CME Group

A Bayesian Interpretation of the Federal Reserve's dual mandate and the Taylor Rule

R/Finance 2013

The research views expressed herein are those of the author and do not necessarily represent the views of the CME Group or its affiliates.

All examples in this presentation are hypothetical interpretations of situations and are used for explanation purposes only.

This report and the information herein should not be considered investment advice or the results of actual market experience.

Samantha Azzarello
Economist, CME Group

May 2013

Risk Disclosures

Futures trading is not suitable for all investors, and involves the risk of loss. Futures are a leveraged investment, and because only a percentage of a contract's value is required to trade, it is possible to lose more than the amount of money deposited for a futures position. Therefore, traders should only use funds that they can afford to lose without affecting their lifestyles. And only a portion of those funds should be devoted to any one trade because they cannot expect to profit on every trade.

The information within this presentation has been compiled by CME Group for general purposes only. CME Group assumes no responsibility for any errors or omissions. Although every attempt has been made to ensure the accuracy of the information within this presentation, CME Group assumes no responsibility for any errors or omissions. Additionally, all examples in this presentation are hypothetical situations, used for explanation purposes only, and should not be considered investment advice or the results of actual market experience.

All matters pertaining to rules and specifications herein are made subject to and are superseded by official CME, CBOT, NYMEX and CME Group rules. Current rules should be consulted in all cases concerning contract specifications.

CME Group

Outline

- Objective
- Taylor Rule
- Econometrics – Why Bayesian Statistics?
- Model
- Other Applications

CME Group

Contribution

- **To look at the Fed's interest rate policy through the lens of the Taylor Rule.**
- **Using a Dynamic Linear model with Bayesian Inference to update parameters over time.**
- **Using only the information available to the Fed at each point in time.**

CME Group

Original Taylor Rule

Analyzes interest rate policy in the context of the Fed's Dual Mandate:

Promoting price stability and encouraging full employment

Target Federal Funds Rate =

Actual Inflation Rate

- Short-Term Real Rate Assumption

+ 0.5 X (Actual Inflation – Desired Inflation)

+ 0.5 X (Output Gap in Percent)

CME Group

Relative Influence of Inflation and Economic Growth

Adjusted Level of Federal Funds Rate =

+ β_0 x Constant

+ β_1 x (Inflation – Desired Inflation)

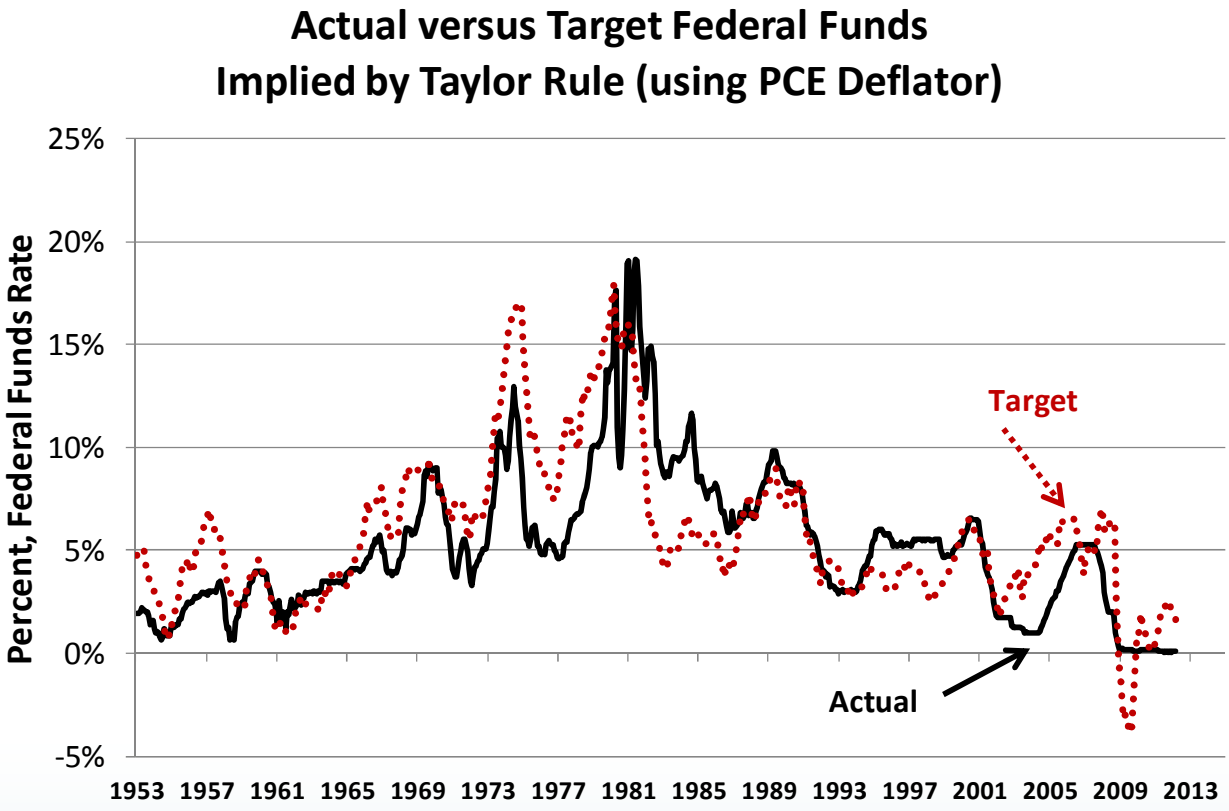
+ β_2 x (Output Gap)

