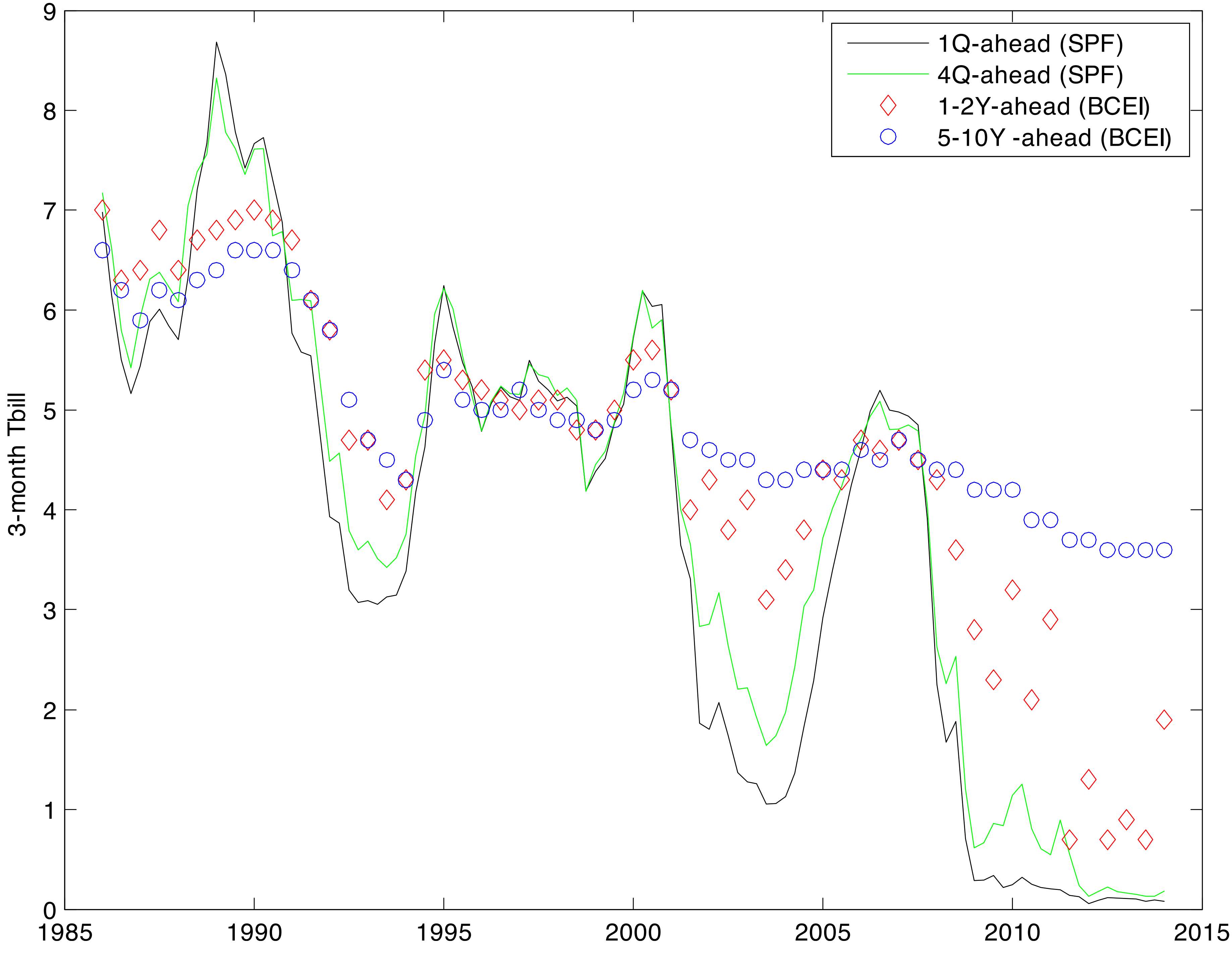
The Limits of Monetary Policy with Long-Term Drift in Expectations

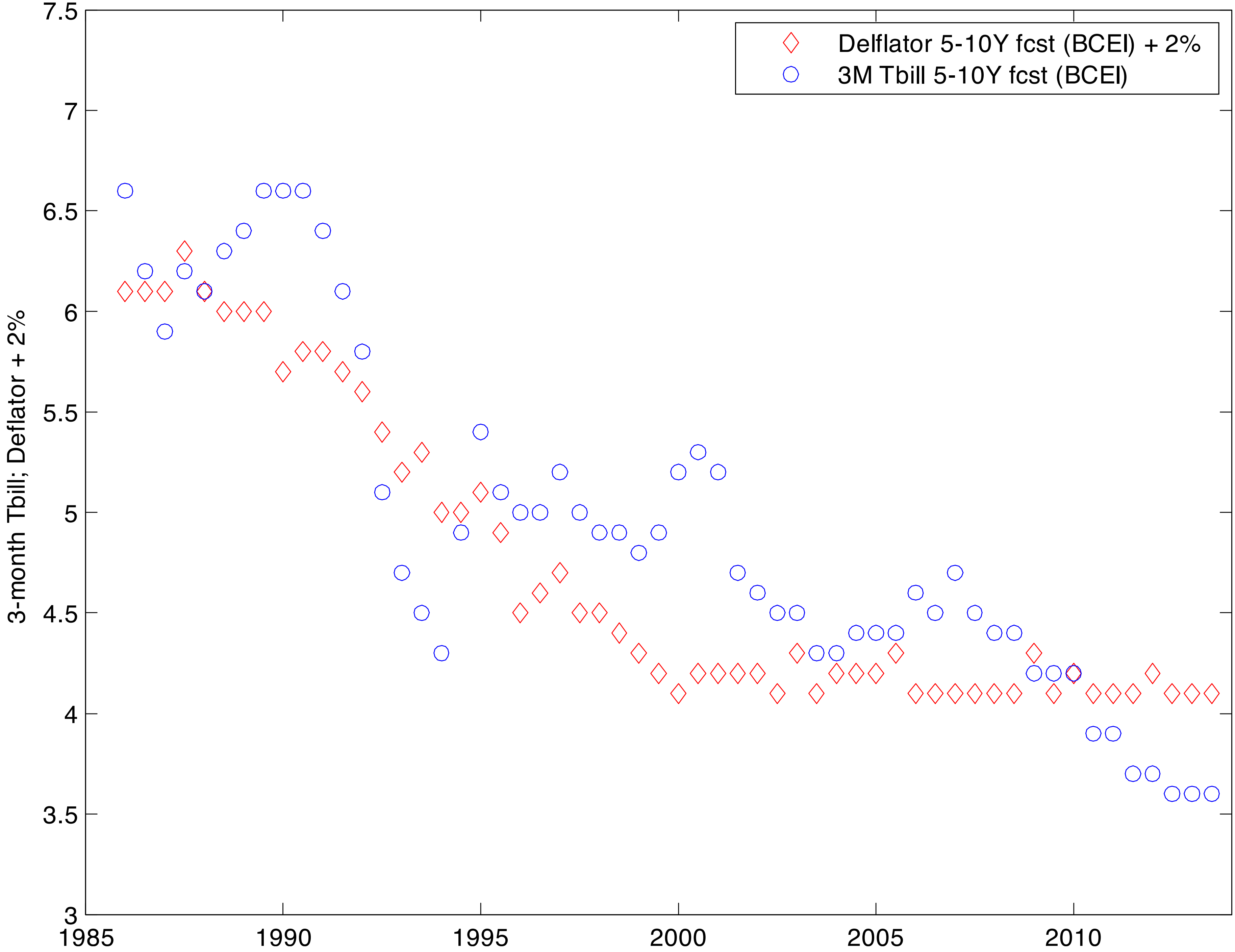
Stefano Eusepi Marc Giannoni Bruce Preston

