BANK INDONESIA and BANK FOR INTERNATIONAL SETTLEMENTS WORKSHOP

Structural Dynamic Macroeconomic Models in Asia-Pacific Economies

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DSGE Models for Monetary Policy: Promises and Pitfalls

Keynote Lecture

by

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Models: Take a broad view!

- Economy-wide dynamic stochastic models for macroeconomic policy analysis.
- New contributions of micro-founded models rightly emphasized in academic journals.
- But, these models continue a model building tradition for policy analysis under rational expectations.
  - ➔Lucas (1976), Taylor (1980), Kydland & Prescott (1982), Taylor (1993), Fuhrer-Moore (1995), FRB-US, Rot./Wood.-Good./King (1997), Christ.Eich.Ev. (2001), ..

Promise: Major benefits for policy!

- Quantitative models are an essential tool for a rational policy-making process.
  - ➔Enforce logical arguments consistent with economic principles.
  - ➔Confront theory with macroeoconomic data.
  - ➔Useful tool for obtaining forecasts.
  - ➔Essential for a rational discussion of alternative policy scenarios.
  - ➔Required for ex-post evaluation of policy performance.

Promise: Major benefits for policy!

Central banks‘ suite of macro models should

- ➔incorporate short-run and long-run policy tradeoffs that are consistent with the empirical evidence. Possible avenues include price and wage rigidities and information frictions.
- ➔consider implications of rationality of market participants, but also account for the possibility of deviations from full rationality.
- ➔fit the macroeconomic data, for example, observed inflation and output persistence.

Pitfall #1: Knowing the right way

- Fortunately, monetary economists today agree on many important questions. But beware of overconfidence and exclusive reliance on a narrow consensus approach.
  - ➔Develop a suite of models using different modeling and estimation approaches.
  - ➔Replicability (model and data), systematic comparison of different modeling approaches.
  - ➔Design policy recommendations that are robust to competing models.

Pitfall #2: Taking the easy way

- Widely available benchmark models are tremendously useful,
  - ➔but central banks should make a serious effort to understand and model those factors that are specific to their economies.
- Standard tools (log-linear approx., ..) and assumptions (rational exp., Calvo fairy + index...) help us improve our understanding and obtain easily tractable models,
  - ➔but at the danger of neglecting important risks for policymakers.

Outline

1. Modelling frameworks
   1.1 Micro foundations and LQ methodology
   1.2. Expectations formation
   1.3. Benchmark models and emerging economies
   ➔**1.4. Case study:** Modeling Chile‘s transition
2. Policy design with models
   2.1. Robustness of policy recommendations
   2.2. Central bank learning
   ➔**2.3. Case study:** EMU and the ECB‘s models
3. A platform for comparison

1.1. Micro foundations and LQ methodology

- Great! Structural interpretation in terms of deep parameters.
  - ➔Simple example: NK Phillips curve, notation as in Walsh (2003)

$$\pi_t = \beta E_t \pi_{t+1} + \lambda x_t \qquad (1)$$

discount factor: β

slope κ ?

output gap x?

Structural interpretation

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\omega)(1-\beta\omega)}{\omega}(\sigma+\eta)\left[\hat{y}_t - \left(\frac{1+\eta}{\sigma+\eta}\right)\hat{z}_t\right] \qquad (2)$$

- Calvo signal probability: ω
- Household's (CES) utility fn: η,σ
- Firms' prod.fn/ prod.shock: z
  - ➔Lucas critique taken into account w.r.t. to expectations formation and optimizing decision-making of firms and households.

But, some humility is in order ...

- The key Keynesian feature, that is price rigidity, is simply introduced by assumption.
- The representative agent exists for mathematical convenience. The implied restrictions might be quite different from those that would be consistent with optimizing behavior of heterogenous individuals.
- Rationality assumption of micro-foundations used for macro models is questioned in other areas of economic theory.

Linear-quadratic methodology

- The speed at which modelling efforts are proceeding at central banks of leading industrial economies, but more recently also at emerging markets is truly impressive.
- This was possible due to the
  - ➔ transparency of log-linear approximations of complex nonlinear macro models,
  - ➔ the applicability of linear-quadratic methods that are easily accessible in standard software.

Nonlinearities

- But, nonlinarities may have crucial influence on the economy and policy design, and magnify effects of uncertainty.
  - ➔Nonlinear micro-founded model may imply different disinflation costs (Ascari&Merkl).
  - ➔Learning introduces a nonlinearity.
  - ➔Zero bound on nominal interest rates.
  - ➔Regime change is nonlinear.
  - ➔Policy targets and ranges.

1.2. Expectations formation

- Standard framework:
  - ➔ expectations are fully rational, unique and incorporate much information regarding the known structure of the economy.
  - ➔ persistence in macro variables is due to a variety of frictions, policy and serial correlation in shocks, all incorporated in rational expectations.
  - ➔Important benefit: policy recommendations derived from such models do not require that the central bank can systematically fool market participants.

Deviations from rational expectations

- But, the RE hypothesis typically does not fare well in empirical tests or in explaining survey expectations.
- RE hypothesis may overstate structural rigidities.
- Policy relevant deviations may arise due to
  - ➔imperfect information and rational learning
  - ➔bounded rationality, (see least-squares learning literature, Marcet&Sargent, Evans&Honkapohja, Orphanides&Williams)
  - ➔belief heterogeneity, (see rational beliefs literature, Kurz et al.)

1.3. Benchmark models and emerging economies

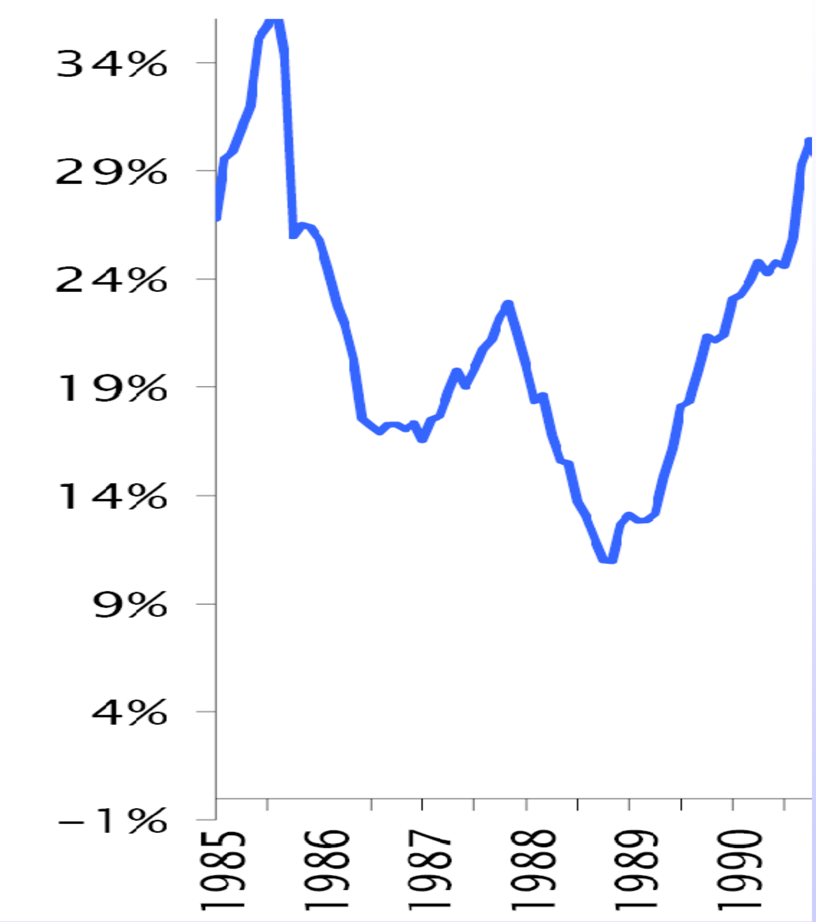
- DSGE models developed first for the U.S. such as CEE are estimated assuming
  - ➔ a constant, credible policy regime;
  - ➔ a constant share of firms with fixed prices;
  - ➔ a constant share of firms that are indexing to past inflation;
  - ➔ a constant degree of persistence in shocks.
- These assumptions may hold up for a sufficiently long estimation period in the U.S., and some industrial economies, but probably not in emerging economies.

