Central Bank Models: Lessons from the Past and Ideas for the Future

John B. Taylor
Stanford University

National Bank of Ukraine Conference

May 19, 2017

When it all began

- First macroeconomic model built by Jan Tinbergen in 1936. Developed to answer a key monetary policy question:
  - Should the Dutch guilder be devalued and would that stimulate the economy?
- The paper was prepared for the October 24, 1936 meeting of the Dutch Economics and Statistics Association. The paper itself was already available in September.
- On 27 September the Netherlands abandoned the gold parity of the guilder and the currency was devalued by about 20%.

Policy Analysis with Models in "Path Space"

- Instruments and Targets
  - Different scenarios or paths for policy instruments
    - Exchange rate, government purchases,…
  - Observe impact on target variables

- Cowles Commission and Foundation–Chicago, Yale
  - Need estimates of structural models, not reduced forms
  - Simultaneous equation estimation (FIML LIML, TSLS)
  - Model simulations: monetarist v Keynesian debate
  - Many policy question addressed (Lawrence Klein)

- Models introduced in central banks in 1960s
  - MPS model at Fed
  - RDX1 at the Bank of Canada
  - Other central banks too

4 Decades Ago: Major Paradigm Shift

- Policy analysis moved from "Path-Space" to "Rules Space"
- Many antecedents:
  - Time series models, control theory, A.W. Phillips
  - Realization that Milton Friedman's arguments about rules v discretion applied to feedback rules
  - Joint estimation and control led to rules
  - Rational expectations: Lucas critique, time inconsistency
  - Introduction of sticky prices and RE made approach amenable for monetary policy
- Some Papers:
  - Anderson & Taylor (1976), Lucas (1976), Kydland & Prescott (1977), Taylor (1979)

From Complex Models to Simple Rules

.

- Models were complex so, at first, rules were complex.
  - Serious doubts about the framework.
- Could simple rules consistent with the research be found?
- Yes! Interest rate should react to real GDP & inflation
  - Set inflation target to 2% based on measurement bias and ZLB
- The research showed that the
  - interest rate reaction to inflation should be greater than 1; chose 1.5.
  - interest rate reaction to GDP gap should be greater than 0; chose 0.5
  - interest rate reaction to other variables should be small; chose 0.
- Equilibrium interest rate: 2% real and 4% nominal.
- The bottom line: set the interest rate equal to 1.5 times the inflation rate, plus .5 times the GDP gap, plus 1.
- Not a curve fitting exercise in which various instruments of policy were regressed on variables. Derived from monetary models.
- Same approach worked internationally

Paradigm Shift at Central Banks

- In early 1990s, FRB/MPS model replaced by FRB/US.
  - Computational and conceptual barriers were overcome
  - Brayton and Tinsley (1996) "Expectations of private sectors are explicit; these expectations...constitute a major transmission channel of policy." Brayton, Levin, Tryon, and Williams (1997).
- Bank of Canada: In early 1990s RDX1 was replaced by QPM. (Quarterly Projection Model)
  - Coletti et al (1996): "Two important features: forward-looking expectations and endogenous policy rules."
- NBU Quarterly Projection Model Derived from QPM of the Bank of Canada and others around 2005
  - Sergiy Nikolaychuk and Yurii Sholomytskyi (2015) "Using Macroeconomic Models for Monetary Policy in Ukraine"
  - IS curve, Price adjustment, Policy rule (Taylor rule)

Surprising Similarities Across Models in this Paradigm

Consider the Pre-Crisis Models in Macro Model Data Base

1. Small Calibrated Models

Rotemberg, Woodford (1997)
Levin, Wieland, Williams (2003)
Clarida, Gali, Gertler (1999)
Clarida, Gali, Gertler 2-Country (2002)
McCallum, Nelson (1999)
Ireland (2004)
Bernanke, Gertler, Gilchrist (1999)
Gali, Monacelli (2005)

2. Estimated US Models

Fuhrer, Moore (1995)
Orphanides, Wieland (1998)
FRB-US model linearized as in Levin, Wieland, Williams (2003)
FRB-US model 08 linearized by Brayton and Laubach (2008)
FRB-US model 08 mixed expectations, linearized by Laubach (2008)
Smets, Wouters (2007)
CEE/ACEL Altig, Christiano, Eichenbaum, Linde (2004)
New Fed US Model by Edge, Kiley, Laforte (2007)
Rudebusch, Svensson (1999)
Orphanides (2003b)
IMF projection model by Carabenciov et al. (2008)
De Graeve (2008)
Christensen, Dib (2008)
Iacoviello (2005)

3. Estimated Euro Area Models
Coenen, Wieland (2005) (ta: Taylor-staggered contracts)
Coenen, Wieland (2005) (fm: Fuhrer-Moore staggered contracts)
ECB Area Wide model linearized as in Dieppe et al. (2005)
Smets, Wouters (2003)
Euro Area Model of Sveriges Riksbank (Adolfson et al. 2007)
Euro Area Model of the DG-ECFIN EU (Ratto et al. 2009)
ECB New-Area Wide Model of Coenen, McAdam, Straub (2008)
4. Estimated Small Open-Economy Models
RAMSES Model of Sveriges Riskbank, Adolfson et al.(2008b)
Model of the Chilean economy by Medina, Soto (2007)
CA_ToTEM10--ToTEM model of Canada (Murchison-Rennison (2006))
5. Estimated/Calibrated Multi-Country Models
Taylor (1993a) model of G7 economies
Coenen,Wieland (2002, 2003) G3 economies
IMF model of euro area by Laxton, Pesenti (2003)
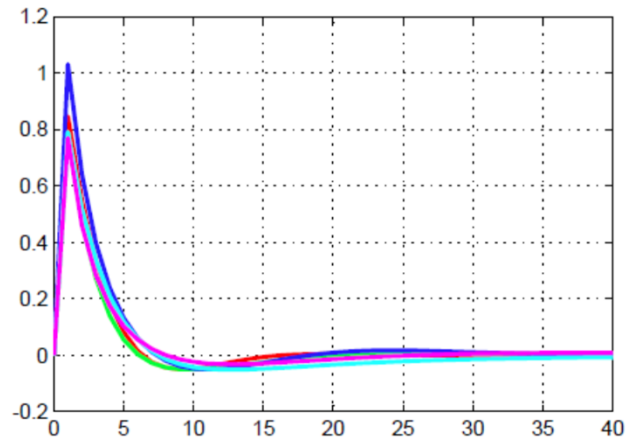FRB-SIGMA model by Erceg, Gust, Guerrieri (2008)

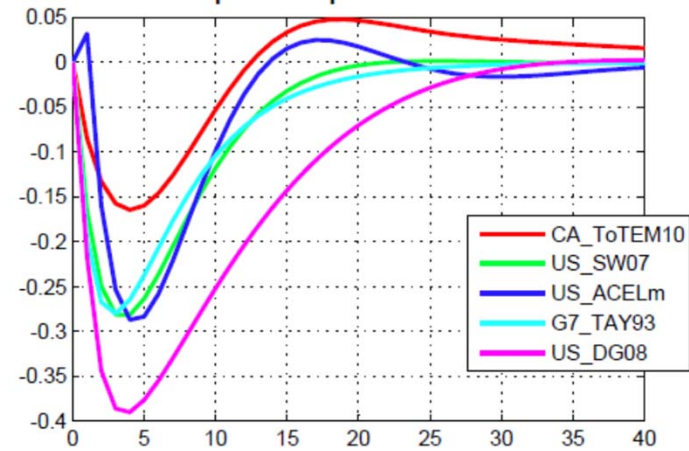# Compare Impact of Monetary Shocks in this Modelling Framework