April 15, 2014

Motivation

- Observation:
  - Macroeconomic data exhibit long-run drift
  - Yet: all models used for policy evaluation assume long-run beliefs anchored


1Q-ahead (SPF)
4Q-ahead (SPF)
1-2Y-ahead (BCEI)
5-10Y -ahead (BCEI)
3-month Tbill
0
1
2
3
4
5
6
7
8
9
1985
1990
1995
2000
2005
2010
2015



Delflator 5-10Y fcst (BCEI) + 2%
3M Tbill 5-10Y fcst (BCEI)
3-month Tbill; Deflator + 2%
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
1985
1990
1995
2000
2005
2010

Motivation

- Observation:
  - Macroeconomic data exhibit long-run drift
  - Yet: all models used for policy evaluation assume long-run beliefs anchored

- Criticism:
  - Commitment equilibria rely heavily on managing expectations
  - What happens when this management is "loose" — i.e. cannot influence beliefs through announcements
  - Does this compromise standard policy advice?

A Simple Model

- Consider a standard neo-Wicksellian model with
  - no money
  - fixed capital stock
  - flexible wages
  - Calvo-type staggered pricing
  - monopolistic competition

A Simple Keynesian Model

- To a log-linear approximation aggregation of household and firm optimal decisions provides

$$\pi_t = \kappa x_t + \hat{E}_t^i \sum_{T=t}^{\infty} (\alpha\beta)^{T-t} \left[\kappa\alpha\beta\hat{w}_{T+1} + (1-\alpha)\beta\hat{\pi}_{T+1}\right] \quad (1)$$

$$x_t = -(i_t - \hat{r}_t^n) - \hat{E}_t^i \sum_{T=t}^{\infty} \beta^{T-t} \left[\beta\hat{\imath}_{T+1} - \hat{\pi}_{T+1} + (1-\beta)\hat{w}_{T+1}\right] \quad (2)$$

where $0 < \alpha, \beta < 1$ and $\psi > 0$

  - The first is a New Keynesian aggregate supply relation

  - The second is an intertemporal Euler equation

A Simple Keynesian Model II

- Remaining model equations

$$
\begin{aligned}
x_t &= \hat{Y}_t - \hat{Y}_t^n = \left(\hat{w}_t - \hat{A}_t\right) \\
\hat{H}_t &= \hat{Y}_t - \hat{A}_t \\
\hat{C}_t &= \hat{Y}_t \\
\hat{r}_t^n &= \hat{\xi}_t - \hat{A}_t + \hat{\phi}_t \\
\hat{Y}_t^n &= \hat{A}_t - \hat{\phi}_t + \hat{g}_t
\end{aligned}
$$

  – Shocks: preference, $\hat{\xi}_t$, disutility of labor supply, $\hat{\phi}_t$, government purchases, $\hat{g}_t$, and technology, $\hat{A}_t$, all i.i.d.

Belief Formation: Imperfect Knowledge

- Agents construct forecasts according to

$$\hat{E}_t^i X_{t+T} = a_{t-1}^X$$

where $X = \{\pi, \hat{w}, \hat{\imath}_t\}$ for any $T > 0$.

  - In period t forecasts are predetermined.
  - Beliefs are updated according to the constant gain algorithm

$$a_t^X = (1 - g)\, a_{t-1}^X + g X_t$$

    where $g > 0$

  - With i.i.d. shocks nests the REE
    - Learning only about the constant — represents a first-order accurate approximation to any more general beliefs

A Simple Keynesian Model III: Rational Expectations

- Under rational expecations

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1} \tag{3}$$

$$x_t = E_t x_{t+1} - (i_t - E_t \pi_{t+1} - \hat{r}_t^n) \tag{4}$$

  - The first is a New Keynesian aggregate supply relation
  - The second is an intertemporal Euler equation

Policymaker Objectives

- Assume the policymaker seeks to minimize

$$E_t^{RE} \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \lambda_x \left(x_t - x^* \right)^2 \right] \tag{5}$$

  where $\lambda > 0$ and $x^* \geq 0$

  - This objective can be shown to represent a second-order accurate approximation to household utility
  - In this approximation, the parameters λ_x and x^* are composites of model primitive. For example

$$\lambda_x = \frac{\kappa}{\theta}$$

  - Central Bank supposed to have rational beliefs — best case scenario

Rational Expectations Policy Problem

- Minimize

$$E_t^{RE} \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \lambda_x (x_t - x^*)^2\right] \tag{6}$$

subject to

$$\pi_t = \kappa x_t + \beta E_t \pi_{t+1}$$

  - The aggregate demand curve

$$x_t = E_t x_{t+1} - (i_t - E_t \pi_{t+1} - \hat{r}_t^n)$$

    is not a constraint — for any bounded paths for inflation and the output gap can always determine a bounded unique interest rate path

Basic Issues in Monetary Policy Design

- Managing expectations central: with forward-looking decision makers and a short interest rate as the main instrument of policy — little else matters

- Rational expectations logic emphasizes importance of *systematic* component of policy
  - Kydland and Prescott (1977)
  - Implies that optimal policy is not in general purely forward looking
  - Optimal policy is history dependent

Properties of Rational Expectations Policy

- Under discretion long-run inflation is

$$\lim_{T\to\infty} E_t \pi_{t+T} = \frac{\kappa \lambda_x}{(1-\beta)\,\lambda_x + \kappa^2} x^*$$