Emerging economies features

- As a first step, it is very useful to estimate a standard small-open economy DSGE model with macro data of an emerging economy.
  - ➔But regime change may be recent and not fully credible.
  - ➔The informal sector may be large.
  - ➔Certain sectors may be dominating the economy (raw materials prices, etc.)
  - ➔ Certain institutions may be changing, (legal system, rule of law, property rights..)

➔1.4. Case study: Modeling Chile's experience

Chilean inflation
(late 1980s)



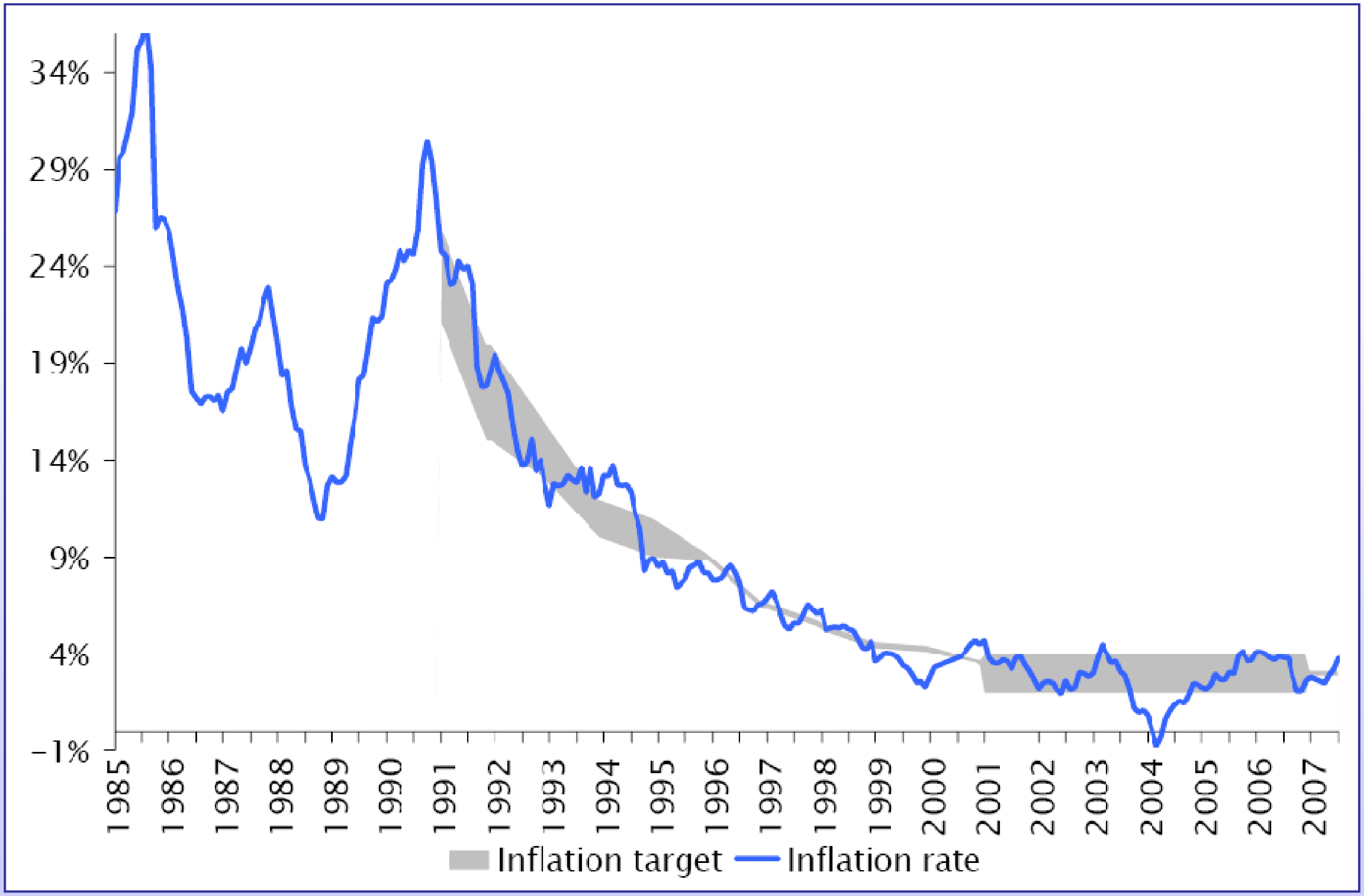
Inflation targeting in Chile

- Sep 1990: First official target.
  15-20% annual CPI inflation Dec 90 to Dec 91

- 1991-2001: annual targets lowered gradually, target ranges or point targets.

- Since 2001: constant range of 2 to 4 %.

Chile‘s successful disinflation



From Schmidt-Hebbel and Werner (2002) extended to 2007.

Inflation targeting in Chile

Year	Range	Midpoint
1991	15-20	17.5
1992	13-16	14.5
1993	10-12	11
1994	9-11	10
1995	8	8
1996	6.5	6.5
1997	5.5	5.5
1998	4.5	4.5
1999	4.3	4.3
2000	3.5	3.5
2001	2-4	3

Wieland (2008)

1. Allows for adaptive learning by price setters.
2. Endogenizes the degree of backward-looking indexation by linking it to learning.
3. Investigates disinflation costs with temporary versus long-run targets.

   Lesson for models: Treating backward-looking indexation as exogenous overstates the cost of disinflation.

   Lesson for policy: Announcing temporary targets helps reducing the cost of disinflation.

