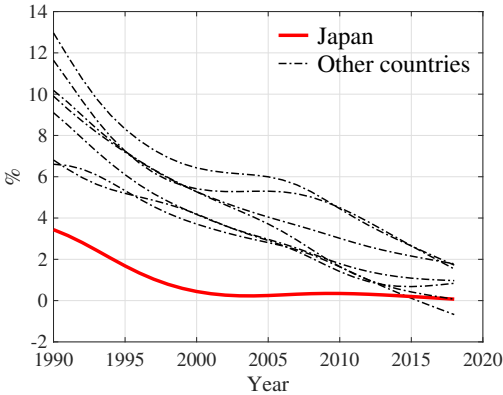
Without inflation target shocks

Illustration 2

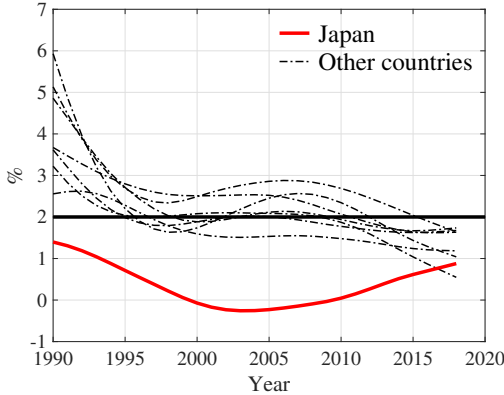
Implications for Data Analysis of OECD Countries

1. The filter does capture the inflation target shock (regime change?)
2. The filter captures nothing if there is no such target shock (Germany?)
3. The “realistic details” of the NK agenda are inessential to understand the main effects of the target shock.

Concluding Remarks



Interest rates



Inflation rates

Low-frequency movements of Group 1 countries since 1990

Model Details

- ▶ Three-equation system (Euler equation, Phillips curve, and Taylor rule)

$$x_t = (z - \ln \beta) - (i_t - \mathbb{E}_t \pi_{t+1}) + \mathbb{E}_t x_{t+1} + (1 - \omega)(1 - \rho_a) a_t$$

$$\pi_t = (1 - \beta) \pi^s + \beta \mathbb{E}_t \pi_{t+1} + \psi x_t - e_t$$

$$i_t = i_t^* + \rho_i (i_{t-1} - i_{t-1}^*) + \phi_\pi (\pi_t - \pi_t^*) + \phi_x x_t + \varepsilon_{i,t}.$$

- ▶ Money demand:

$$\mu_t = m_t - m_{t-1} + \pi_t + g_t$$

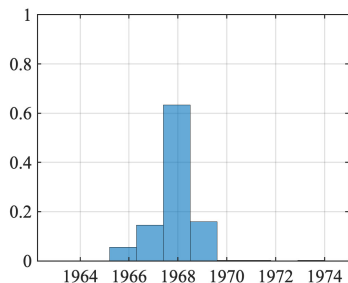
$$m_t = \bar{m} + \rho_m m_{t-1} - (1 - \rho_m) \eta \left(\frac{1 + i^s}{i^s} \right) i_t + \xi_t$$

- ▶ Non-policy shocks:

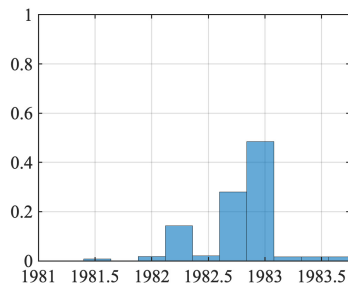
- ▶ Preference shock
- ▶ Markup shock
- ▶ Money demand shock
- ▶ Technology shock

Estimation: Key Parameters

	Prior distribution			Posterior distribution			
	Shape	Mean	StdDev.	Mode	Mean	5 %	95 %
ρ_π	Beta	0.5	0.2	0.97	0.98	0.97	0.98
$100 \times \Delta$	Uniform	[-2 , 6]		1.03	0.98	0.18	1.95



T^{on}



T^{off}

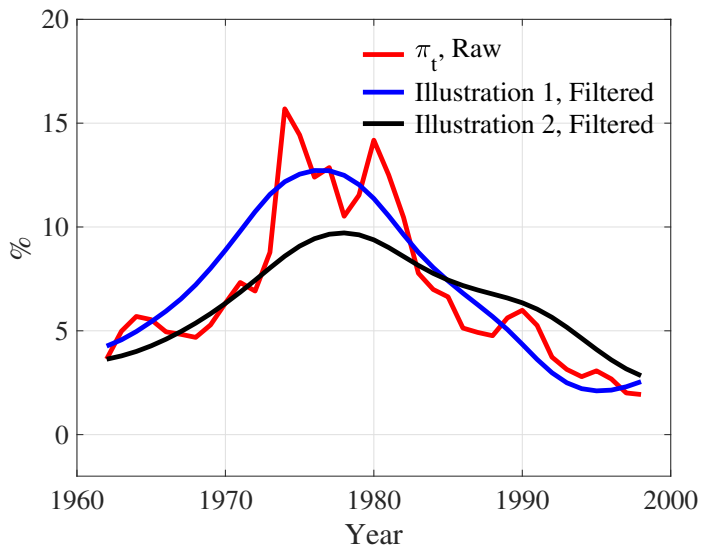
Estimation: Other Structural Parameters

	Prior distribution			Posterior distribution			
	Shape	Mean	StdDev.	Mode	Mean	5 %	95 %
ρ_i	Beta	0.5	0.2	0.90	0.90	0.86	0.93
ϕ_π	Normal	2	0.5	2.06	2.12	1.40	2.74
ϕ_x	Normal	0.125	0.05	0.37	0.37	0.31	0.42
$10 \times \omega$	Normal	0.5	0.1	0.52	0.53	0.37	0.69
η	Normal	0.5	0.05	0.46	0.46	0.38	0.55
ρ_m	Beta	0.5	0.2	0.95	0.96	0.91	0.98
ρ_a	Beta	0.5	0.2	0.88	0.88	0.84	0.91
ρ_e	Beta	0.5	0.2	0.46	0.47	0.34	0.56
ρ_τ	Beta	0.5	0.2	0.79	0.80	0.68	0.89
ρ_ξ	Beta	0.5	0.2	0.60	0.59	0.46	0.74

Estimation: Standard Deviations

	Prior distribution			Posterior distribution			
	Shape	Mean	StdDev.	Mode	Mean	5 %	95 %
$100 \times \sigma_i$	Inv. Gamma	1	2	0.08	0.08	0.06	0.10
$100 \times \sigma_a$	Inv. Gamma	1	2	1.45	1.33	1.17	1.84
$100 \times \sigma_e$	Inv. Gamma	1	2	0.11	0.11	0.09	0.14
$100 \times \sigma_z$	Inv. Gamma	1	2	0.47	0.47	0.42	0.53
$100 \times \sigma_\pi$	Inv. Gamma	1	2	0.10	0.10	0.09	0.12
$100 \times \sigma_\tau^{obs}$	Inv. Gamma	1	2	0.16	0.15	0.12	0.20
$100 \times \sigma_\xi$	Inv. Gamma	2	3	1.25	1.25	1.11	1.41
κ	Normal	2	0.3	2.00	1.99	1.82	2.20
κ_m	Normal	2	0.3	1.37	1.32	1.14	1.61

Illustrations of OECD Country Average



Illustrations of OECD Country Average