- Under commitment long-run inflation is

$$\lim_{T\to\infty} E_t \pi_{t+T} = 0$$

- Under both commitment and discretion optimal policy completely stabilizes disturbances to technology, disutility of labor supply, preferences, and government purchases

Properties of Rational Expectations Policy II

- Under rational expectations in any bounded equilibrium

$$x_t = -E_t \sum_{T=0}^{\infty} \left(i_{t+T} - E_t \pi_{t+T+1} - \hat{r}^n_{t+T} \right)$$

  - Optimal policy should have nominal interest rate track the natural rate of interest — given inflation expectations

Optimal Policy

- Central Bank seeks to minimize

$$\min_{\{x_t,\pi_t,a_t^{\pi} a_t^{w}\}} \bar{E}_0^{RE} \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \lambda_x (x_t - x^*)^2\right]$$

subject to the constraints:

  - Aggregate demand and supply
  - Beliefs
  - Disturbances

Optimal Policy II

- Written explicitly, the policy problem is to minimize

$$\sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} \frac{1}{2}\left[\pi_t^2 + \lambda_x \left(x_t - x^*\right)^2\right] \\ +\lambda_{1,t}\left(-\hat{\pi}_t + \kappa x_t + \frac{\kappa\alpha\beta}{1-\alpha\beta} a_{t-1}^w + \frac{(1-\alpha)\beta}{1-\alpha\beta} a_{t-1}^\pi\right) \\ +\lambda_{2,t}\left(-x_t - \left(i_t - \hat{r}_t^n\right) - \frac{1}{1-\beta}\left(\beta a_{t-1}^i - a_{t-1}^\pi\right) + (1-\beta)\, a_{t-1}^w\right) \\ +\lambda_{3,t}\left(-a_t^\pi + a_{t-1}^\pi + g\left(\pi_t - a_{t-1}^\pi\right)\right) \\ +\lambda_{4,t}\left(-a_t^w + a_{t-1}^w + g\left(x_t + A_t - a_{t-1}^w\right)\right) \\ +\lambda_{5,t}\left(-a_t^i + +a_{t-1}^i + g\left(i_t - a_{t-1}^i\right)\right) \end{array} \right\}$$

by choice of

$$\left\{x_t, \pi_t, a_t^\pi, a_t^x, \lambda_{1,t}, \lambda_{2,t}, \lambda_{3,t}, \lambda_{4,t}, \lambda_{5,t}\right\}$$

Properties of Optimal Policy

Proposition 1 *The first-order conditions representing a solution to the minimization of the loss subject to i) the aggregate demand and supply equations; and ii) the law of motion for the beliefs* $a_t^{\pi},, a_t^{w}$ *have a unique bounded rational expectations solution for all parameter values. In particular, model dynamics are unique for all possible gains.*

- First-order conditions constitute a linear rational expectations model
  - Can be solved using standard methods
  - Does not imply that learning is irrelevant for policy outcomes

Some Results

- Steady state inflation given by

$$\pi^{LR} = \lim_{T\to\infty} E_t \pi_{t+T} = \frac{\kappa \lambda_x x^*}{\kappa^2 \left(\frac{(1-\alpha\beta)(1-\beta(1-g))+\alpha\beta^2 g}{(1-\alpha\beta)(1-\beta(1-g))-g(1-\alpha)\beta^2} \right) + \lambda_x (1-\beta)}$$

- Two limiting results of interest
  - When $g \to 0$ and $\beta < 1$ then

$$\lim_{g\to 0} \pi^{LR} = \frac{\kappa \lambda_x x^*}{\kappa^2 + \lambda_x (1-\beta)}$$

  - When $g > 0$ and $\beta \to 1$ then

$$\lim_{\beta\to 1} \pi^{LR} = 0$$

- Plot average inflation bias under optimal policy and learning

- Parametric Assumptions are: $\lambda_x = 0.1$; $x^* = 0.05$; $\kappa = 0.05$; $\beta = 0.99$; $g = 0.05$; and $\alpha = 0.75$

