

“Monetary Policy When Wages Are Downwardly Rigid:

Friedman Meets Tobin”

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coauthored with Francisco Ruge-Murcia (University of Montreal)

for presentation at the JEDC conference in Tokyo, January 23–24, 2010.

This discussion represents the views of the author and should not be interpreted as reflecting those of the Board of Governors of the Federal Reserve System or any other person associated with the Federal Reserve System.

Thanks and Congratulations!

- Sims (1980)
 - Leeper and Sims (1994, NBER MA)
 - * “Toward a **Modern** Macro. Model **Usable** for Policy Analysis”
 - Kim (2000, JME)
 - * “Constructing & Estimating a **Realistic** **Optimizing** Model of MP”
- Christiano, Eichenbaum and Evans (2005)
- Their Efforts Are Bearing Fruit at the Federal Reserve.
 - FRB/EDO via J.P. Laforte
 - SIGMA via Chris Gust

Motivation for this paper (as well as 2009, JME)

- Friedman's rule
 - zero nominal interest rate
 - negative inflation
 - with sticky prices, between negative and zero
- Tobin's 1971 AEA Presidential Address
 - positive level of optimal inflation
 - downward stickiness of nominal wages
- N.B. Olivera's 1959 AAPE Presidential Address (later in OEP, 1964)

Optimal Inflation: Theory and Practice

Friedman (1969)
(Monetary economy)