SW Rule

$$i_t = 0.81 i_{t-1} + 0.39 \pi_t + 0.97 y_t - 0.90 y_{t-1} + \varepsilon_t^i$$

Model Comparisons of
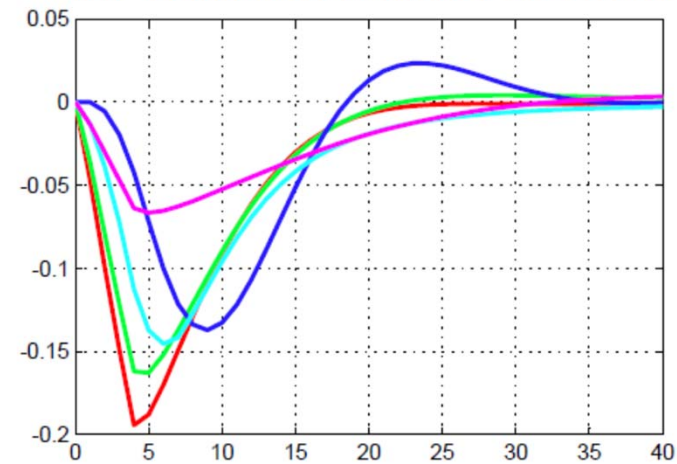Monetary Policy Impact in
ToTEM, SW, CEE-ACEL, Taylor, DG

IRF of Output Gap to Mon. Pol. Shock

CA_ToTEM10
US_SW07
US_ACELm
G7_TAY93
US_DG08

IRF of Interest Rate to Mon. Pol. Shock
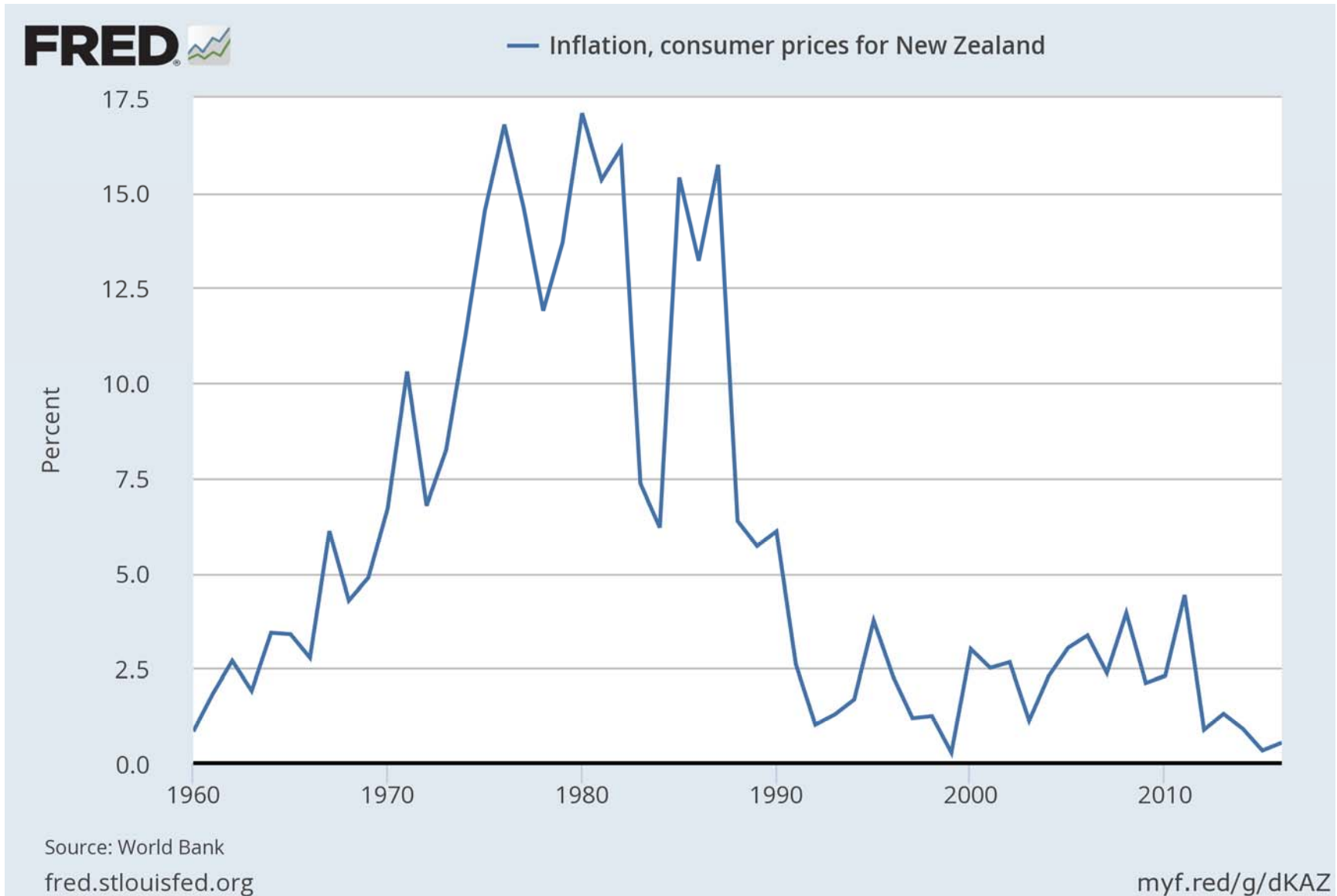
IRF of Inflation to Mon. Pol. Shock

