Economic Modelling 27 (2010) 1292–1301

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Federal reserve monetary policy and the non-linearity of the Taylor rule☆

Aziz Hayat *, Sagarika Mishra [1]

School of Accounting, Economics and Finance, Deakin University, VIC 3125, Australia

ARTICLE INFO

Article history:
Accepted 25 January 2010

JEL classification:
E5
C14

Keywords:
Monetary policy rule
Taylor rule
Semi-parametric estimation
US Fed rate

ABSTRACT

We propose and estimate a generalized Taylor rule for the monetary policy of the US Federal Reserve (Fed) to find out how the Fed funds rate is sensitive to changes in inflation and output gap variables in the post war period. We find that Fed's monetary policy has only reacted significantly to changes in inflation when they were between approximately 6.5–8.5%. However, the policy stance change on these changes was relatively small. The findings suggest that the US Fed has been too averse to change from its current monetary policy stance, and that it has not reacted noticeably to changes in the US economic activity, as measured by the output gap. The generalized functional form for the monetary policy rule suggests that similar non-linearity exists in the directional change of the Fed rate.

1. Introduction

Over the years, US policymakers have given primary importance to the achievement of price and output stability in the US economy. The primary policy instrument in the hand of the US Federal Reserve (Fed) is the Federal funds rate (Fed rate). Using this instrument, the Fed tries to stabilize the output and inflation of the US economy (Taylor, 1993). The seminal paper on US monetary policy was by Taylor in 1993. He showed that movements in the Fed rate are driven by movements in inflation and output gap variables. Following Taylor (1993), the US monetary policy rule has been investigated further by Clarida et al. (2001), Clarida et al. (1998), Clarida et al. (2000), Judd & Rudebusch (1998), Kozicki (1999), Orphanides (1998), Rudebusch (2002) and Taylor (1999) using a linear framework and going back for the sample period as far as 1949[2]. The above-mentioned studies claim that the US Fed rate reacts differently to changes in the inflation and output gap variables, depending on who chairs the US Federal Reserve and their views on current macroeconomic conditions. They estimated the Taylor rule in the sub-sample periods of Miller and Burns (using the sample period from the March quarter of 1970 to the June quarter of 1979), Paul Volcker (using the sample period from the September quarter of 1979 to the June quarter of 1987), and Alan Greenspan (using the sample period

☆ We would like to thank Professor Santosh Mishra (West Virginia University, USA), Professor Don Harding (La Trobe University, Australia) and Professor David Papell (University of Houston, USA) for their helpful comments and suggestions.

* Corresponding author. Tel.: +61 3 9244 6358.
E-mail addresses: aziz.hayat@deakin.edu.au (A. Hayat), sagarika.mishra@deakin.edu.au (S. Mishra).
[1] Tel.: +61 3 9251 7653.

[2] In the prewar period, the US monetary policy for inflation control and output stability nearly not existed. Almost all work done on the Fed's monetary policy utilizes postwar data. Nevertheless, we can divide US monetary policy era in its four episodes. First, during the period from about 1879 to 1914 during which short term interest rates (it is to be noted that the Federal funds rate did not exist during this time.) were very unresponsive to the fluctuations in inflation and real output. The second phase covers the period from 1915 to 1948. During this time, the Fed was not able to find an effective policy rule for its monetary policy. The disastrous economic performance during the Great Depression bears testimony to this fact. There was no search of policy rule until beginning 1950s. The third phase of the Fed's history of monetary policy covers the period from 1949 to 1979. During this period money growth became the instrument for setting the Fed rate. The money growth played a very important role in the disinflation of 1979–81 because whenever the Fed lowered the growth rate of money supply the interest rate would rise. In this period the Fed rate was more responsive to inflation and output in the sense that the response of the nominal interest rate to changes in inflation was less than 1%. The Breton Woods system provides constraint on inflation during early 1960s and its collapse together with inadequate responsiveness to inflation and output gap and more accommodative monetary policy had lead to the Great Inflation period. The fourth phase spans the period from about 1986 to present. During this period, the nominal interest rate has been much more responsive to both inflation and to real output fluctuations. This is evident in the seminal paper by Taylor (1993). For details on monetary episodes in the US history, see for instance Taylor (1999) and Orphanides (2003).

0264-9993/$ – see front matter.
doi:10.1016/j.econmod.2010.01.019

from the September quarter of 1987 to the June quarter of 2006) using linear methods. The reason for performing policy analysis over different regimes is to avoid the potential for a non-linear response of the Fed funds rate to output gap and inflation gap variables. If such non-linearity exists in the Taylor rule, and if we use a linear framework, then the ordinary least square estimates are biased. Moreover, the results are inconsistent and the hypothesis tests are meaningless. Such a rule will misguide the economy.

Very few studies have shown the non-linearity of the Taylor rule. However, these studies have imposed restrictions on their policy rule and have contradictory findings. For example, Dolado et al. (2003) showed that the US monetary policy can be characterized by a non-linear rule after 1983, but not before 1979. They used a Generalized Method of Moments (GMM) type estimation to estimate a reduced form equation derived from the Central Bank's loss minimization problem to model the policy rule. They did not do the analysis for the whole sample considered in the study but only for part of the Burn-Miller and the Volcker–Greenspan regimes. Osborn et al. (2005) showed, using the framework of Hamilton (2001), which parameterizes non-linear relationships, that the Fed operated a non-linear monetary policy rule during the pre-Volcker period (1960–1979) but not the post-Volcker period. Similarly, Dolado et al. (2005) did not find any evidence of non-linearity in the Taylor rule for the US, but they did find non-linearity in the monetary policy rule of France, Spain, Germany and the ECB.