Broke down analysis into the Inflation and Output components

- **Are estimated $\beta_1$and β_2 stable over time?**
- **Close to their expected values of 0.5 given the Taylor Rule?**

CME Group

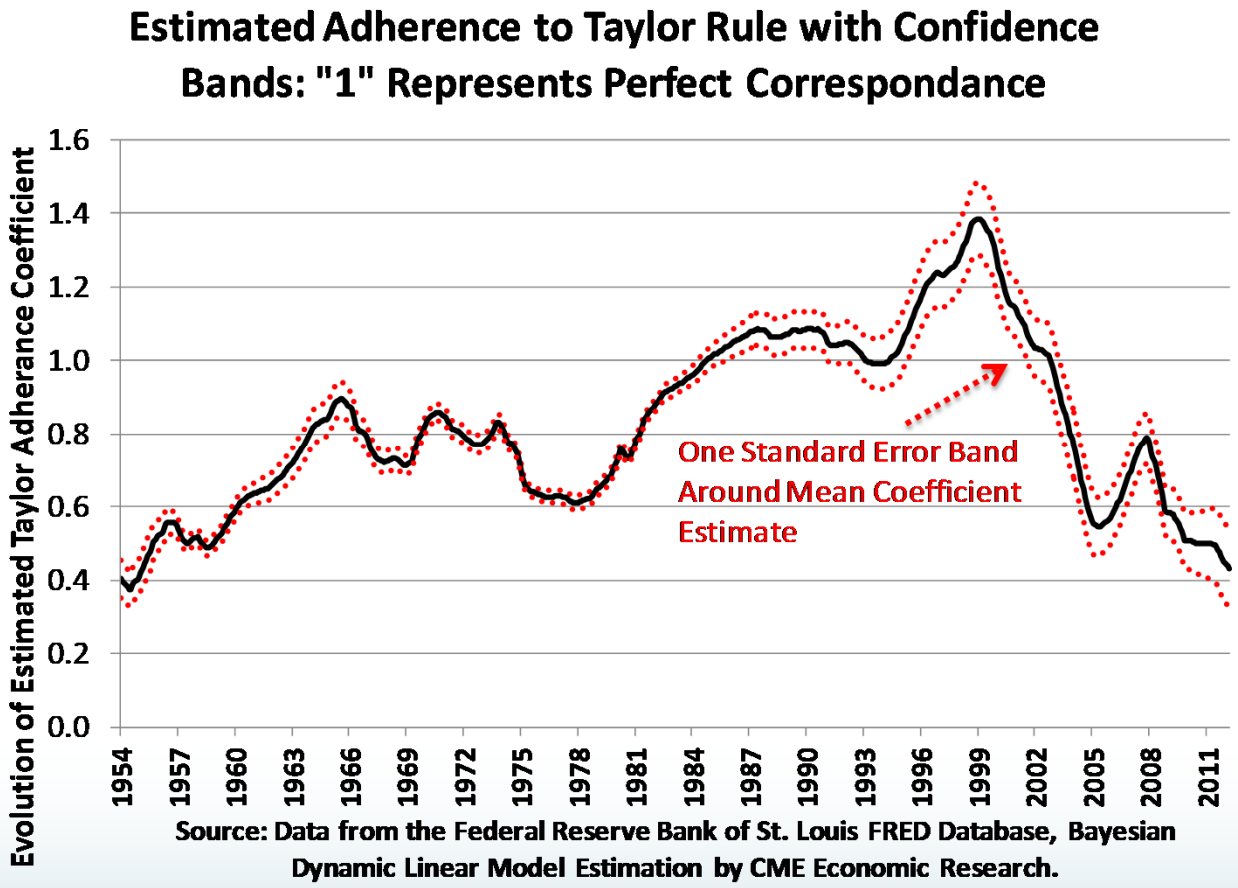
Federal Reserve Policy
Original Taylor Rule and Level of FFR