-4.0

-3.0

-2.0

-1.0

0.0

1.0

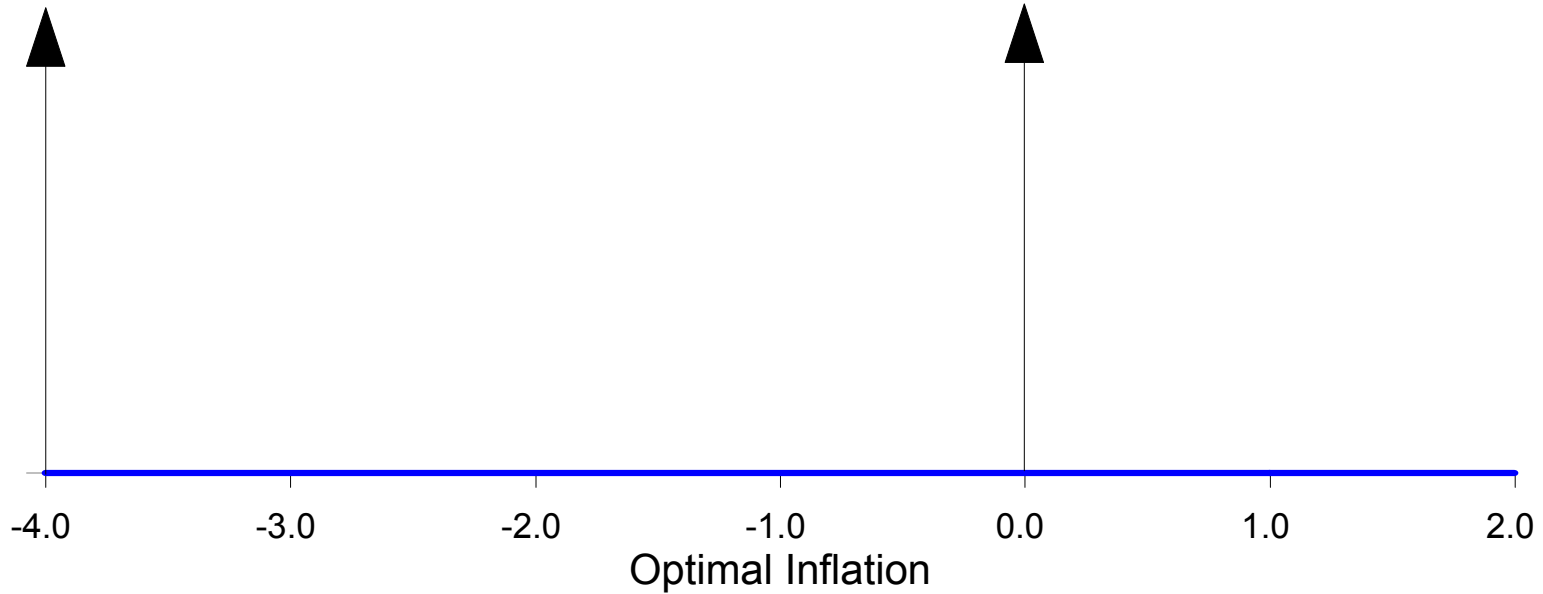
2.0

Optimal Inflation

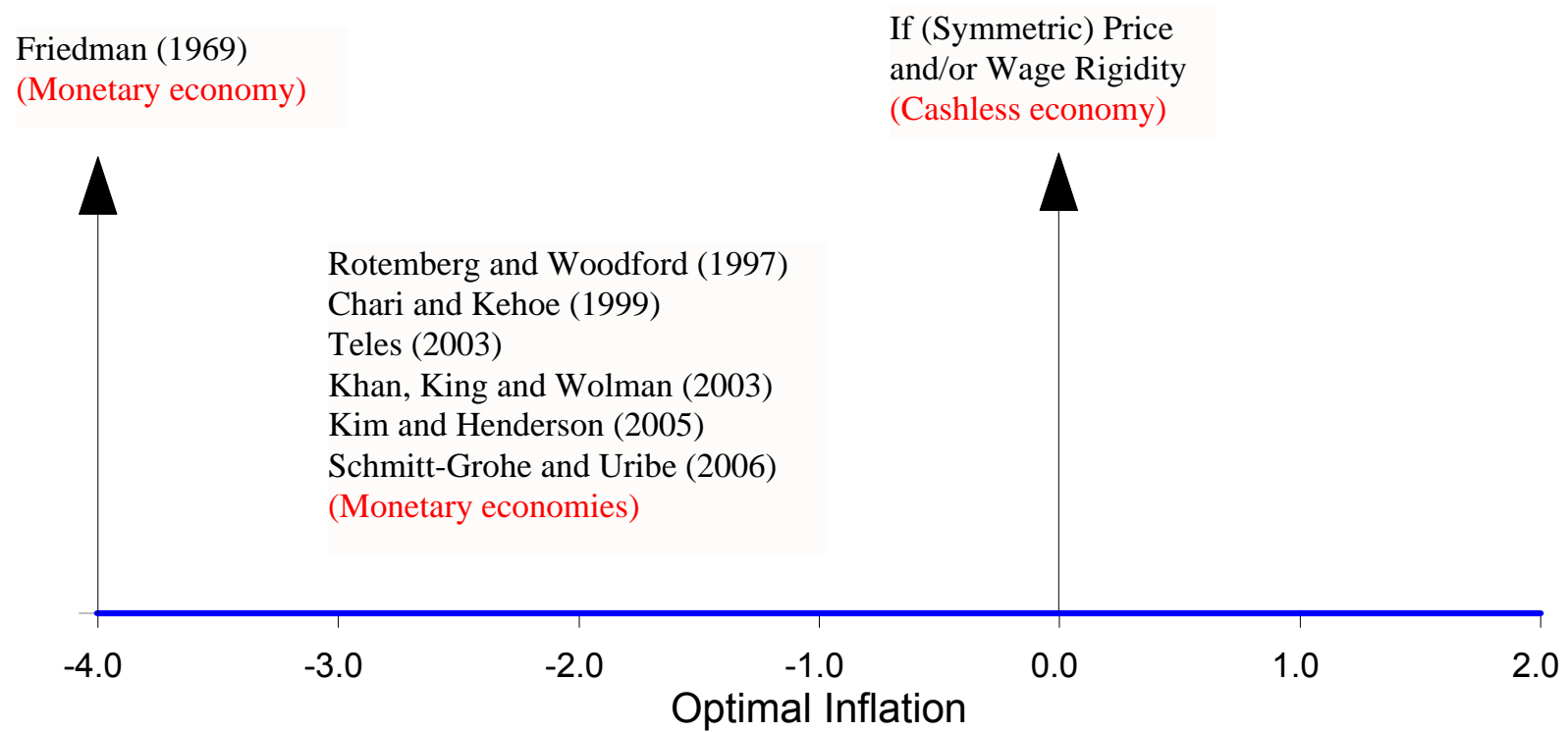
Optimal Inflation: Theory and Practice

Friedman (1969)
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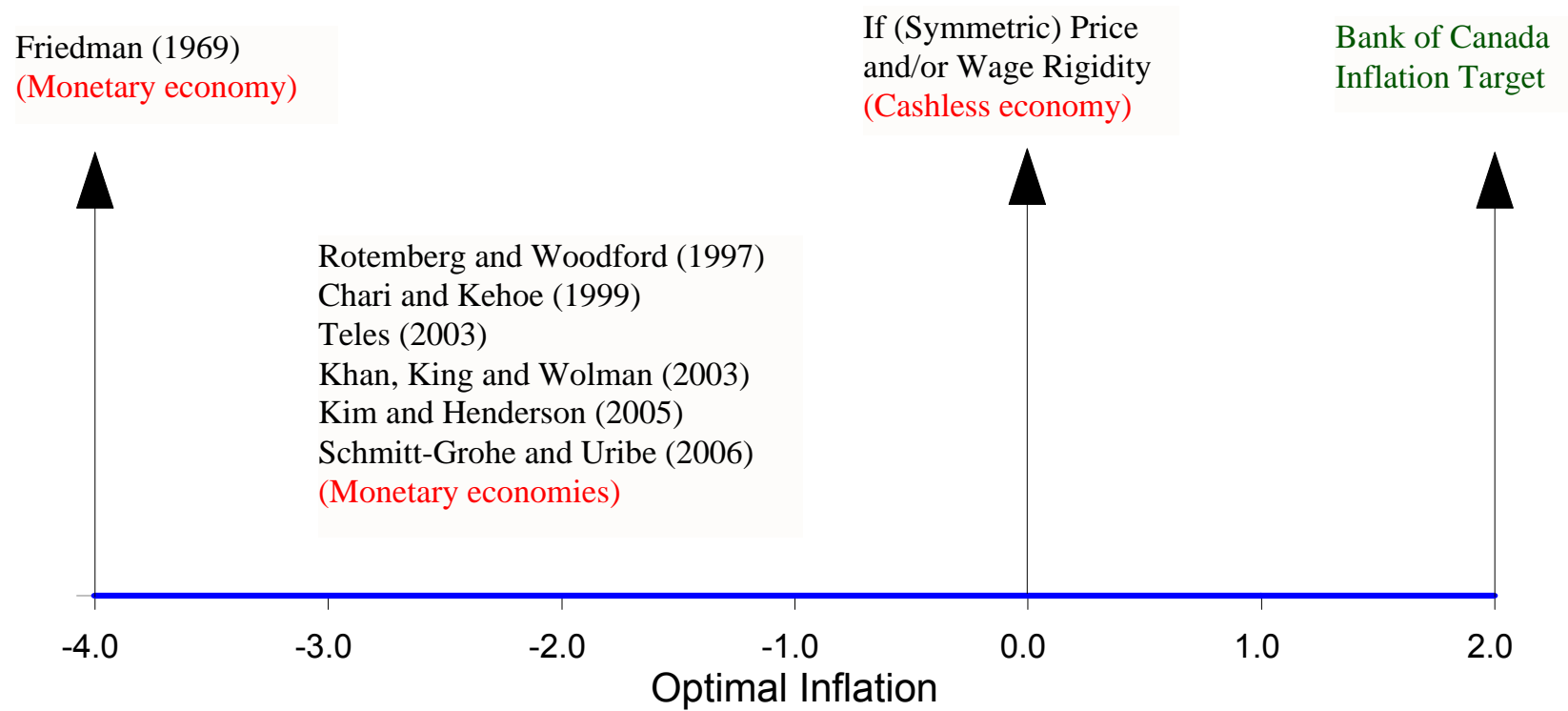
If (Symmetric) Price
and/or Wage Rigidity
(Cashless economy)



Optimal Inflation: Theory and Practice



Optimal Inflation: Theory and Practice



Statement on Monetary Policy

1. At the Monetary Policy Meeting held today, the Policy Board of the Bank of Japan decided, by a unanimous vote,¹ to set the following guideline for money market operations for the intermeeting period:

The Bank of Japan will encourage the uncollateralized overnight call rate to remain at around 0.1 percent.

2. Japan's economy is picking up mainly due to various policy measures taken at home and abroad, although there is not yet sufficient momentum to support a self-sustaining recovery in domestic private demand. Exports and production have been increasing against a backdrop of progress in inventory adjustments both at home and abroad as well as an improvement in overseas economies, especially a recovery in emerging economies. Business sentiment, especially at large manufacturing firms, has been improving moderately. The decline in business fixed investment has been coming to a halt. Private consumption, notably durable goods consumption, is picking up mainly due to policy measures, despite the continued severe employment and income situation. Public investment has started to level off. Meanwhile, the financial environment, with some lingering severity, has continued to show signs of improvement. The year-on-year rate of change in the CPI (excluding fresh food) has declined, mainly due to the prices of petroleum products, which are lower than their high levels a year ago, in addition to the substantial slack persisting in the economy as a whole.
3. The Bank's baseline scenario projects that the pace of improvement of the economy is likely to remain moderate until around the middle of fiscal 2010. Thereafter, as improvements in the corporate sector originating from exports are expected to spill over to the household sector, the growth rate of the economy is likely gradually to rise. With regard to prices, assuming that medium- to long-term inflation expectations remain stable, the year-on-year rate of decline in the CPI (excluding fresh food) is likely to moderate as the effects of the changes in the prices of petroleum products abate.

¹ Voting for the action: Mr. M. Shirakawa, Mr. H. Yamaguchi, Mr. K. G. Nishimura, Ms. M. Suda, Mr. T. Noda, Mr. S. Nakamura, and Mr. H. Kamezaki. Voting against the action: None.

4. With regard to economic activity, while there are some upside risks, such as economic developments in emerging and commodity-exporting economies, there remain downside risks, although somewhat diminished; downside risk factors include the possible consequences of balance-sheet adjustments in the United States and Europe as well as potential changes in firms' medium- to long-term growth expectations. For the time being, attention should continue to be paid to the risk that international financial developments might adversely affect economic activity, for example through their impact on business sentiment. With regard to prices, there is a possibility that inflation will rise more than expected due to a rise in commodity prices brought about by higher growth rates in emerging and commodity-exporting economies. On the other hand, there is also a risk that the rate of inflation might decline due, for example, to a decline in medium- to long-term inflation expectations.
5. The Bank recognizes that it is a critical challenge for Japan's economy to overcome deflation and return to a sustainable growth path with price stability. To this end, the Bank will continue to consistently make contributions as central bank. In the conduct of monetary policy, the Bank will aim to maintain the extremely accommodative financial environment.
6. Based on the above recognition, the Policy Board discussed the "understanding of medium- to long-term price stability" (hereafter "understanding"²), which is expressed in terms of the year-on-year rate of change in the CPI. The Policy Board has concluded that it is appropriate to further disseminate the Bank's thinking on price stability, by stating more clearly that the Policy Board does not tolerate a year-on-year rate of change in the CPI equal to or below 0 percent and that the midpoints of most Policy Board members' "understanding" are around 1 percent.
7. On this basis, the Policy Board has agreed that each Policy Board member's "understanding" falls in a positive range of 2 percent or lower, and the midpoints of most Policy Board members' "understanding" are around 1 percent.
8. Based on the experience of the recent global financial crisis, it has been increasingly recognized around the world that, in order to realize sustainable economic growth with price stability, it is necessary to make wide-ranging assessments of risk factors, including accumulation of financial imbalances observed in, for example, asset prices and credit

² The "understanding," reviewed in April 2009, was expressed in terms of the year-on-year rate of change in the CPI and fell in the range approximately between 0 and 2 percent, with most Policy Board members' median figures at around 1 percent.

aggregates. The Bank, while keeping in mind the above "understanding," will strive for proper conduct of monetary policy, based on assessments of the economic and price developments from the "two perspectives"³ with due attention to various risk factors.

³ The first perspective involves assessing the most likely outlook for economic activity and prices. The second perspective assesses the risks considered most relevant to the conduct of monetary policy, including risks that have a longer time horizon than the first perspective.

(Reference)

Meeting hours:

December 17: 14:00-16:27

December 18: 9:00-12:08

Policy Board members present:

Masaaki Shirakawa (Governor)

Hirohide Yamaguchi (Deputy Governor)

Kiyohiko G. Nishimura (Deputy Governor)

Miyako Suda

Tadao Noda

Seiji Nakamura

Hidetoshi Kamezaki

(Others present)

December 17

From the Ministry of Finance:

Shunsuke Kagawa, Deputy Vice Minister for Policy Planning and Co-ordination
(14:00-16:27)

From the Cabinet Office:

Kenji Umetani, Deputy Director-General, Economic and Fiscal Management
(14:00-16:27)

December 18

From the Ministry of Finance:

Shunsuke Kagawa, Deputy Vice Minister for Policy Planning and Co-ordination
(9:00-11:59,12:03-12:08)

From the Cabinet Office:

Keisuke Tsumura, Parliamentary Vice-Minister(9:00-11:59,12:03-12:08)

Release of the *Monthly Report of Recent Economic and Financial Developments*:

14:00 on Monday, December 21 (Japanese)

16:30 on Tuesday, December 22 (English)

-- The English translation of the summary of the Monthly Report will be released at 14:00 on Monday, December 21

Release of the minutes:

8:50 on Friday, January 29, 2010

5. The Bank recognizes that it is a critical challenge for Japan's economy to overcome deflation and return to a sustainable growth path with price stability. To this end, the Bank will continue to consistently make contributions as central bank. In the conduct of monetary policy, the Bank will aim to maintain the extremely accommodative financial environment.

6. Based on the above recognition, the Policy Board discussed the "understanding of medium- to long-term **price stability**" (hereafter "understanding"), which is expressed in terms of the year-on-year rate of change in the **CPI**. The Policy Board has concluded that it is appropriate to further disseminate the Bank's thinking on price stability, by stating more clearly that the Policy Board does not tolerate a year-on-year rate of change in the CPI equal to or below 0 percent and that the midpoints of most Policy Board members' "understanding" are around 1 percent.