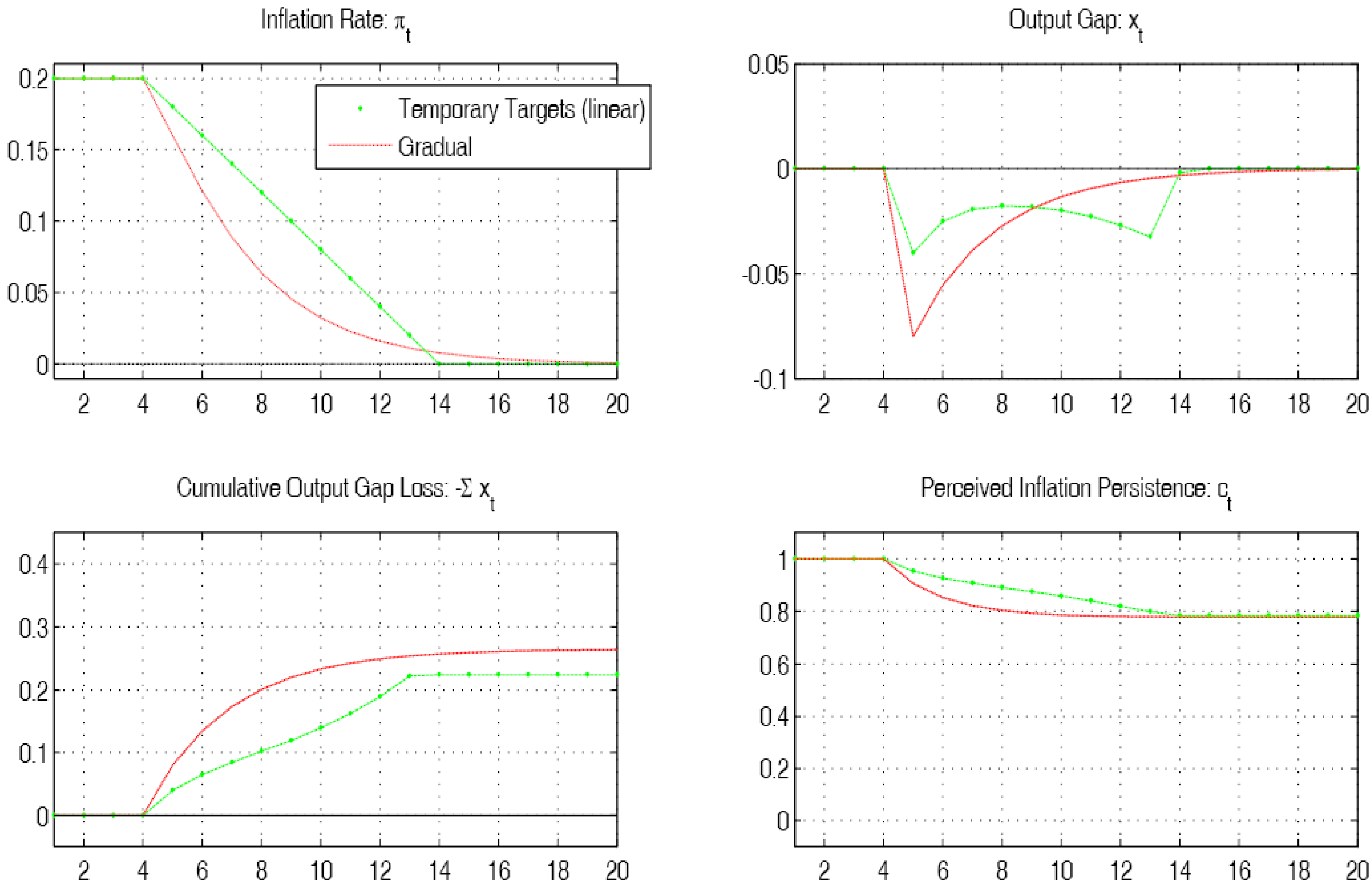
NK Phillips curve with indexation

- Christiano, Eichenbaum, Evans (01, 05) introduce exogenous degree of backward-looking indexation, κ:

$$\pi_t = \frac{\kappa}{1+\beta\kappa}\pi_{t-1} + \frac{\beta}{1+\beta\kappa}E_t\,\pi_{t+1} + \frac{\lambda}{1+\beta\kappa}x_t \qquad (3)$$

$$+\frac{\left(1-\kappa\right)(1-\beta)}{1+\beta\kappa}\pi^S$$

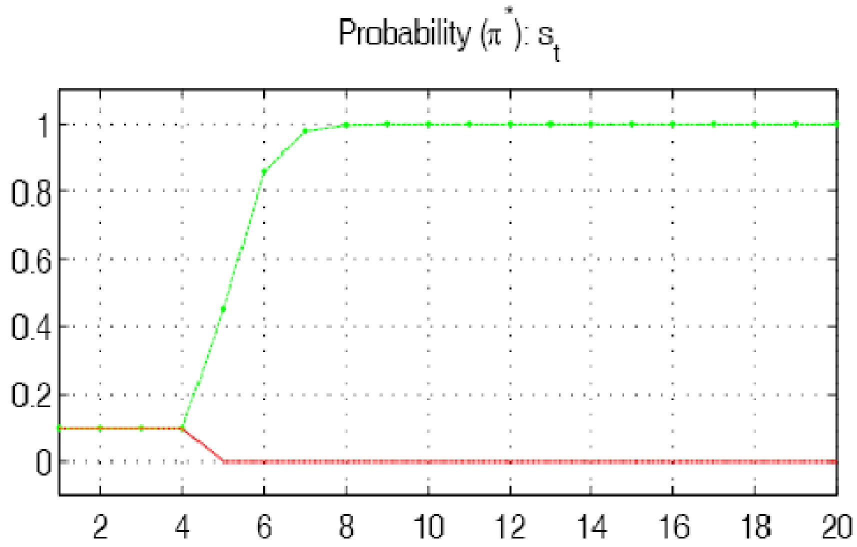
Long-run target vs temporary targets

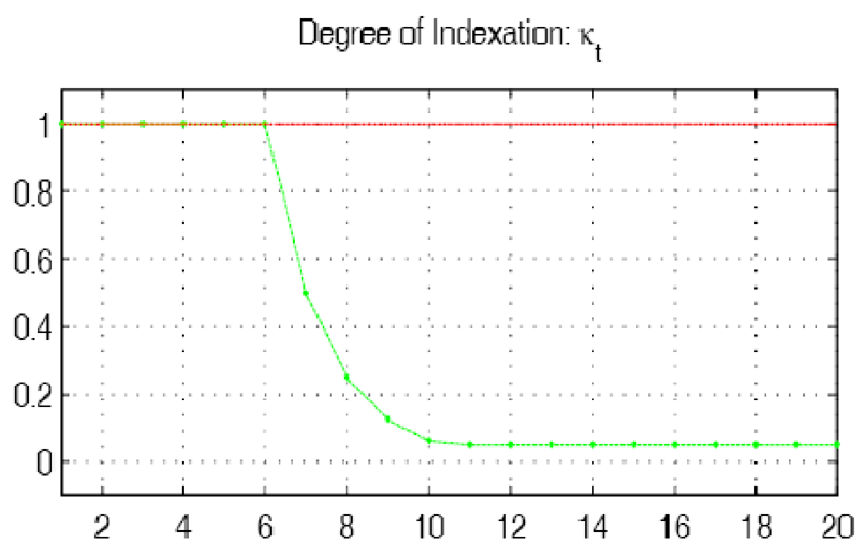


Gradual disinflation to a long-run target

- Inflation declines gradually,
- Market participants revise their beliefs regarding the persistence of inflation and inflation expectations decline,
- Thus, disinflation costs decline.
- Gradual disinflation implies smaller output losses than immediate disinflation.