In this paper, we adopt a different perspective to examine whether or not non-linearity exists in the US Fed monetary policy rule; that is, whether the US Fed has reacted non-linearly, depending on the levels of inflation, output gap, and the lagged Fed rate variables rather than who runs the Fed, as previous studies have done. If it has reacted non-linearly, we also examine the nature of such non-linearity. The other subsidiary questions that we attempt to answer are:

- Does the US Fed target a particular inflation range, and if it does, what is that target range?
- Is the US Fed more sensitive to the inflation range than the output growth target for its monetary policy rule?

We propose a non-linear Taylor type rule in a generalized framework, which shows that Fed responses vary with the levels of inflation and output gap variables. Neglecting such a rule leads to a non-linear Fed reaction function, which prior studies have viewed as being due to the monetary regime effect (i.e., who chairs the Fed) rather than the level effect of inflation, for instance. These studies have therefore estimated the Taylor rule in the sub-samples only, to avoid similar non-linearities in the Fed's reaction function.

The rest of the paper is organized as follows. In the next section, we discuss the Taylor rule and its forward-looking and backward-looking versions in detail. In Section 3, using a linear framework, we show that the US monetary policy is seen as depending on the monetary regime—masking the level effect of variables like inflation on the Fed's fund rate. Section 4 provides an analytical model for our proposed non-linear monetary policy rule for a Central Bank that unmasks the true relationship between the variables and the Fed's fund rate. The estimation procedure for our proposed monetary policy rule and the estimation results are discussed in Section 5. In the last section, we provide some concluding remarks.

2. Monetary policy rule

The monetary policymaker sees that the price and output stability in the economy is controlled by the Fed rate. In connection with this, the Taylor rule recommends a setting of the nominal Fed funds rate that depends primarily on four factors. The first factor is the current inflation rate, the second is the equilibrium real interest rate, the third is the current inflation rate relative to its target, and the fourth is the real GDP relative to its potential. The first two factors together determine the benchmark rate. The idea is that if the inflation rate rises above (below) its target rate, then the Fed rate is raised (lowered) above (below) its benchmark rate. Similarly, if the output goes above (below) its potential, then the Fed rate is increased (decreased) above (below) its benchmark rate. The third and fourth factors summarize the two objectives of monetary policy, maintaining low inflation while promoting sustainable growth. The Taylor rule is given as follows:

$$i_t = \pi_t + i_t^* + \theta_\pi\left(\pi_t - \pi^*\right) + \theta_y y_t, \tag{1}$$

where i_t is the nominal Fed funds rate, i_t^* is the equilibrium interest rate, π_t is the current inflation rate, π^* is the target inflation rate, and y_t is the current output gap. The equilibrium interest rate and the target inflation rate are both set by the US Fed at 2% each. The corresponding econometric model for estimation purposes can be written as,

$$i_t = \theta_0 + \theta_\pi\left(\pi_t - \pi^*\right) + \theta_y y_t + \epsilon_t, \tag{2}$$

where ϵ_t is assumed to have zero mean and constant variance, and not be serially correlated. Taylor (1993), using $\theta_y = \theta_\pi = 0.5$, showed that Eq. (1) fits the Fed's actual policy rule remarkably well from the first quarter of 1984 to the third quarter of 1992. This suggests that when the inflation goes above (below) its target or the real output goes above (below) its potential by 1%, the federal funds rate is increased (decreased) by half a percentage point.

Past literature has estimated many variants of Eq. (2) that can be broadly classified as backward-looking and forward-looking Taylor rules. The important modifications of Eq. (2) are the inclusion of expected inflation instead of lagged inflation, the inclusion of the lagged Fed rate, and the inclusion of the expected growth rate of output, relative to its potential. These variations in the Taylor rule have been considered in the literature because researchers think that Eq. (2) was merely a simple rule for modeling complex monetary policy rules. It has been argued that the Fed became more forward-looking (proactive) only in the period post-1979. If lagged inflation is used in Eq. (2), it is called the backward-looking Taylor rule (BLT), and when lagged inflation is replaced by expected inflation, it is called the forward-looking Taylor rule (FLT).

Studies that have estimated the Taylor rule under both the BLT and FLT frameworks are Rudebusch (2002); Orphanides (2002); Osborn et al. (2005), and Dolado et al. (2005), while Rudebusch & Svensson (1999); Clarida et al. (2000); Orphanides (2001), and Batini & Nelson (1999) have estimated only the FLT policy rule. Orphanides (2003) has also estimated the Taylor rule under both settings; however, in his FLT he included the expected growth rate of output relative to its potential, in addition to other variables.

3. Is there non-linearity in the monetary policy due to monetary regimes?

Previous studies have estimated the monetary policy rule for three major regimes in order to account for the differences in the policy focus across monetary regimes. Alternatively, it can be stated that the importance (weight) of the inflation gap and output gap variables varies with the Fed chairmanship. However, the policy differences across regimes have never been explicitly tested in the literature.

We estimate regressions similar to Eq. (2), for various combinations of variables, under the BLT (from the March quarter of 1949 to the June quarter of 2008) and FLT (from the December quarter of 1965 to the June quarter of 2008) rules, where the policy variable is the Fed funds rate. The data sources and definitions are provided in Section 1. We select the model with the variables associated with the minimum Akaike's Information Criterion (AIC) value under the BLT and FLT