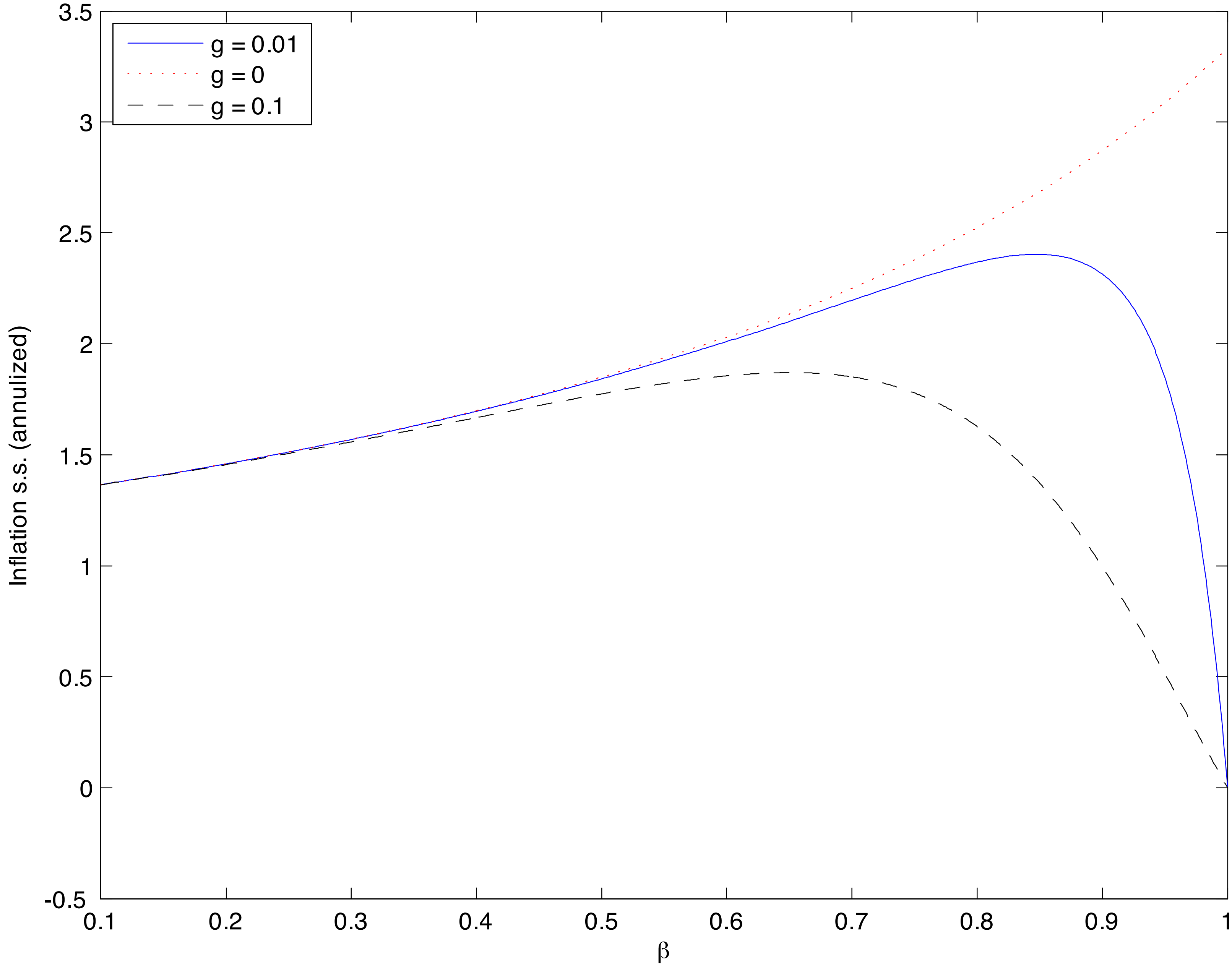


Figure 1: Steady state inflation as a function of the discount factor for different gains.

Intuition

- Two effects operative as the discount factor of households rises
  - The short-run trade-off between inflation and the output gap worsens — standard logic of discretionary policy
  - But Central Bank internalizes the effects of policy on the evolution of inflation expectations — higher inflation leads to higher present discounted losses
- Long-run inflation policy involves a trade-off of these two factors
  - This second effect is stronger the larger the gain — i.e. the more sensitive beliefs are to inflation
  - The limiting case of perfectly patient household would lead to an infinite loss at any positive rate of inflation

Patient Central Banker

- Are there advantages to appointing a patient Central Banker — anologue to Rogoff's (1985) "conservative" Central Banker
  - Suppose Central Bank has discount factor $0 \leq \tilde{\beta} \leq 1$
  - Optimal long-run inflation rate

$$\pi = \frac{\lambda_x x^*}{\kappa \Xi\left(\tilde{\beta}; g, \beta\right) + \lambda_x \frac{(1-\beta)}{\kappa}}$$

where the function $\Xi\left(\tilde{\beta}; g, \beta\right)$ is bounded below by unity and has the properties

$$\frac{\partial \Xi\left(\tilde{\beta}; g, \beta\right)}{\partial \tilde{\beta}} > 0 \text{ for } g > 0 \text{ and } \lim_{g \to 0} \Xi\left(\tilde{\beta}; g, \beta\right) = 1$$

- A patient central banker will give a lower long-term equilibrium inflation rate than observed under discretion

- In the limit of a very patient Central Banker who values each period's loss equally

$$\pi = \frac{\kappa \lambda_x x^*}{\kappa^2 \frac{((1-\alpha\beta)+\kappa\alpha\beta)}{(1-\beta)} + \lambda_x (1-\beta)}$$

Optimal Responses to Disturbances

- Difference in equilibrium outcomes under optimal discretion and commitment not confined to average outcomes for inflation
  - The two approaches also lead to difference state-contingent responses to disturbances
  - So-called "divine coincidence" no longer obtains

- Under rational expectations optimal policy gives

$$\pi_t = x_t = 0$$

  - Complete stabilization possible
  - True under commitment and discretion

Optimal Responses to Disturbances II

Proposition 2 *In general optimal policy cannot fully stabilize inflation and the output gap. For*

$$g > 2(1-\beta)$$

all disturbances engender a stabilization trade-off. For

$$0 < g < 2(1-\beta)$$

only technology disturbances engender stabilization trade-offs. For $g = 0$ *policy is equivalent to discretion and full stabilization is feasible.*

- Ability to manage short-run trade-off depends on the nature of long-run drift in expectations
  - The closer beliefs are to being rational, the tighter is potential control of the Central Bank