Indexation and temporary targets





Indexation and temporary targets

- Temporary inflation targets that are achieved induce firms to move away from backward-looking indexation and index to the announced targets.
- Perceived inflation persistence also declines.
- These two effects together ensure that temporary targets achieve disinflation at lower output costs.

2. Policy design with models

2.1. Robustness of policy recommendations

2.2. Central bank learning

➔ **2.3. Case study:** EMU and the ECB's models

2.1. Robustness of policy recommendations

- Models with rational expectations emphasize that policy should be thought of in terms of rules and deviations from such rules.
- These models emphasize the benefits from committing to a rule.
- Simple rules capture most of the benefits that may be attained by fully optimal policy under commitment.
- Simple rules may be more robust in terms of performance across a range of models. (Taylor (1999), Levin et al. 1999).

Optimizing simple rules for a given model

- Taylor-style rules with int. rate smoothing:

$$i_t = \rho i_{t-1} + \alpha \pi_t + \beta y_t \qquad (4)$$

- Loss function (or model-based utility):

$$L = Var(\pi_t) + \lambda_y Var(y_t) + \lambda_i Var(\Delta i_t) \qquad (5)$$

Robust policy design with multiple reference models

- **Bayesian:** derive policy rule that minimizes expected loss across models:

$$L^B = \min_{(\rho,\alpha,\beta)} E_M\left[L_m\right] = \min_{(\rho,\alpha,\beta)} \sum_{m \in M} p_m L_m \qquad (6)$$

Robust policy design with multiple reference models

- **Worst-Case Analysis:** Minimize loss assuming nature will confront you with the worst-case scenario (meaning model)

$$L^{MM} = \min_{(\rho,\alpha,\beta)} \max_{(m \in M)} L_m \qquad (7)$$

Robust policy design with multiple reference models

- **Intermediate ambiguity aversion:** Combining Bayesian decision-making with a preference for guarding against worst-cases.

$$L^{AA} = \min_{(\rho,\alpha,\beta)} \left\{ (1-e) \sum_{m \in M} p_m L_m + e \max_{(m \in M)} L_m \right\} \qquad (8)$$

2.2. Central Bank Learning with Models

- Use Bayesian methods to compute posterior model probabilities with incoming data.
- Keep model parameters, equations and policy rule.
- Select data to be matched and make use of Bayes law as new observations arrive, to derive posterior model probabilities.

Posterior Model Probabilities

- Prior model probabilities: $p(M_i)$
- Likelihood of model i: $p(Y^T|M_i)$
- Bayes law implies that posterior model probabilities are:

$$p\left(M_i \middle| Y^T\right) = \frac{p\left(Y^T \middle| M_i\right) p\left(M_i\right)}{\sum_{j=1}^{M} p\left(Y^T \middle| M_i\right) p\left(M_i\right)} \qquad (9)$$

2.3. Case Study: EMU and the ECB's Models (1999)

ECB President Willem Duisenberg:

``We at the ECB are committed to developing and maintaining a set of tools that are useful for analyzing the euro area economy, and examining the implications for future inflation.

This is, however, not a trivial task given the large uncertainties that we are facing due to the establishment of a multi-country monetary union …

Duisenberg (1999) continued

… *Not only can we expect some of the historical relationships to change due to this shift in regime, but also, in many cases, there is a lack of comparable and cross-country data series that can be used to estimate such relationships."*

ECB Chief Economist Otmar Issing (1999):

``Given the degree of model uncertainty, central bankers highly welcome the recent academic research on the robustness of monetary policy rules across a suite of different models.“

Pointing towards research on the U.S. economy at the time as an example.

What happened then ...

- 1998-2001: researchers at the ECB developed a first suite of macroeconomic models for the euro area.
- These models were estimated with synthetic pre-EMU data constructed at the ECB.
- Researchers around the world developed alternative approaches to robust policy design.

The first-generation ECB toolbox

(1) **AW: Area-Wide Model** (ECB-WP 42, 1/2001, EM 2005)

(2) **SW: Smets & Wouters Model,** (WP 171, 8/02, JEEA 2003)

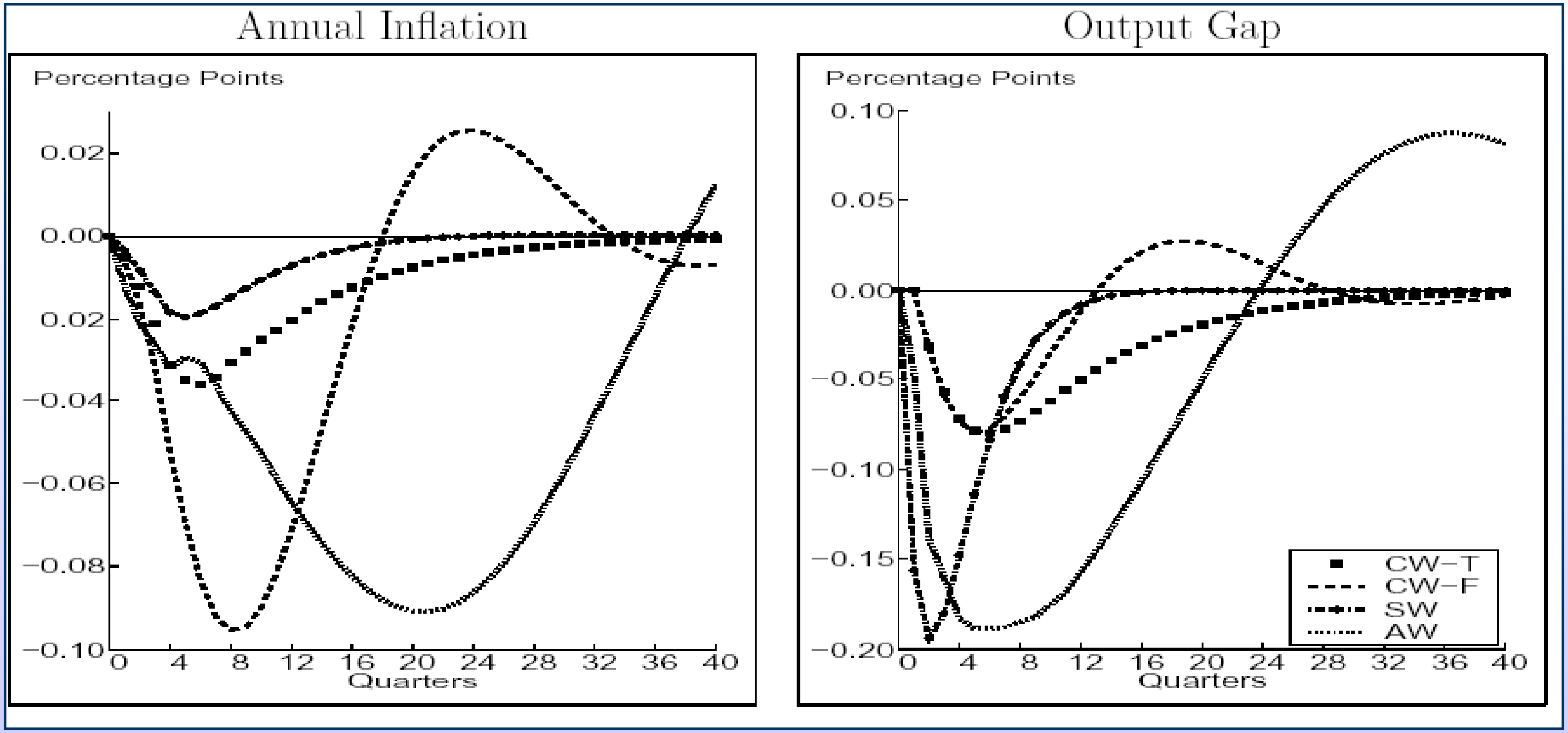
(3) **CW-F: Coenen & Wieland Model with Fuhrer-Moore Contracts** (ECB-WP 30, 9/2000, EER 2005)

