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Great Deviation from the Taylor Rule-guided Monetary Policy Caused Great Recession- Historical and Empirical Analyses

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This paper investigates if the Great Recession of 2007 and onward was a consequence of the Great Deviation from rule-guided monetary policy. Using US data for the period between 1957 and 2010 the study concludes that Taylor-rule based monetary policy is a good policy that has substantial strength to tackle economic turbulences. We find evidence that Great Deviation of the Federal Reserve from Taylor-type monetary policy led the US economy to a prolonged recession. The paper discusses the background of Taylor rule, optimality property of the rule and its major modifications. Also we provide evidence that past policy mistakes caused economic turbulences like Great Depression of 1930s and Great Inflation of 1970s. We observe that the performance of US economy was better in terms of inflation and output during the period when federal funds rates were equal to or above the Taylor's prescribed rates. Based on both historical and empirical analyses the paper also concludes that policy-makers deviate from commitment either myopically or intentionally that deliberately generate economic crises.

Field of Research: Taylor Rule-guided Monetary Policy

1. Introduction

Well designed monetary policy can foster major policy objectives such as price and output stability, thus can avoid economic turbulences. There is a consensus that historical economic turmoil like the Great Depression of 1930s, the Great Inflation of 1970s and the Great Recession of 2007 were the consequences of policy mistakes. Allan H. Meltzer (2009) in his *A History of the Federal Reserve* identifies the massive contraction in money as the cause of Great Depression. Meltzer states, "From the peak of the cycle in the summer of 1929 to the bottom of the depression in March 1933, the stock of money— currency and demand deposits—fell by 28 percent and industrial production fell by 50 percent"(p. 271). According to Meltzer this contraction could be prevented if Federal Reserve officials would have identified the real interest rate and broader monetary aggregates as the measures of monetary tightness instead of nominal interest rate and member bank borrowings (Taylor 2010a). Meltzer argues that this faulty view together with incorrect view of the monetary transmission mechanism and above all the absence of a sensible rule or strategy of the

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Federal Reserve to guide its decisions resulted in discretionary actions that worsened the situation. The Great Inflation during 1965-70 was caused by reverse mistaken action of careless increase in money supply at a low real rate of interest. Evidence suggests that this economic turmoil is attributable to the narrow view of Federal Chairman Martin who said Fed should be “independent within the government”. Moreover, Fed officials were convinced with the argument that higher inflation would reduce unemployment permanently therefore did not increase interest rate in the face of massive increase in money supply which eventually accelerated inflation. Federal Chairman Paul Volcker’s desperate role against inflation resulted in excellent economic performance during post 1983 but *myopic* moves of policymakers form rule-like behaviour to more interventionist again called in financial crisis and economic recession in 2007. It is widely accepted that well designed monetary policy can counteract macroeconomic disturbances and dampen cyclical fluctuations in prices and employment, thereby improving overall economic stability and welfare (Orphanides, 2007).

This paper argues that recent economic crises could have been avoided, had the Federal Reserve not deviated from Taylor rule-guided monetary policy. We investigate that monetary policy in the USA during 2003 onward was much discretionary rather than rule-guided that might have caused several disturbances in the economy. Taylor (2010b) terms this prolonged deviation from rule-guided policy as the Great Deviation. As the key objective of this study we hypothesize that such Great Deviation is largely responsible for the Great Recession started in 2007. Quarterly US data between 1957 and 2010 have been used to estimate Taylor rule for the entire period and several sub-periods. It seems when Federal Reserve’s policy action was consistent with Taylor rule, US economy performed better than any other period. Next section reviews literatures, discusses historical and analytical background of Taylor rule and subsequent modifications of the rule. Section 3 illustrates data and methodology used in the study, section 4 illustrates empirical results and section 5 concludes.

2. Literature Review and Taylor Rule

2.1 About Taylor Rule

Stanford University professor John B. Taylor (1993) presented an influential paper at *Carnegie-Rochester Conference Series on Public Policy 39* where he proposed a very simple interest rate reaction function by considering inflation and output deviations as the determinants of federal funds rate. He claimed that expressing the federal funds rate as a linear function of current inflation’s deviation from an inflation target and the output gap was not only a good description of previous monetary policy in the US, but also a reasonable policy recommendation (Österholm, 2003).

Taylor rule is a linear algebraic rule described by equation (1.1) below that specifies how the Federal Reserve must adjust its funds rate following deviations of inflation and output from targets.

$$i_t = \bar{r} + \pi_t + \beta_\pi(\pi - \pi^*) + \beta_y y_t \quad .... \; .... \; .... \quad (1.1)$$

Where,

i_t : nominal rate of interest

$\bar{r}$: long run equilibrium real rate of interest

π_t: rate of GDP-deflator-inflation over the previous four quarters

π^*: target rate of inflation and

y_t: percentage deviation of real output from potential (target) output.

Taylor rule recommends a target for the level of nominal interest rate (i_t) that depends on four factors. First factor is the equilibrium real interest rate $(\bar{r})$. Second factor is the current inflation rate (π_t). When added together these two factors provide a benchmark recommendation for the nominal interest rate that would keep inflation at its current rate, provided the economy is operating at its potential. Third factor is inflation gap adjustment factor based on the gap between the inflation rate and a given target rate of inflation. This factor recommends raising the interest rate above the benchmark if inflation is above the target and lowering the interest rate below benchmark if inflation is below the target. Fourth factor is an output gap adjustment factor based on the gap between real GDP and potential GDP. This factor recommends raising interest rate above the benchmark if the gap is positive and lowering interest rate below the benchmark if the gap is negative. The third and fourth factors summarise two objectives of monetary policy- targeting stable rate of inflation while promoting maximum sustainable growth. These adjustment factors can also be seen as incorporating both long-run and short-run goals. The inflation gap adjustment factor incorporates the central bank's long-run inflation goal. The output gap adjustment factor incorporates the view that in the short-run policy should lean against cyclical winds (Kozicki, 1999).