7. On this basis, the Policy Board has agreed that each Policy Board member's "understanding" falls in a positive range of **2 percent or lower**, and the midpoints of most Policy Board members' "understanding" are around 1 percent.

Clarification of the "Understanding of Medium- to Long-Term Price Stability"

■ The "understanding of medium- to long-term price stability" is:

- The level of inflation that each member of the Policy Board understands, when conducting monetary policy, as being consistent with price stability over the medium to long term (introduced in March 2006).
- **Previously:** In terms of the year-on-year rate of change in the CPI, "in the range approximately between **0 and** 2 percent, with most Policy Board members' median figures at around 1 percent" (April 2009).

■ Clarification of the "understanding"

Basic recognition

- It is a critical challenge for Japan's economy to overcome deflation and return to a sustainable growth path with price stability.

Points of clarification

- ✓ The Policy Board does not tolerate a year-on-year rate of change in the CPI equal to or below 0 percent.
- ✓ The midpoints of most Policy Board members' "understanding" are around 1 percent.

In a positive range of 2 percent or lower, and the midpoints of most Policy Board members' "understanding" are around 1 percent.

■ Importance of risk assessments

- While keeping in mind the above "understanding," will assess various risk factors, including accumulation of financial imbalances.

Minutes of the Federal Open Market Committee

January 27-28, 2009

A meeting of the Federal Open Market Committee was held in the offices of the Board of Governors of the Federal Reserve System in Washington, D.C., on Tuesday, January 27, 2009, at 1:30 p.m. and continued on Wednesday, January 28, 2009, at 9:00 a.m.

PRESENT:

Mr. Bernanke, Chairman
 Mr. Dudley, Vice Chairman
 Ms. Duke
 Mr. Evans
 Mr. Kohn
 Mr. Lacker
 Mr. Lockhart
 Mr. Warsh
 Ms. Yellen

Mr. Bullard, Ms. Cumming, Mr. Hoenig, Ms. Pinalto, and Mr. Rosengren, Alternate Members of the Federal Open Market Committee

Messrs. Fisher, Plosser, and Stern, Presidents of the Federal Reserve Banks of Dallas, Philadelphia, and Minneapolis, respectively

Mr. Madigan, Secretary and Economist
 Ms. Danker, Deputy Secretary
 Mr. Luecke, Assistant Secretary
 Mr. Skidmore, Assistant Secretary
 Ms. Smith, Assistant Secretary
 Mr. Alvarez, General Counsel
 Mr. Ashton,¹ Assistant General Counsel
 Mr. Sheets, Economist
 Mr. Stockton, Economist

Messrs. Altig, Clouse, Connors, Kamin, Slifman, Tracy, and Wilcox, Associate Economists

Ms. Mosser, Temporary Manager, System Open Market Account

Ms. Johnson,² Secretary of the Board, Office of the Secretary, Board of Governors

Mr. Frierson,² Deputy Secretary, Office of the Secretary, Board of Governors

Mr. Struckmeyer, Deputy Staff Director, Office of Staff Director for Management, Board of Governors

Ms. Bailey, Deputy Director, Division of Banking Supervision and Regulation, Board of Governors

Mr. English, Deputy Director, Division of Monetary Affairs, Board of Governors

Mr. Blanchard, Assistant to the Board, Office of Board Members, Board of Governors

Messrs. Reifschneider and Wascher, Associate Directors, Division of Research and Statistics, Board of Governors

Mr. Levin, Associate Director, Division of Monetary Affairs, Board of Governors

Ms. Shanks,³ Associate Secretary, Office of the Secretary, Board of Governors

Mr. Reeve, Deputy Associate Director, Division of International Finance, Board of Governors

Mr. Sichel, Deputy Associate Director, Division of Research and Statistics, Board of Governors

Mr. Meyer, Senior Adviser, Division of Monetary Affairs, Board of Governors

Mr. Oliner, Senior Adviser, Division of Research and Statistics, Board of Governors

Ms. Dynan, Assistant Director, Division of Research and Statistics, Board of Governors

Mr. Small, Project Manager, Division of Monetary Affairs, Board of Governors

¹ Attended Wednesday's session only.

² Attended portion of the meeting that was a joint session of the Board and the FOMC.

³ Attended portion of the meeting on Tuesday that was a joint session of the Board and the FOMC.

Summary of Economic Projections

In conjunction with the January 27-28, 2009 FOMC meeting, the members of the Board of Governors and the presidents of the Federal Reserve Banks, all of whom participate in deliberations of the FOMC, provided projections for economic growth, unemployment, and inflation in 2009, 2010, 2011, and over the longer run. Projections were based on information available through the conclusion of the meeting, on each participant's assumptions regarding a range of factors likely to affect economic outcomes, and on his or her assessment of appropriate monetary policy. "Appropriate monetary policy" is defined as the future policy that, based on current information, is deemed most likely to foster outcomes for economic activity and inflation that best satisfy the participant's interpretation of the Federal Reserve's dual objectives of maximum employment and price stability. Longer-run projections represent each participant's assessment of the rate to which each variable would be expected to converge over time under appropriate monetary policy and in the absence of further shocks.

FOMC participants viewed the outlook for economic activity and inflation as having weakened significantly since last October, when their last projections were made. As indicated in Table 1 and depicted in Figure 1, participants projected that real GDP would contract this year, that the unemployment rate would increase substantially, and that consumer price inflation would be significantly lower than in recent years. Given the strength of the forces currently weighing on the economy, participants generally expected that the recovery

would be unusually gradual and prolonged: All participants anticipated that unemployment would remain substantially above its longer-run sustainable rate at the end of 2011, even absent further economic shocks; a few indicated that more than five to six years would be needed for the economy to converge to a longer-run path characterized by sustainable rates of output growth and unemployment and by an appropriate rate of inflation. Participants generally judged that their projections for both economic activity and inflation were subject to a degree of uncertainty exceeding historical norms. Nearly all participants viewed the risks to the growth outlook as skewed to the downside, and all participants saw the risks to the inflation outlook as either balanced or tilted to the downside.

The Outlook

Participants' projections for the change in real GDP in 2009 had a central tendency of -1.3 to -0.5 percent, compared with the central tendency of -0.2 to 1.1 percent for their projections last October. In explaining these downward revisions, participants referred to the further intensification of the financial crisis and its effect on credit and wealth, the waning of consumer and business confidence, the marked deceleration in global economic activity, and the weakness of incoming data on spending and employment. Participants anticipated a broad-based decline in aggregate output during the first half of this year; they noted that consumer spending would likely be damped by the deterioration in labor markets, the tightness of credit conditions, the continuing decline in house prices, and the recent sharp

Table 1. Economic projections of Federal Reserve Governors and Reserve Bank presidents, January 2009
Percent

Variable	Central tendency ¹				Range ²			
	2009	2010	2011	Longer Run	2009	2010	2011	Longer Run
Change in real GDP.	-1.3 to -0.5	2.5 to 3.3	3.8 to 5.0	2.5 to 2.7	-2.5 to 0.2	1.5 to 4.5	2.3 to 5.5	2.4 to 3.0
October projection.	-0.2 to 1.1	2.3 to 3.2	2.8 to 3.6	n.a.	-1.0 to 1.8	1.5 to 4.5	2.0 to 5.0	n.a.
Unemployment rate.	8.5 to 8.8	8.0 to 8.3	6.7 to 7.5	4.8 to 5.0	8.0 to 9.2	7.0 to 9.2	5.5 to 8.0	4.5 to 5.5
October projection.	7.1 to 7.6	6.5 to 7.3	5.5 to 6.6	n.a.	6.6 to 8.0	5.5 to 8.0	4.9 to 7.3	n.a.
PCE inflation.	0.3 to 1.0	1.0 to 1.5	0.9 to 1.7	1.7 to 2.0	-0.5 to 1.5	0.7 to 1.8	0.2 to 2.1	1.5 to 2.0
October projection.	1.3 to 2.0	1.4 to 1.8	1.4 to 1.7	n.a.	1.0 to 2.2	1.1 to 1.9	0.8 to 1.8	n.a.
Core PCE inflation ³	0.9 to 1.1	0.8 to 1.5	0.7 to 1.5		0.6 to 1.5	0.4 to 1.7	0.0 to 1.8	
October projection.	1.5 to 2.0	1.3 to 1.8	1.3 to 1.7		1.3 to 2.1	1.1 to 1.9	0.8 to 1.8	

NOTE: Projections of change in real gross domestic product (GDP) and of inflation are from the fourth quarter of the previous year to the fourth quarter of the year indicated. PCE inflation and core PCE inflation are the percentage rates of change in, respectively, the price index for personal consumption expenditures (PCE) and the price index for PCE excluding food and energy. Projections for the unemployment rate are for the average civilian unemployment rate in the fourth quarter of the year indicated. Each participant's projections are based on his or her assessment of appropriate monetary policy. Longer-run projections represent each participant's assessment of the rate to which each variable would be expected to converge under appropriate monetary policy and in the absence of further shocks to the economy. The October projections were made in conjunction with the FOMC meeting on October 28-29, 2008.