(4) **CW-T: Coenen-Wieland with Taylor Contracts.**

➔ Assess the range of uncertainty about inflation and output dynamics implied by these models.

Range of uncertainty implied by models

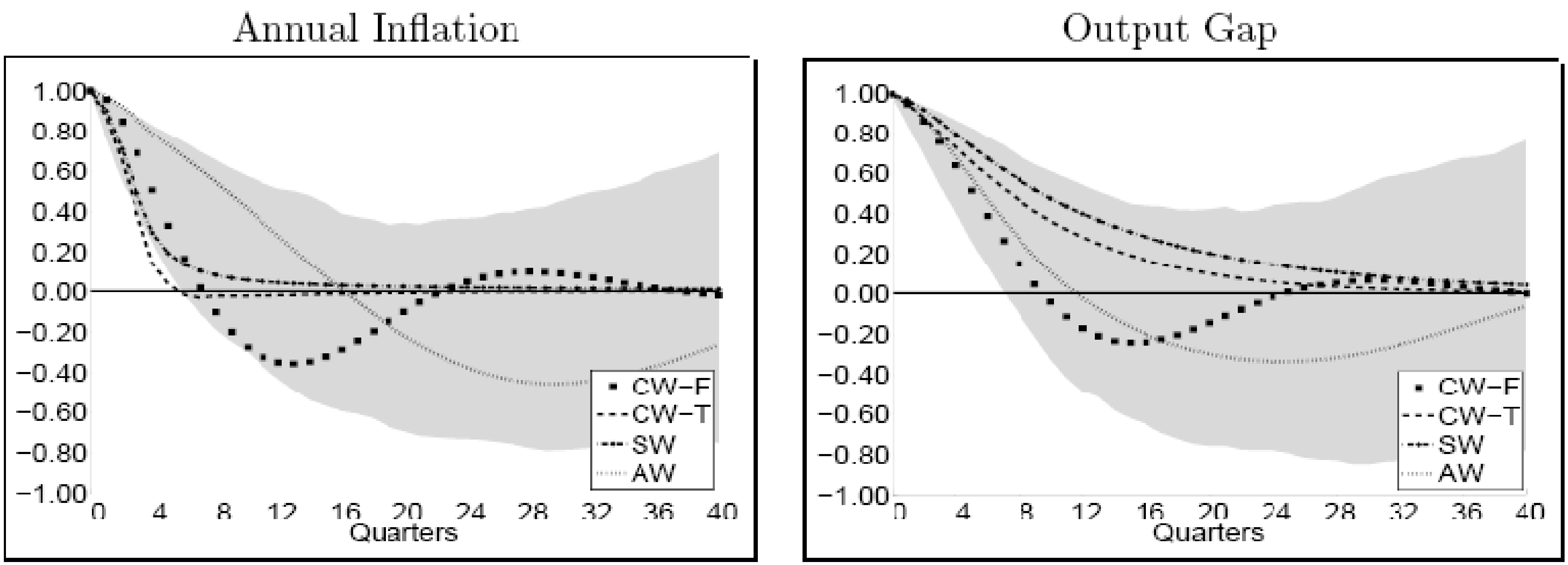
- Regarding policy transmission:



Use same interest rate rule in models, 100 basis point shock.

Uncertain Inflation & Output Persistence

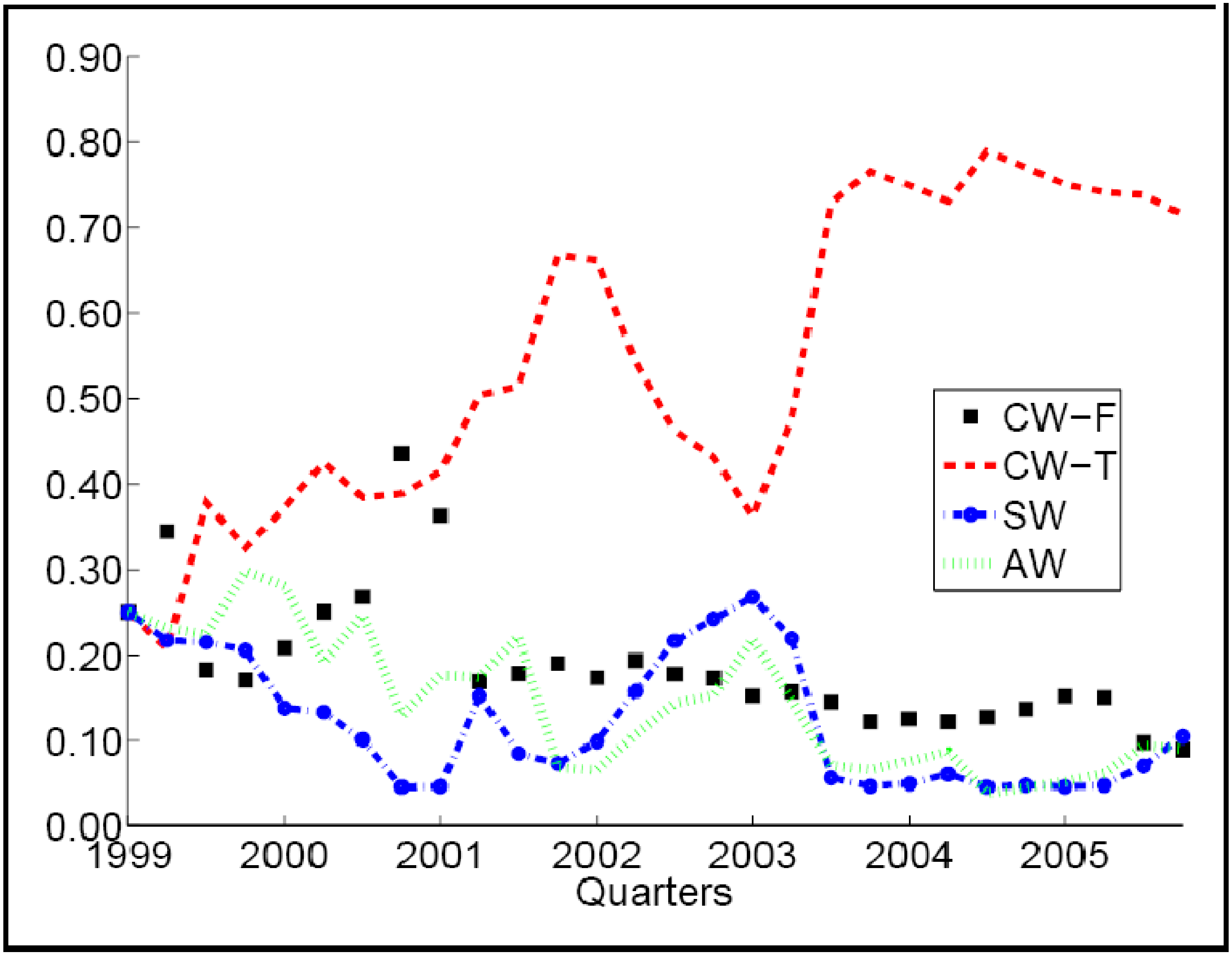
- Serial correlations reflecting all shocks.