The use of the equilibrium real rate in the Taylor rule emphasises that real rates play a central role in formulating monetary policy. Although the nominal interest rate is identified as the instrument that policymakers adjust, the real interest rate is what affects real economic activity. In particular, the rules clarify that real interest rates will be increased above equilibrium when inflation is above target or output is above its potential.

Taylor (1993) sets both the long run equilibrium real interest rate and the target inflation rate equal to 2, and β_π are β_y set equal to 0.5. Using these values, equation (1) can be rewritten as,

$i_t = 1 + 1.5\pi_t + 0.5y_t$ .... (1.2), it follows that $\frac{\partial i_t}{\partial \pi_t} = 1.5 > 1$. This indicates alone percent increase in inflation rate results in more than one percent increase in nominal rate of interest and vice versa. This is termed as Taylor's principle instructing that central bank should react more than 1-1 to inflation in order to lower the current inflationary pressure. The mechanism is straightforward. If nominal rate of interest is increased more than one percent following a one percent increase in inflation, real rate of interest will rise and demand will fall that eventually will dampen inflationary pressure. Equation (1.2) also signifies that if both inflation rate and real GDP are on target then Federal

Funds rate would be 4% or 2% in real term. By linking interest rate decision to inflation and economic activity, Taylor rules offered a convenient tool for studying monetary policy while abstracting from a detailed analysis of demand and supply of money (Orphanides, 2007).

Since its inception, Taylor rule gained tremendous currency from the researchers around the world. Enormous enthusiasm grew over the fact that, even being a hypothetical rule, time paths of Taylor's proposed interest rate almost overlapped with actual federal funds rate during the period 1987-92.

2.2 Optimality of Taylor Rule

Although Taylor proposed a hypothetical rule but it has optimality property because such a rule can be derived by minimizing a loss function. Assuming

Loss function: $$\sum_{t=0}^{\infty}\delta^t\left[(\pi_t-\pi_t^*)^2+\alpha_y y_t^2+\alpha_i(i_t-i_t^*)^2\right]$$

IS equation or AD equation : $$y_t = E_t y_{t+1} - \varphi(i_t - E_t\pi_{t+1} - r_t^n)$$

AS equation or Phillips curve: $$\pi_t - \pi_t^* = \alpha(E_t\pi_{t+1} - \pi_{t+1}^*) + \kappa y_t$$

Lagrangian Function,

$$\begin{aligned}L_t &= (\pi_t-\pi_t^*)^2+\alpha_y y_t^2+\alpha_i(i_t-i_t^*)^2+\delta(\pi_t-\pi_t^*)^2+\delta\alpha_y y_t^2\\&+\delta\alpha_i(i_t-i_t^*)^2+\delta^2(\pi_t-\pi_t^*)^2+\delta^2\alpha_y y_t^2+\delta^2\alpha_i(i_t-i_t^*)^2+\delta^3\ldots\\&+\phi_{1,t}\left\{E_t y_{t+1}-\varphi(i_t-E_t\pi_{t+1}-r_t^n)-y_t\right\}+\phi_{2,t}\left\{\alpha(E_t\pi_{t+1}-\pi_{t+1}^*)+\kappa y_t-(\pi_t-\pi_t^*)\right\}\\&+\delta\phi_{1,t}\left\{E_t y_{t+1}-\varphi(i_t-E_t\pi_{t+1}-r_t^n)-y_t\right\}+\delta\phi_{2,t}\left\{\alpha(E_t\pi_{t+1}-\pi_{t+1}^*)+\kappa y_t-(\pi_t-\pi_t^*)\right\}\\&+\delta^2\phi_{1,t}\left\{E_t y_{t+1}-\varphi(i_t-E_t\pi_{t+1}-r_t^n)-y_t\right\}+\delta^2\phi_{2,t}\left\{\alpha(E_t\pi_{t+1}-\pi_{t+1}^*)+\kappa y_t-(\pi_t-\pi_t^*)\right\}+\delta^3\ldots\end{aligned}$$

First period optimization solution is below:

$$\begin{aligned}L_t &= (\pi_t-\pi_t^*)^2+\alpha_y y_t^2+\alpha_i(i_t-i_t^*)^2+\phi_{1,t}\left\{E_t y_{t+1}-\varphi(i_t-E_t\pi_{t+1}-r_t^n)-y_t\right\}+\\&+\phi_{2,t}\left\{\alpha(E_t\pi_{t+1}-\pi_{t+1}^*)+\kappa y_t-(\pi_t-\pi_t^*)\right\}\end{aligned}$$

First order condition, $$\frac{\partial L_t}{\partial(\pi_t-\pi_t^*)}=\frac{\partial L_t}{\partial y_t}=\frac{\partial L_t}{\partial i_t}=0$$

$$\frac{\partial L_t}{\partial(\pi_t-\pi_t^*)}=2(\pi_t-\pi_t^*)-\phi_{2,t}=0 \quad ; \quad \frac{\partial L_t}{\partial y_t}=2\alpha_y y_t-\phi_{1,t}+\phi_{2,t}\kappa=0$$

$$\Rightarrow \phi_{2,t}=2(\pi_t-\pi_t^*) \qquad \Rightarrow \phi_{1,t}=2\alpha_y y_t+2(\pi_t-\pi_t^*)\kappa$$

$$\frac{\partial L_t}{\partial i_t} = 2\alpha_i (i_t - i_t^*) - \phi_{1,t}\varphi = 0$$

$$\Rightarrow 2\alpha_i (i_t - i_t^*) = \phi_{1,t}\varphi = (2\alpha_y y_t + 2(\pi_t - \pi_t^*)\kappa)\varphi$$

$$\Rightarrow \alpha_i (i_t - i_t^*) = \varphi\alpha_y y_t + \kappa\varphi(\pi_t - \pi_t^*)$$

$$\Rightarrow (i_t - i_t^*) = \frac{\varphi\alpha_y}{\alpha_i} y_t + \frac{\kappa\varphi}{\alpha_i}(\pi_t - \pi_t^*)$$

$$\Rightarrow i_t = i_t^* + \frac{\varphi\alpha_y}{\alpha_i} y_t + \frac{\kappa\varphi}{\alpha_i}(\pi_t - \pi_t^*)$$