1. The central tendency excludes the three highest and three lowest projections for each variable in each year.
2. The range for a variable in a given year includes all participants' projections, from lowest to highest, for that variable in that year.
3. Longer-run projections for core PCE inflation are not collected.

- FRB: Governor Mishkin's Speech (11/29/2007)
 - to the MIT Undergraduate Economics Association
 - “The Federal Reserve's Enhanced Communication Strategy and the Science of Monetary Policy”
 - discussed the Longer-Term Projections for Inflation
 - underscored the Pitfalls resulting from zero or negative inflation rate
 - * Zero lower bound for nominal interest rate
 - * Fear of deflation, adversely affecting financial markets
 - * Downward rigidities in nominal wages
 - another speech (3/27/2008, “Comfort Zones, Shmumfort Zones”)
 - * the three issues in the reverse order

- “Greasing the Wheels”
 - a negative productivity shock
 - desirable for real wage to decrease
 - Given nominal wage, price should increase.
 - Given price, nominal wage should decrease.
 - * very costly under the downward stickiness of W

Optimal Monetary Policy

- positive level of inflation
 - intuition
 - Figure 1: asymmetric costs

Figure 1: Adjustment Cost Functions

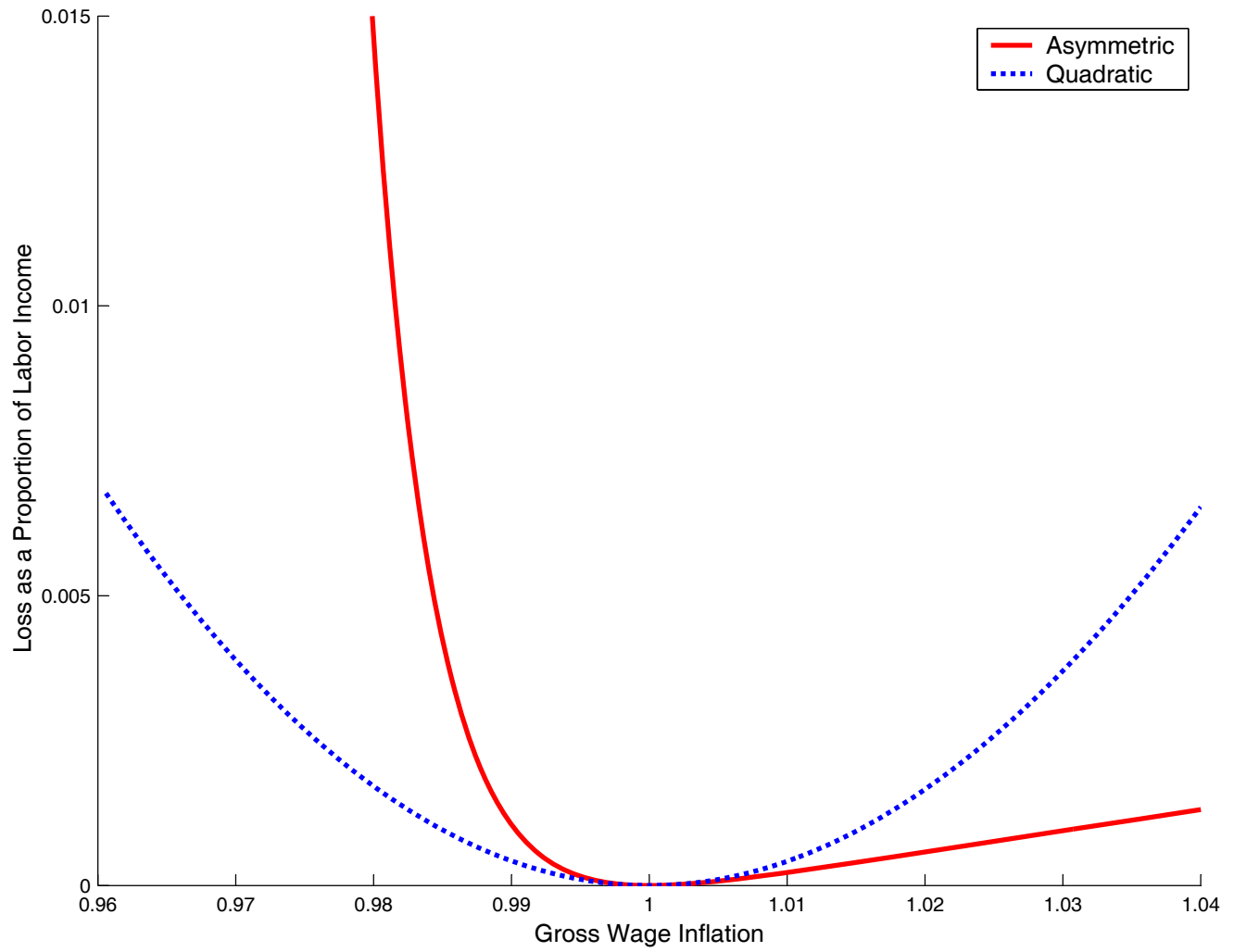
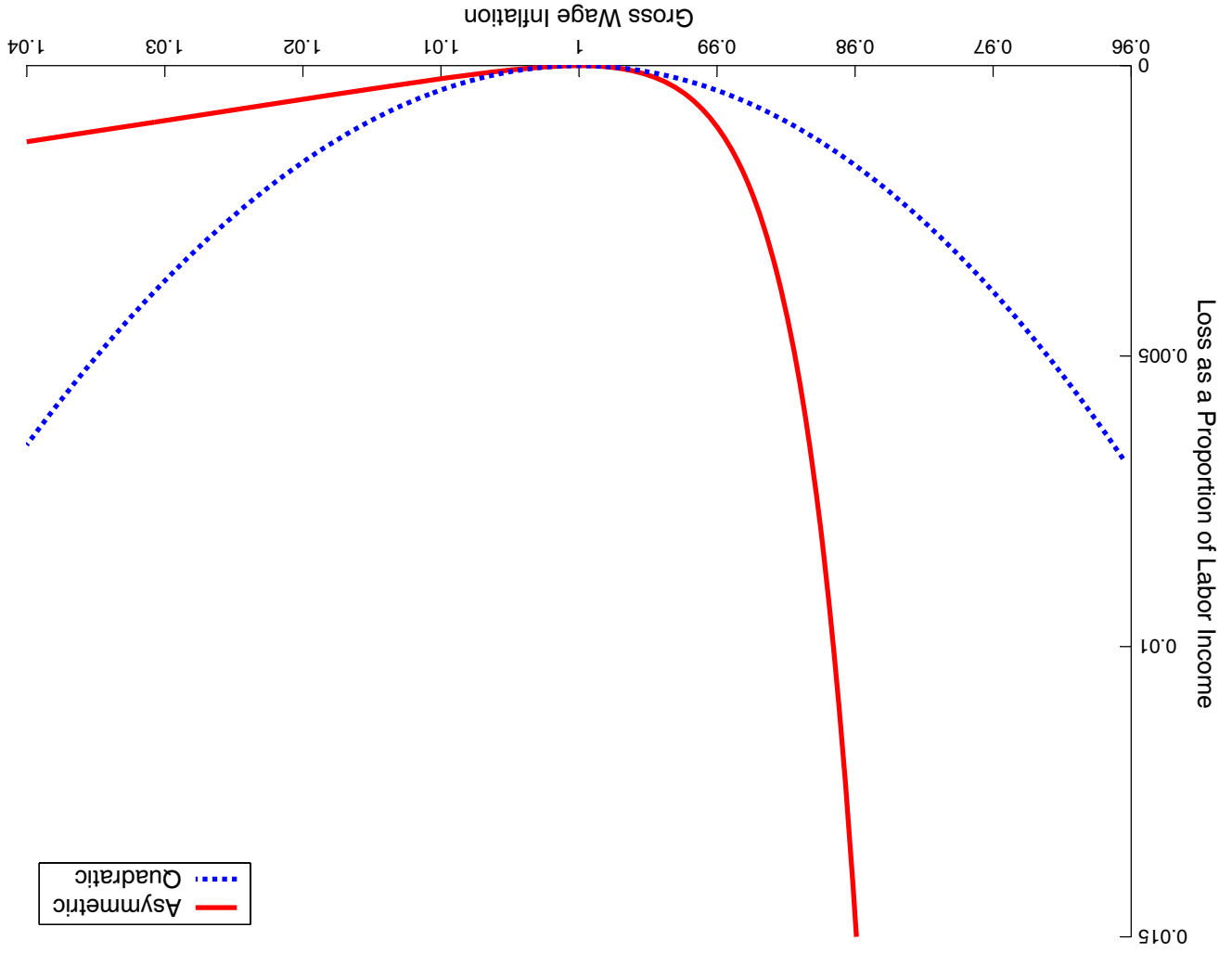


Figure 1: Adjustment Cost Functions





Main Results

- Presence of Money relative to Kim and Ruge-Murcia (2009, JME)
- Both prices and wages are rigid.
 - Wage rigidity is asymmetric, more rigid downwardly.
- Ramsey monetary policy
 - optimal grease inflation of 0.4% per year
- Simple policy (of strict inflation targeting)
 - optimal grease inflation of 0.7% per year

Sketch of the Model

Households

- Supply differentiated labor skills
- Face (possibly) asymmetric costs to adjust nominal wages

Firms

- Produce differentiated goods using labor input
- Face (possibly) asymmetric costs to adjust nominal prices

Monetary Authority

- Sets the interest rate following a Taylor rule

Households

- At time τ , the household $h \in [0, 1]$ maximizes

$$E_{\tau} \sum_{t=\tau}^{\infty} \beta^{(t-\tau)} \left(\frac{(c_t^h)^{1-\eta}}{1-\eta} - n_t^h \right)$$

where

$$c_t^h = \left(\int_0^1 (c_{j,t}^h)^{1/\mu} dj \right)^{\mu}$$

Households (cont.)

