Expectations, Asset Prices, and Monetary Policy: The Role of Learning

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Overview

- Should monetary authority respond to asset prices?

- How does the answer depend on:
  - Presence of financing frictions (in addition to price-setting frictions)
  - Information regarding the state of technology growth

- Asset prices as an indicator, not the policy objective

This Paper

Study the performance of alternative monetary policy rules in an economy with:

- **Financial market imperfections**
  - Financial accelerator: Bernanke, Gertler, and Gilchrist (1999)
- **Imperfect information regarding the state of technology growth**
  - Transitory and persistent shocks to technology growth: Edge, Laubach, and Williams (2004), Saito (2006)
  - Perceptions about the state of technology growth determine:
    - Market values
    - Policymaker's inference about the potential level of asset prices and the policy stance
  - Consider identical vs. differential information between private sector and policymaker

Financial Market Imperfections: Business Cycle Implication

Provide an amplification mechanism

- Asymmetric information between lenders and borrowers→Countercyclical premium on external funds

  A favorable shock

  →Investment and asset prices increase

  →Borrower's net worth and balance sheet condition improve

  →External finance premium falls

  →*Investment and asset prices increase further*

  →*Borrower's net worth and balance sheet condition improve further*

  → ... ["financial accelerator"]

Financial Market Imperfections: Policy Implication

Introduce additional source of distortion on economic activity

- Amplification mechanism reflects a distortion
  - Excessively procyclical asset prices and investment
- Variables related to this distortion have a special role in stabilization policy
  - Asset prices: relative price of capital

Findings

- **Absent financial market imperfections, a policy of responding strongly to inflation is sufficient.**
  - Only one source of distortion: price-setting frictions

Findings (ctd.)

- **In the presence of financial market imperfections, allowing a policy response to asset prices can be beneficial.**
  - Two sources of distortion:
    - (1) Price-setting frictions introduce distortion through time-varying markup
      - Stabilizing inflation helps reduce this distortion
    - (2) Financing frictions introduce distortion through time-varying premium on external funds
      - Stabilizing asset prices around frictionless level helps reduce this distortion
  - Policy should balance the effects of two distortions:
    - Responding only to inflation leaves a large output gap volatility
    - Responding too strongly to asset prices destabilizes inflation

Findings (ctd.)

- **Performance of a monetary policy rule depends on the information structure.**
  - When the central bank is fully informed about the state of technology growth, allowing a policy response to "asset price gap" is beneficial
    - Potential is computed correctly
    - Benefits are larger when the private sector is imperfectly informed
  - When the central bank is imperfectly informed, better to use a policy that does not require inferences about the potential
    - Rules that include asset price growth or output growth work well in reducing the distortions due to financing frictions
    - Rules that include the level of asset prices are destabilizing in the presence of shocks affecting the potential

Model

- Key features:
  - Two sources of distortion: price-setting frictions, financing frictions
  - Information about technology growth: full vs. imperfect
- Agents:
  - Private sector: households, final goods producers, retailers, capital producers, entrepreneurs
  - Monetary authority: (Taylor) interest rate rule

Financial Market Imperfections

- Entrepreneurs produce wholesale goods using capital and labor

- Finance expenditures on capital with net worth (internal funds) and debt (external funds):

$$Q_t K_{t+1} = N_{t+1} + \frac{B_{t+1}}{P_t}$$

- Asymmetric information and costly state verification
  - Premium on external funds inversely related to entrepreneur's balance-sheet condition

Financial Market Imperfections (ctd.)

- Premium on external funds is increasing in borrower's leverage (BGG, 1999):

$$s\left(\frac{Q_t K_{t+1}}{N_{t+1}}\right) = \left(\frac{Q_t K_{t+1}}{N_{t+1}}\right)^{\chi}$$

  $\chi > 0$: Balance-sheet conditions relevant (financial market imperfections)

  $\chi = 0$: Balance-sheet conditions irrelevant (no financial market imperfections)

- Evolution of net worth:

$$N_{t+1} = \eta \left[R_t^k Q_{t-1} K_t - s\left(\frac{Q_{t-1} K_t}{N_t}\right) E_{t-1}\left[R_t^n \frac{P_{t-1}}{P_t}\right](Q_{t-1} K_t - N_t)\right] + \frac{W_t^e}{P_t}$$

- Provides a link between asset prices, balance sheet conditions, and the external finance premium

Monetary Policy Rules

- **Inflation only:** $\ln R^n_{t+1} = \ln R^n + \phi_\pi \ln \pi_t$
  - Weak inflation response ($\phi_\pi = 1.1$) vs. strong inflation response ($\phi_\pi = 2.0$)
- **Asset price gap:** $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q^*_t)$
  - Q^*_t: policymaker's inference about the potential level of asset prices (in the absence of both pricing and financing frictions)
- **Natural rate of interest:** $\ln R^n_{t+1} = \ln R^*_{t+1} + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q^*_t)$
  - R^*_{t+1}: policymaker's inference about the natural rate of interest
- **Asset price level:** $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q)$
- **Asset price growth:** $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q_{t-1})$
- **Output growth:** $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Y(\ln Y_t - \ln Y_{t-1} - \mu)$

Two Sources of Distortion on Economic Activity

- **1. Price-setting frictions:** introduce fluctuations in markup

- **2. Financing frictions:** introduce fluctuations in external finance premium

- Variations in $\widetilde{mc}_t$ (inverse of markup) and $\widetilde{s}_t$ (premium) work as "tax wedges":

  (1) Labor market:

$$\widetilde{y}_t + \widetilde{mc}_t - \widetilde{c}_t = (1+\gamma)\widetilde{h}_t$$

  (2) Capital market:

$$\widetilde{s}_t + \widetilde{r}^n_{t+1} - E_t\widetilde{\pi}_{t+1} = \left(1 - \frac{1-\delta}{R^k}\right)(E_t\widetilde{y}_{t+1} - \widetilde{k}_{t+1} + E_t\widetilde{z}_{t+1} + E_t\widetilde{mc}_{t+1}) + \frac{1-\delta}{R^k}(E_t\widetilde{q}_{t+1} - \widetilde{q}_t)$$

Monetary Policy in the Presence of Two Distortions

- **1. Stabilize inflation**

  $\rightarrow$Stabilize markup

  $\rightarrow$Reduce distortions due to price-setting frictions

- **2. Stabilize "excessive" asset price movements**

  $\rightarrow$Stabilize the external finance premium

  $\rightarrow$Reduce distortions due to financing frictions

- Rationale:

  1. 'Stabilize nominal prices that are sticky'
  2. Stabilize relative price related to distortion

Complications

- Stabilizing nominal-price inflation does not necessarily ensure "efficient" level of relative price (asset prices) in the presence of two distortions
  - Two distortions, one policy instrument
- Not all the asset price movements are inefficient
  - Policymaker must make inference
  - We assume that the central bank can solve a frictionless model to compute the potential level of asset prices, but may do so under imperfect information regarding the state of technology growth

Transitory and Persistent Movements in Technology Growth

- Two sources of variations in technology growth:

$$\ln A_t = \ln A_{t-1} + \mu_t + \varepsilon_t$$

where A_t: technology in period t

- Persistent component is $AR(1)$:

$$\begin{aligned} (\mu_t - \mu) &= \rho_d(\mu_{t-1} - \mu) + v_t \\ v_t &\sim i.i.d.N(0, \sigma_v^2) \end{aligned}$$

- Transitory component is $i.i.d.$:

$$\varepsilon_t \sim i.i.d.N(0, \sigma_\varepsilon^2)$$

Information Structures

- **Full Information:** observe two shocks (μ_t, ε_t) separately
  - state is (μ_t, ε_t)
- **Imperfect Information:** observe technology (A_t) but not the two shocks (μ_t, ε_t)
  - state is inference about (μ_t, ε_t)
- Based on available information:
  - Private sector optimizes
  - Central bank computes (Q_t^*, R_{t+1}^*): inputs for policy
- Case of identical vs. differential information between private sector and policymaker
- Assumption: monetary authority's information affects the private sector's decisions through changes in the policy interest rate, but not their *inferences* regarding shocks

Optimal Inference Under Imperfect Information

- Let percentage deviation from mean technology growth μ:

$$\begin{aligned} \widetilde{z}_t &\equiv \ln A_t - \ln A_{t-1} - \mu \\ \widetilde{d}_t &\equiv \mu_t - \mu \end{aligned}$$

- Rewrite the technology growth process:

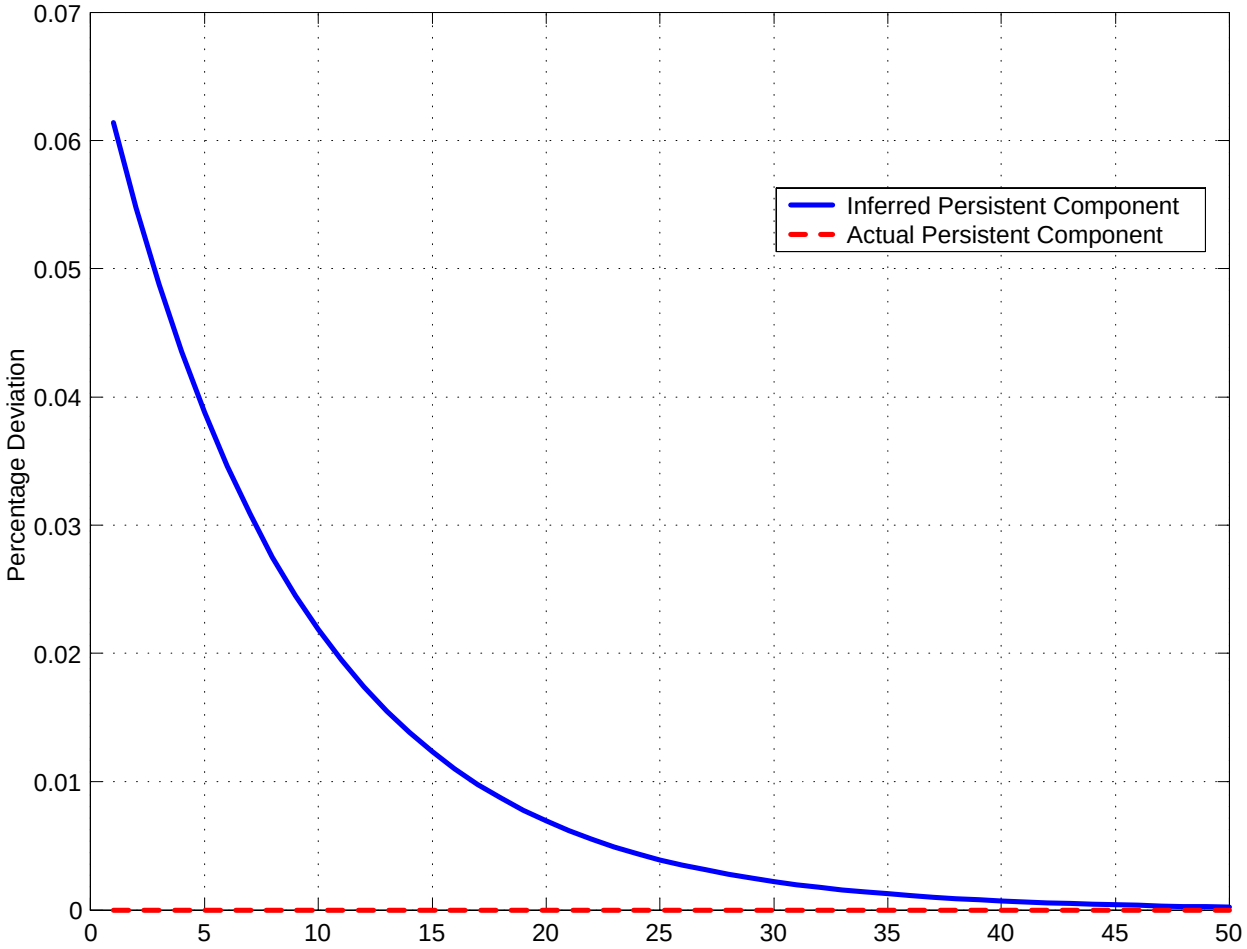
$$\begin{aligned} \widetilde{z}_t &= \widetilde{d}_t + \varepsilon_t \\ \widetilde{d}_t &= \rho_d \widetilde{d}_{t-1} + \nu_t \\ v_t &\sim i.i.d.N(0, \sigma_v^2) \\ \varepsilon_t &\sim i.i.d.N(0, \sigma_\varepsilon^2) \end{aligned}$$