Equation above is like Taylor's interest rate reaction function.

2.3 Link of Taylor Rule with Other Monetary Policy Rules

Taylor-type rule can even be derived from Friedman's quantity theory of money:

$$MV = PY \quad \dots \dots (A.1)$$

Logarithmic transformation yields:

$$m_t + v_t = p_t + y_t$$

$$v_t = y_t - (m_t - p_t) \quad \dots \dots (A.2)$$

Equilibrium velocity,

$$v_t^* = y_t^* - (m_t - p_t)^* \quad \dots \dots (A.3)$$

Equation (*A.4*) below reveals money demand relation that relates real money balances to income and interest rate.

$$m_t - p_t = \omega_y y_t - \omega_i i_t + \xi_t \quad \dots \dots (A.4)$$

$$m_t = p_t + \omega_y y_t - \omega_i i_t + \xi_t$$

$$\Delta m_t = \pi_t + \omega_y \Delta y_t - \omega_i \Delta i_t + \Delta\xi_t$$

Combining (*A.3*) and (*A.4*)

$$v_t^* = y_t^* - (\omega_y y_t^* - \omega_i i_t^* + \xi_t^*)$$

$$\Rightarrow v_t^* = (1 - \omega_y) y_t^* + \omega_i i_t^* - \xi_t^*$$

$$\Rightarrow \Delta v_t^* = (1 - \omega_y)\Delta y_t^* + \omega_i \Delta i_t^* - \Delta\xi_t^*$$

$$\Rightarrow \Delta v_t^* = (1 - \omega_y)\Delta y_t^* - \Delta\xi_t^* \quad \dots \dots (A.5)$$

(abstracting from changes in nominal interest rate)

Given, $m_t + v_t = p_t + y_t$

It implies, $\Delta m_t^* + \Delta v_t^* = \pi_t^* + \Delta y_t^*$

$$\Delta m_t^* = \pi_t^* + \Delta y_t^* - \Delta v_t^*$$

$$\Rightarrow \Delta m_t^* = \pi_t^* + \Delta y_t^* - (1-\omega_y)\Delta y_t^* + \Delta \xi_t^* \qquad \text{(using } A.5)$$

$$\Rightarrow \Delta m_t^* = \pi_t^* + \omega_y \Delta y_t^* + \Delta \xi_t^* \ldots \ldots (A.6)$$

Deviation of money growth from target:

$$\Delta m_t - \Delta m_t^* = \pi_t + \omega_y \Delta y_t - \omega_i \Delta i_t + \Delta \xi_t - \pi_t^* - \omega_y \Delta y_t^* - \Delta \xi_t^*$$

If money growth is in target, i.e., $\Delta m_t = \Delta m_t^*$, then

$$\omega_i \Delta i_t = \pi_t - \pi_t^* + \omega_y (\Delta y_t - \Delta y_t^*) + \Delta \xi_t - \Delta \xi_t^*$$

$$\Delta i_t = \frac{1}{\omega_i}(\pi_t - \pi_t^*) + \frac{\omega_y}{\omega_i}(\Delta y_t - \Delta y_t^*) + \frac{1}{\omega_i}(\Delta \xi_t - \Delta \xi_t^*)$$

$$i_t = i_{t-1} + \frac{1}{\omega_i}(\pi_t - \pi_t^*) + \frac{\omega_y}{\omega_i}(\Delta y_t - \Delta y_t^*) + \frac{1}{\omega_i}(\Delta \xi_t - \Delta \xi_t^*) \ldots \ldots (A.7)$$

Equation (*A.7*) is a Taylor-type interest rate reaction function augmented with lagged interest rate and money demand shock. Friedman's rule is a quantity rule but Taylor rule is price of money- interest rate rule. Interest rate based monetary policy rule was first proposed by Wickshell (1898). Wickshell argues that theoretically price stability would be obtained if interest rate is set equal to natural rate. But natural rate is unobservable hence Wickshell suggested a rather realistic rule, "If prices rise, the rate of interest is to be raised; and if prices fall, the rate of interest is to be lowered; and he rate of interest is henceforth to be maintained at its new level until a further movement in prices calls for a further change in one direction or the other" (Wickshell, 1898, p. 189). Notationally,

$$\Delta i = \theta \pi \ \ldots \ldots \ldots (C.1)$$

$$i - i_{-1} = \theta \pi$$

$$i = i_{-1} + \theta \pi \ \ldots. \ \ldots. \ \ldots. \ (C.2)$$

Equation (C.2) is similar to Taylor rule but it does not take explicit account of real economic activity what Taylor rule does.

2.4 Alternative Specifications of Taylor Rule

Since its inception, Taylor rule underwent a handsome amount of research in terms of its explanatory power (role of other variables than inflation and output gap), nature of variables (forward vs backward lookingness), degree of optimality and so forth. Few modifications are summarized below:

The most important modification in Taylor rule is attributed to introducing forward lookingness in setting interest rate. Keynes (1923) in *A Tract on Monetary Reform* observes that "If we wait until a price movement is actually afoot before applying remedial measures, we may be too late." Emphasizing this issue, several papers contributed to updating Taylor rule through the inclusion of forecast variables.

