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## Monetary policy deviations: A Bayesian state-space analysis<sup>☆</sup>

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### ABSTRACT

The following paper contributes to a growing body of literature examining the degree to which monetary policy deviates from a systematic rule. We extend an error correction model of the Fed's reaction function by [Judd and Rudebusch \(1998\)](#) by endogenizing the unobserved inflation target in a model that nests the constant target model as a special case. The model is iteratively updated using a Kalman filter and estimated using Bayesian methods. The draws from the posterior distribution are used to estimate a distribution of Taylor rules with which to compare observed policy and more appropriately estimate deviations. This approach more accurately represents the parameter space given our data. Estimates imply a significant deviation in Fed policy over the years preceding the housing market decline. Restricted model variations imply no evidence of strict inflation targeting, but strict output gap targeting behavior cannot be ruled out over the Burns and Volcker tenure.

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### 1. Introduction

Ever since [Taylor \(1993\)](#) wrote his seminal paper characterizing the Federal Reserve's reaction function with a simple rule, macroeconomists have examined closely how the Fed does or does not adhere to this rule. As noted by [Poole \(2007\)](#), the relative simplicity of the Taylor rule not only neatly summarizes the dual mandate of the Fed, but also broadly characterizes the actual Fed funds rate. However, the idea of a rule based policy approach existed long before Taylor's rule (see [Kydland & Prescott, 1977](#)). As noted by [Khoury \(1990\)](#), econometric analysis of Fed reaction functions for the sake of policy predictions and evaluation can be found as early as the mid 1960s though with little consistency in the significance of various regressors in the reaction functions. [Judd and Rudebusch \(1998\)](#) attributed Khoury's findings to the changes in the composition of the FOMC over time as evidenced by changes in the Fed chairmanship. They argued that there are exogenous as well as

endogenous elements associated with changes in the Fed leadership to the extent that there is a tendency to avoid the mistakes of the past. Accordingly, [Judd and Rudebusch](#) estimated a dynamic version of the Taylor's rule under three empirical subsamples identified by respective appointments of Chairmen Burns, Volcker and Greenspan.<sup>1</sup>

The discussion of monetary policy deviations from Taylor's rule has received renewed attention in recent years in view of the discussion surrounding the Federal Reserve's role in facilitating the housing market boom and subsequent bust that preceded the Great Recessionary period of 2007–2009. [Taylor \(2007\)](#) held the Fed's monetary policy responsible to a great extent for the recent turmoil in the housing market. [Taylor \(2012\)](#) examined the trends in monetary policy under various Fed chairs dating back to 1982. Taylor divided this period into two halves – the Rule based Era of 1985–2003 and the Ad Hoc Era of 2003 onward. Taylor showed that there was a close correspondence between the actual rate and the Taylor rule based rate for nearly two decades dating back to around 1985. But starting around 2003, the actual rate began to fall well below the rule based rate of the 1980s and the 1990s. The deviation

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<sup>1</sup> The results for the Greenspan period did not capture his full tenure as Fed Chairman.

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was large and comparable to the discretionary decade of the 1970s. According to Taylor, this accommodative policy stance helped foster the extraordinary surge in housing demand leading up to the crisis.

Kahn (2010) arrived at a similar conclusion using four different specifications of the Taylor rule and different combinations of real interest rate and weights on the output gap. Ahrend (2010) in a somewhat similar study looked into the association between short term interest rates that were persistently below Taylor prescribed rules and the increase in asset prices, especially in the housing market. Unlike Kahn who focused on the US, Ahrend carried out a cross country study consisting of 21 OECD countries. Ahrend defined a “below Taylor” episode as a time period with a cumulated deviation from a Taylor rule of at least 12 percentage points. The focus on cumulated episodes was driven by the idea that it is the sustained or persistent deviation from a Taylor rule that matters, not deviations that are quickly reversed. However, the use of 12 percentage points as the cutoff for a significant deviation was necessarily arbitrary.

In a 2010 speech, Bernanke addressed the question of whether monetary policy was easier than needed in the years leading up to the housing crisis. Bernanke argued that the validity of Taylor’s claim that the actual Fed Funds rate fell short of the Taylor prescribed rule by as much as 200 basis points between 2002 and 2006 hinged on specific assumptions made about the weights used in Taylor’s rule and how inflation and output gaps are measured. Dokko et al. (2011) at the Federal Reserve Board constructed a band from 16 permutations of policy rules and plotted it over time. They concluded that the magnitude of deviations from the band was significant prior to the mid 1980s as the actual Fed funds rate was outside of the band throughout. By contrast, the Fed funds rate lay within the band in the post 1987 period except for a short time during 2003–2005 and that too for a modest amount.