Alleged Problems with the Framework

- Too simple to assume that policy interest rate affects consumption and investment directly?
  - Textbook versus practical versions
- Assumed away financial frictions?
  - Measurement problems forced modelers away from the quantities of credit and foreign exchange toward the prices of these items
  - But financial accelerator was there (De Graeve)
- Did not deal with zero lower bound?
  - 1% was the lower bound in early work in 1980s
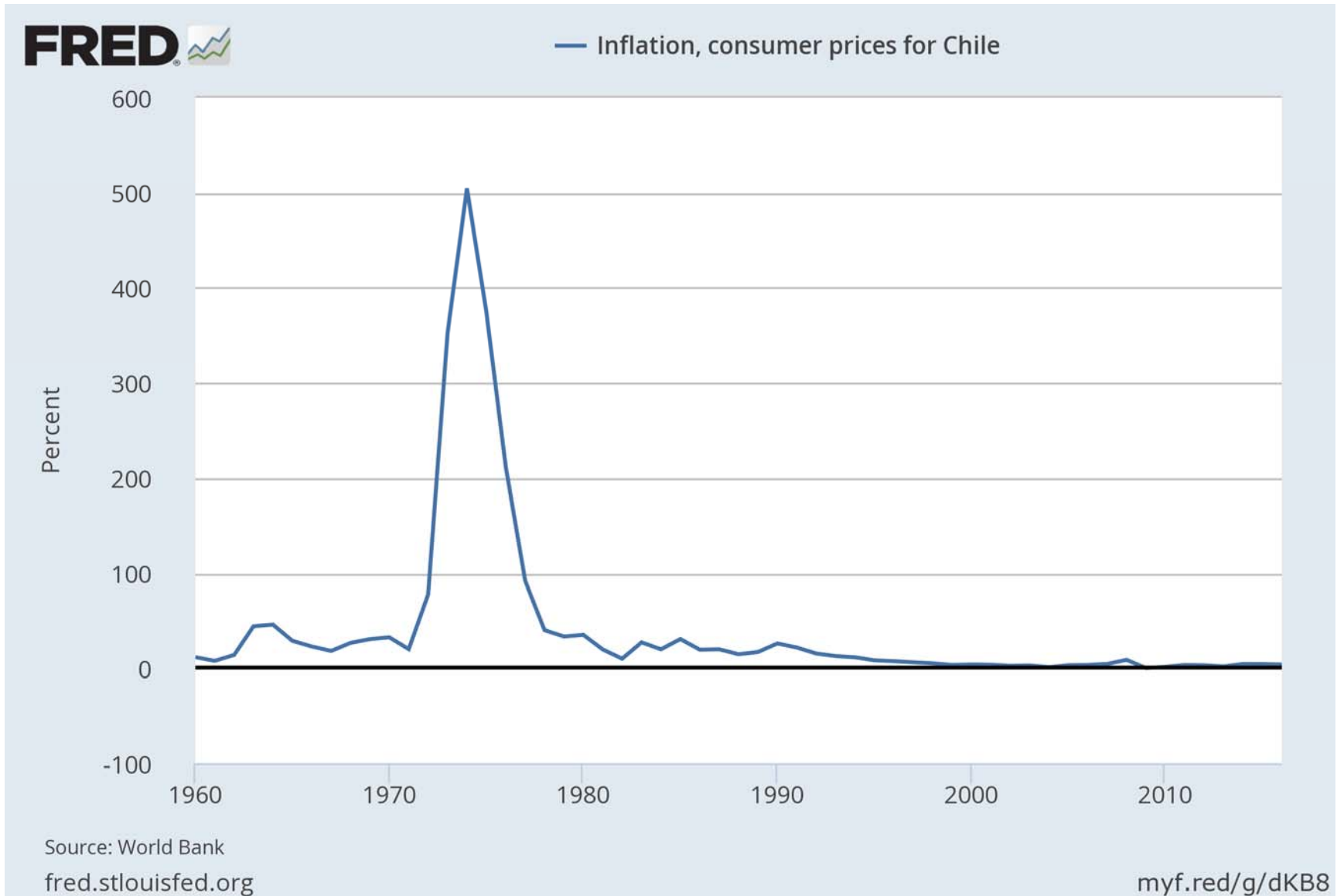 - Reifschneider-Williams (2000) method

The Framework Worked

- Central banks moved toward more transparent rules-based policies in 1980s, 1990s
  - including through a focus on price stability
  - Detected by Clarida, Gali, Gertler in the US; later confirmed by others
  - Dramatic improvement compared with 1970s when policy was highly discretionary and unfocused.
  - Mervyn King called it the NICE period
- Emerging market countries joined with formal Inflation Targeting
  - New Zealand
  - Chile
  - Rules-based: "The inflation target is an efficient framework to conduct monetary policy. The issue then is how to operationalize this framework. When should monetary policy be tightened or loosened? The most traditional answer is the Taylor rule…." (Jose De Gregorio (2014) *How Latin America Weathered the Global Financial Crisis)*
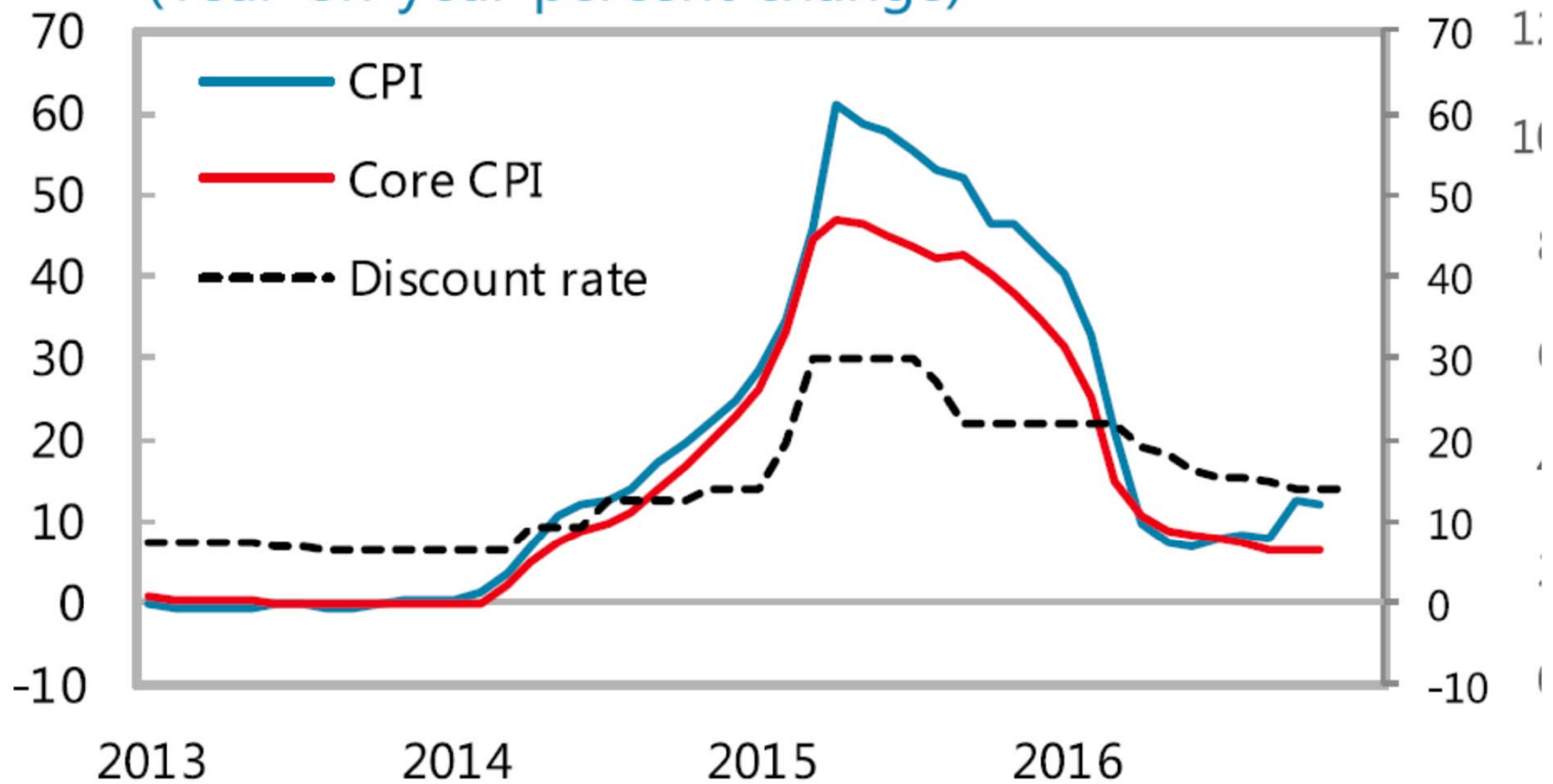
Inflation in New Zealand

Inflation in Chile

Inflation in Chile since 1980

FRED ~

— Inflation, consumer prices for Chile

Source: World Bank

fred.stlouisfed.org

myf.red/g/dKBc

Inflation and the NBU Policy Rate
(Year-on-year percent change)

CPI
Core CPI
Discount rate

2013   2014   2015   2016

Source: NBU and IMF staff calculations.