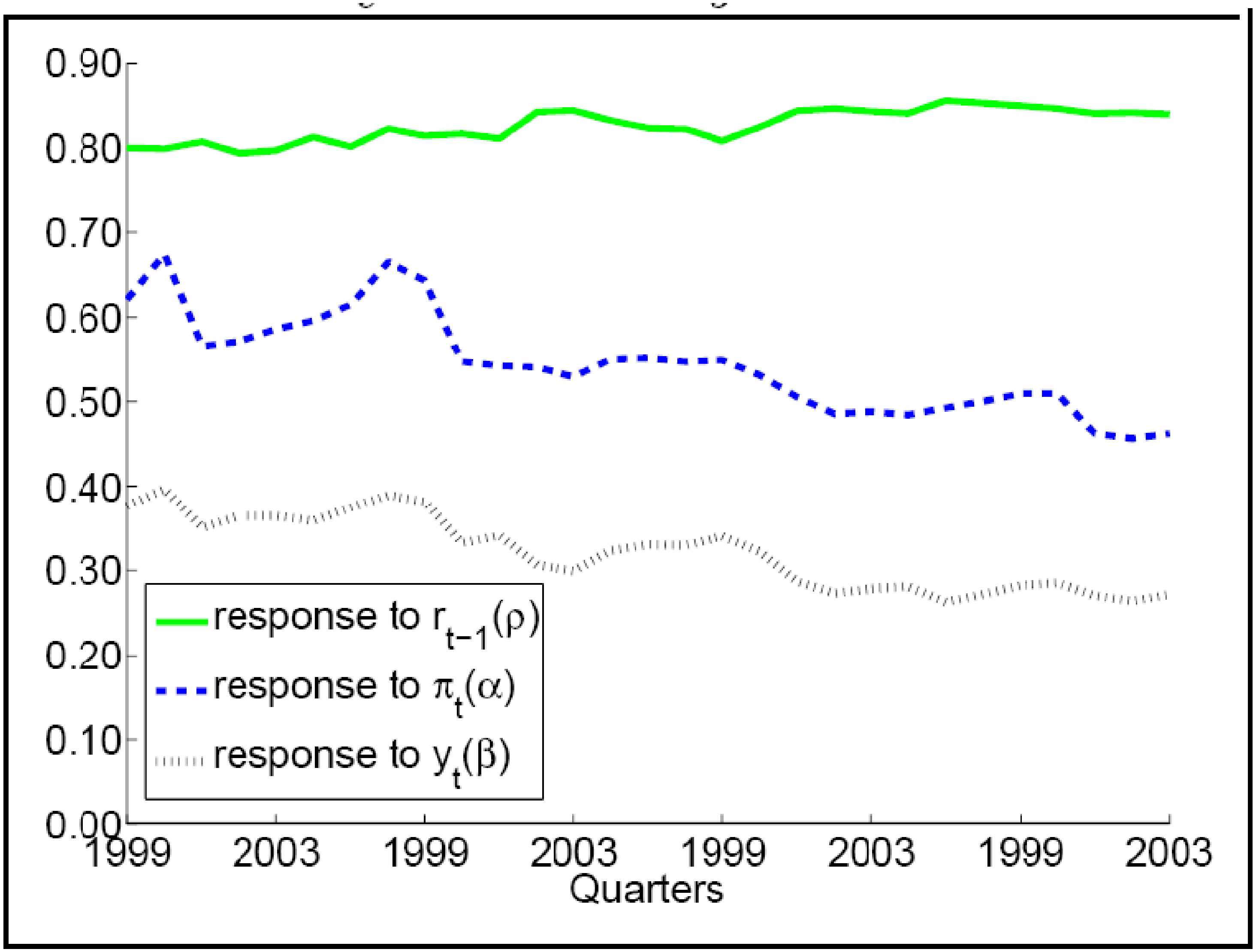
Kuester and Wieland (2008 rev.)

- Imagine being at the start of monetary union with four models estimated from synthetic data.
- You checked and found out that optimized policy rules from one model do not always perform well in all other three models (lack of robustness).
- Design a monetary policy that is robust to the range of uncertainty spanned by the first generation of ECB models, and allow for learning from EMU data.

