

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

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80 Years Ago: 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 in this mode; Lawrence Klein
- Models introduced in central banks for policy in 1960s
 - RDX1 (and RDX2, RDXF) at the Bank of Canada
 - Story told by Helliwell, Officer, Shapiro, and Stewart
 - MPS model at Fed
 - Story told by de Leeuw and Gramlich

40 Years Ago: Major Paradigm Shift

- Policy analysis moved from “Path-Space” to “Rules Space”
- Many antecedents:
 - Time series models, dynamic stochastic, control theory, A.W. Phillips
 - Realization that 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)

Paradigm Shift at Central Banks

- Change evident in Brooking Model Comparison project.
 - Bryant, Hooper and Mann (1993)
 - previous model-comparison exercises looked at *one-time changes* in instruments; this one emphasized comparison of *policy rules*.
 - Computational and conceptual barriers were overcome
- Bank of Canada: In early 1990s the RDX1, RDX2, RDXF were replaced by QPM.
 - Poloz, Rose and Tetlow (1994). Coletti et al (1996): “Two important features: forward-looking expectations and endogenous policy rules.”
 - Continued through the 1990s and into the 2000s with ToTEM
- Fed: In early 1990s, MPS model was replaced by FRB/US.
 - Brayton and Tinsley (1996) “Expectations of private sectors are explicit; these expectations...constitute a major transmission channel of policy.” Also Brayton, Levin, Tryon, and Williams (1997).
 - Continued with newer models such as SIGMA

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

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, Laforge (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 based on Murchison and 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)

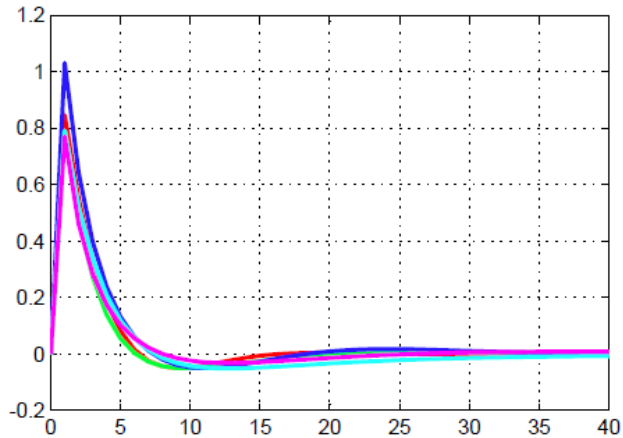
Compare Impact of Monetary Shocks in this Modelling Framework

SW Rule

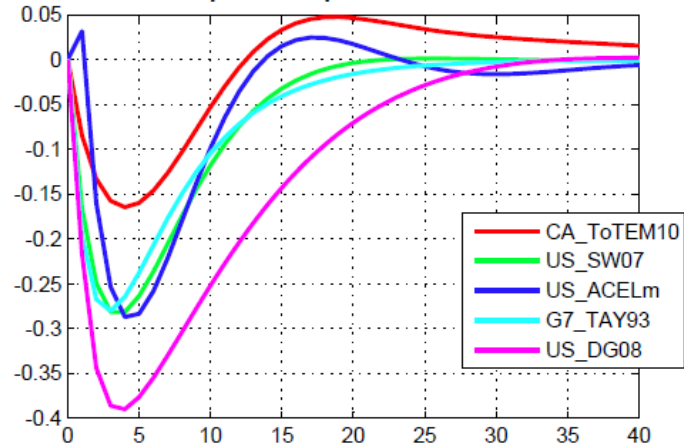
$$i_t = 0.81i_{t-1} + 0.39\pi_t + 0.97y_t - 0.90y_{t-1} + \varepsilon_t^i$$