- Optimal inference about $\widetilde{d}_t$ based on observations $(\widetilde{z}_t, \widetilde{z}_{t-1}, \widetilde{z}_{t-2}, ...)$ and the knowledge of $(\rho_d, \sigma_v^2, \sigma_\varepsilon^2)$:

$$\widetilde{d}_{t|t} = \lambda \widetilde{z}_t + (1-\lambda)\rho_d \widetilde{d}_{t-1|t-1}$$

where $\widetilde{d}_{t|t} \equiv E[\widetilde{d}_t |\ \widetilde{z}_t, \widetilde{z}_{t-1}, \widetilde{z}_{t-2}, ...]$, Kalman gain λ increasing in $\frac{\sigma_v^2}{\sigma_\varepsilon^2}$ and ρ

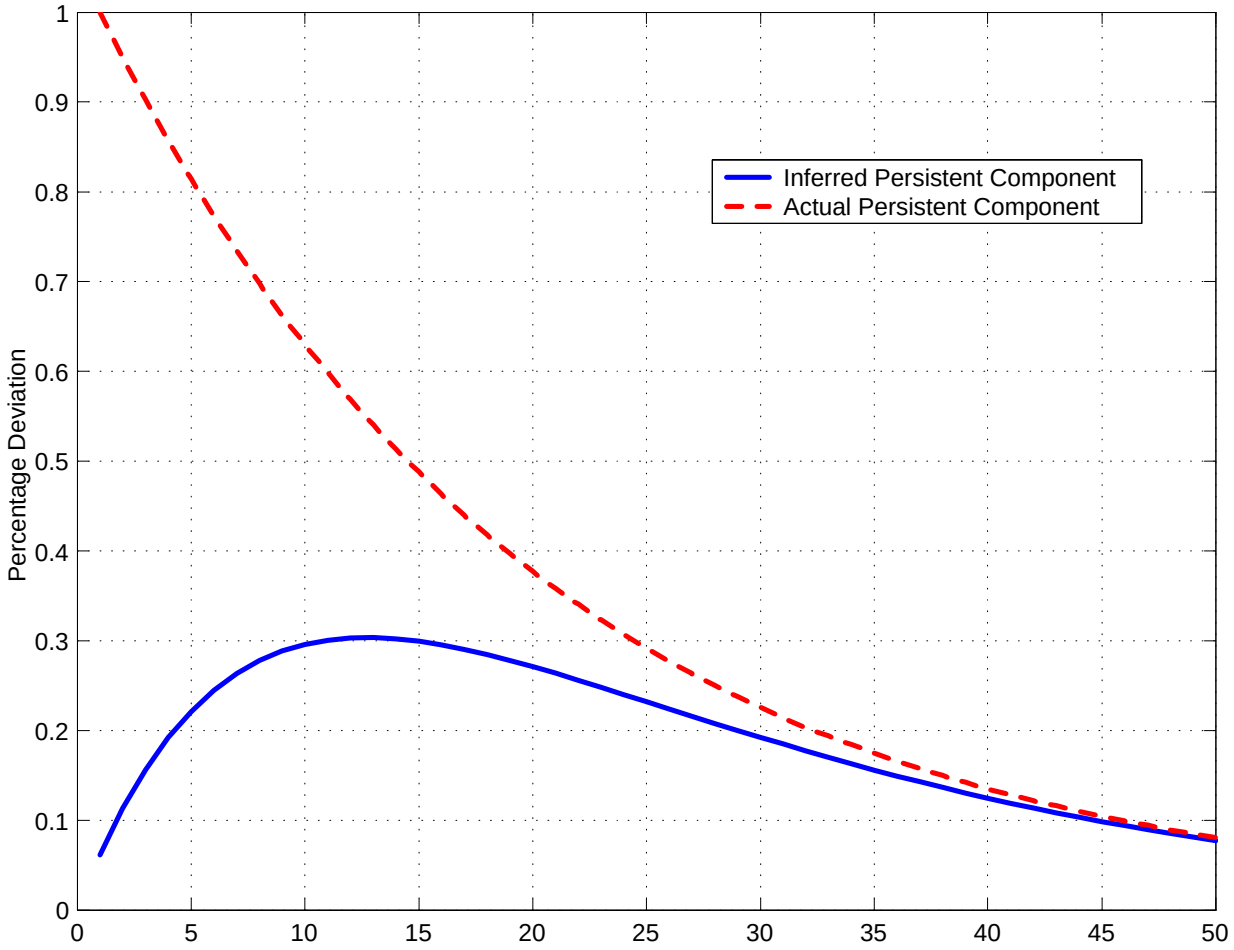
Changes in Inferences After a Transitory Shock



- - - - - : **Actual** persistent component of technology growth $\left(\widetilde{d}_t\right)$

———: **Inferred** persistent component of technology growth $\left(\widetilde{d}_{t|t}\right)$

Changes in Inferences After a Persistent Shock



- - - - : **Actual** persistent component of technology growth $\left(\widetilde{d}_t\right)$

———: **Inferred** persistent component of technology growth $\left(\widetilde{d}_{t|t}\right)$

Calibration

Preferences, Technology, and Price-Setting

Discount factor	0.984
Labor share of income	0.667
Labor supply elasticity	1.25
Depreciation rate of capital	2.5%
Elasticity of asset prices to investment	0.25
Steady-state markup	10%
Average duration of prices	4 quarters

Financial Market Imperfections

Steady-state leverage ratio	80%
Elasticity of the external finance premium to leverage	0.05

$\Longrightarrow$Implies a steady-state external finance premium of 3%

Increasing these enhances the financial accelerator mechanism.

Shock Process and Filtering

std of shocks to the transitory component	1%
std of shocks to the persistent component	0.1%
$AR(1)$ coefficient on the persistent component	0.95

$\Longrightarrow$Implies a Kalman gain of $\lambda = 0.06138$

Agents initially attach a large weight on the transitory shock.