Chart from IMF report by Pamela Madrid and Evan Luis de Oliveira Lima (2016)
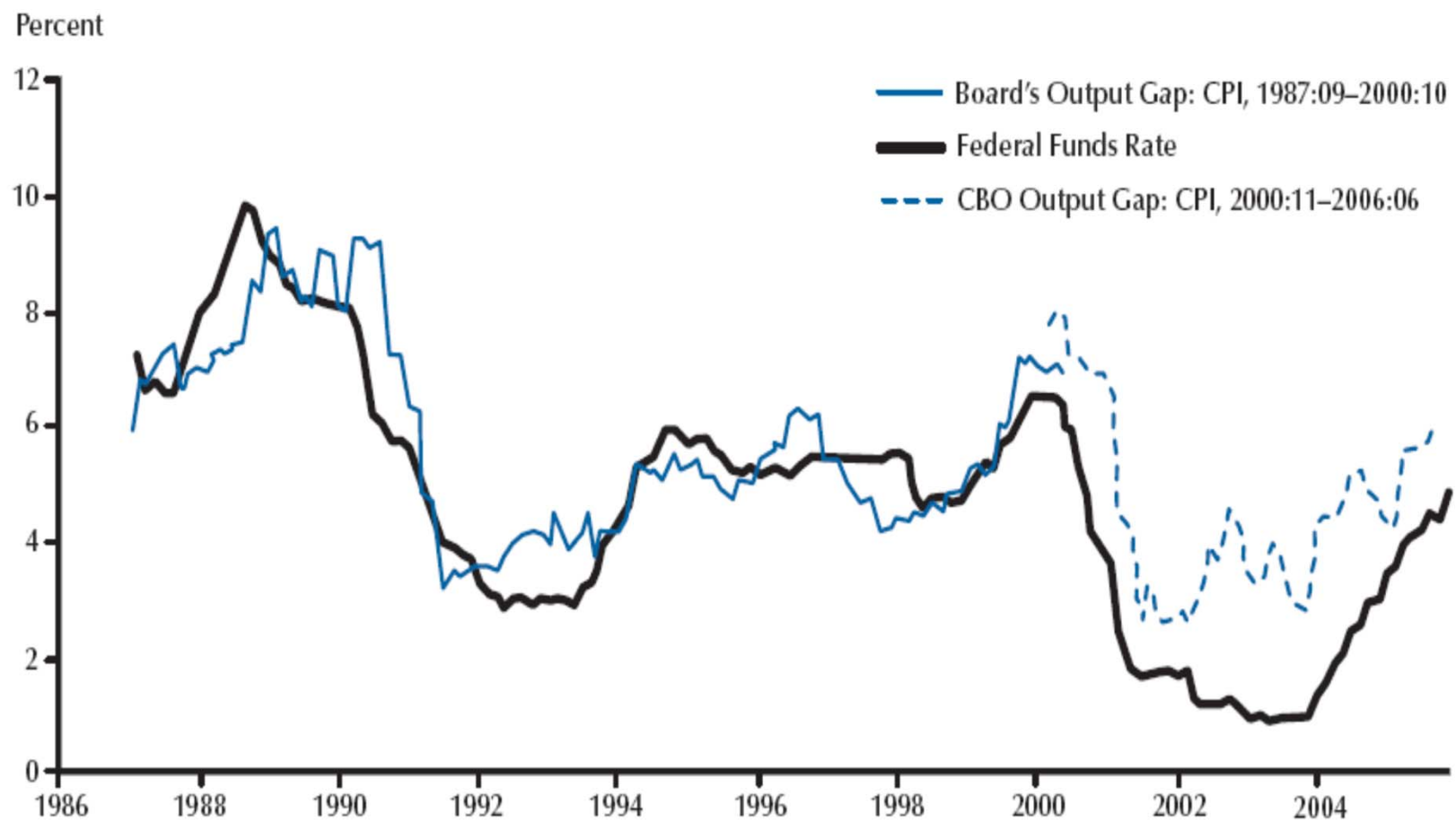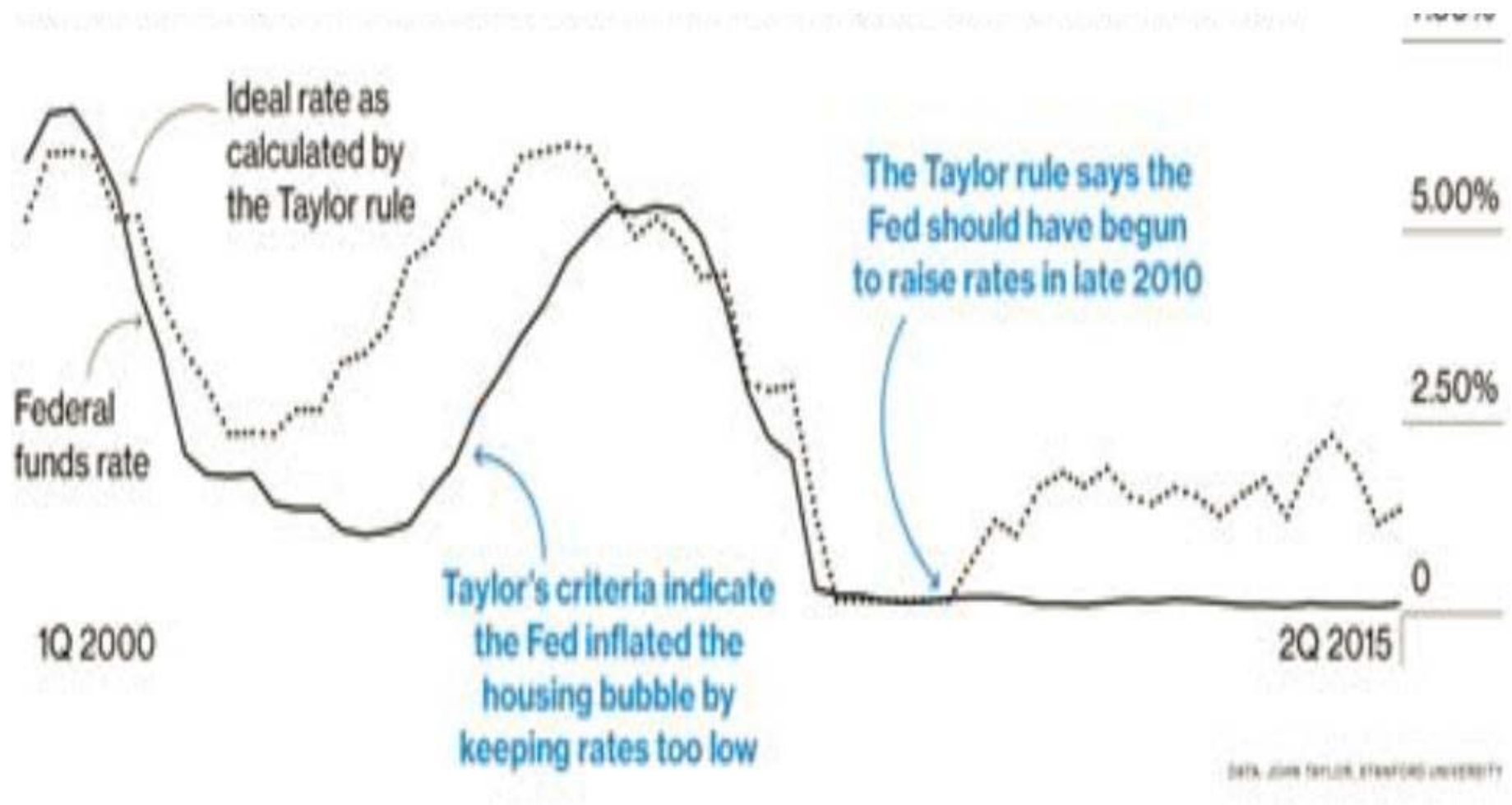
Deviating from Framework Didn't Work