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

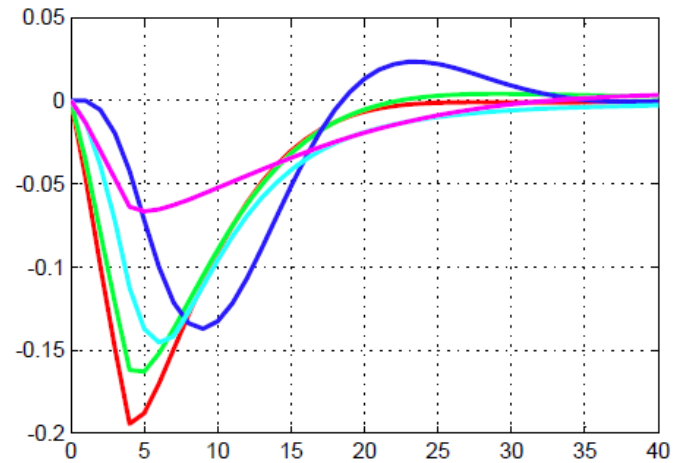
IRF of Interest Rate to Mon. Pol. Shock



IRF of Output Gap to Mon. Pol. Shock



IRF of Inflation to Mon. Pol. Shock



Alleged Problems with the Framework

- Short term interest rate affects consumption and investment directly?
 - Textbook versus practical versions
- Assumed away financial frictions?
 - Measurement problems forced econometric modelers away from the quantities of credit and foreign exchange toward the prices of these items
 - But financial accelerator was there (DeGraeve)
- Did not deal with zero lower bound?
 - 1% was the lower bound in early work in 1980s
 - Reifschneider-Williams method in 1999

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, and Gertler, and later confirmed by others
- Dramatic improvement compared with 1970s when policy was highly discretionary and unfocused.
- Mervyn King called it the NICE period
- Many emerging market countries joined
 - Including through Inflation targeting
 - Performance improved & contributed to global stability

Deviating from Framework Didn't Work

- The end of NICE in both senses of the word.
- Great Recession & Not-So-Great Recovery
- Unconventional policies have not worked very well, or have now reached diminishing or negative returns
- Concerns about international spillover effects
- Small open economies impacted

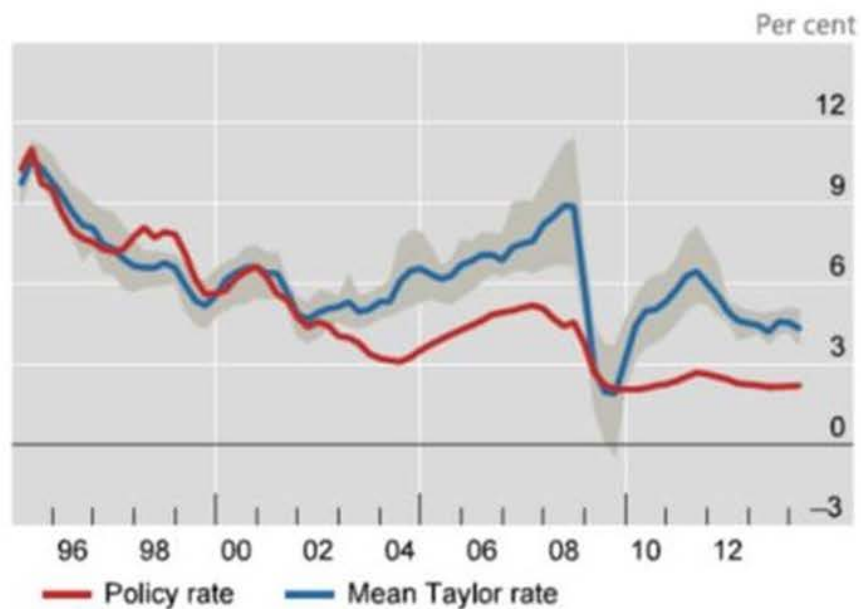
Evidence

- Evidence of monetary policy swinging away from rule-like policies
- Detected by many (Taylor, Kahn, Ahrend, Lane)
 - 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
 - History: Meltzer
- “Global Great Deviation” Hofmann & Bogdanova
 - Policy spillovers: Siklos-Neuenkirch (2014), Gray (2013)

