Monetary Policy when the NAIRI is unknown:
The FED and the Great Deviation

Ronny Mazzocchi
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Department of Economics and Management, University of Trento, Italy.

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Monetary Policy when the NAIRI is unknown: 
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Ronny Mazzocchi †

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Abstract

The outbreak of the financial crisis of 2007 has generated a lively debate on the real or alleged faults of the Federal Reserve (Fed). Some economists argue that in the period 2002-2005 the U.S. central bank has taken its target interest rate below the level implied by monetary principles that had been followed for the previous 20 years. One can characterize this decision as a deviation from a policy rule such as a Taylor rule. This behavior determined the end of the Great Moderation and gave birth to the Great Recession. In this paper I challenge this view. I show how the deviations from the Taylor-rule's hypothetical interest rate can be explained by the ambiguity on inflation indicators to use. I also explain how the Great Deviation was instead caused by an error in the estimate of one of the fundamental components of the Taylor rule, i.e. the natural rate of interest. Too expansionary monetary policy of the Fed was therefore not due to discretionary choices, but to a structural problem of the Taylor rule. Finally, I show how an adaptive rule based only on observable variables would have avoided the huge gap between short-term rates and natural rates.

JEL Classification: E52, E58, G010, G280

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† Department of Economics and Management, University of Trento. Via Inama 1 - 38122 Trento (Italy). Tel: +39 0461 282387. Mail: ronny.mazzocchi@unitn.it
1 Introduction

One eternal question in monetary economics has been how the monetary authority should formulate and implement policy decisions so as to best foster ultimate policy objectives such as price stability and full employment over time. It is widely accepted that well-designed monetary policy can counteract macroeconomic disturbances and dampen cyclical fluctuations in prices and output, thereby improving overall economic stability and welfare. The rules-versus-discretion debate concerns whether monetary policy should be conducted by rules known in advance to all or by policymaker discretion. For many years, the case for a monetary rule was associated with a particular proposal by Friedman (1959). Building on a tradition initiated by Simons (1936), Friedman introduced the idea that the effects of monetary policy were uncertain, occurring with long and variable lags. Therefore he argued that discretion in the management of money supply in the face of such uncertainty actually amplified economic fluctuations. Hence, Friedman argued for a constant-money-growth rule.

The case for rules has changed fundamentally since an important paper by Kydland and Prescott (1977) in which they show that pre-commitment to a rule could have beneficial effects that discretionary policies cannot have. Indeed, by committing to follow a rule, policymakers can avoid the inefficiency associated with the time-inconsistency problem that arises when policy is formulated in a discretionary manner. By making future policy decisions more predictable, rule-based policy facilitates forecasting by financial market participants, businesses and households, thereby reducing uncertainty.

Various proposal for monetary policy rules have been made over time, and a vast literature continues to examine the relative advantages and drawbacks of alternatives in theoretical and empirical terms. In the last two decades Taylor-type rules (Taylor, 1993; Orphanides, 2007) have become the standard by which monetary policy is introduced in macroeconomic and in small or large econometric models. They serve as a benchmark for policymakers in assessing the current stance of monetary policy and in determining a future policy path (Asso et al., 2007).

Nevertheless the argument of Kydland and Prescott trivialized an important concern of policymakers: how to account for uncertainty in the link between policy instruments and ultimate objectives. Once one allows for uncertainty, there is a potential role for flexibility to deal with variability in the links. To the extent that some variations are systematic and can in some way be predicted, it is possible to incorporate feedback into a rule. However, some contingencies cannot be foreseen. When such events are potentially destabilizing, discretion may not be ruled out a priori. The previous Chairman of the Federal Reserve Bank of United States (Fed) regarded a substantial degree of discretion as desirable so as to respond to shocks that were “outside our previous experience, policy rules might not
always be preferable” (Greenspan, 1997). He claimed that “simple rules will be inadequate as either descriptions for policy” and he explicitly said that “the economic world in which we function is best described by a structure whose parameters are continuously changing. The channels of monetary policy, consequently, are changing in tandem. An ongoing challenge for the Federal Reserve [...] is to operate in a way that does not depend on fixed economic structure based on historically average coefficients” (Greenspan, 2004, p. 38).

The debate between rules and discretion came back in fashion with the arrival of the crisis of 2008. The discussion has not focused only on unconventional decisions taken when the crisis had already begun, but also to analyze the possible effects that the monetary policies of the Fed has had in causing the crisis. The widespread assumption is that too low short-term nominal interest rates have led financial institutions to raise leverage and have provided investors with incentives to hold riskier assets, including structured products, which have promised higher returns at supposedly little extra risk (Rajan, 2005). Taylor (2007), using his original rule as a benchmark, argues that the federal funds rate was as much as three percentage points below the implied Taylor rule rate, causing the housing bubble, the financial crisis and the Great Recession. He calls this experience the Great Deviation (Taylor, 2010).