Clarida, Gali and Gertler (1998) provided one variant of forward looking version :

$$i_t^* = \alpha + \beta_\pi (E_t \pi_{t+1} - \pi^*) + \beta_y y_t; \quad \alpha = \bar{r} + \pi^* \text{.....(B.1)}$$

Where i_t^* is the target rate of interest. Under this specification interest rate responds to expected inflation as opposed to lagged inflation. If expected inflation or a linear combination of lagged inflation and output gap is a sufficient statistic for future inflation, then the specification collapses to the Taylor rule.

Clarida, Gali and Gertler argue that central banks may have the tendency to smooth interest rate adjustments hence a static version like (B.1) cannot capture the serial correlation present in data. Equation $(B.2)$ specifies the process of partial adjustment. $i_t = \rho i_{t-1} + (1-\rho) i_t^* \quad .... \; .... \; .... \; (B.2)$

(B.2) and (B.1) together result in:

$$i_t = \rho i_{t-1} + (1-\rho)\left\{\alpha + \beta_\pi (E_t \pi_{t+1} - \pi^*) + \beta_y y_t\right\} \quad .... \; .... \; .... \; (B.3)$$

ρ stands as the inertia parameter.

Clarida, Gali and Gertler (1998) proposed one baseline policy rule $(C.1)$ very similar to (B.1):

$$i_t^* = \alpha + \beta_\pi \left(E\left[\pi_{t,q} / \Omega_t\right] - \pi^* \right) + \beta_y E\left[y_{t,q} / \Omega_t\right] \quad .... \; .... \; .... \; (C.1)$$

Where i_t^* targeted federal funds rate in period *t*

$\pi_{t,q}$ is annual price inflation between periods *t* and *t+q*, and $y_{t,q}$ denotes average output gap between period *t* and *t+q.*

α stands for desired nominal rate of interest when both inflation and output are at their target levels. At the time of this rule's emergence, major central banks around the world behaved closely as *(C.1)*.

Forecast based rules are lag-encompassing and therefore may be viewed countercyclical. This virtue of a rule is emphasized because of the lag in monetary transmission mechanism. Monetary policy takes some time in impacting inflation and output therefore contemporaneous policy action may be rather porcyclical.

Batini and Haldane (1999) advocated forecast based rule like equation (D.1) below.

$$r_t = \rho r_{t-1} + (1-\rho) r_t^* + \beta (E_t \pi_{t+j} - \pi^*) \ \ .... \ .... \ .... \ (D.1)$$

Where, $r_t \equiv i_t - E_t \pi_{t+1}$ denotes short-term real interest rate.

$E_t(.) = E(./\Omega_t)$, *E* indicates expectation and Ω_t is the information set available at time *t*.

According to this rule monetary authority controls nominal interest rate that hits a path for the real interest rate. Deviation of expected inflation from the inflation target is feedback term which calls for remedial measure.

j indicates central bank's targeting horizon when forming its forecast. For example, the Bank of England chooses $j = 8$, i.e., feeds back from an inflation forecast of two years ahead.

Although rule (C.1) does not include output explicitly but Batini and Haldane argue that a judicious choice of j, β and j can well stabilize output.

Orphanides and Williams (2002) consider a modified variant of Taylor rule that responds to the unemployment gap instead of the output gap.

$$i_t = \hat{r}_t^* + \pi_t + \beta_\pi (\pi_t - \pi^*) + \beta_y (u_t - \hat{u}_t^*) \ \ .... \ .... \ .... \ (E.1)$$

Where $\hat{r}_t^*$ and $\hat{u}_t^*$ are the policymaker's estimates of the natural rates of interest and unemployment. Natural rate of unemployment is the unemployment rate consistent with stable inflation, the natural rate of interest is the real interest rate consistent with natural rate of unemployment, therefore with stable inflation. The complexity arises because policymakers do not know the values of these natural rates in real time, that is, when they make policy decision. Friedman (1968) argues that natural rate changes from time to time. Moreover, problem of measurements of natural rates intensifies when there is structural change.

In essence, link between unemployment and output through Okun's (1962) law locates a route to determine stabilizing parameters β_π and β_y in $(E.1)$. Okun's coefficient 2 corresponds to $\beta_y = -1.0$.

$$i_t = \hat{r}_t^* + \pi_t + 0.5(\pi_t - \pi^*) - 1.0(u_t - \hat{u}_t^*) \ \ ... \ ... \ ... \ (E.2)$$

The problem in the measurement of natural rates was stressed by Orphanides and Williams. They suggest replacing the response to the unemployment gap with one to the change in the unemployment rate. They further recommend an inertia element in accordance with other researchers like Williams (1999), Levin et al. (1999, 2003), Rotemberg and Woodford (1999) who argue that a substantial degree of inertia can significantly improve the stabilization performance of the Taylor rule in forward looking models.

Generalized version of Orphanides and Williams takes the form of equation (E.3) below:

$$i_t = \rho i_{t-1} + (1-\rho)(\hat{r}_t^* + \pi_t) + \beta_\pi(\pi_t - \pi^*) + \beta_y(u_t - \hat{u}_t^*) + \beta_{\Delta u}(u_t - u_{t-1}) \quad \dots\dots\dots\dots (E.3)$$

Orphanides and Williams further suggest that if there remains the possibility of huge measurement error in natural rates that could hamper stabilization policy then a "difference" rule with $\rho = 1$ and $\beta_y = 0$ like (E.4) could be in place.

$$i_t = i_{t-1} + \beta_\pi(\pi_t - \pi^*) + \beta_{\Delta u}(u_t - u_{t-1}) \quad \dots\dots\dots\dots (E.4)$$

Rule (E.4) is simpler than even Taylor rules in the context of implementation but it ignores some potentially useful information about the natural rates of interest or unemployment, therefore its relative performance will depend on the degree of mismeasurement and the structure of the model economy.