Model Properties

Compare economic outcomes under:

(1) Frictionless economy with full information:

No price-setting frictions ($\widetilde{mc}_t = 0$), no financing frictions ($\widetilde{s}_t = 0$)

(2) Policy with weak response to inflation:

$$\ln R^n_{t+1} = \ln R^n + 1.1 \ln \pi_t$$

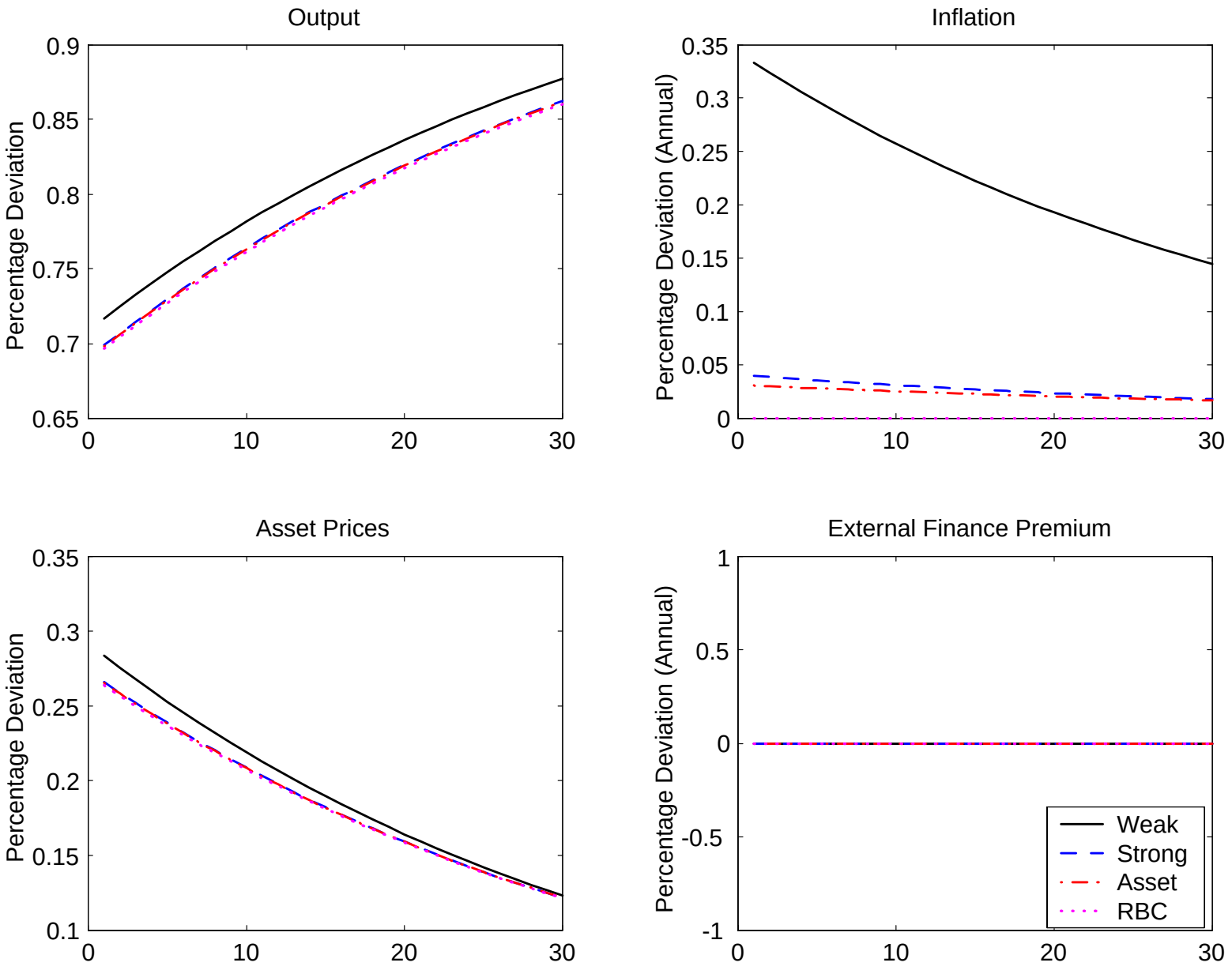
(3) Policy with strong response to inflation:

$$\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t$$

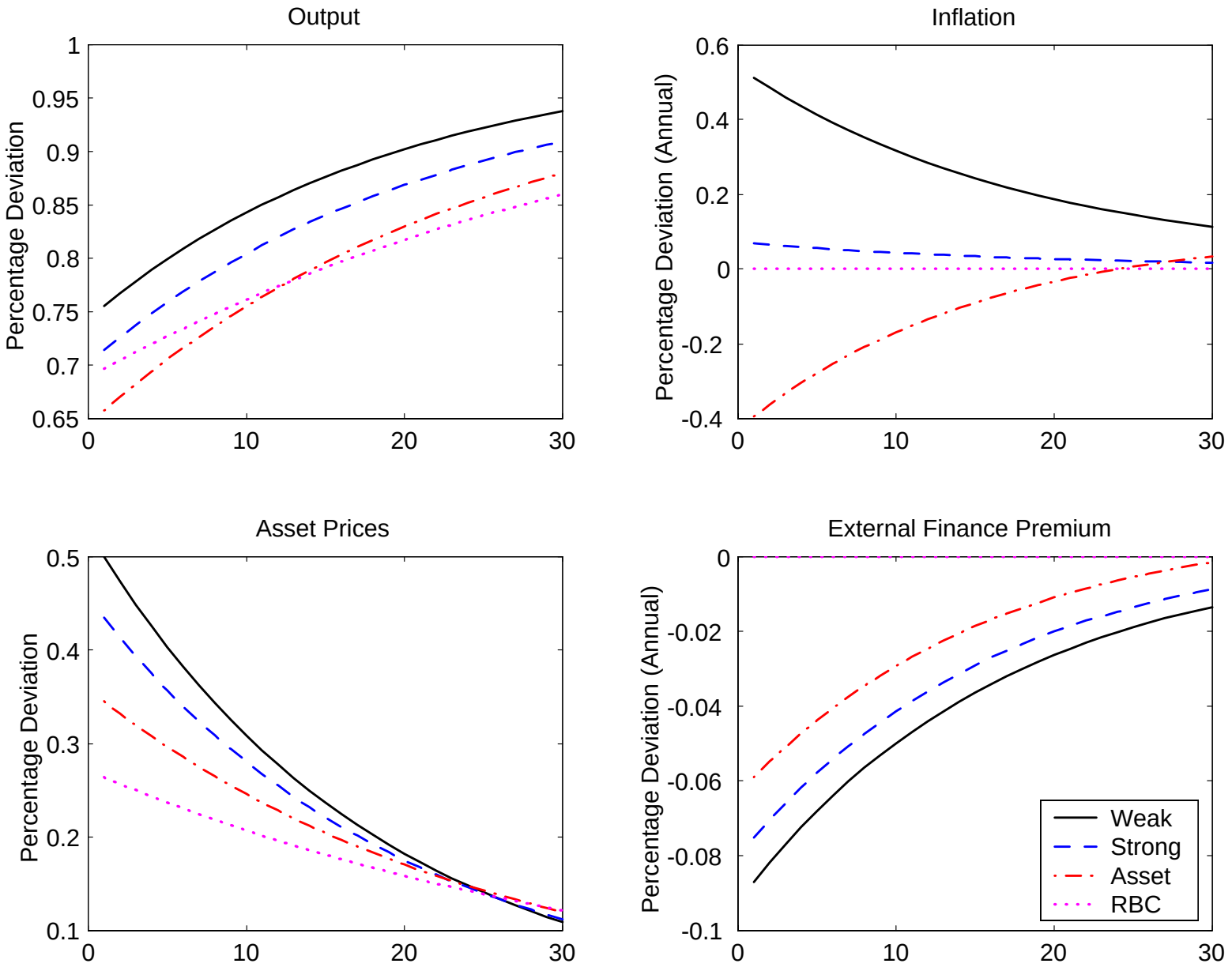
(4) Policy with asset price gap on top of (3):