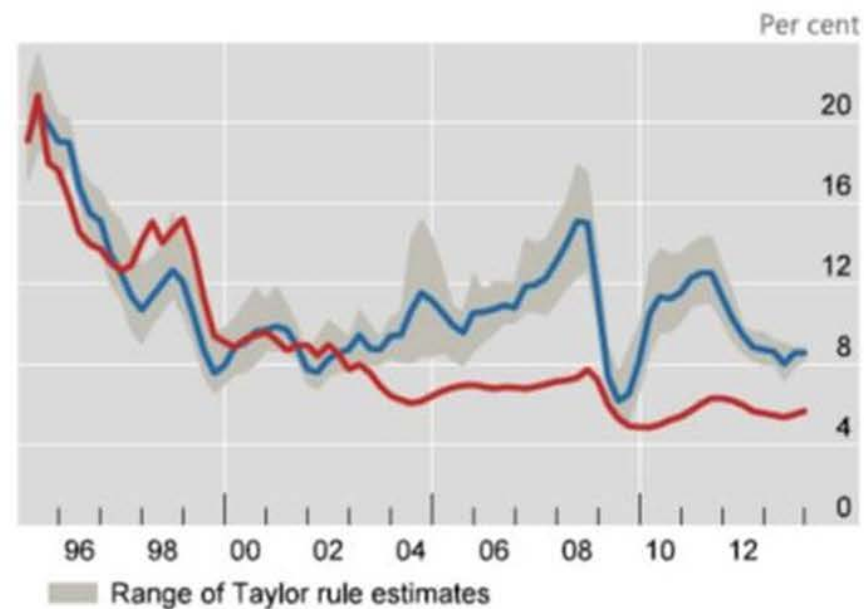
Policy rates compared to Taylor rules¹

Graph 2

Global

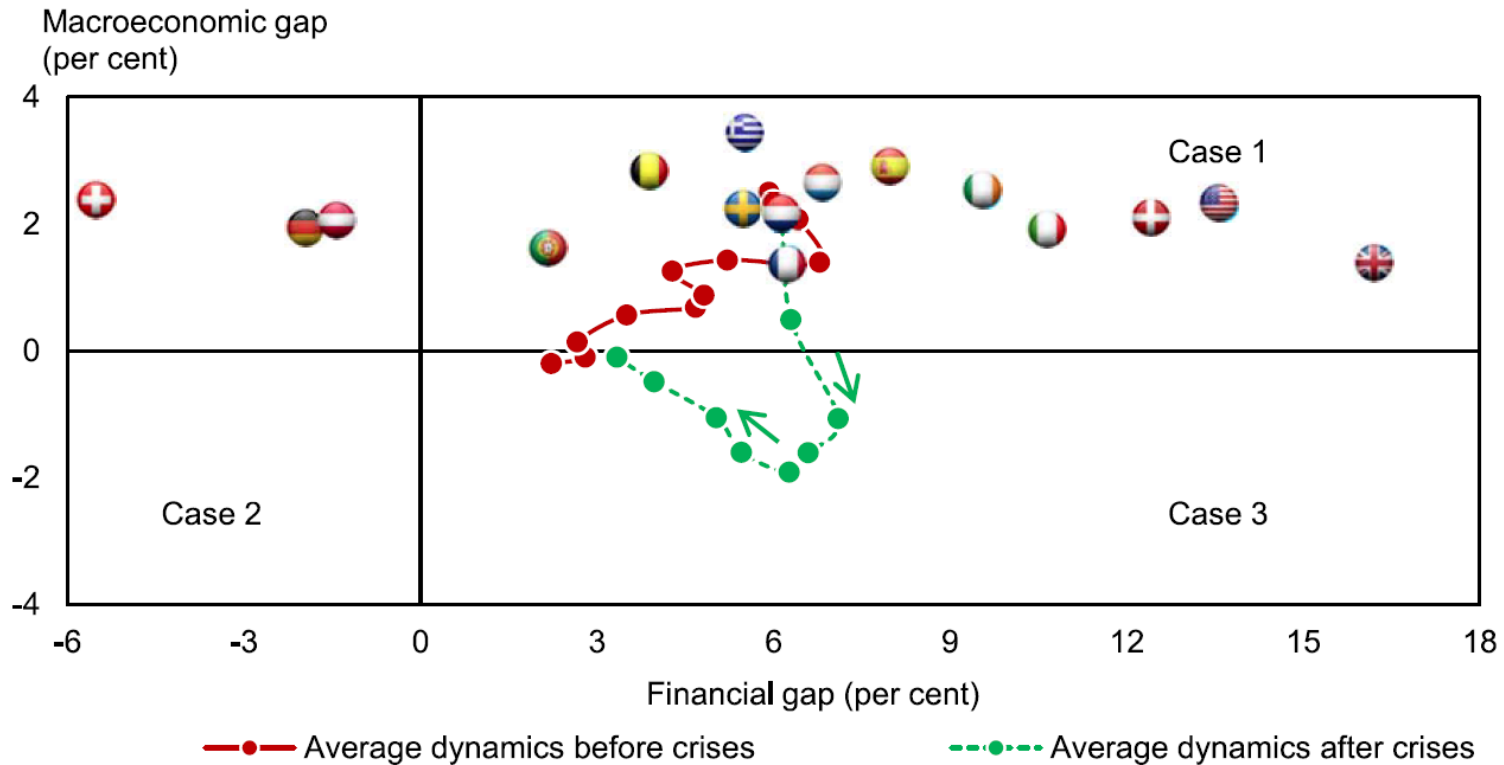


Emerging markets



Source: BIS, Shin

From Timothy Lane (2016)