While most subsequent commentary has agreed with Taylor’s conclusion (Lombardi and Sgherri, 2007), the agreement has not been universal. Others have asserted that policy was appropriate for the macroeconomic conditions that prevailed, and that it was neither a principal cause of the housing bubble nor the right tool for controlling the increase in house prices. Bernanke (2010) argued that the systematic deviation largely disappears when real-time output gap estimates and inflation forecasts are used in the construction of the Taylor-rule benchmark. Specifically, Bernanke argued that the Fed policy closely followed a Taylor rule if forecasted, rather than realized, inflation is used. In fact, since monetary policy works with a lag, effective decisions must take into account the forecast values of the goal variables. Therefore, if one takes into account that policymakers should respond differently to temporary and longer-lasting changes in inflation, monetary policy after 2001 appears to have been reasonably appropriate, at least in relation to a simple rule. The deviation denounced by Taylor and others, that has been identified ex-post, would therefore reflect real-time measurement problems with the Taylor rule’s input variables rather than a change in the monetary policy regime.

The debate on the use of different measures of inflation and output gap has unfortunately obscured a serious monetary policy analysis of the period 2002-2006. Almost no attention has been devoted to the role played by another key variable of the Taylor rule, namely the natural rate of interest. This lack of analysis is quite amazing since the natural rate of interest is a
central concept in the current monetary policy literature (Woodford, 2003). The indictment that monetary policy has been systematically too accommodative\(^1\) over the past decade from the perspective of the Taylor rule would be explained if the market rate of interest were lower than the natural rate. This phenomenon would occur despite the presence of a downward trend of the natural rate.

There are a number of factors that might have pushed down the natural rate over this period. Some call into question the policy of low short-term interest rates practiced by the Fed in those years. Others speculate that low long-run real rates may in part reflect secular demographic trends, specifically the influence of the baby boomer generation on the asset markets (Takats, 2010). Also, high saving rates and underdeveloped financial markets in emerging market economies may have given rise to global asset shortage that has lowered natural rate of interests worldwide (Caballero et al., 2008). Another potential factor is a possible increase in the perceived riskiness of capital assets in the wake of the recurrent asset price booms and busts since the late 1990s. Such higher capital price risk could drive long-run risk-free real interest rate levels well below trend output growth.

However, the problem is not the natural interest rate that is too low, but the fact that it is an unobservable variable. No doubt the Fed has conducted a monetary policy by setting an interest rate that was systematically lower than the *ex-post* natural rate of interest. But the origin of this error is different from that traditionally presented in the literature. In this paper I will show how this mistake, rather than caused by an incorrect application of the Taylor rule, seems to lie primarily in a systematic error of the estimate of the natural rate. Since the natural rate is an integral part of the Taylor rule, the problem seems to lie not so much in the application of the rule, but in the rule itself. This element has undoubtedly played a role in driving monetary policy onto a wrong track. The absence of inflationary pressures that characterized the so-called Great Moderation\(^2\) had finally prevented

\(^{1}\)It should however be stressed that on this point there is no general consensus. For example, Justiniano and Primiceri (2010) argue that monetary policy was not too loose in the 2002-2006 period.

\(^{2}\)The popular explanation of this period of substantial price stability is the cheap Chinese imports. But, as Milton Friedman argued that inflation is always and everywhere a monetary phenomenon, we could say that also the absence of inflation is also a monetary phenomenon. As Leijonhufvud (2007) recently stated, it is mostly the willingness of a number of central banks to accumulate enormous dollar reserve which explains the absence of inflation: China takes reserves in dollars as a tonic for exports, Russia as a medicine against the Dutch disease, while a number of others are doing the same on the principle that a few million a day, keeps the IMF doctors away. These policies keep American import prices from rising, and competition from imports keeps American consumer prices in check. Another relevant factor is the positive association between favourable supply-side developments (which push down the prices) and asset price booms (easier access to external finance and optimistic assessment of risk). The combination of rising asset prices, strong economic growth and low inflation can lead to overly optimistic expectations about
the central bank from realizing the error. Indeed, the central bank discovers whether its market rate is too low or too high with the price level starting to rise or fall, and it can then adjust its rate accordingly. A constant inflation rate gives no information about whether monetary policy is right or not. As I have showed in another paper (Mazzocchi, 2013), a wrong monetary policy allows the financial imbalances to grow for many years.