$$\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + 1.5(\ln Q_t - \ln Q^*_t)$$

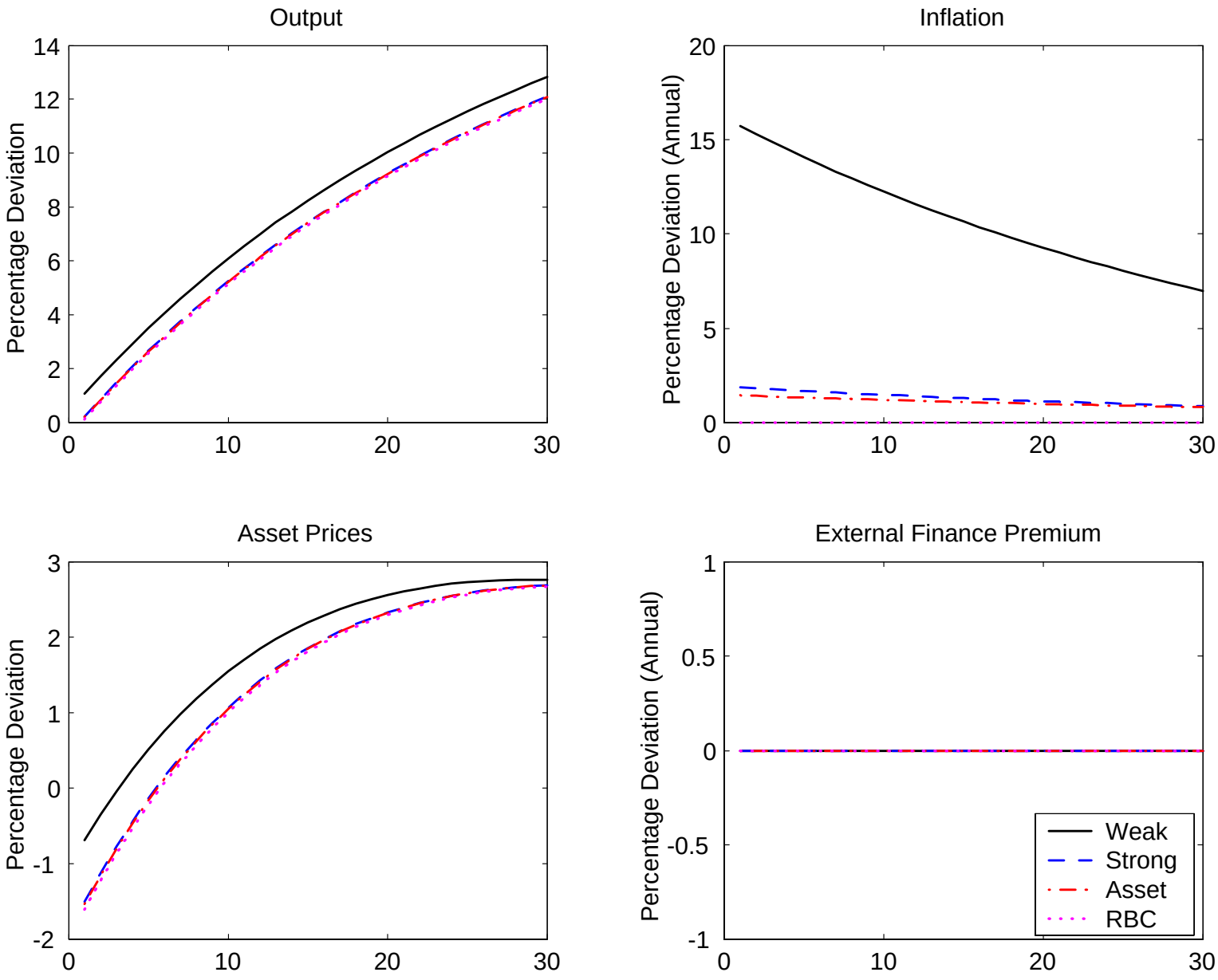
Transitory Shock: Full Info, Pricing Friction Only