- Evidence that monetary policy moved away from rule-like policies
- Detected by many
  - More than a decade ago—*before* the financial crisis
  - Too low for too long
- Econometric and historical evidence of effects
  - Econometrics: Nikolsko-Rzhevskyy, Papell, Prodan
- "Global Great Deviation" Hofmann & Bogdanova

Greenspan Years: Federal Funds Rate and Taylor Rule
(CPI $p^* = 2.0$, $r^* = 2.0$) $a = 1.5$, $b = 0.5$

Ideal rate as calculated by the Taylor rule

Federal funds rate

The Taylor rule says the Fed should have begun to raise rates in late 2010

Taylor's criteria indicate the Fed inflated the housing bubble by keeping rates too low

5.00%

2.50%

0

1Q 2000

2Q 2015

From Timothy Lane (2016)
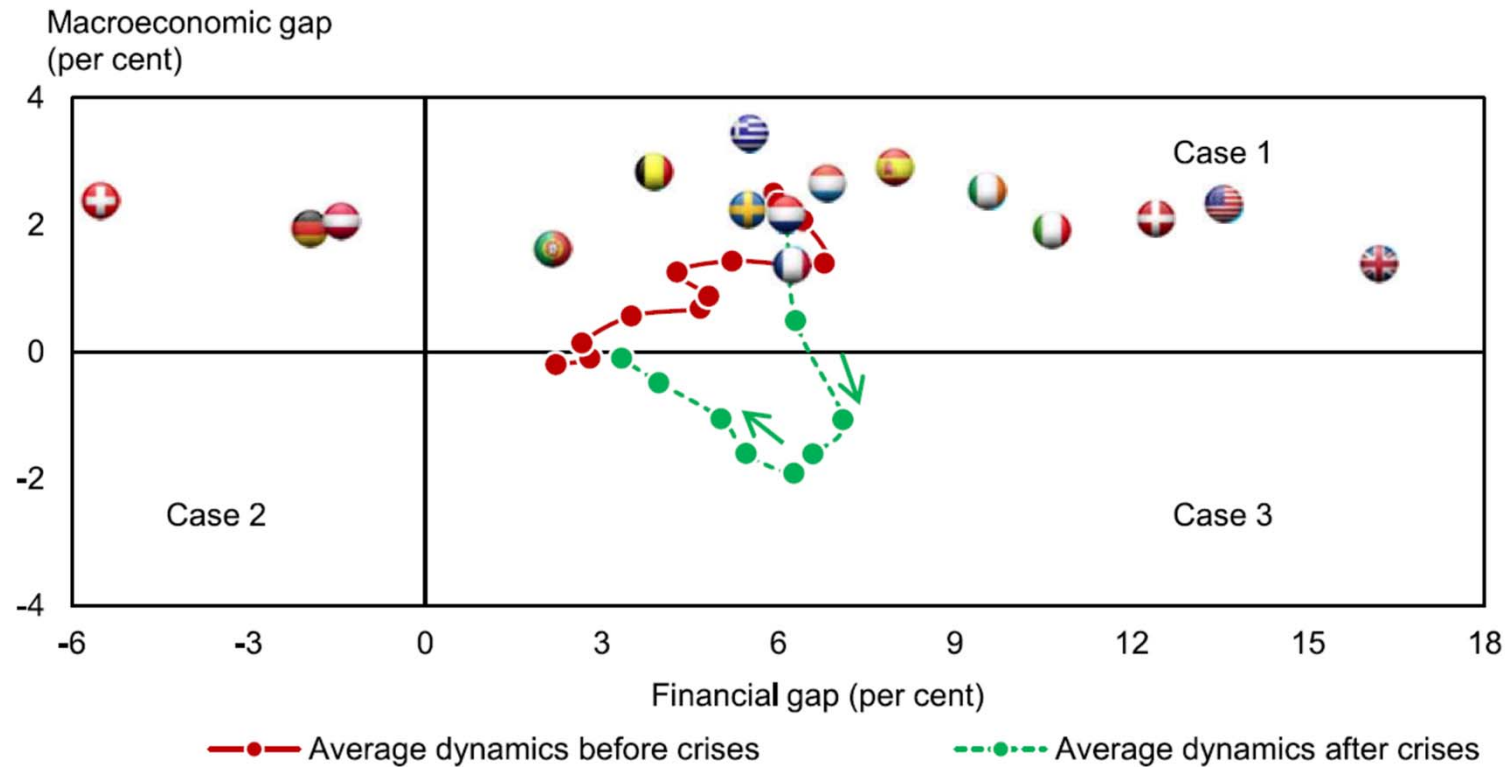
Note: Data for selected advanced economies that faced a banking crisis in 2007–08. Vertical axis shows economic gap, measued as average of estimated output gap and inflation deviation from target. Horizontal axis shows financial gap, measured as average of deviations in the credit-to-GDP ratio and real house prices from historical trends.
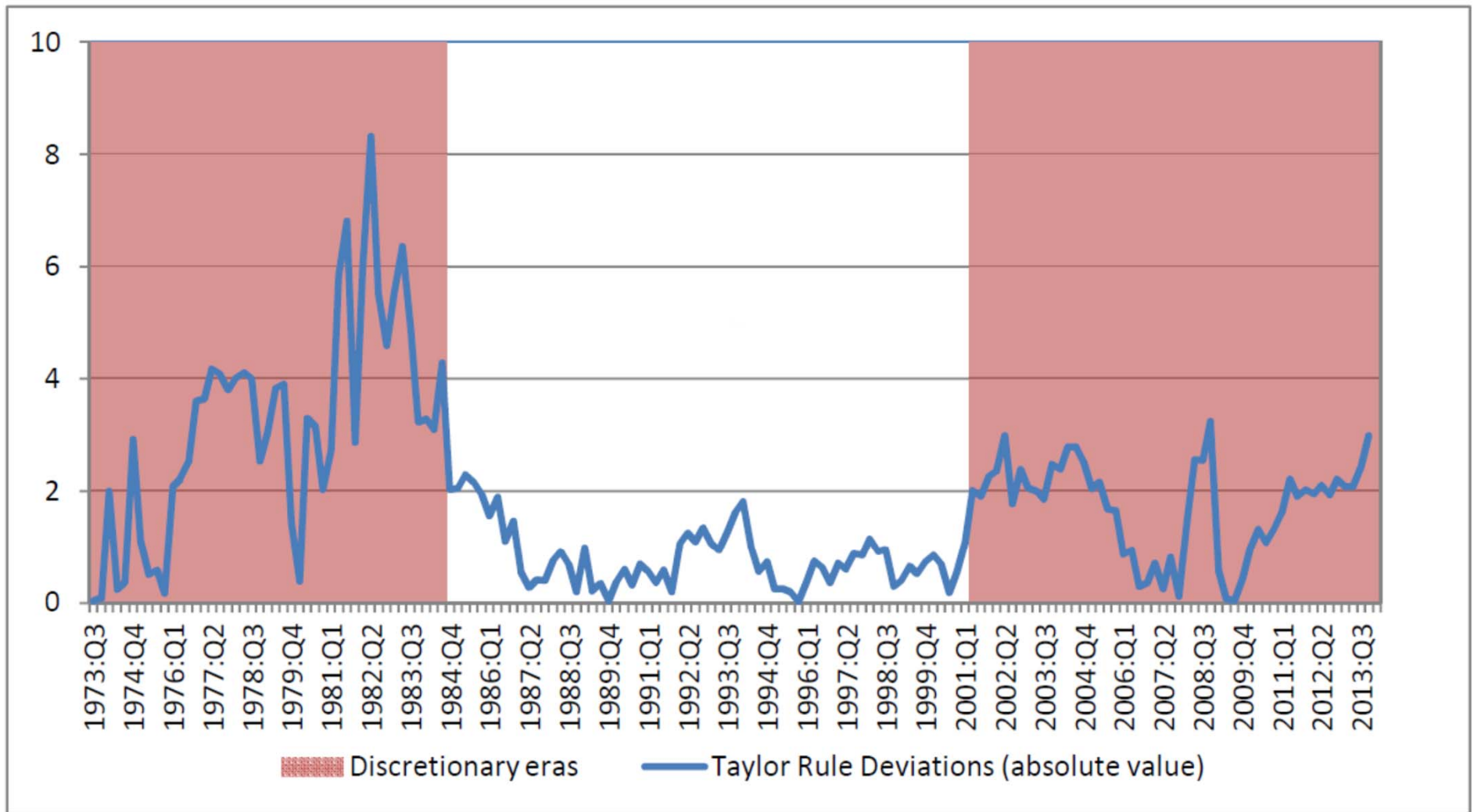Sources: International Monetary Fund staff estimates. Based on presentation by Giovanni Dell'Ariccia at Bank of Korea-IMF conference on *Leverage in Asia*, December 2015.