- There are three types of financial assets

Money

One-period nominal bonds

Arrow-Debreu securities

- Households have differentiated job skills so nominal wage is a choice variable
- Labor market frictions induce a cost in the adjustment of nominal wages

Wage Adjustment Costs

- Asymmetric function (Varian, 1974)

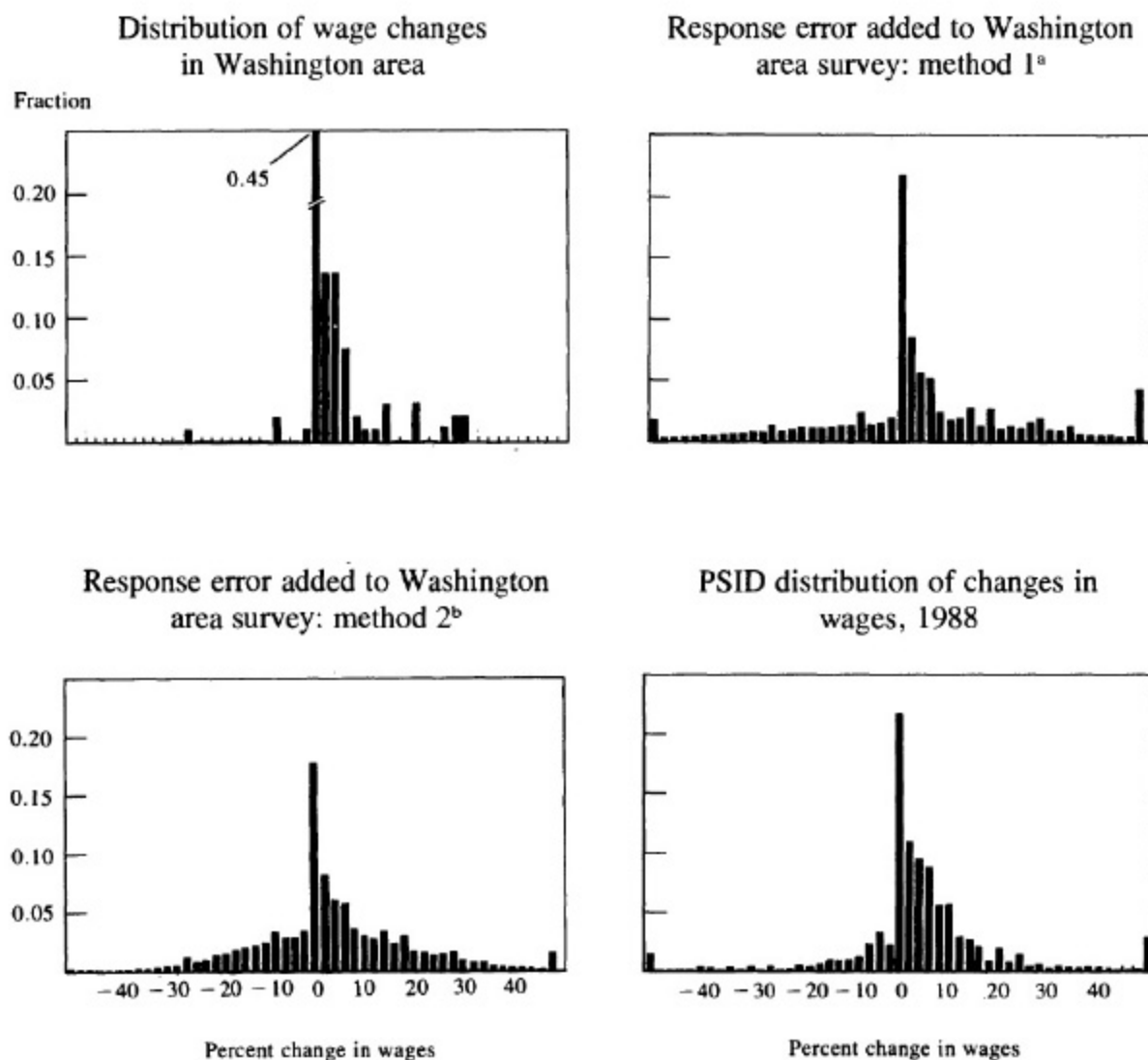
$$\Phi_t^h = \phi \left(\frac{\exp(-\psi(W_t^h/W_{t-1}^h - 1)) + \psi(W_t^h/W_{t-1}^h - 1) - 1}{\psi^2} \right)$$

Properties

- Asymmetry: cost depends on both magnitude and sign of adjustment
- When $\psi \rightarrow 0$, Φ_t^h is a quadratic function
- When $\psi > 0$, a wage decrease is more costly than an increase, even if magnitude is the same

Empirical Evidence on Downward Nominal Wage Rigidity

- Surveys on attitudes of employers
Bewley and Brainard (1993), Campbell and Kamlani (1995)
- Surveys on attitudes of individuals
Kahneman, Knetsch and Thaler (1986)
- Micro data on wages
Akerlof *et al.* (1996) and Card and Hyslop (1997) for the U.S.
Kuroda and Yamamoto (2003) for Japan
Fehr and Goette (2005) for Switzerland
- Macro estimates
Kim and Ruge-Murcia (2009)

Figure 1. Distribution of Wage Changes for Job Stayers

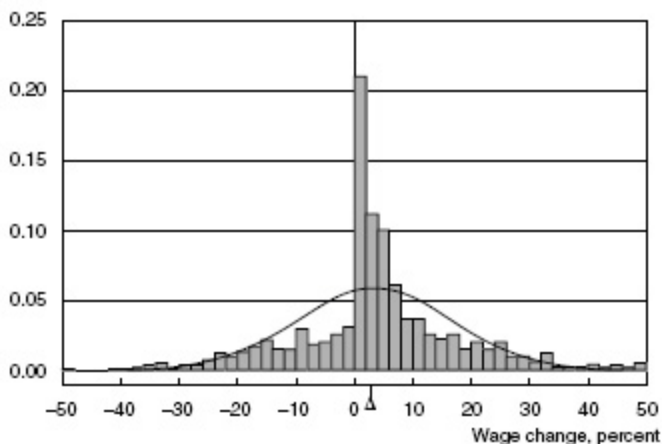
Source: Data for the upper left panel are from the authors' survey; for the lower right panel, from the Panel Study of Income Dynamics (PSID); and for the other panels, from the authors' calculations as described in text.

a. With correlation of correct responses in consecutive years of 1.0, and standard deviation of response error of 0.167.

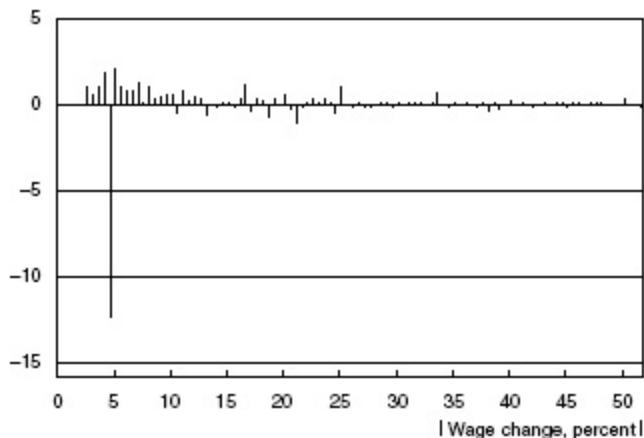
b. With correlation of correct responses in consecutive years of 0.5, and standard deviation of response error calculated so that standard deviation of distribution equals standard deviation of wage changes in the PSID.

**Figure 2 Nominal Wage Change Distribution:
Histogram and Symmetrically Differenced Histogram**

[1] Histogram



[2] Symmetrically Differenced Histogram



Note: The bell-shaped line on the histogram shows the normal distribution calculated from the mean and standard deviation of the data. The small triangle (Δ) located on the horizontal axis slightly above the zero point indicates the median.