Transitory Shock: Full Info, Both Frictions



Persistent Shock: Full Info, Pricing Friction Only



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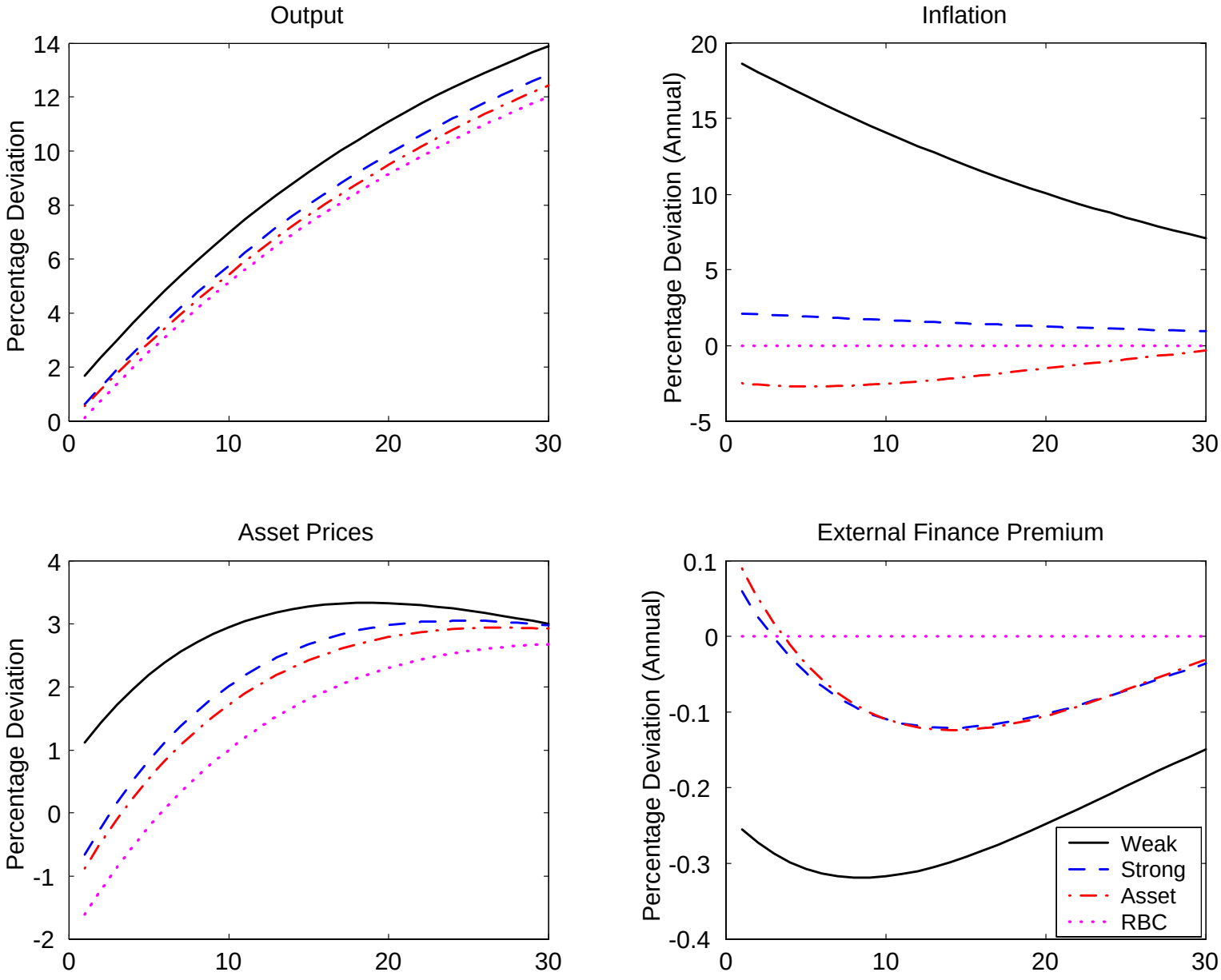


Performance of Monetary Policy Rules

- Evaluate economic outcomes with:

$$var(\ln \pi_t)$$

$$var\left(\ln Y_t - \ln Y^*_{full,t}\right)$$

Equal-weighted loss: $0.5var(\ln \pi_t) + 0.5var\left(\ln Y_t - \ln Y^*_{full,t}\right)$

- $Y^*_{full,t}$ $\equiv$output in the absence of both price-setting and financial frictions and under full information

Policy Rule with Inflation Only

$$\ln R^n_{t+1} = \ln R^n + \phi_\pi \ln \pi_t$$

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Full information for the private sector						
$\phi_\pi = 1.1$	0.431	2.811	1.621	1.923	3.022	2.473
$\phi_\pi = 2.0$	0.006	0.044	0.025	0.470	0.056	0.263
Imperfect information for the private sector						
$\phi_\pi = 1.1$	0.579	2.103	1.341	2.247	2.265	2.256
$\phi_\pi = 2.0$	0.099	0.028	0.063	0.870	0.045	0.458

Gains from Allowing Policy Response to Other Variables

- **Relative gain** from using Policy Rule x:

$$\frac{\text{loss(weak inflation response)} - \text{loss(Policy Rule } x\text{)}}{\text{loss(weak inflation response)} - \text{loss(strong inflation response)}}$$

- Interpretation:

  If **Relative gain**> 1, Policy Rule x is better than "strong inflation response"

  If **Relative gain**< 0, Policy Rule x is worse than "weak inflation response"

Including Asset Price Gap: (1) Full Information for the Private Sector

$$\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q^*_t)$$

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Full information for the policymaker						
$\phi_Q = 0.1$	1.00	1.00	1.00	1.03	1.01	1.01
$\phi_Q = 1.0$	1.00	1.00	1.00	1.13	0.98	1.03
$\phi_Q = 2.0$	1.01	1.00	1.00	1.22	0.92	1.02
Imperfect information for the policymaker						
$\phi_Q = 0.1$	0.98	1.00	1.00	1.02	1.01	1.01
$\phi_Q = 1.0$	0.59	0.99	0.94	0.93	0.98	0.97
$\phi_Q = 2.0$	0.21	1.00	0.90	0.79	0.88	0.85

Including Asset Price Gap: (2) Imperfect Information for the Private Sector

$$\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q^*_t)$$

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Full Information for the policymaker						
$\phi_Q = 0.1$	1.02	1.00	1.00	1.09	1.00	1.04
$\phi_Q = 1.0$	1.12	0.99	1.01	1.50	0.98	1.18
$\phi_Q = 2.0$	0.97	0.99	0.99	1.53	0.86	1.12
Imperfect Information for the policymaker						
$\phi_Q = 0.1$	0.92	1.00	0.98	1.20	1.01	1.08
$\phi_Q = 1.0$	0.96	1.00	0.99	1.38	0.97	1.12
$\phi_Q = 2.0$	0.96	1.00	1.00	1.42	0.87	1.08

Policy Rule without Central Bank's Inferences: (1) Full Information for the Private Sector