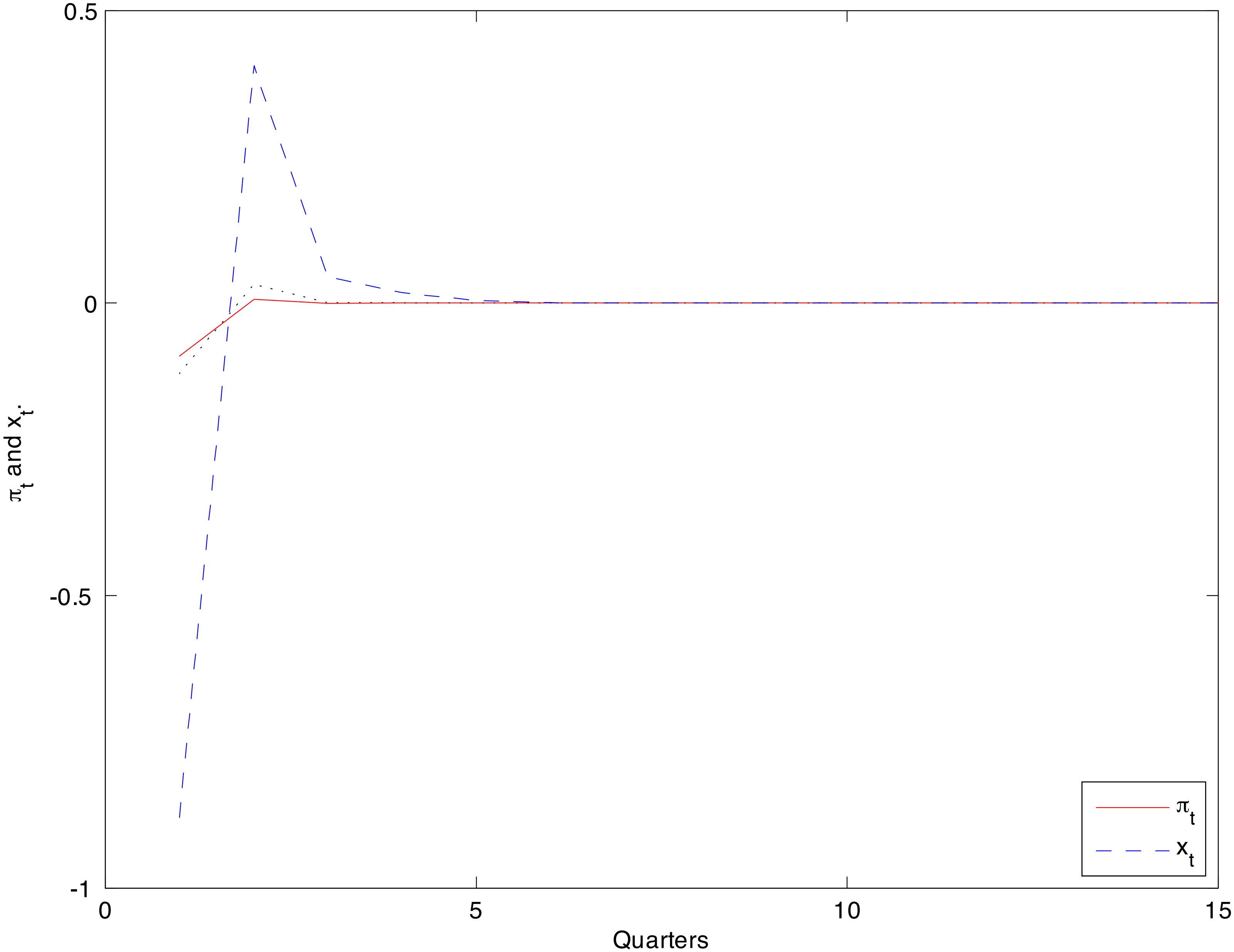


Figure 2: Impulse response functions for inflation, output and interest rates.

Optimal Responses to Disturbances III

- Recall inflation and output dynamics are governed by

$$\pi_t = \psi x_t + \psi \frac{\alpha\beta}{1-\alpha\beta} a_{t-1}^w + \frac{(1-\alpha)\beta}{1-\alpha\beta} a_{t-1}^\pi$$

$$x_t = -(i_t - \hat{r}_t^n) - \frac{1}{1-\beta}\left(\beta a_{t-1}^i - a_{t-1}^\pi\right) + (1-\beta) a_{t-1}^w$$

- Even if beliefs $\left\{a_t^\pi, a_t^w, a_t^i\right\}$ initially at rational expectations equilibrium — i.e. equal to zero — stabilization not possible.
  - Nominal interest rate policy must track natural rate r_t^n. But this implies subsequent movements in long-run interest-rate beliefs
  - This is destabilizing — optimal not to move current interest rates too much
  - Analogous to optimal policy under RE when there is a cost-push shock

Some Details

- Suppose the Central Bank can control the output gap directly and ignores the aggregate demand constraint

- Optimal policy problem is

$$\max_{\{x_t,\pi_t,a_t^\pi,a_t^w\}} E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \begin{array}{c} \frac{1}{2}\left[\pi_t^2 + \lambda_x (x_t - x^*)^2\right] \\ +\lambda_{1,t}\left(-\hat{\pi}_t + \kappa x_t + \frac{\kappa\alpha\beta}{1-\alpha\beta} a_{t-1}^w + \frac{(1-\alpha)\beta}{1-\alpha\beta} a_{t-1}^\pi\right) \\ +\lambda_{2,t}\left(-a_t^\pi + a_{t-1}^\pi + g\left(\pi_t - a_{t-1}^\pi\right)\right) \\ +\lambda_{3,t}\left(-a_t^w + a_{t-1}^w + g\left(x_t + A_t - a_{t-1}^w\right)\right) \end{array} \right\}$$

  – Has unique boudned solution for all initial conditions $\left\{a_{-1}^\pi, a_{-1}^w\right\}$

  – Can full stabilize inflation and output gap in absence of technology shocks

  – Technology shocks are problematic — shift wages beliefs which have implications for firm's marginal costs

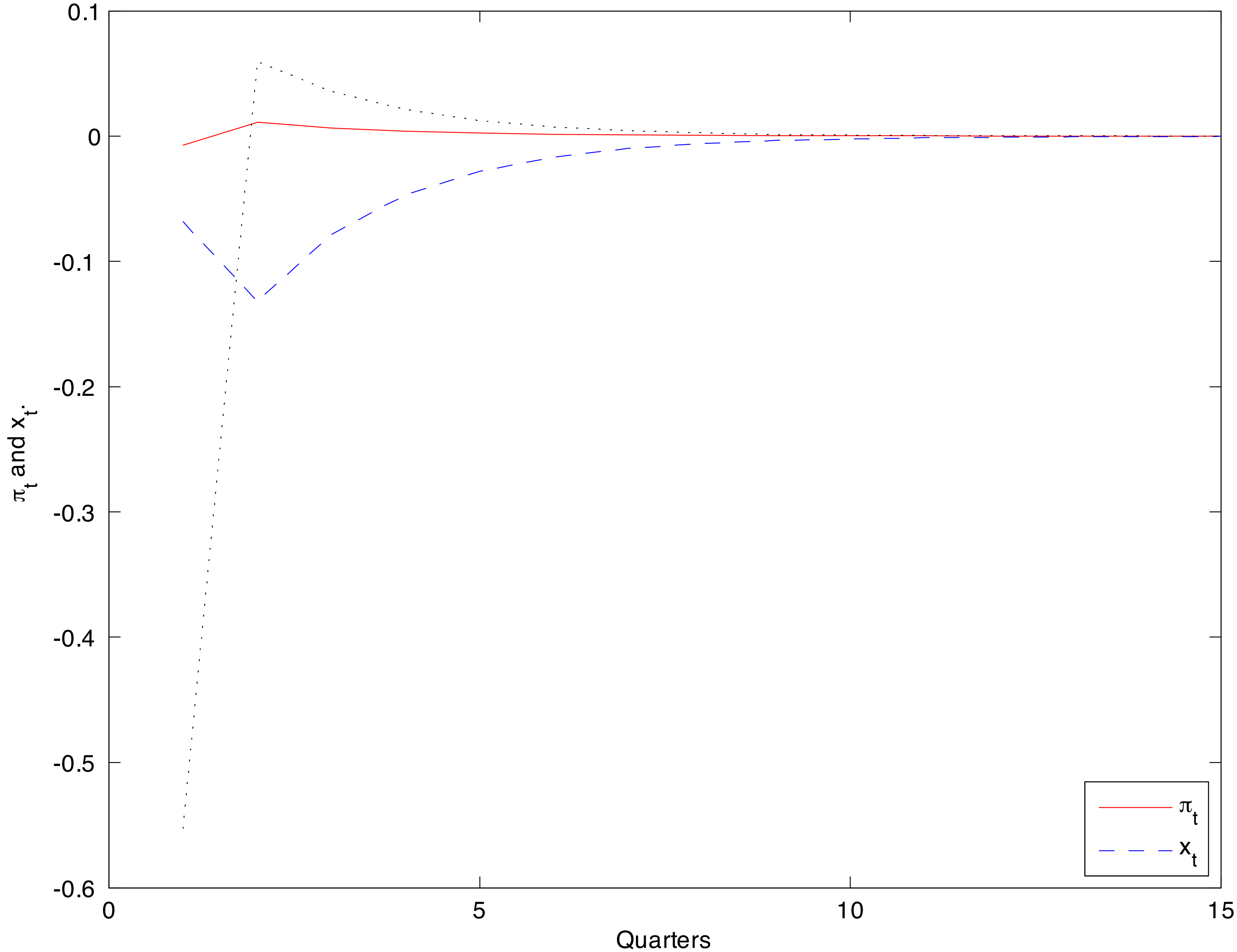


Figure 3: Impulse responses to technology shock under optimal policy.