In a similar vein, Hofmann and Bogdanova (2012) applied what they call a “thick modeling approach” to examine the degree of policy deviation since the early 2000s using a sample of both advanced and emerging market economies. They considered many combinations of different measures of inflation and output gap to obtain a range of possible implied Taylor rule rates. Their findings revealed that since 2003, global policy rates have almost always been below the Taylor Rule range suggesting that global monetary policy was systematically more accommodative during this time.

This brief survey of literature makes it clear that no consensus has emerged yet regarding a consistent measure of deviations between actual policy rates and the Taylor prescribed rule. These studies imply the same underlying position, that there is some relevant range about a policy rule at which the deviations are approximately or effectively zero and some at which they are not. The interpretation given to them is one of statistical equivalence, but when the coefficients in the policy rule are not estimated with data (Ahrend, 2010; Dokko et al., 2011; Kahn, 2010; Taylor, 2007) this interpretation is harder to justify. Thus there is a need to treat deviations from the rule in terms of statistical equivalence that is inferred by data through estimation of the rule.

One draw back to the Taylor rule is the imposed assumption of a constant inflation target. In one sense the notion of a constant inflation target is intuitive given a fundamental lack of knowledge about the ends that the Fed seeks. However the aforementioned literature by Kahn (2010) and Hofmann and Bogdanova (2012) implies prolonged periods in which the Fed might have deviated from a set rule. The Fed’s lack of commitment to a rule based approach undermines the argument for a constant inflation target. Put another way, if the Fed lacks the technology to commit to a rule based approach, how can it commit with credibility to a constant level of inflation? There have been successes in modeling time varying inflation targets in macro models. Ireland (2007) models a time varying target that shifts according to technology shocks and realized cost-push

**Table 1**  
Prior distributions.

Parameter	Distribution	Mean (SD)
$\alpha$	Normal	0.415 (0.123)
$\delta$	Normal	2.049 (2.599)
$\varphi_1$	Normal	0.5 (0.250)
$\varphi_2$	Normal	0.25 (0.125)
$\eta_1$	Normal	0.5 (0.125)
$\eta_2$	Normal	-0.416 (1.180)
$\theta$	Normal	0.308 (0.213)
$\rho$	Normal	0.5 (1.0)
$\sigma_u^2$	Inv. Gamma	1.678 (2.000)
$\sigma_{\varepsilon\pi}^2$	Inv. Gamma	1.678 (2.000)

inflation shocks. Dossche and Everaert (2005) model a time varying target rate in a structural model of inflation persistence. Leigh (2008) models the same time varying target process as Dossche and Everaert in a framework similar to the one examined here. Leigh’s model is also clearly derived from Judd and Rudebusch (1998) but does not account for the possibility of nonstationarity in the level of the interest rate.

Our paper contributes to the Taylor rule deviation literature in two ways. First, we examine monetary policy deviations without the overly restrictive assumption that the inflation target is constant. We extend a relatively flexible error correction model first examined by Judd and Rudebusch (1998) to estimate a Taylor rule with an endogenous time varying inflation target. The endogenized inflation target is modeled such that it nests a constant target as a special case. This allows us to empirically test for constancy to determine if the Federal Reserve adjusts its inflation target over time. Second, we estimate the state-space form of this model using Bayesian methods which allows us to construct a confidence band for the estimated rule using the joint posterior distribution of the parameters. This enables us to examine whether monetary policy deviated significantly from the estimated rule in a probabilistic fashion that is more realistic than simulating a policy rule for a range of arbitrarily chosen coefficients. Following Judd and Rudebusch (1998), we estimate the policy rule and the deviations under various Fed Chairs to see if the FOMC leadership has had any impact on policy deviation.

Results from these exercises tell us a few things.

1. Our estimates of the policy rule (at the mean) and corresponding confidence bands are sensitive to the measure of the output gap and choice of inflation measure. This is reflected in the shape of the statistically significant band of policy rules and is consistent with previous literature.<sup>2</sup>
2. Our estimates independently confirm Taylor’s (2007) conclusion that the Fed was significantly accommodative from 2002 to 2006.
3. The Fed’s inflation target is not constant over any of the four subsamples examined. It generally follows the trend of inflation producing an inflationary gap that is smaller in mean and variance than its constant target rate counterpart. These results are

<sup>2</sup> Bernanke (2010), Kahn (2010), and Hofmann and Bogdanova (2012).

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