Beyer et al. (2009) specifies the following form (ignoring stochastic shocks) of policy rule which encompasses both first and second lag of interest rate in order to fully capture interest rate dynamics.

$$i_t = \rho_1 i_{t-1} + \rho_2 i_{t-2} + (1-\rho_1-\rho_2)\begin{Bmatrix} \alpha + \beta_\pi E(\pi_{t+n} - \pi^*)/\Omega_t + \\ + \beta_{y1} E(y_t)/\Omega_t + \beta_{y2} E\Delta_4(y_t)/\Omega_t \end{Bmatrix}$$

Where, $E(\pi_{t+n}/\Omega_t)$ is policymaker's inflation forecast for period *t+n* formed in *t* on the basis of the information available at time *t*. Δ_4 denotes changes over the previous four quarters. $E(y_t)/\Omega_t$ denotes policymaker's estimate of the current output gap formed on the basis of information available at time *t*. Dynamic specification of Taylor rule was opposed by some authors. Rudebusch (2002) argues that dynamic Taylor rule with lagged interest rate is a mis-specified representation of monetary policy because a large coefficient on the lagged interest rate would imply that future interest rate changes are highly predictable which contradicts with the yield curve evidence.

Major modification of Taylor rule encompasses forward looking treatment, interest rate smoothing, introduction of lagged variables as opposed to contemporaneous values and use of unemployment instead of output gap. Taylor and Williams (2010) take into account the leading modifications and summarize those in rule (1.3) below:

$$i_t = E_t\left\{(1-\rho)(r^* + \pi_{t+j}) + \rho i_{t-1} + \beta_\pi(\pi_{t+j} - \pi^*) + \beta_y y_{t+k}\right\} \quad \dots\dots\ \dots\dots\ \dots\dots (1.3)$$

This paper concentrates on the original format of Taylor rule described as equation (1.1) above. Estimable form (2) is obtained by manipulating (1.1).

$$i_t = \beta_1 + \beta_2 \pi_t + \beta_3 y_t \quad \dots\dots\ \dots\dots\ \dots\dots (2)$$

where, $\beta_1 \equiv \bar{r} - \beta_\pi \pi^*, \beta_2 \equiv 1 + \beta_\pi$ and $\beta_3 \equiv \beta_y$

Next section discusses data and methodology employed in the estimation process.

3. Data and Methodology

Quarterly US data on Federal Funds rate, GDP at 2005 prices, industrial production, CPI (all items) and GDP deflator for the period between 1957:Q1 and 2010:Q2 have been collected from IFS online source which is available at http://www.imfstatistics.org/imf/[i]. All series have been seasonally adjusted by applying moving average methods.

Output gap, $y = (\hat{y} - y^*) \times 100$; where, $\hat{y} = \log(real\,GDP)$ and y^* stands for potential output that is obtained by taking Hodrick-Prescott (HP) filter of $\hat{y}$. To examine robustness one more measure of output gap is computed by using industrial production series. Extant literature utilizes latter measure of output gap but Taylor (1993) used real GDP instead of industrial production while computing output gap. We find substantial difference in estimation results under alternative measures of output gap. Potential output, however, is unobservable and there is no consensus which measure should be representative. Taylor termed this as trend real GDP which equals 2.2 percent per year from 1984:Q1 to 1992:Q3. In this study we have a long sample hence without restricting at 2.2 percent we use HP trend as the measure of potential output, y^*.

Annual inflation rate for each quarter is computed by taking percent log difference of GDP deflator: $100 \times (\ln(GDP\,deflator) - \ln(GDP\,deflator(-4)))$. Taylor (1993) suggested to take account of the rate of inflation over the previous four quarters, i.e., $\frac{1}{4}\sum_{j=0}^{3}\pi_{t-j}$ where, $\pi_t = 400(\ln(GDP\,deflator) - \ln(GDP\,deflator(-1)))$. These two measures of inflation have same results and do not affect estimation outcome. What really matters is that CPI inflation and GDP deflator inflation have different repercussion on Taylor rule estimation. Here I report only the results based on GDP deflator inflation.

Another vital issue is the time series properties of the variables in question which is generally ignored by available papers. ADF test shows both federal rate and inflation for the whole period have unit root but output gap is strongly stationary. The mixture of stationary and nonstationary variables in regression process involves high possibility of spurious results though there is no substantial consensus in this, for example, Sims, Stock and Watson (1990) argue that nonstationarity of variables in Taylor rule does not create much problems. Indeed, nonstationarity arises from the existence of structural breaks in data that is tackled here by splitting the series into several subsamples. During a specific regime inflation rate is highly likely to be stationarity because the policy aims at a constant target rate of inflation and inflation on average is expected to be equal to that target rate. To remain centred on the basic objective of this study less attention is paid to the stationarity of the variables, of course in every case we have ensured if the residuals of the estimation is I(0) or not. We did not rely on the estimations that resulted in nonstationary residuals.

In the first instance Taylor rule is estimated for the whole period by applying OLS. In order to address the variable attitudes of different Chairmen at Federal Reserve Taylor rule is then estimated under different chairmanship. Policy response coefficients vary significantly under Volcker period who was strict inflation-averse.

The deviation between actual federal fund rate and Taylor rule based interest rate is computed in order to establish the link between such deviation and macroeconomic performance which is the key objective of this research. Empirical results are summarised in next section.