The paper is organized as follows. In section [2] I present the Taylor rule and I deal with its empirical problems highlighted both by the economic literature and by the Fed. The debate on the effective application of the Taylor rule from 2001 to 2005 is presented in Section [3]. Section [4] illustrates the difficulties faced by the Fed in implementing a monetary policy rule in the presence of imperfect information regarding the natural rate of interest. I will show that it was the error in the estimate of the natural rate made by the U.S. central bank - and not the abandonment of the Taylor rule - that determined the policy of low interest rates and thus the financial crisis. In Section [5] I introduce a monetary policy rule that is independent from unobservable variables and I show that, following this rule, the short-term interest rate would not deviate so much from the natural rate. Section [6] concludes.

## 2 Taylor rules in theory and practice

Taylor rules are simple monetary policy rules that prescribe how a central bank should adjust its interest rate policy instrument in a systematic manner in response to developments in inflation and macroeconomic activity. Taylor (1993) developed a “hypothetical but representative policy rule” where the nominal interest rate $i_t$ should respond to divergences of actual inflation rates $\pi_t$ from target inflation $\pi^*$ and of actual output $y_t$ from potential output $y^*$, namely:

$$i_t = r^* + \pi_t + \eta(\pi_t - \pi^*) + \sigma(y_t - y^*)$$

where $r^*$ is the natural rate of interest whereas $\eta$ and $\sigma$ are the two policy parameters. After simple algebraic manipulations, it can be rewritten as:

$$i_t = \mu + \gamma_\pi \pi_t + \gamma_y \hat{y}_t$$

where $\mu = r^* - \eta \pi^*$, $\gamma_\pi = 1 + \eta$, $\sigma = \gamma_y$ and $\hat{y}_t = y_t - y^*$. Based on the data of the previous few years, Taylor calibrated the long run target for the future which could generate increases in asset and credit markets significantly beyond those justified by the original improvement in productivity. Yet, a self-reinforcing boom can emerge, with increases in asset prices supporting by stronger demand and sustaining, at least for a while, the optimistic expectations. While stronger demand can put upward pressure on inflation, this pressure can be masked by the improvement in the supply side of the economy.
inflation and the two parameters that determine the responsiveness of the federal funds rate to the two gaps. Moreover the natural rate of interest was based on a longer history of actual rates of interest. Thus, by setting the inflation target and the natural rate of interest equal to two and the response parameter $\eta$ and $\sigma$ equal to one half, he arrived at what is known as the classic Taylor rule:

$$i_t = 1 + 1.5\pi_t + 0.5\hat{y}_t$$

(2.3)

The positive econometric evaluations and its usefulness for understanding historical monetary policy generated a growing interest and almost all central banks began to monitor this policy rule or related variants to provide guidance in policy decisions. Furthermore, by linking interest rate decisions to inflation and economic activity, Taylor rules greatly influenced also monetary policy research and teaching (Woodford, 2003; Clarida et al., 1999). As Clarida et al. (1999) emphasized, the rule is consistent with the main principles of optimal policy, that is a) it has the nominal rate to adjust more than one-to-one with inflation rate, b) real rates adjust to drive inflation back to target and, finally, c) the rule calls for countercyclical response to demand shocks and accommodation of shocks to potential GDP that do not affect the output gap.

Despite the Fed announcement in February 1987 that it would no longer set M1 targets and despite Chairman Greenspan testifying before the Congress that starting from July 1993 the central bank would downgrade the use of M2 as a reliable indicator of financial condition in the economy, it was only in 1995 that the Federal Open Market Committee (FOMC) begun regularly consulting the Taylor rule for guidance in setting monetary policy. During the meeting of the FOMC in January of that year Janet Yellen said that “[...] it seems that a reaction function in which the real funds rate changes by roughly equal amounts in response to deviation of inflation from a target of 2 percent and to deviations of actual from potential output describes reasonably well what this committee has done since 1986. If we wanted a rule I think the Greenspan Fed has done very well following such a rule, and I think that is what sensible central banks do”. A review of the transcript of meetings from 1993 to 2001 shows that the FOMC used the Taylor rule very much in the way recommended by Taylor in 1993. Not only did the staff prepare a range of estimates of the current stance of policy and the future policy path based on various policy rules, but members of the FOMC also regularly referred to rules in their deliberations.

A crucial element for the design and operational implementation of a Taylor rule is the detailed description of inputs. As McCallum (1993) pointed out, Taylor’s formulation was not “operational”. It required information that the policymaker did not necessarily have at his disposal. In particular it requires specificity regarding the measures of inflation and economic activity that the policy rule should respond to. The choice of the
source of information and the type of updating processes regarding the un-
observable concepts are essential for practical analysis because there is often
a multitude of competing alternatives and a lack of consensus about the ap-
propriate concepts and sources of information that should be used for policy
analysis.