Source: Data from the St. Louis Federal Reserve FRED Database, Calculations by CME Economic Research.

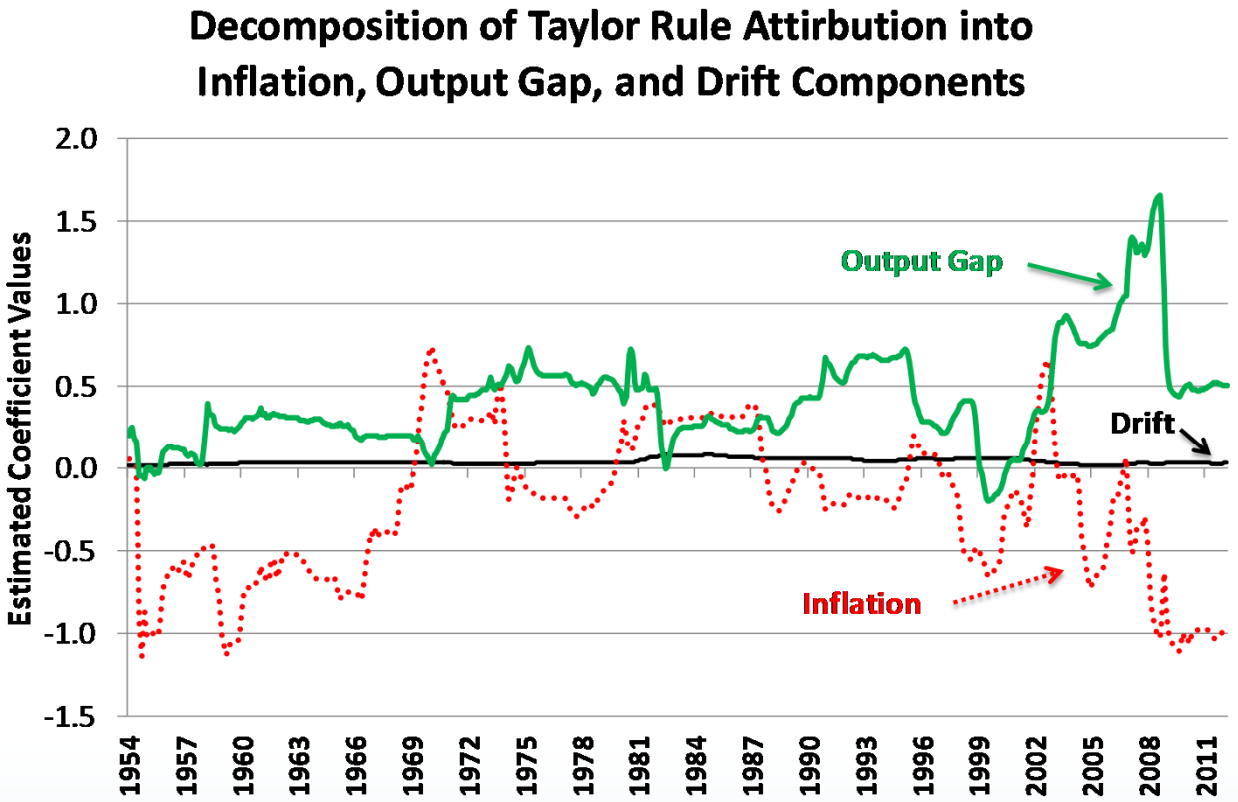
CME Group

Estimated Beta Coefficient for the Target Rate Given by the Taylor Rule



CME Group

Taylor Rule Adherence Analyzed by Components



Source: Data from the Federal Reserve Bank of St. Louis FRED Database, Bayesian Dynamic Linear Model Estimation by CME Economic Research.