4. Empirical Findings

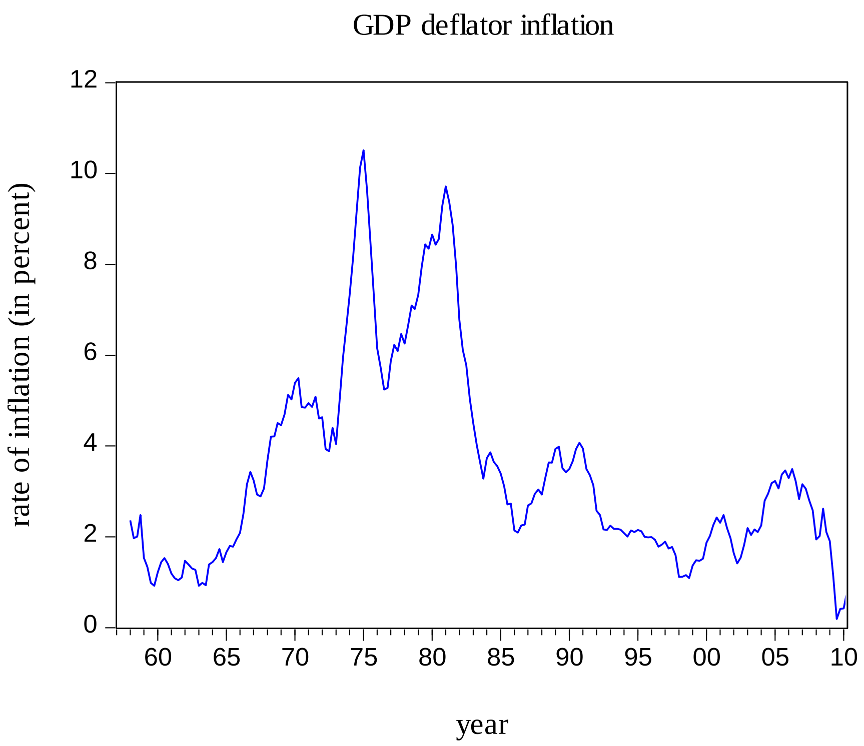
Table-1: Estimated Taylor Rule for the US

	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$
	1.90	1.09	0.48
1958:Q1-2010:Q2	(3.44)	(6.09)	(2.02)
	(0.00)	(0.00)	(0.04)
	1.97	0.81	0.61
1958:Q1-1979:Q4	(7.15)	(10.04)	(6.07)
	(0.00)	(0.00)	(0.00)
	4.60	1.11	-0.09
1979:Q1-1987:Q4	(6.01)	(6.76)	(-0.43)
	(0.00)	(0.00)	(0.67)
	2.58	0.91	1.07
1987:Q1-2006:Q4	(2.50)	(2.07)	(3.89)
	(0.01)	(0.04)	(0.00)
	0.51	0.83	0.72
2002:Q1-2010:Q2	(0.97)	(3.22)	(4.33)
	(0.34)	(0.00)	(0.00)
	1.32	1.61	0.42
1980:Q1-2006:Q4	(1.95)	(9.74)	(1.45)
	(0.05)	(0.00)	(0.15)
	2.62	1.25	0.75
1987:Q1-2000:Q4	(3.61)	(5.63)	(4.32)
	(0.00)	(0.00)	(0.00)

Numbers in parentheses across first and second row represent t-statistic and probability value respectively.

Table 1 presents coefficient estimates of Taylor rule for whole period and different sub-samples. Estimated Taylor rule for 1958-1979 has inflation coefficient which is smaller than one- indicating that an increase in inflation was followed by less proportionate increase in interest rate hence real interest rate rather fell in the face of increasing inflation which further aggravated inflation situation. Figure 1 demonstrates that rising inflation until 1979 was a big concern for the US economy.

Figure 1: Inflation in the US during 1957-2010



There was no effective action against surge in inflation until Volcker's appointment. Inflation started to decline dramatically when Paul A. Volcker was appointed as the Chairman of Federal Reserve in August 1979. Volcker took stern action against inflation by, if required, disregarding output. In Table-1 Volcker period's Taylor rule has inflation coefficient larger than one and output gap coefficient is insignificant. Volcker's successor Alan Greenspan enjoyed the benefit of low inflation and got the opportunity to focus on output stabilization. Indeed, US economy and therefore the entire world economy experienced great moderation in terms of inflation and output stability together with low inflation and high growth. From the end of the Great Inflation to 2007, the United States experienced three of its longest expansions interrupted by relatively mild, brief recessions (Meltzer, 2009).

Estimated Taylor rule for the period 1987-2000 has response coefficients those are consistent with Taylor's original recommendation. Figure 1 and 2 exhibit that during this time period US economy experienced low inflation and stable output. In general it can be argued that if actual policy is not considerably deviated from Taylor rule-guided rate then economy performs better. In order to justify this argument we compute the difference between actual federal rate and rule-guided policy rate which is illustrated in Figure 3.