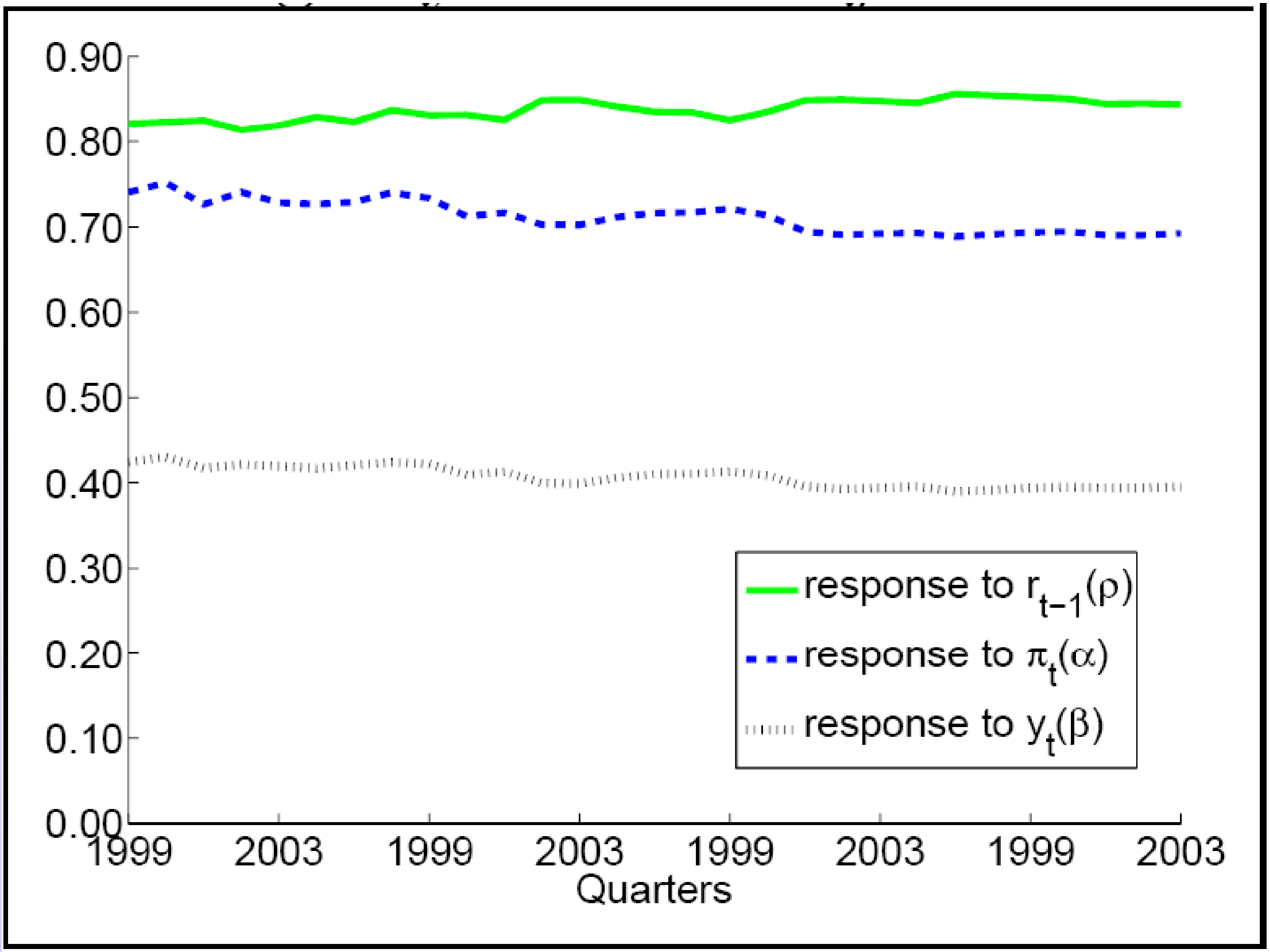
Evolution of Model Probabilities



Evolution of Bayesian Policy



Ambiguity-averse rule (e=0.5)

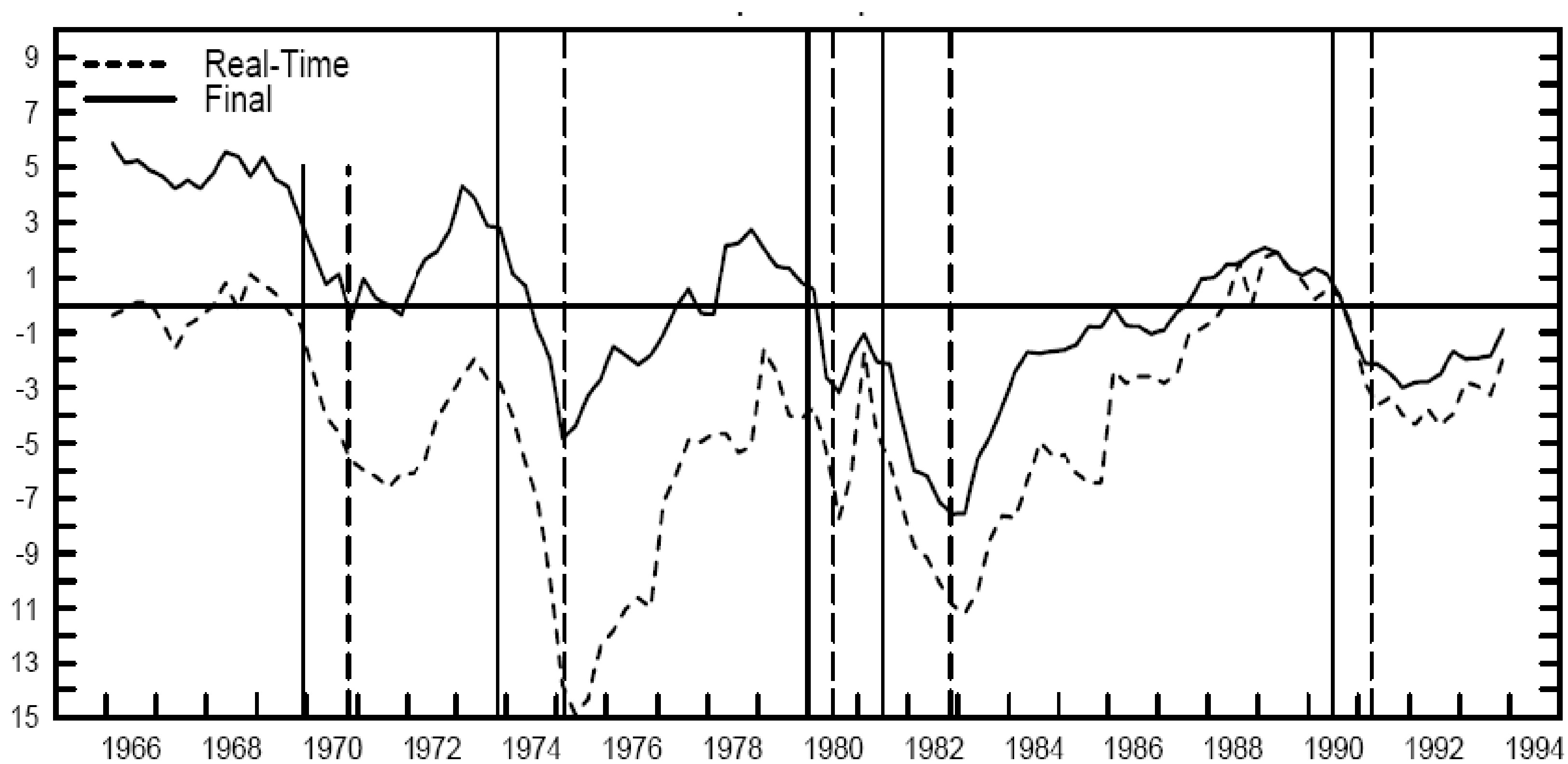


Note: The unobservables

- So far, we have treated potential output and thus the output gap as observed.
- Uncertainty about gaps and equilibrium values bigger issue than dynamics. Recall historical central bank misperceptions.
- Studies of optimal policy under uncertainty often derive conclusions on the basis of rather courageous a-priori assumptions.
- Possible solution: use very simple models for cross-checking (Beck and Wieland 2007, 2008)