Household's Budget Constraint

- The budget constraint is

$$c_t^h(1 + f(c_t^h, m_t^h)) + \frac{M_t^h - M_{t-1}^h}{P_t} + \frac{Q_t A_t^h - A_{t-1}^h}{P_t} + \frac{B_t^h - i_{t-1} B_{t-1}^h}{P_t} = w_t^h n_t^h (1 - \Phi_t^h) + \frac{T_t^h}{P_t} + \frac{D_t^h}{P_t}$$

where

$$f(c_t^h, m_t^h) = a \left(\frac{c_t^h}{m_t^h} \right) + b \left(\frac{m_t^h}{c_t^h} \right) - 2\sqrt{ab}$$

and

$$P_t = \left(\int_0^1 (P_{j,t})^{1/(1-\mu)} dj \right)^{1/(1-\mu)}$$

Firms

- Firm $j \in [0, 1]$ produces a differentiated good using technology

$$y_{j,t} = x_t n_{j,t}^{1-\alpha}$$

- The labor input is a combination of labor types

$$n_{j,t} = \left(\int_0^1 (n_{j,t}^h)^{1/\theta} dh \right)^\theta$$

- The productivity shock follows

$$\ln(x_t) = (1 - \rho) \ln(x) + \rho \ln(x_{t-1}) + u_t$$

where $u_t \sim i.i.d.(0, \sigma_u)$

Price Adjustment Costs

- Price-adjustment costs (Varian, 1974)

$$\Gamma_t^j = \gamma \left(\frac{\exp(-\zeta(P_{j,t}/P_{j,t-1} - 1)) + \zeta(P_{j,t}/P_{j,t-1} - 1) - 1}{\zeta^2} \right)$$

- We consider special case where $\zeta \rightarrow 0$
- Then, Γ_t^j is a quadratic function as in Rotemberg (1982)
- Empirical evidence: Peltzman (2000) and Chen *et al.* (2008)

Equilibrium

- Symmetric equilibrium: all households and firms are identical *ex-post*
- Arrow-Debreu securities and bonds are not held
- Economy-wide resource constraint

$$c_t(1 + f(c_t, m_t)) + (W_t n_t / P_t) \Phi_t = y_t(1 - \Gamma_t)$$

Monetary Authority

- Interest rate rule

$$\ln(i_t/i) = \lambda_1 \log(i_{t-1}/i) + \lambda_2 \log(\Pi_t/\Pi) + \lambda_3 \log(y_t/y) + v_t$$

where $v_t \sim i.i.d. (0, \sigma_v)$

- Supplies the money balances demanded at this interest rate using lump-sum transfers or taxes to adjust money stock

$$\frac{T_t}{P_t} = \frac{M_t - M_{t-1}}{P_t}$$

Solution Method

- Second-order approximation to the policy functions
- Expansion taken around the deterministic steady
- Model is nonlinear

Estimation

- Simulated Method of Moments (SMM) by Lee and Ingram (1991)

$$\tilde{\theta} = \underset{\{\theta\}}{\operatorname{argmin}} \mathbf{G}(\theta)' \mathbf{W} \mathbf{G}(\theta)$$

where

$$\mathbf{G}(\theta) = (1/T) \sum_{t=1}^T \mathbf{g}_t - (1/\lambda T) \sum_{t=1}^{\lambda T} \mathbf{g}_t(\theta)$$

and \mathbf{W} is a weighting matrix

Estimation (cont.)

In the expression

$$\mathbf{G}(\boldsymbol{\theta}) = (1/T) \sum_{t=1}^T \mathbf{g}_t - (1/\lambda T) \sum_{t=1}^{\lambda T} \mathbf{g}_t(\boldsymbol{\theta})$$

\mathbf{g}_t is the vector of empirical observations on variables whose moments are of interest

$\mathbf{g}_t(\boldsymbol{\theta})$ to be the synthetic counterpart of \mathbf{g}_t whose elements are computed using artificial data generated by the model using parameter values $\boldsymbol{\theta}$

Intuition

- Suppose, for example, that

$$\mathbf{g}_t = [y_t^2 \quad y_t y_{t-1}]'$$

where y_t is measured in deviation from trend (thus, $E(y_t) = 0$)

- Then

$$(1/T) \sum_{t=1}^T \mathbf{g}_t = [\text{Var}(y_t) \quad \text{Cov}(y_t, y_{t-1})]'$$

computed using actual U.S. data

Intuition (cont.)

- And

$$(1/\lambda T) \sum_{i=1}^{\lambda T} \mathbf{g}_i(\boldsymbol{\theta}) = [\text{Var}(y_i(\boldsymbol{\theta})) \quad \text{Cov}(y_i(\boldsymbol{\theta}), y_{i-1}(\boldsymbol{\theta}))]'$$

computed using data simulated from the model

- SMM minimizes the distance between the moments from the data and those predicted by the model

Distribution of SMM Estimator

- Under regularity conditions in Duffie and Singleton (1993)

$$\sqrt{T}(\hat{\boldsymbol{\theta}} - \boldsymbol{\theta}) \rightarrow N(\mathbf{0}, (1 + 1/\lambda)(\mathbf{D}'\mathbf{W}^{-1}\mathbf{D})^{-1}\mathbf{D}'\mathbf{W}^{-1}\mathbf{S}\mathbf{W}^{-1}\mathbf{D}(\mathbf{D}'\mathbf{W}^{-1}\mathbf{D})^{-1}),$$

where

$$\mathbf{S} = \lim_{T \rightarrow \infty} \text{Var} \left((1/\sqrt{T}) \sum_{t=1}^T \mathbf{g}_t \right),$$

and $\mathbf{D} = E(\partial \mathbf{g}_t(\boldsymbol{\theta})/\partial \boldsymbol{\theta})$ are assumed to be finite and of full rank

Data Set

Sample Period and Frequency

Quarterly from 1964:1 to 2006:2

Data

- CPI inflation
- Wage inflation
- Real money balances per-capita
- Real consumption per-capita
- Hours worked
- Nominal interest rate

SMM Estimates

Description	Symbol	Wage Adjustment Costs	
		Asymmetric	Quadratic
Consumption curvature	η	1.746* (0.401)	1.292* (0.388)
Parameter of transaction function	a	0.009 (0.121)	0.008 (0.097)
Parameter of transaction function	b	0.133* (0.022)	0.147* (0.027)
Wage adjustment cost	ϕ	215.9* (39.5)	711.3* (168.6)
Price adjustment cost	γ	77.5* (18.4)	42.0* (23.4)
Wage asymmetry	ψ	7146.3* (1840.4)	0

SMM Estimates (cont.)

Description	Symbol	Wage Adjustment Costs	
		Asymmetric	Quadratic
Interest-rate smoothing	λ_1	0.986* (0.274)	0.986† (0.514)
Inflation coefficient in policy rule	λ_2	0.717† (0.368)	1.286 (1.008)
Output coefficient in policy rule	λ_3	0.058 (0.074)	0.126 (0.172)
Standard deviation	σ_v	0.0025* (0.0004)	0.0034* (0.0004)
AR coefficient of productivity	ρ	0.956* (0.009)	0.971* (0.009)
Standard deviation	σ_u	0.0135* (0.0016)	0.0111* (0.0021)