Figure 2: Real GDP growth in the USA during 1957-2010

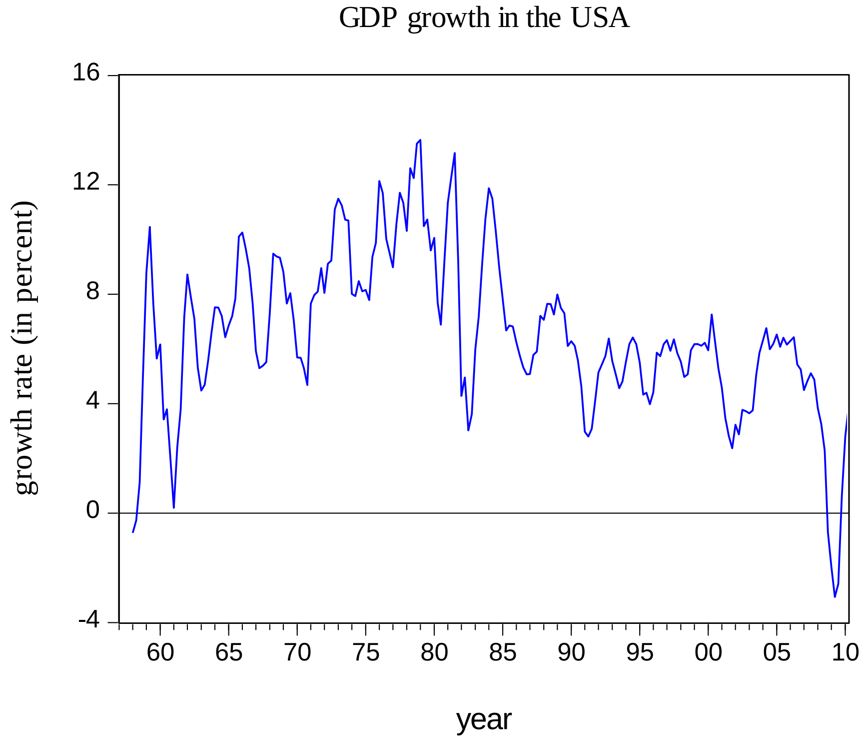
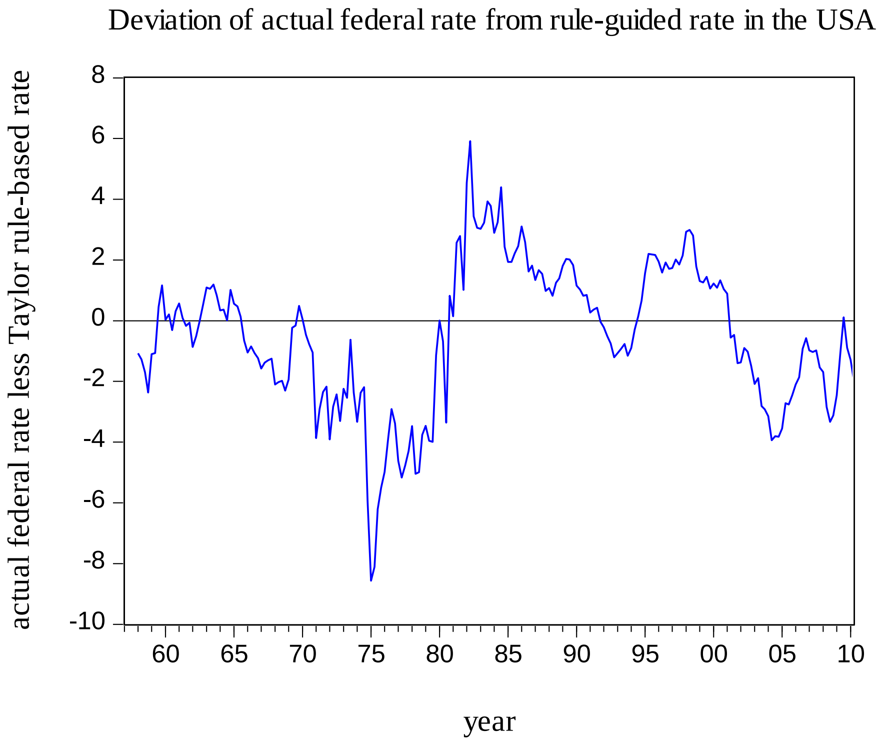


Figure 3 clearly shows that pre-Volcker period federal fund rate was smaller than rule-generated interest rate whereas federal rate was higher after Volcker's appointment until 2000. One can argue that multiple macroeconomic achievements during this period were in place due to the adherence of policy to Taylor rule. It surprises many of us when we observe that Federal Reserve again deviated from rule-like behaviour during post 2000 period. Holding interest rate too low for too long generated a big deviation that was larger than any other during the Great Moderation—on the order of magnitude seen in the unstable decade before the Great Moderation.

The real interest rate was negative for a very long period, similar to what happened in the 1970s. The intervention was an intentional departure from a policy approach that was followed in the decades before. The Fed's statements that interest rates would be low for a "prolonged period" and that interest rates would rise at a "measured pace" is the evidence that the intervention was intentional. The low interest rates added fuel to the housing boom, which in turn led to risk taking in housing finance and eventually a sharp increase in delinquencies, foreclosures, and the deterioration of the balance sheets of many financial institutions as toxic assets grew rapidly (Taylor 2010).

Figure 3: Difference between federal funds rate and Taylor rule-guided interest rate.



Empirical results indicate that during post 2002 period the Federal Reserve authority might have focused on output stabilisation. Response coefficient of inflation of Taylor rule for the period 2002:Q1-2010:Q2 got smaller than one although coefficient of output gap got larger and significant. But is there any reason to believe that economy gained output achievement? The answer should be 'no' because with a short-lived output increment the economy went into deep recession. It is not unreasonable to blame the policymakers of Federal Reserve for this artificial recession. In figure 3 we notice, such prolonged low interest rate relative to rule is unprecedented since when Volcker's disinflation started in 1980. Taylor (2010b) terms this as the Great Deviation. By Great Deviation, Taylor means, the recent period during which macroeconomic policy became more interventionist, less rules-based, and less predictable. It is a period during which policy deviated from the practice of at least the previous two decades, and from the recommendations of most macroeconomics theory and models. Taylor also argues that the Great Deviation killed the Great Moderation, gave birth to the Great Recession, and left a troublesome legacy for the future. At the 25th NBER Macro Annual Meeting in May 2010 Taylor presented more than half a dozen evidences of deviation from rule.