CME Group

Why Bayes? Thought process is the same as in finance.

Develop a hypothesis based on available information/theories and assess one's confidence.

Receive new information, evaluate errors in terms of previous hypothesis, then develop new hypothesis and new confidence assessment.

Photo Source: Public (Unknown)

CME Group

Motivation
Dynamic Linear Model

- Dynamic allows time varying parameter estimates.
- Sequential analysis allows for updating of estimates as new observations are observed.
- Compare:

  OLS - One set of Beta Estimates for whole time period.

  DLM – Impact of variable X on Y can change and vary over time. DLM estimates capture this change.

- Modified Kalman Filter

CME Group

Classical vs. Bayesian Statistics
How uncertainty is treated

Classical:

Uncertainty about quantities or parameters estimated is captured by looking at how estimates would change in repeated sampling from the same population.

Bayesian:

Uncertainty is addressed by updating *prior* opinions about quantities and parameters estimated as new data is observed.

CME Group

Bayesian Analysis

PRIOR x LIKELIHOOD → POSTERIOR

- Prior – Initial probability distribution of parameters
- Likelihood – Joint probability of observing the data given the parameters estimated
- Posterior - Probability of parameters given the data
- The process of moving from Prior to Posterior is called Bayesian Learning

CME Group

Priors

Non-informative Priors:

- Variance of 10,000 and mean of 0
- Reflection of lack of knowledge

Informative Priors:

- Controversy regarding use and variability of results

CME Group

DLM Equations

The DLM is a two equation system estimated as:

Observation Equation

$$Y_t=(F_t)' \beta_t + v_t \qquad v_t \sim N[0,V_t]$$

- **Where F are the explanatory factors and β are the Beta parameter estimates**

State Equation

$$\beta_t = G_t \beta_{t-1} + w_t \qquad w_t \sim N[0,W_t]$$

- **Governs the path of Beta Estimates changing over time**

CME Group

DLM Iteration Steps

1. Posterior at t-1 $(\beta_{t-1}|D_{t-1})\sim N[m_{t-1},C_{t-1}]$
2. Prior at t $(\beta_t|D_{t-1})\sim N[a_t,R_t]$
3. Next-step ahead forecast $(Y_t|D_{t-1})\sim N[f_t,Q_t]$
4. Posterior at t $(\beta_t|D_t)\sim N[m_t,C_t]$

CME Group

DLM Output

- **Update the Distribution of parameters, and hence update the 2 moments which characterize each distribution.**

- **From the Posterior Distribution at time t:**

  Mean → Beta Coefficient

  Standard Deviation → Standard Error

CME Group

Applications

- **Federal Reserve Policy**
- **Natural Gas Price and Power Price**
- **GDP Forecasting**
- **Trade Volume Models**

CME Group

References

Harrison, J. & West,M. (1997). *Bayesian Forecasting and Dynamic Models.* New York: Springer-Verlag.

Harrison, J., Pole, A., & West,M. (1994). *Applied Bayesian Forecasting and time series analysis.* New York: Chapman and Hall.

Orphanides, A. (2003). Historical monetary policy analysis and the Taylor Rule. *Journal of Monetary Economics, 50(5), 983-1022.*

Putnam, B. & Azzarello, S. (2012). A Bayesian interpretation of the Federal Reserve's dual mandate and the Taylor Rule. *Review of Financial Economics, 21, 111-119.*

Taylor, J. (1993b). The use of new macroeconometrics for policy formation. *American Economic Review, Papers and Proceedings, 83(2),* (300-305).

CME Group

CME Group

A Bayesian Interpretation of the Federal Reserve's dual mandate and the Taylor Rule

R/Finance 2013

The research views expressed herein are those of the author and do not necessarily represent the views of the CME Group or its affiliates.

All examples in this presentation are hypothetical interpretations of situations and are used for explanation purposes only.

This report and the information herein should not be considered investment advice or the results of actual market experience.

Samantha Azzarello
Economist, CME Group

May 2013