U.S. output gap misperceptions

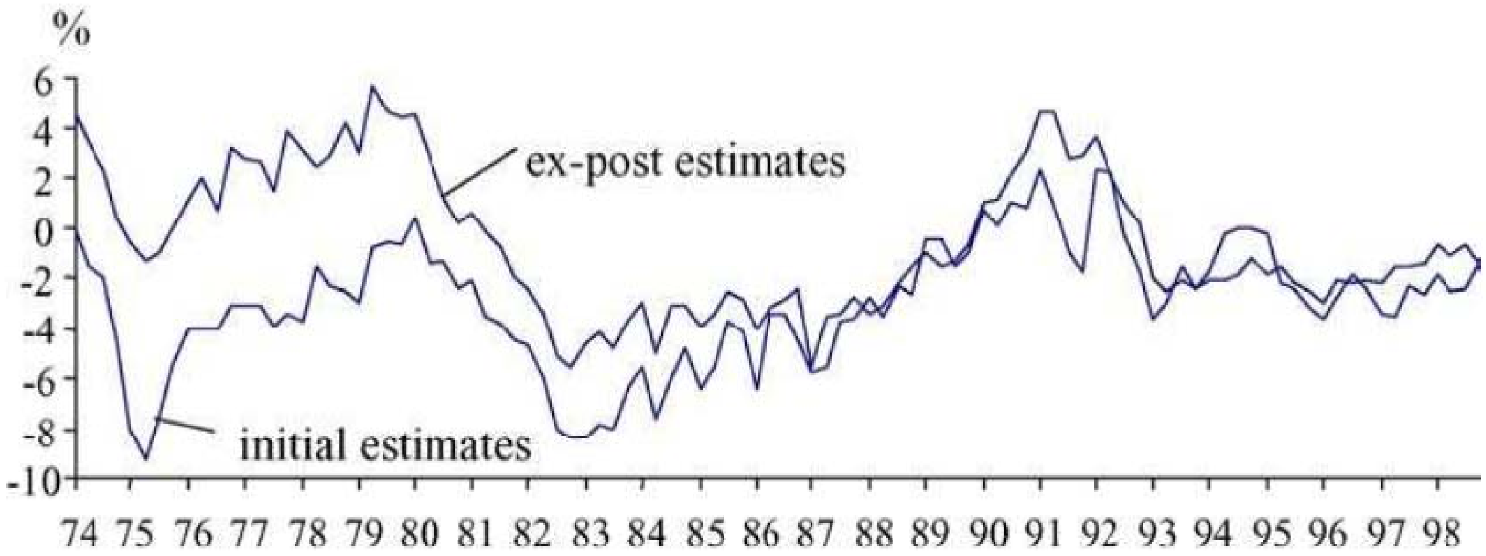
Figure 1: U.S. real-time and final (1994) output gap from Orphanides (2003)



Orphanides, The quest for prosperity without inflation, Journal of Monetary Economics, 2003.

The Bundesbank‘s output gap misperceptions

Figure 2: German real-time and final (1999) output gap from Gerberding et al. (2005)



Gerberding, Seitz, Worms, How the Bundesbank *really* conducted policy, North American Journal of Economics and Finance, 2005.

NK output gap vs trend-based gap

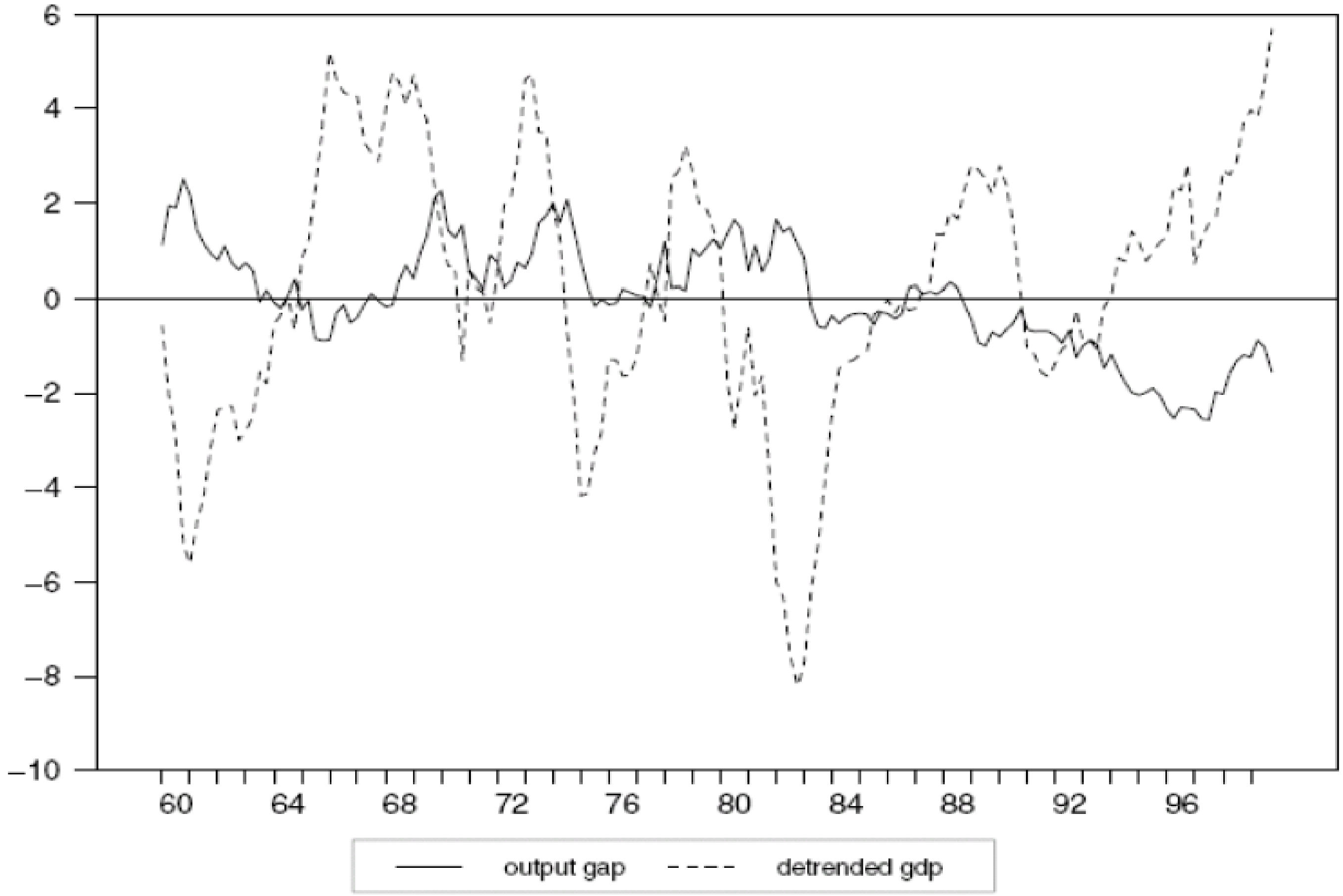


Figure 5.2. Model-based output gap vs. detrended GDP.

Source: Galí (2003)

3. A platform for comparison: *MacroModelBase*

- Taylor-Wieland (in progress): create a database of macroeconomic models on a common platform (Dynare)
- Objective:
  - ➔Tool to encourage comparative instead of insular approach to model-based research.
  - ➔Tool to provide policy advice at central banks and treasuries by comparing competing models, or by comparing across different economies.