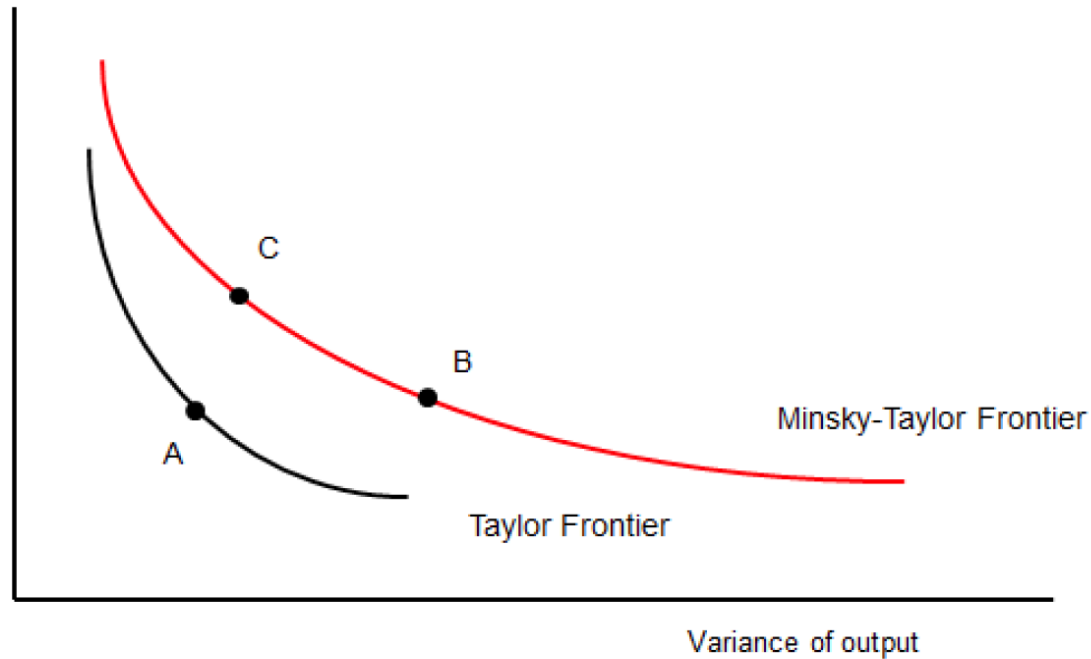
Note: Data for selected advanced economies that faced a banking crisis in 2007–08. Vertical axis shows economic gap, measured as average of estimated output gap and inflation deviation from target. Horizontal axis shows financial gap, measured as average of deviations in the credit-to-GDP ratio and real 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.

Of course, there are other views!

Chart from Carney (2013), also King (2012)

Variance of inflation



Ideas for the Future

- This history implies that a goal of central bank research should be to get back to “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 do? What research ideas can help?
- Here are some ideas...

Determine How Changes in Models Affect Policy Rules

- Many changes: new distributional channels (Auclert(2016)), behavioral considerations (Gabaix (2016)), 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 (2016)). See Chart.
- Need unlikely combination of shocks, or new relationships:
 - Financial accelerator; makes a small difference DG—de Graeve
 - CMR --Christiano, Lawrence, Motto, Rostagno is better
 - Iacoviello (2005) Iacoviello & Neri (2010) borrowing constraints
- How do these models affect the policy rule?
- Research by Wieland, Afanasyeva, Kuete, Yoom (2016)...