Figure 3: Responses to Monetary Policy Shocks. Quadratic Costs

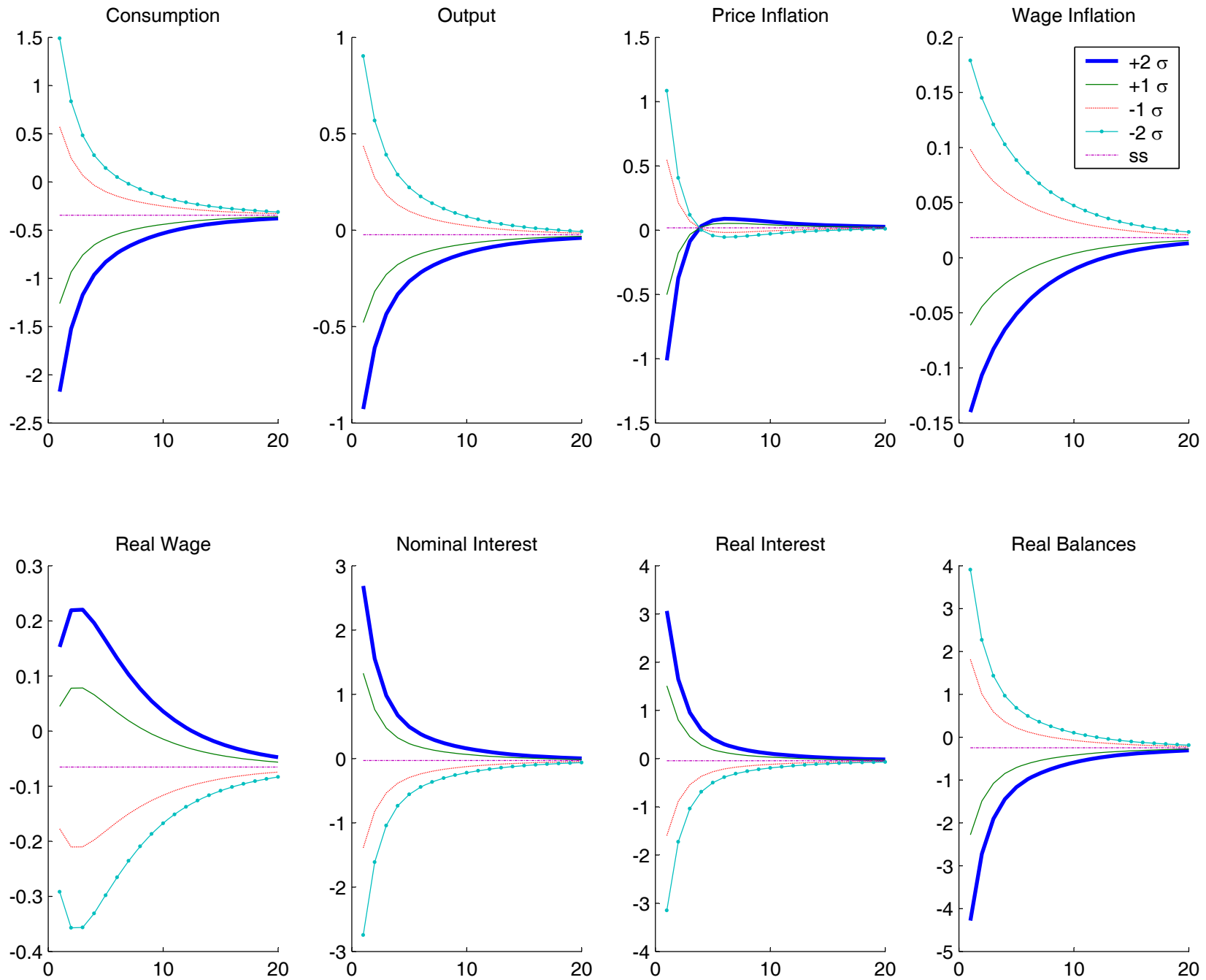
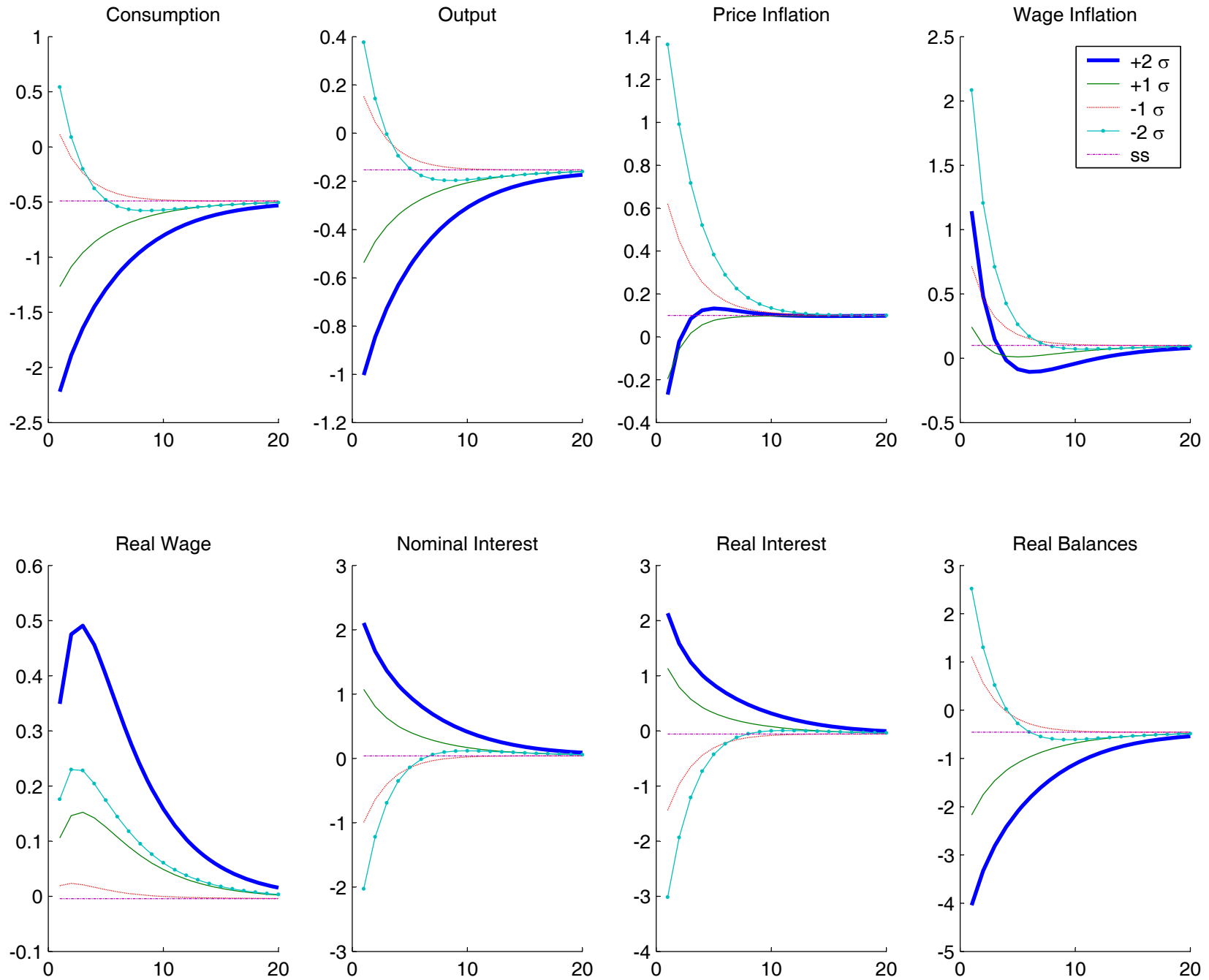


Figure 2: Responses to Monetary Policy Shocks. Asymmetric Costs



What Would Ramsey Do?

- The benevolent government maximizes

$$E_{\tau} \sum_{t=\tau}^{\infty} \beta^{(t-\tau)} \left(\frac{(c_t)^{1-\eta}}{1-\eta} - n_t^h \right)$$

subject to:

the social resource constraint

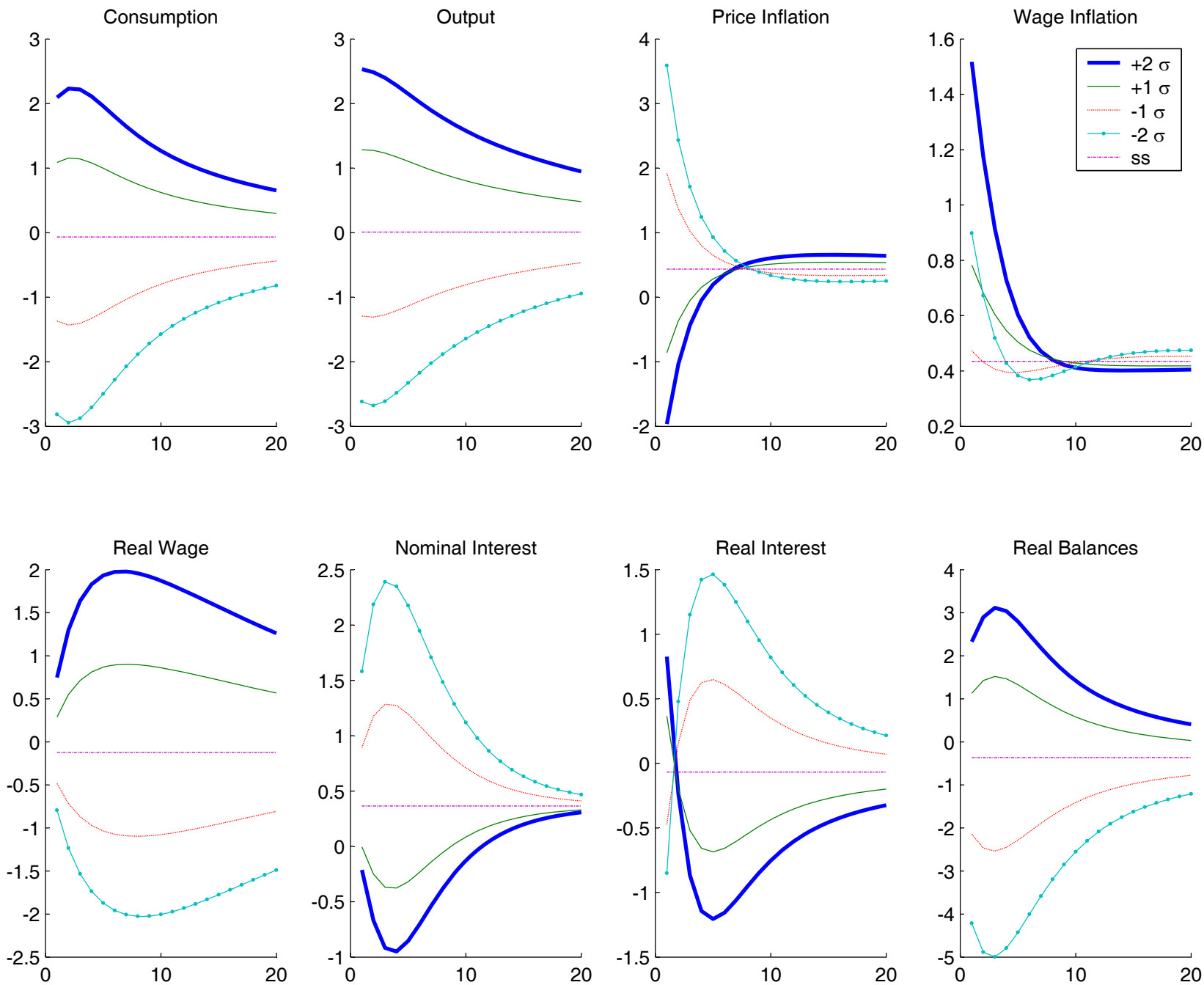
first-order conditions of firms

first-order conditions of households

Optimal Inflation

- The optimal rate of gross inflation is 1.0040
- Thus, optimal net inflation is 0.40 percent per year