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Output growth: $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Y(\ln Y_t - \ln Y_{t-1} - \mu)$						
$\phi_Y = 0.1$	0.99	1.00	1.00	1.03	1.01	1.01
$\phi_Y = 1.0$	0.57	1.00	0.95	1.04	1.01	1.02
$\phi_Y = 2.0$	−0.05	0.94	0.81	0.83	0.95	0.91
Asset price growth: $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q_{t-1})$						
$\phi_Q = 0.1$	1.00	1.00	1.00	1.07	1.00	1.02
$\phi_Q = 1.0$	0.87	1.00	0.99	1.04	1.00	1.02
$\phi_Q = 2.0$	0.69	1.00	0.96	0.96	1.00	0.99
Asset price level: $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q)$						
$\phi_Q = 0.1$	0.99	1.01	1.00	1.01	1.01	1.01
$\phi_Q = 1.0$	0.13	−0.01	0.00	1.05	−0.31	0.13
$\phi_Q = 2.0$	−2.16	−3.60	−3.41	0.71	−4.18	−2.57

Policy Rule without Central Bank's Inferences: (2) Imperfect Information for the Private Sector

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Output growth: $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Y(\ln Y_t - \ln Y_{t-1} - \mu)$						
$\phi_Y = 0.1$	0.97	1.00	1.00	1.20	1.01	1.08
$\phi_Y = 1.0$	0.74	1.00	0.95	1.40	1.01	1.16
$\phi_Y = 2.0$	0.33	0.90	0.79	1.37	0.92	1.24
Asset price growth: $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q_{t-1})$						
$\phi_Q = 0.1$	0.95	1.00	0.99	1.11	1.00	1.05
$\phi_Q = 1.0$	0.96	1.00	0.99	1.33	1.00	1.13
$\phi_Q = 2.0$	0.98	1.00	0.99	1.39	1.00	1.15
Asset price level: $\ln R^n_{t+1} = \ln R^n + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q)$						
$\phi_Q = 0.1$	0.96	1.01	1.00	1.21	1.02	1.09
$\phi_Q = 1.0$	0.49	−0.65	−0.44	1.52	−0.80	0.09
$\phi_Q = 2.0$	−0.78	−4.54	−3.83	1.30	−5.42	−2.85

Conclusions

- Absent financial market imperfections, a policy of responding strongly to inflation is sufficient

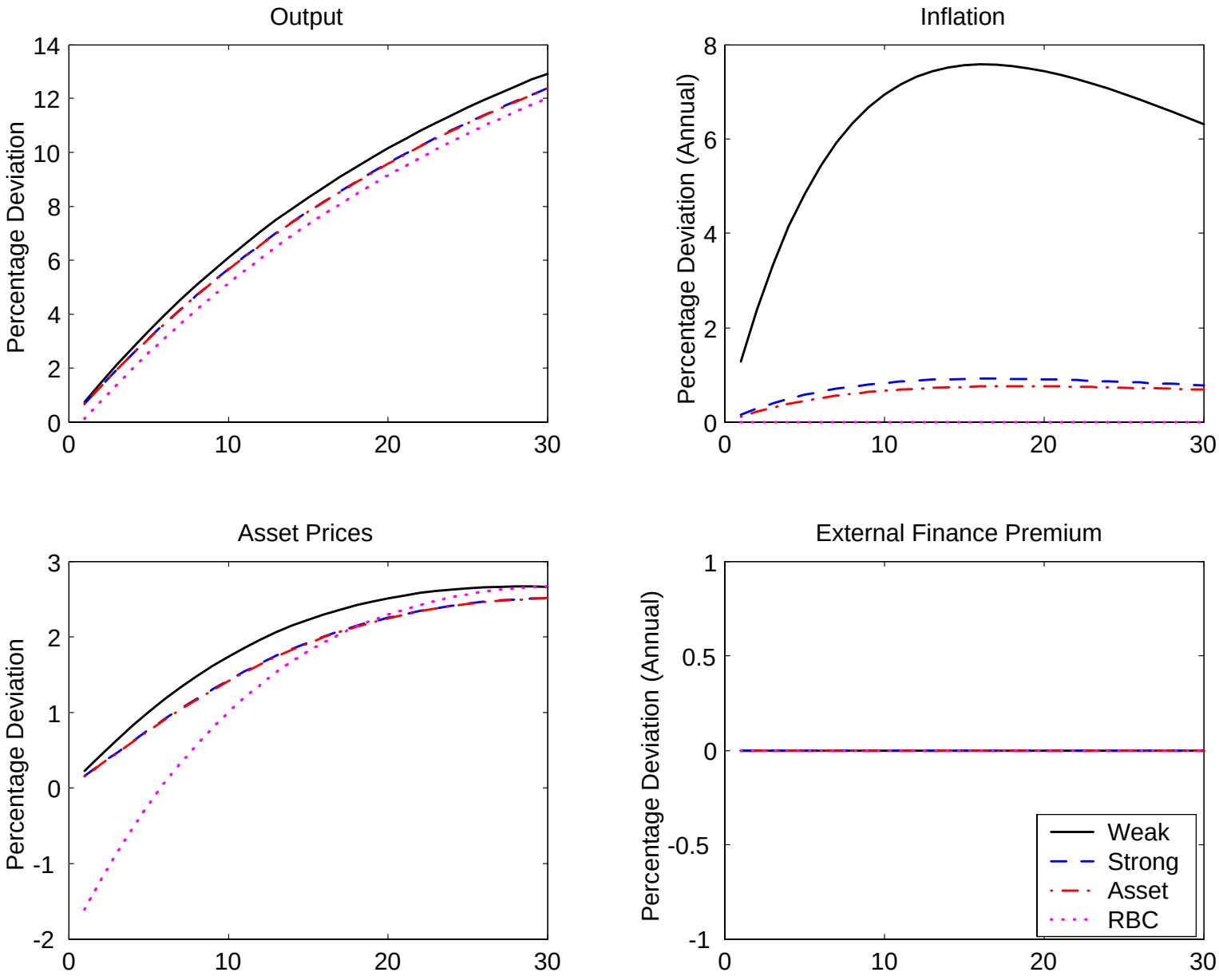
- Financial market imperfections introduce additional distortion
  - Allowing a *modest* policy response to asset prices *can* be beneficial
    - Responding to the asset price gap is beneficial when central bank computes the potential correctly
      - Benefits are larger when the private sector is imperfectly informed about the state of technology growth
    - Policy rule that includes the growth rate of asset prices or output are robust to incorrect inferences and work well in reducing the distortion due to financing frictions
    - Policy rule with asset price level shows worst performance in the presence of shocks affecting the potential