Housing Investment versus Deviations from Policy Rule in Europe During 2001-6
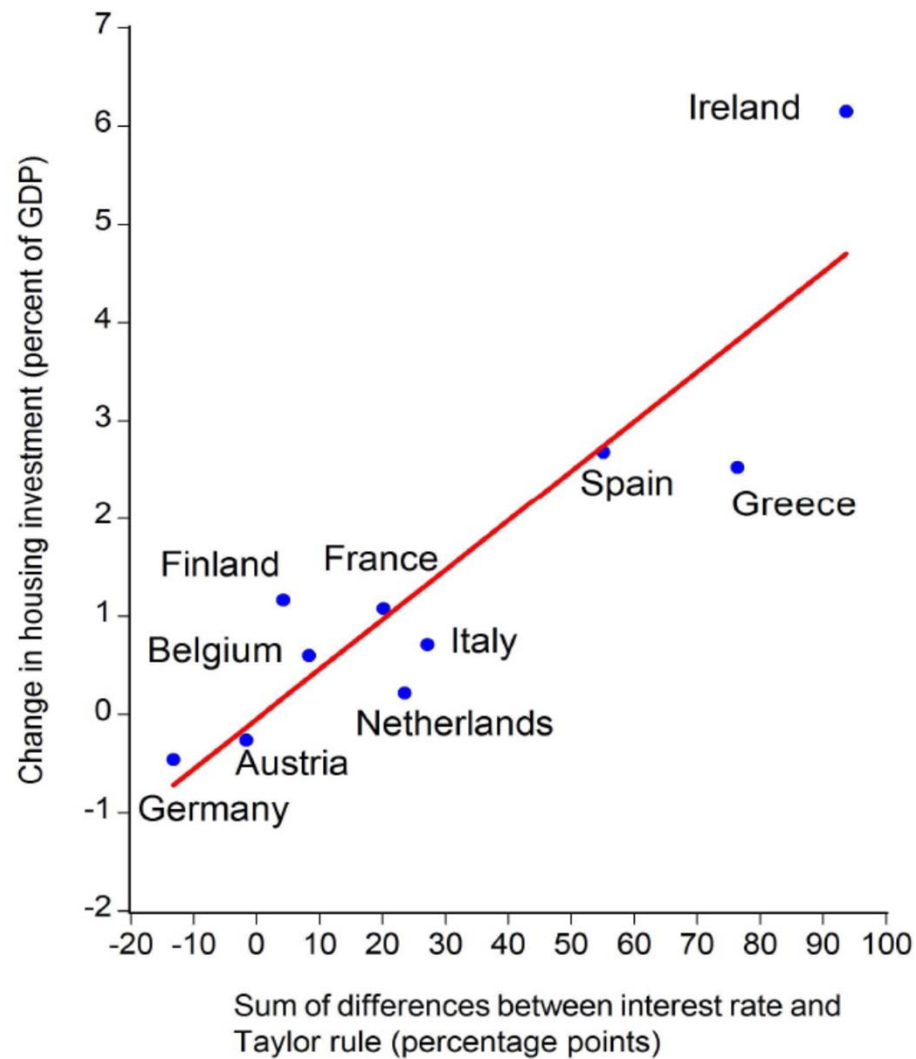
Source: OECD

Nikolsko-Rzhevskyy, Papell, Prodan

Economic Performance Comparisons

	Rules-Based	Discretionary
$(\pi-2)^2$	3.69	11.62
$(U-U^*)^2$	1.41	4.29

Inflation in Brazil

Inflation, consumer prices for Brazil

Source: World Bank

fred.stlouisfed.org

myf.red/g/dKBn
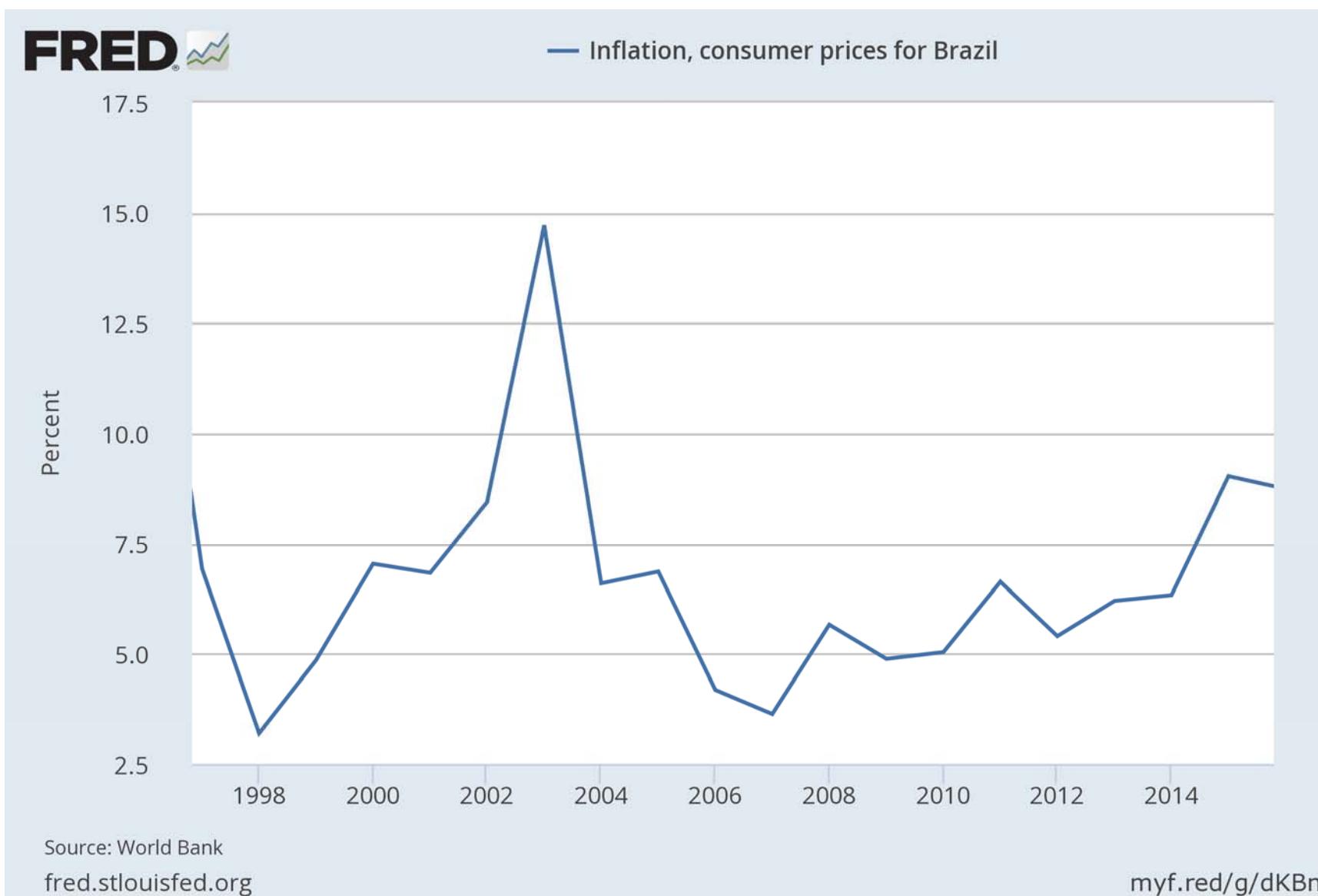
Policy rates compared to Taylor rules[1]