i. Deviation from the monetary policy of the Great Moderation, 2003-2005
ii. Term auction facility (TAF), created by Federal Reserve, 2007
iii. U.S. discretionary fiscal stimulus, 2008
iv. On-again/off-again interventions of financial firms by the Fed, 2008
v. Money market mutual fund liquidity facility, 2008
vi. Commercial paper funding facility, 2008

vii. U.S. discretionary fiscal stimulus, 2009
viii. G-20 fiscal stimulus agreement, 2009
ix. MBS purchase program of the Fed, 2009-2010
x. Trillion dollar European rescue package, 2010
xi. The ECB joining the rescue package by buying distressed debt, 2010
xii. The Fed joining the rescue package by making swap loans, 2010
xiii. Interventions by the federal government to encourage Fannie Mae and Freddie Mac to purchase high risk mortgages

On the top of this list is what has been discussed regarding intentional move from rule-guided interest rate to a discretionary low rate. Some empirical literatures find that a higher federal funds rate could avoid economic crises including housing boom and bust. Fed's term auction facility (TAF) created in December 2007 was another variety of intervention. The TAF provided a way for banks to get loans from the Fed without using the discount window through which it was expected to reduce tensions in the interbank market which had risen sharply in August 2007. After this facility was created tensions in the interbank market—as measured by the spreads between Libor at various maturities and the overnight index swap (OIS)—abated for a while, but soon shot up again. This new facility had little or no affect on these interest rate spreads, rather prolonged the crisis. Countercyclical discretionary fiscal policy action of 2008 is another example of deviation under which checks were sent to people on a one-time basis that resulted in a temporary dramatic increase in disposable income but aggregate personal consumption expenditures did not increase by much at all around the time of the stimulus payments. Needless to say that the fiscal stimulus program of 2009 also went in vain without any significant impact on consumption. According to J. B. Taylor the most unusual and significant set of interventions were the on-again/off again rescues of financial firms and their creditors starting with the Fed's opening of balance sheet to rescue the creditors of Bear Stearns in March 2008 and then making loans available to Fannie Mae and Freddie Mac. The Fed's interventions were then turned off for Lehman, turned on again for AIG, and then turned off again when the TARP was proposed. These interventions could not lower the panic that began in September 2008, rather made the panic worse. The Mortgage Backed Securities (MBS) purchase program worth $1.25 trillion is another variant of Fed's intervention that had only a small effect on mortgage rates once prepayment risk and default risk are controlled for. Latest measures like 750 billion euro rescue package by European governments and the IMF, the agreement by the ECB to buy distressed government debt, and the agreement by the Fed to provide dollar swap loans to the ECB to relieve pressure in the interbank market are examples of further interventions although it is too early to determine their impact, but there is no sustainable symptom of something getting favourable.

Our historical and empirical analyses suggest that the Great Deviation from rule-guided policy caused and intensified economic recession. Although Ben Bernanke (2010), who is the chairman of the Fed at present and largely responsible for deviation, argues that low interest rates in 2003-2005 were not a deviation if a modified policy rule with 'forecasts' of inflation rather than actual inflation is used. But Taylor (2010b) finds that the Fed's forecasts of inflation were too low in this period, which suggests that such a modified rule is not such a good one. Indeed the debate between Bernanke and Taylor dates back to 1992 when J. B. Taylor proposed a simple monetary policy rule which later widely known as Taylor rule. At a Macro Annual conference in 1992, Taylor commented on a paper by Ben Bernanke and Rick Mishkin (1992) where they raised doubts about the use of rules for the policy instruments and made the case for a considerable amount of discretion in monetary policy making. They said that “Monetary policy rules do not allow the monetary authorities to respond to unforeseen circumstances.” Taylor dissented from that view in his comments, referring to research on policy rules in which the instruments of policy adjust to contingencies (Taylor, 1993b). Bernanke’s 2010 statement about modified policy rule bears the evidence that he is no more sticking to discretionary stance of 1992, that should be viewed very positively because discretion can’t dominate rule-based outcome anyway. At the same time if policymakers can be generous and unintentional while formulating and launching policy, there is high possibility of economic agents do not suffer from further catastrophes.

5. Conclusion

Historical analysis suggests that mistakes in monetary policy deliberately cause poor economic performance. In this study we investigate the strength of Taylor rule in terms of macroeconomic performance of US economy. The paper draws some conclusions in connection with formulation, properties and policy implications of Taylor rule. First, Taylor rule is hypothetical rule but the rule is optimal because it’s a solution to constrained loss minimization problem. Second, Taylor rule is price of money, i.e., interest rate rule but still it does not replace quantity rules, rather the rule can be derived from quantity of money rule. Third, estimated Taylor rule for whole period starting from 1957 to 2010 complies with Taylor (1993a) rule, but there is neither historical nor empirical evidence that monetary policy of the US during the pre-Volcker period could be described by Taylor rule. Taylor rule, however, can well describe policy during Volcker-Greenspan period.

The most striking finding is that the Great Moderation took place during the period when monetary policy was rule-like rather than discretionary and *deviationary*. The study finds evidence that whenever policy interest rate substantially differs from rule-guided rate, the respective economy suffers from economic turmoil. The paper finally argues that Fed’s Great Deviation from Taylor-type policy rule is highly likely attributable to recent Great Recession. Of course, Great Deviation is only one out of many other reasons why the global economy faced prolonged recession. We primarily observe that such deviation was largely intentional, but further research is required to delve into the insights of Great Deviation and its repercussions.

Endnotes

[i] Access requires personal user ID and password.

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