Directions

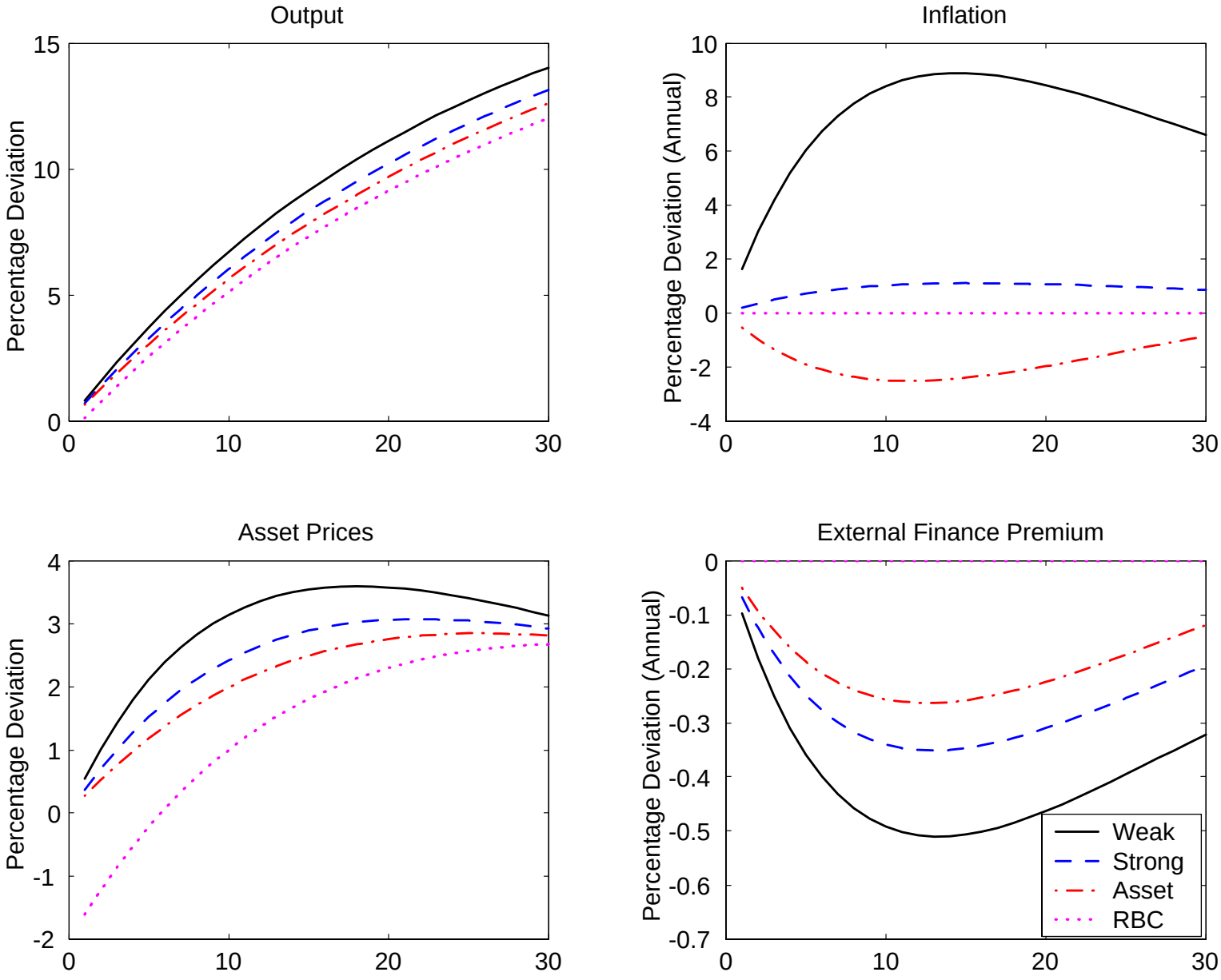
- **Asset price dynamics**
  - Wage stickiness helps a model to generate procyclical asset price movements in response to persistent growth shocks
- **Welfare analysis**
  - Ramsey policy, higher-order approximations
- **Analysis with estimated model**
  - Relative importance of alternative shocks and frictions/wedges
  - Financial market developments, changes in propagation/transmission mechanism over time
- **Central bank's learning from asset price movements regarding the state of technology growth**

Additional slides

Persistent Shock: Imperfect Info, Pricing Friction Only



Persistent Shock: Imperfect Info, Both Frictions



Robustness to Including Natural Rate: (1) Full Information for the Private Sector

$$\ln R^n_{t+1} = \ln R^*_{t+1} + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q^*_t)$$

(Change in relative gain starting from $\phi_Q = 0$)

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Full information for the policymaker						
$\phi_Q = 0.1$	0.00	0.00	0.00	0.02	0.00	0.01
$\phi_Q = 1.0$	0.00	0.00	0.00	0.11	−0.04	0.01
$\phi_Q = 2.0$	0.00	0.00	0.00	0.16	−0.14	−0.04
Imperfect information for the policymaker						
$\phi_Q = 0.1$	−0.01	0.00	0.00	−0.03	0.04	−0.01
$\phi_Q = 1.0$	−0.40	−0.01	−0.06	−0.08	0.00	−0.05
$\phi_Q = 2.0$	−0.89	0.00	−0.12	−0.20	−0.11	−0.16

Robustness to Including Natural Rate: (2) Imperfect Information for the Private Sector

$$\ln R^n_{t+1} = \ln R^*_{t+1} + 2.0 \ln \pi_t + \phi_Q(\ln Q_t - \ln Q^*_t)$$

(Change in relative gain starting from $\phi_Q = 0$)

	Pricing friction only			Both frictions		
	$var(Y\ gap)$	$var(\ln \pi)$	Loss	$var(Y\ gap)$	$var(\ln \pi)$	Loss
Full information for the policymaker						
$\phi_Q = 0.1$	0.00	0.00	0.00	0.02	0.00	0.01
$\phi_Q = 1.0$	0.00	0.00	0.00	0.11	−0.04	0.01
$\phi_Q = 2.0$	0.00	0.00	0.00	0.16	−0.04	−0.04
Imperfect information for the policymaker						
$\phi_Q = 0.1$	0.02	0.00	0.01	0.07	0.00	0.02
$\phi_Q = 1.0$	−0.03	0.00	0.00	0.20	−0.07	0.03
$\phi_Q = 2.0$	−0.02	0.00	0.00	0.24	−0.16	−0.01