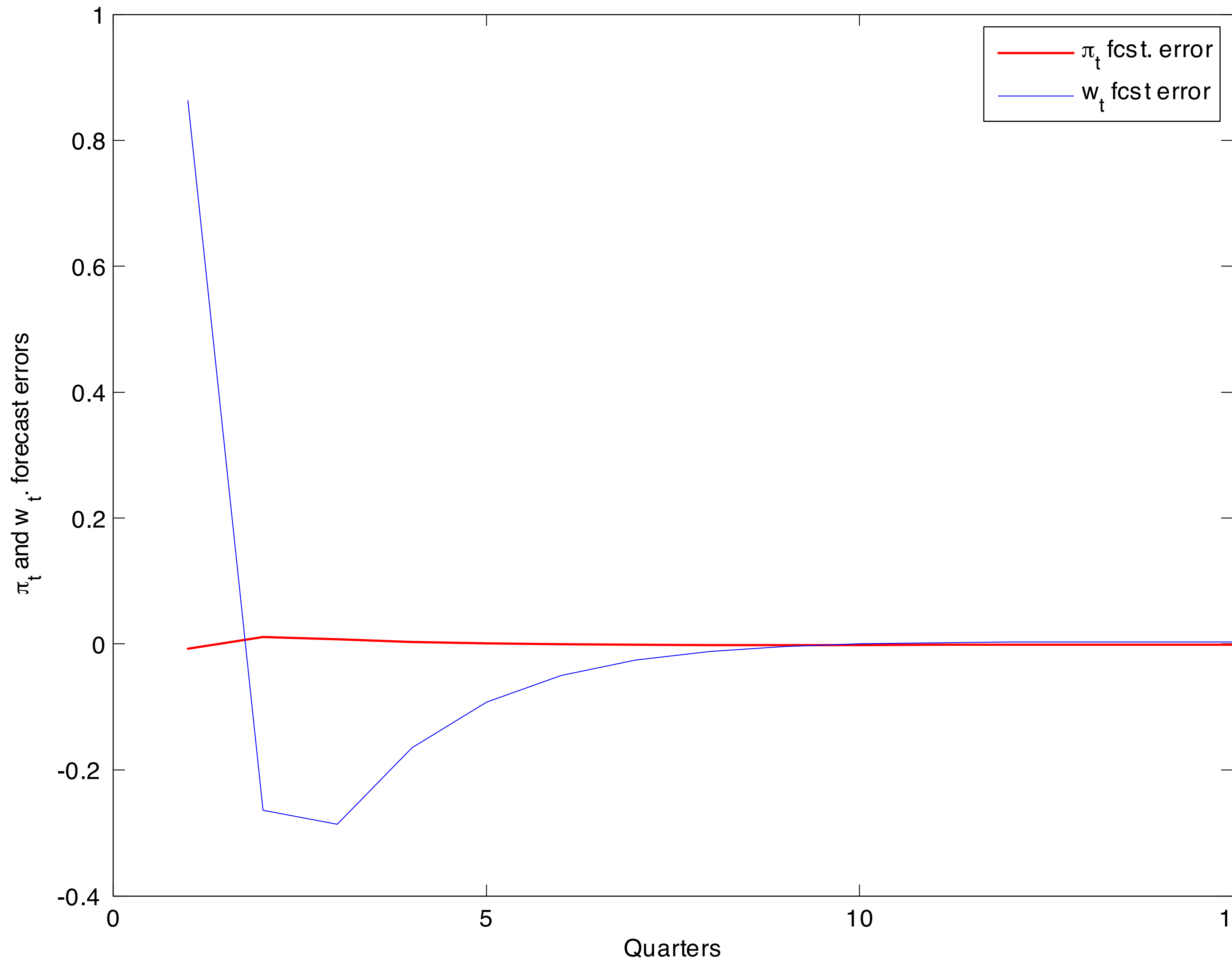


Figure 4: Impulse responses for inflation and wage forecast errors to a technology shock.

Some Details II

- Can the Central Bank Implement this policy?

- Let $\{\tilde{\pi}_t, \tilde{x}_t, \tilde{a}_t^{\pi}, \tilde{a}_t^{w}\}$ be the optimal stationary paths in the modified problem

- Note that the aggregate demand constraint defines implicit instrument rule

$$i_t = -\left(x_t - \hat{r}_t^n\right) - \frac{1}{1-\beta}\left(\beta a_{t-1}^i - a_{t-1}^{\pi}\right) + (1-\beta)\, a_{t-1}^w$$

  - Must be stationary for all sequences $\{\tilde{\pi}_t, \tilde{x}_t, \tilde{a}_t^{\pi}, \tilde{a}_t^{w}\}$.

  - Substitution into

$$a_t^i = a_{t-1}^i + g\left(i_t - a_{t-1}^i\right)$$

    implies $g < 2(1-\beta)$ for stationarity of interest rates beliefs

Some Details III

- Of course if agents have accurate long-run interest rate forecasts so $a_t^i = 0$ then implementation no problem