Figure 6: Optimal Responses to Productivity Shocks. Asymmetric Costs



Optimized Simple Policy

- Back to a decentralized economy
- Central bank targets inflation strictly

- That is, central bank minimizes

$$\frac{1}{2}(\Pi_t - \Pi^*)^2$$

- What is the value of Π^* that maximizes social welfare?
- The (constrained) optimal rate of gross inflation is $\Pi^* = 1.007$
- Thus, (constrained) optimal net inflation is 0.70 percent per year

Optimal Inflation: Theory and Practice

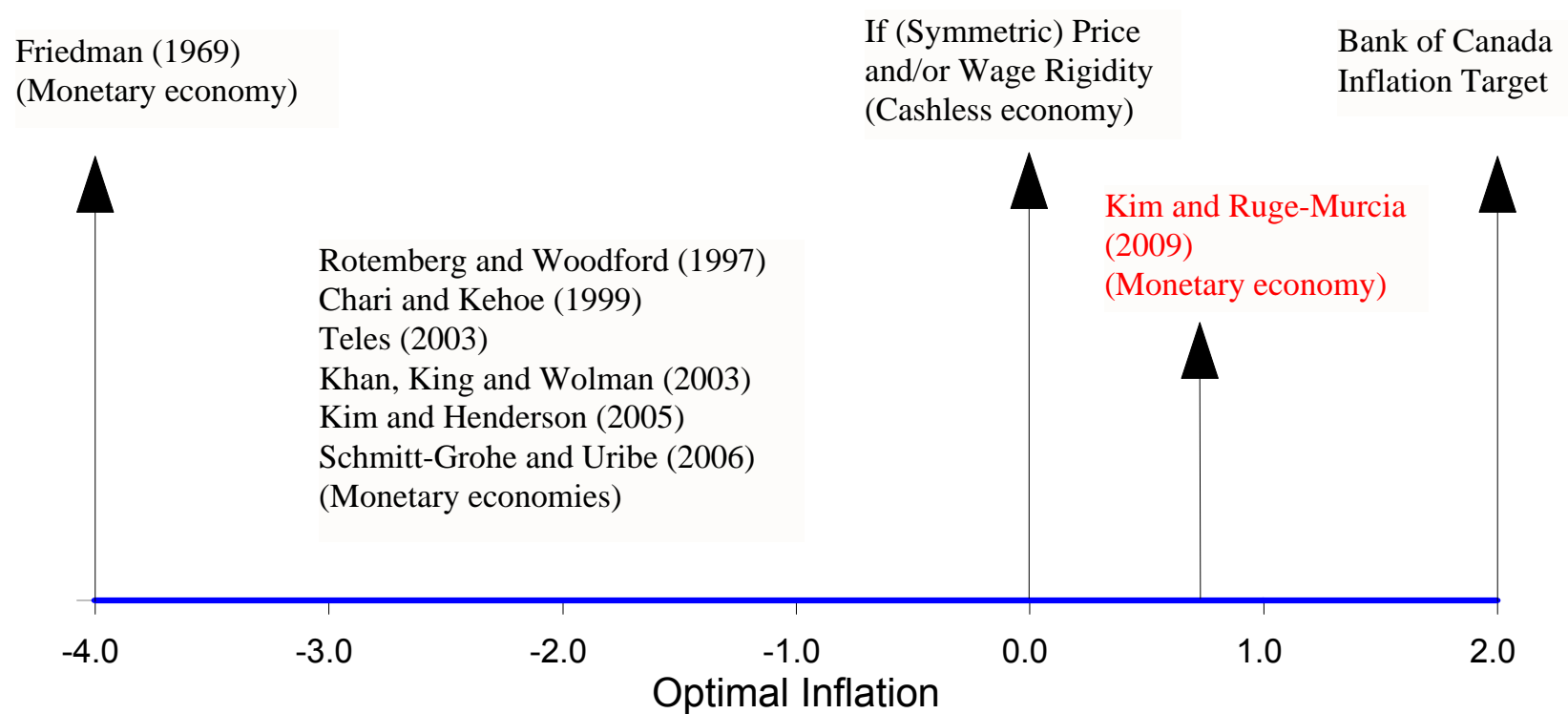
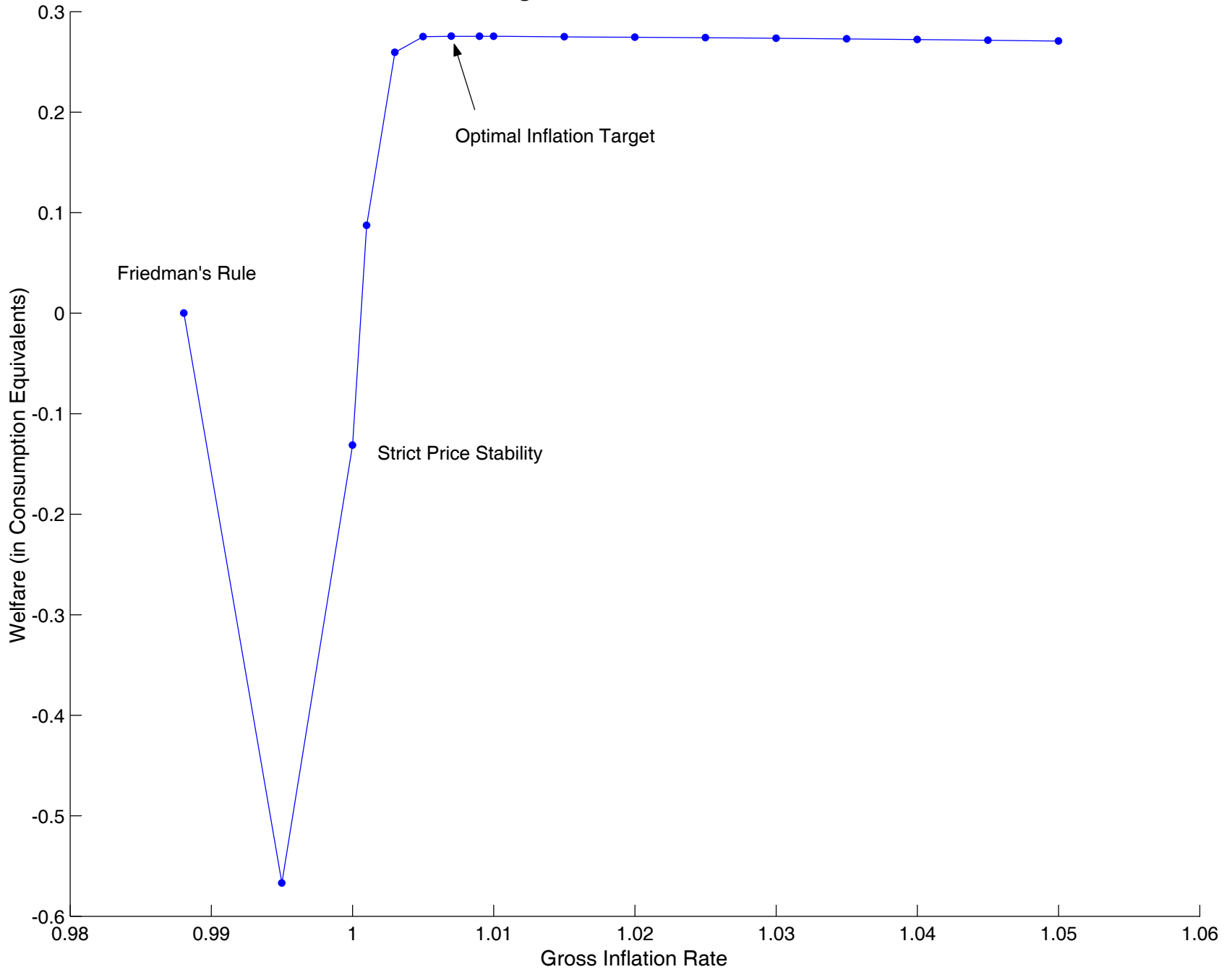


Figure 7: Welfare



Conclusions

When wages are downwardly rigid:

- Monetary policy shocks have asymmetric effects
- Optimal responses to productivity shocks are asymmetric
- The optimal (net) inflation is positive
- A central banker should target a low, but strictly positive, inflation rate

Thank you for listening.