DSGE: Yearly growth

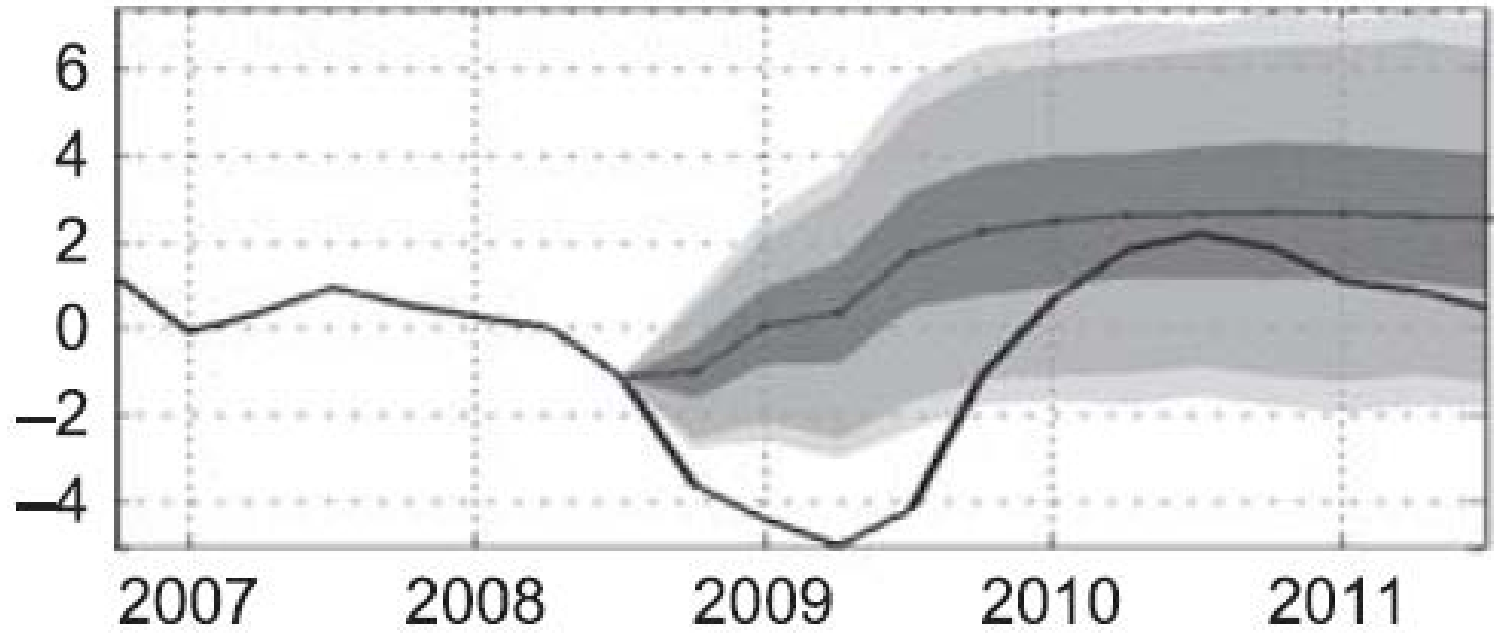


Table 13 Stabilization performance of policy rules with leaning-against-the-wind (credit growth)

	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

Notes: the loss function includes the variance of inflation and the variance of the output gap.

Thoroughly Check New Policy Rules or Interventions For Robustness

- Robustness checks counteract the tendency to exploit special properties of models that lead policy away from rules.
- Consider for example how a rules-based research program would look at the performance of traditional policy rules in the newer models.
- Wieland et al (2016), show that several model specific rules work well in the model they are designed for, but the performance is mixed in the other models

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.
- An example is the construction of a baby ToTEM by Lepetyuk, Maliar and Maliar (2016) for the purpose of examining how policy rules are constrained by the zero lower bound.

Build an Interface Between Policy Rules and Actual Decisions

- Important to find ways to relate actual policy to the policy rules. Not an easy problem.
- Legislation may provide some guidance.
 - Would require that Fed “describe the strategy or rule of the FOMC for the systematic quantitative adjustment” of policy instruments.
- As if the central bank would put the strategy in a glass lockbox for several years with the supposition that it would not be changed for several years.
 - The central bank of course could change its strategy
- There are other ways to deal with the interface.
 - Charles Plosser and Jeff Lacker argue that Fed could simply explain regularly how policy rules are used

Think of a Rules-Based International Monetary System

- Idea: Expand on the idea of rules-based policy in each country with an international agreement in report and commit 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.”
- Raghuraj 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, Forecast Targeting Rules, and Constrained Discretion

- Forecast Targeting Rules
 - Woodford (2012): “Forecasting Targeting as a Monetary Policy Strategy”
 - Example $(\pi_{t+h,t} - \pi^*) + \phi x_{t+h,t} = 0$
- Constrained discretion: goals only. Policymakers do whatever it takes.
 - 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: The important Carney-King hypothesis is that tradeoff curve moved adversely because of Minsky type effects.
 - Should be tested empirically 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 80-year history of macro models started in “path-space” and evolved to “rules-space” with a paradigm shift 40 years 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.