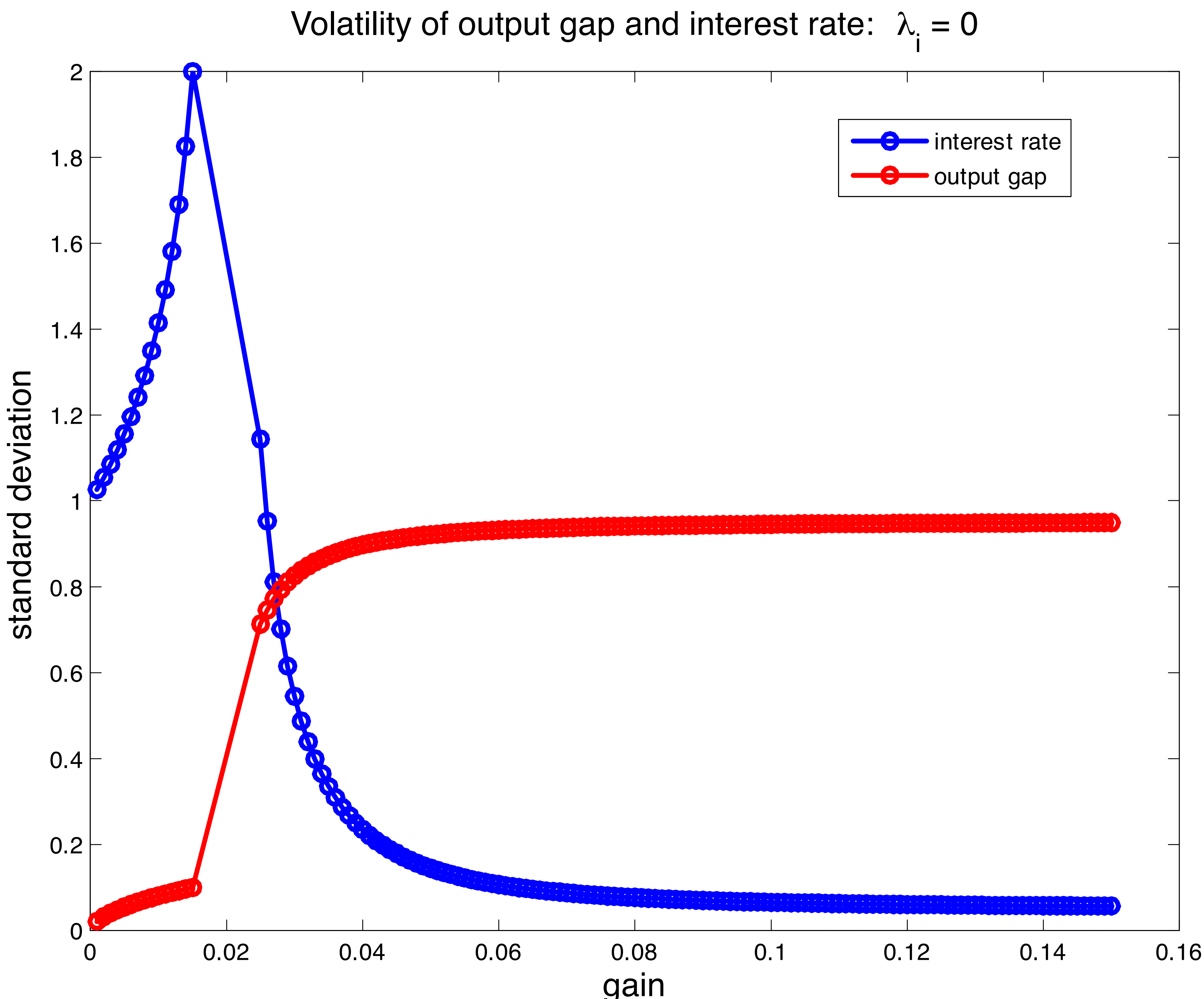
- To summarize when long-run interest rates are uncertain
  - Optimal policy that ignores the IS curve will only be implementable when $g < 2(1 - \beta)$
  - Even if this condition met, technology shocks will create a short-run stabilization trade-off

Some Details IV

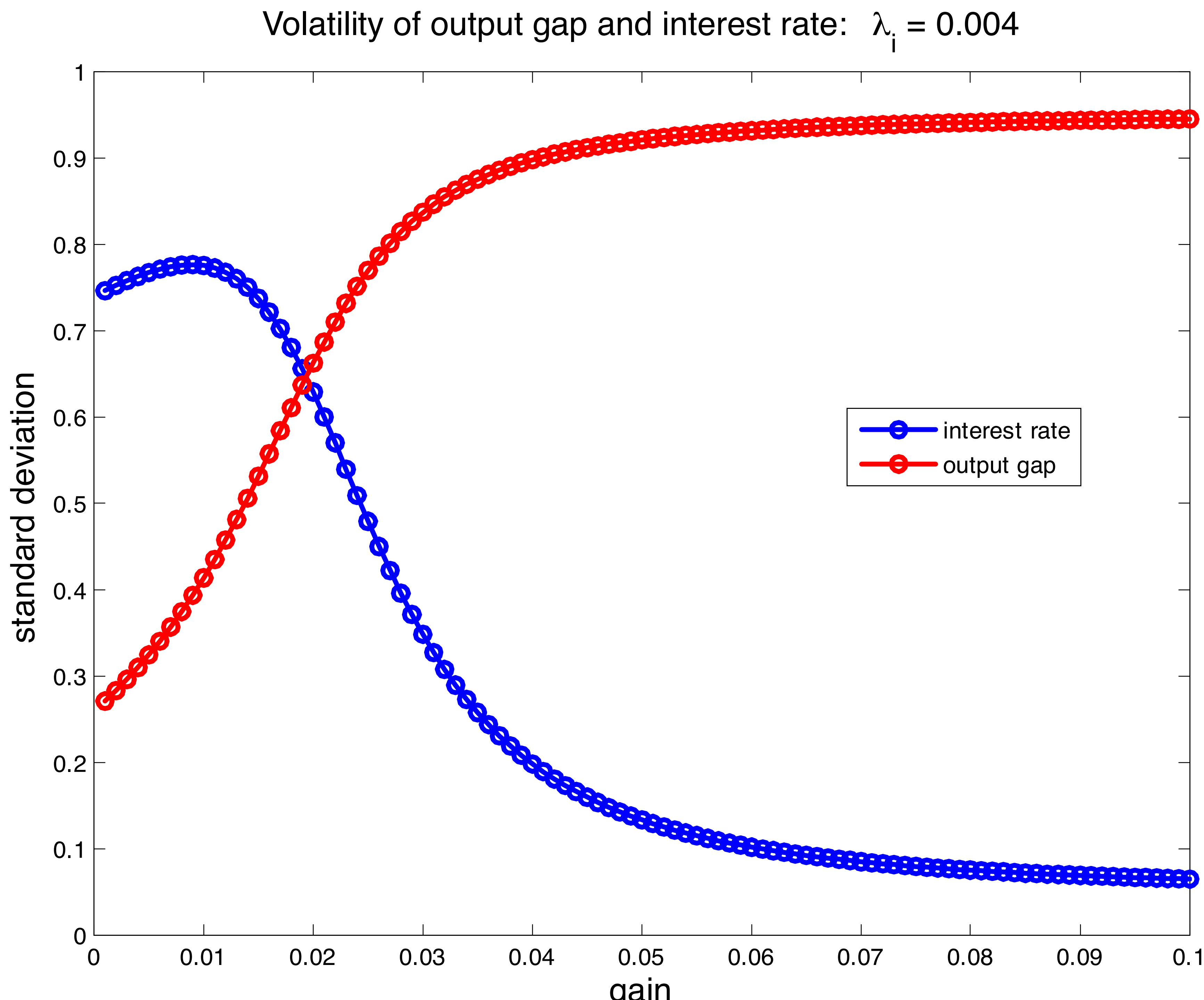
- Implications of limited adjustment of nominal interest rates is greater output gap volatility
  - Consider "volatility frontiers" for the more general loss function