Graph 2
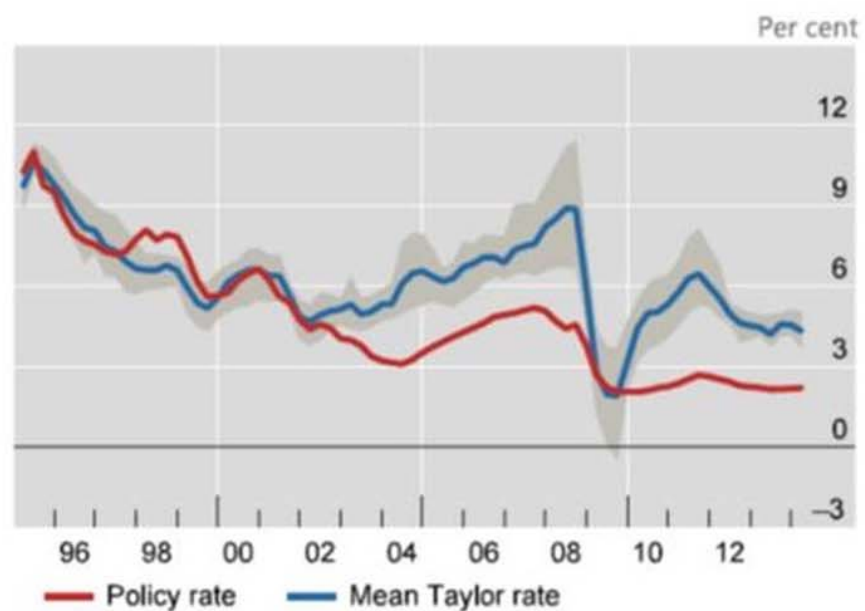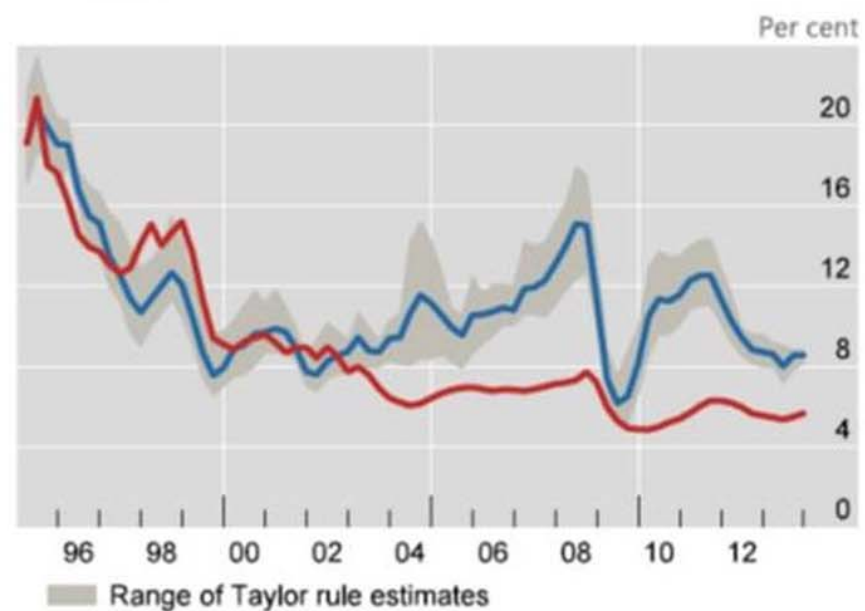
Source: BIS, Shin

Ideas for the Future

- This history implies that a goal of central bank research should be get to and stay in "rule-space."

- It was good while it lasted, and it is still good for many countries.

  - Even expectations of a return to rule-space policy analysis has benefits.

- But what can be done. What can researchers at central banks do? What research ideas can help?

- Here are some ideas…

Determine How Changes in Models Affect Policy Rules

- Many changes: integration of finance and macro, impact of the crisis…

- How do these affect the monetary policy rule?

- Example: "The large drop in output was completely unexpected from the point of the view of the DSGE model" (Linde, Smets, Wouters (2017)). So need new relationships:
  - Financial accelerator; makes a small difference DG—de Graeve
  - CMR --Christiano, Motto, Rostagno is better
  - Iacoviello (2005) Iacoviello &Neri (2010) borrowing constraints

- How do these new relationships affect the policy rule?