$$\bar{E}_0^{RE} \sum_{t=0}^{\infty} \beta^t \left[\pi_t^2 + \lambda_x (x_t - x^*)^2 + \lambda_i (i_t - i^*)^2 \right]$$

where $\lambda_i \geq 0$ determines relative stabilization weight on interest-rate variability



Volatility of output gap and interest rate: $\lambda_i = 0$
interest rate
output gap
standard deviation
gain
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16



Volatility of output gap and interest rate: λ_i = 0.004
standard deviation
gain
interest rate
output gap
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09

Further Insights

- Possible objection: this limitation of optimal policy is encoded directly by the assumption that policymakers understand the evolution of beliefs
  - Other policy alternatives are no more free of this difficulty
- Orphanides and Williams (2005) show that optimal policy, within a class of simple Taylor rules, requires more aggressive responses to inflation under learning than under rational expectations
  - Depends on assumption about the transmission mechanism of monetary policy: only current interest rates — not the term structure of interest rates matter
  - Any model with uncertainty about long-term interest rates will embody an intertemporal trade-off between current interest-rate movements and interest-rate beliefs
    * Requiring slow gradual adjustment of short-term interest rates

Further Insights II

- Consider simple Taylor rule

$$i_t = \phi_\pi \pi_t$$

  where $\phi_\pi \geq 1$

  - What policy response coefficients are consistent with stability for different gain coefficients?
  - This is an example of "robust stability" analysis proposed by Evans and Honkpao-hja (2009)
  - Note: inflation targeting can be thought of a limiting case of this rule

$$\pi_t = \lim_{\phi_\pi \to \infty} \phi_\pi^{-1} i_t = 0$$

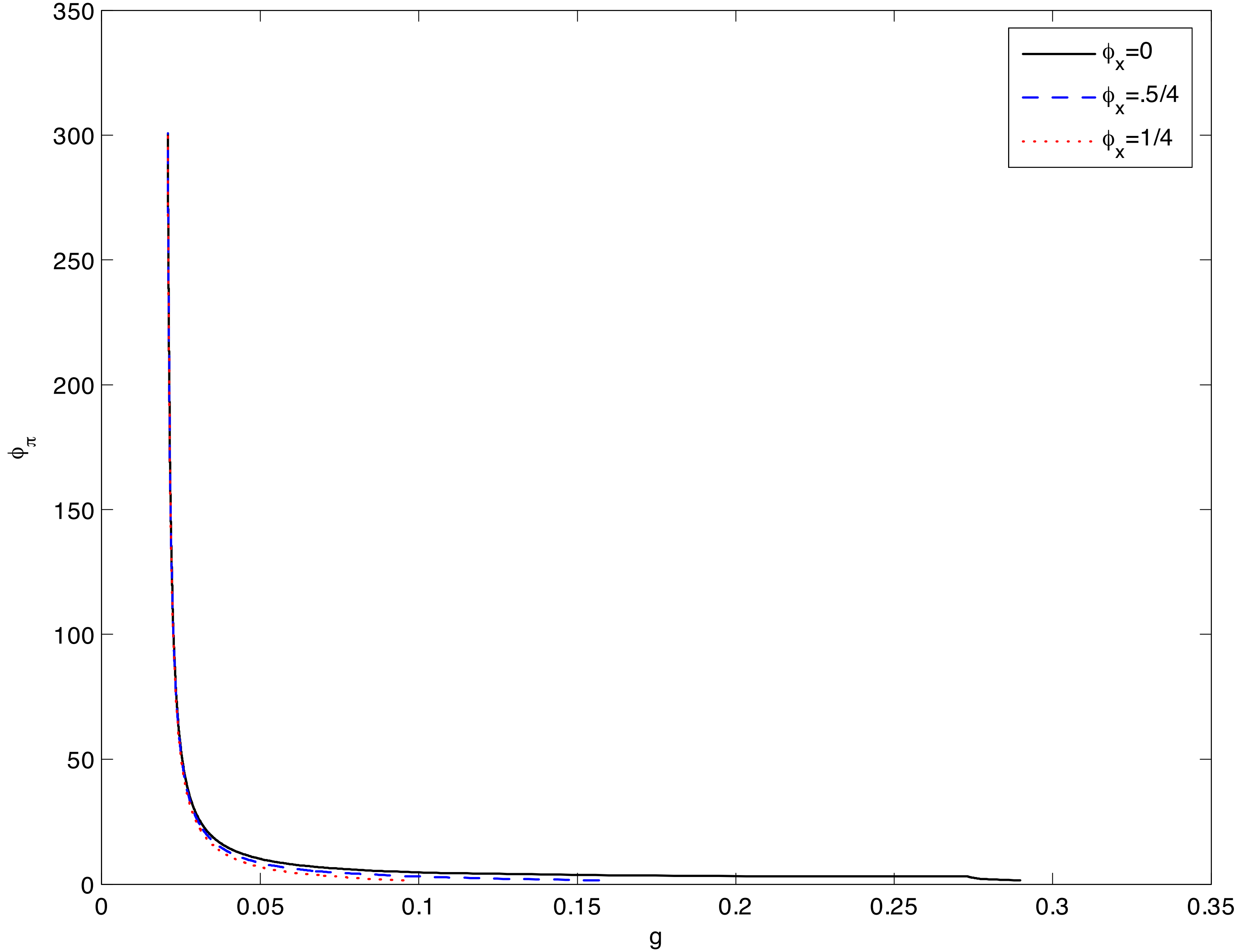


Figure 5: Stability regions in policy-gain space

Conclusions

- With long-term drift optimal policy is more difficult
  - Shifting long-term interest-rate expectations constrain what can be achieved by current interest-rate policy
- Has relevant practical implications
  - Rationale for intertial policy
  - Argument for communication about interest rates in addition to inflation and the output gap