- Research by Wieland, Afanasyeva, Kuete, Yoo (2016)…

DSGE: Yearly growth
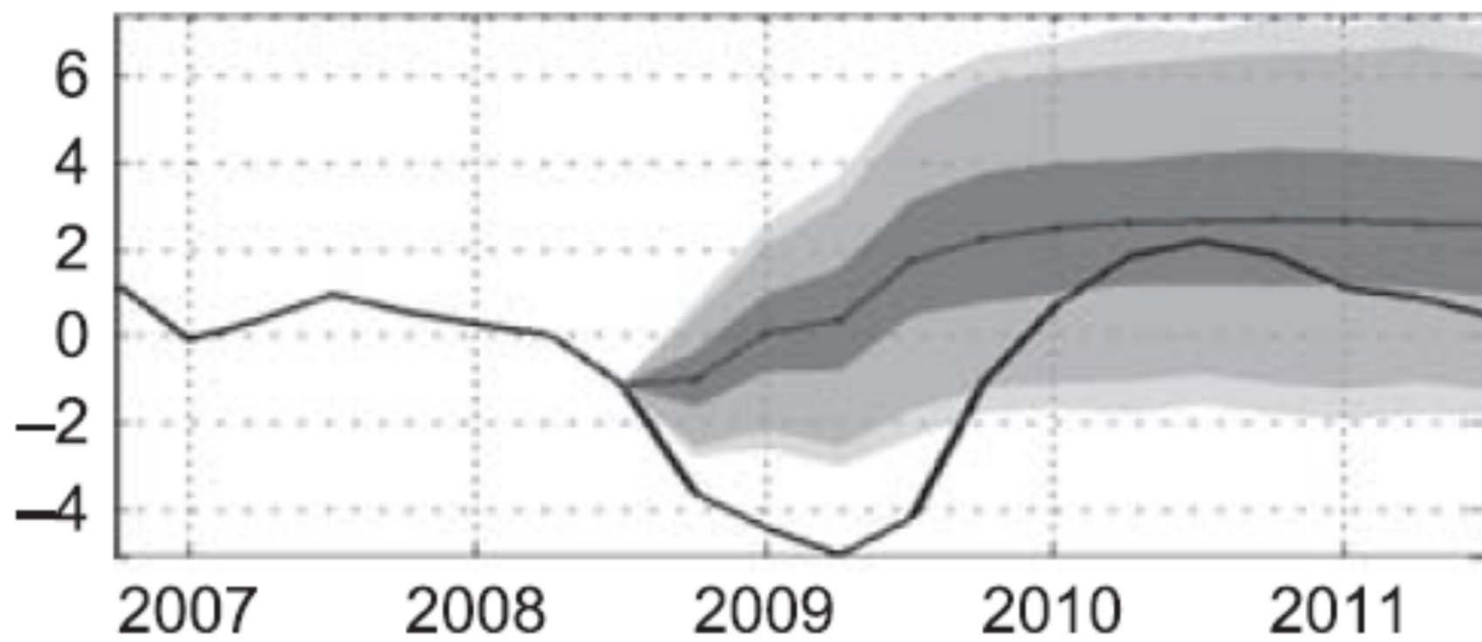
Table 13 Stabilization performance of policy rules with leaning-against-the-wind (credit growth)

	US_DG08	US_CMR14	US_IAC05	US_IN10
Model-specific rule				
Baseline	5.8	47.6	12.3	6.9
Leaning (0.1)	5.3	28.8	11.4	7.0
Leaning (0.3)	6.1	19.8	11.3	7.8

Check New Policy Rules or Deviations For Robustness

- Robustness checks counteract the tendency to exploit special properties of models that lead policy away from rules.

- Example: How a rules-based research program would look at the performance of traditional policy rules in newer models.
  - Wieland et al (2017)

Table 11 Eight interest rate rules

Model-specific rules

DG08 rule	$i_t^z = 0.90i_{t-1}^z + 0.23p_t^z - 0.08p_{t-1}^z + 1.14q_t^z - 1.10q_{t-1}^z$
IAC05 rule	$i_t^z = 0.73i_{t-1}^z + 0.34p_{t-1}^z + 0.14y_{t-1}^z$
IN10 rule	$i_t^z = 0.60i_{t-1}^z + 0.56p_t^z + 0.82y_t^z - 0.82y_{t-1}^z$
CMR14 rule	$i_t^z = 0.85i_{t-1}^z + 0.36p_t^z + 0.05y_t^z - 0.05y_{t-1}^z$

Other simple rules

Taylor rule	$i_t^z = 1.5\pi_t^z + 0.50q_t^z$
SW rule	$i_t^z = 0.81i_{t-1}^z + 0.39p_t^z + 0.97q_t^z - 0.90q_{t-1}^z$
OW08 rule	$i_t^z = 2.34E_t\pi_{t+3}^z + 0.765E_tq_{t+3}^z$
DIF rule	$i_t^z = i_{t-1}^z + 0.5\pi_t^z + 0.5(q_t^z - q_{t-4}^z)$

Note: The superscript z refers to common variables. i_t^z is the annualized short–term federal funds rate in quarter t. p_t^z refers to the annualized quarter–to–quarter rate of inflation, π_t^z is the year–on–year inflation rate, y_t^z is the deviation of quarterly real GDP from its long-run potential, while q_t^z refers to the output gap defined as the difference between actual GDP and the level of GDP that would be realized if prices and wages were flexible. All variables are expressed in percentage deviations from steady-state values.

Table 12 Stabilization performance and robustness

	US_DG08	US_CMR14	US_IAC05	US_IN10	Average loss
Model–specific rule	5.8	47.6	12.3	6.9	—
CMR14 rule	9.1	47.6	20.4	3.0	20.0
Taylor rule	5.3	34.5	6.2	4.3	12.5
SW rule	5.7	19.6	5.1	3.3	8.3
OW08 rule	4.6	29.3	∞	3.0	∞
DIF rule	2.7	5.5	3.3	2.6	3.6

Notes: The loss function is the sum of the unconditional variances of inflation and output gap. ∞ indicates indeterminacy.

Design Models for the Purpose of Evaluating Policy Rules

- Thinking about the policy rule as the main objective of policy research helps keep policy on track.

- Other models—perhaps variants on vector auto-regressions—could focus more on forecasting issues.

- The answers to questions of scope, size and type depend on the purpose of the model. To find policy rules or tradeoff curves smaller and focused models are often sufficient.

Build an Interface Between Policy Rules and Actual Decisions

- The current situation
  - Fed :"Longer-Run Goals and Monetary Policy Strategy" ECB: "Strategy"
  - But statements actually say little about strategy for instruments of policy

- NBU: "Objectives and Tasks of Monetary Policy"
  - "The main monetary policy instrument and the operational target under such a monetary framework is the interest rate. If the projected inflation is above the targeted level, the central bank pursues a tight monetary policy in order to contain inflation, that is, the interest rate is raised. Conversely, if the projected inflation is below the target, an easy monetary policy is conducted, whereby the interest rate is cut.

- Legislation may help:
  - Would require that the central bank describe its strategy
  - Proposal for Fed now in a bill which passed U.S. House
  - Proposal for NBU: "Rada would have to legislate the NBU's commitment….Obeying any reasonable rule would prevent the NBU from taking populist measures. To maintain credibility in the future, switching to a rules-based policy might be the solution….It would improve transparency for the Governor to explain why." Alex Nikolsko-Rzhevskyy (2014)

Think of a Rules-Based International Monetary System

- Idea: Expand on the idea of rules-based policy in each country with an international system with commitments to a monetary strategy

- Models can be enormously helpful here.
  - Show that Nash equilibrium is nearly optimal globally

- Paul Volcker: "the absence of an official, rules-based, cooperatively managed monetary system has not been a great success."

- Raghu Rajan "what we need are monetary rules…"

- Mario Draghi: "We would all clearly benefit from…improving communication over our reaction functions…"

Distinguish between Instrument Rules and Constrained Discretion

- Constrained discretion:
  - Sets goals only.
  - No strategy for the policy instruments.
- Constrained discretion is an appealing term, but it does not induce rules-based policy as the term suggests.

Build Models to Empirically Test Alternative Hypotheses about Monetary Policy Rules

- Example 1: Test alternative hypothesis that global financial crisis had non-policy causes.
  – Should be tested against the view that the problem was switching away from policy rules.
- Example 2: Deviations from rules based policy are (or are not) beneficial abroad
  – Rajan: What policies are Red, Yellow, or Green

Conclusion

- The history of macro models started in "path-space" and evolved to "rules-space" with a paradigm shift 4 decades ago.

- Central bank models followed to the benefit of policy and performance, though with a lag .

- Recently there has been a retrogression in parts of central banking world, and economic performance deteriorated.

- We need to get back to rules-space.

- Seven ideas were proposed.

- Perhaps the most powerful ideas are focus on
  - the interface between models and decisions,
  - the connection between policy rules and an international rules-based monetary system,
  - robustness through macro model comparison initiatives.