This situation is particularly complex in regard to the treatment of un-
observable concepts such as the output gap or the natural rate of interest.
Econometric evaluations suggest that inferences regarding the performance
of the Taylor rule often depend sensitively on assumptions regarding the
availability and reliability of these two inputs. Real time estimates of poten-
tial output can be derived in a number of ways (Hauptmeier et al., 2009)
and - as shown by Orphanides and Williams (2002a) - are subject to large
and persistent errors. Taylor in his original paper proposed the computa-
tion of potential output by putting a time trend to real GDP. McCallum and
Nelson (1999) and Woodford (2001) dissent with the use of time trends as
estimates of potential output for two main reasons: first, the resulting out-
put gap estimates might be overly sensitive to the chosen sample; second,
de-trending ignores the potential impact of permanent shocks on output
(Siklos and Wohar, 2004). Clarida et al. (2000) measured potential output
using the Congressional Budget Office’s (CBO) estimates and by fitting a
segmented trend and quadratic trend to real GDP. Many papers estimate
potential output by applying Hodrick-Prescott filter whereas quite a few use
a band-pass filter.

A similar problem arises with the natural rate of interest. It varies over
time because it depends on factors such as the growth rate of potential
output, fiscal policy and the willingness of savers to supply credit to house-
holds and businesses. As well as for the potential output, the estimation of
the natural rate is not straightforward and is associated with a very high
degree of uncertainty. Furthermore there is not a consensus on the estima-
tion technique and on the determinant of this rate. We can distinguish at
least three different types of estimation technique. The simplest approach
is to assume that the natural rate of interest is equivalent to the trend real
rate of interest (Basdevant et al., 2004; Caresma et al., 2005; Larsen and
McKeown, 2004). This approach is closer to a pure statistical measure and
may be reasonable over short periods, when inflation and output growth
are stable, but leads to substantial biases when output or inflation vary
significantly. A more robust approach is to combine statistical tools with
structural macroeconomic modeling techniques, taking into account also the
evolution of real fundamentals such as determinants of trend GDP growth
and preferences (Giammarioli and Valla, 2003; Mésonnier and Renne, 2004;
Neiss and Nelson, 2001; Sevillano and Simon, 2004). Unfortunately the
econometric results obtained with these specifications are not very precise.
There are at least three major kinds of difficulties that can bias the esti-
mates. First, the general theory of statistics tells us that, in estimating
unobservable variables, the more observations that are used, the more accurate the estimates will be. However we can observe the data only up to today. Thus the estimate of the natural rate of interest based on data that are available today - i.e. the so called one-sided estimate - will be different from the estimate we will make when we have data beyond today - i.e. the so called two-sided estimate - because the latter will take into account future data over next periods. The discrepancy between the one-sided and the two-sided could be as large as one to two percentage points. Second, macroeconomic data are often revised, and sometimes the revision can be quite substantial. Such revisions will bias the estimates of both the parameters of the model and the natural rate of interest. Of course, the magnitude of the biases will depend on the size of the data revisions. As pointed out by Clark and Kozicki (2005) these mistakes could be as high as one to two percentage points. Third, different model specifications can generate very different estimates of the natural rate of interest. Clark and Kozicki (2005) find that estimates of the natural rate are sensitive to model specification and that these differences can be as large as one to two percentage points.

Finally, a last estimation method extracts the natural rate of interest from the financial market indicators (ECB, 2004) or from a money demand function which depends on the expected natural rate of interest (Andres et al., 2009). Comparing these three methods, Caresma et al. (2005) conclude that the differences in levels and volatility are big enough to take the results with caution. As has been shown by Kozicki (1999), Taylor’s proposed target interest rate is not robust to different measures of potential output and natural rates of interest. If policymakers rely on flawed estimates, they will encounter persistent problems in achieving their inflation and/or full employment objectives and they may seriously destabilize the system (Primiceri, 2006; Tamborini, 2010).

These and other problems were already clear from the adoption of the Taylor rule as a policy benchmark. This is proved by the fact that at the November 1995 FOMC meeting, the board of the Fed started to discuss several critical elements which have become items of discussion even in academia. First, it was noted that Taylor prescribed a policy interest rate responding to the inflation rate and output gap that corresponds to the same quarter in which policy decision were made. Contemporaneous setting requires the central bank to know the current quarter values of real GDP and the price index when setting the federal funds rates for the quarter. But in practice the Fed gets provisional data on real GDP one month after the end of the quarter and final data after three months. Moreover, since monetary policy works with lags, effective monetary policy must take into account the

\[^3\text{In his paper Kozicki (1999) uses the Taylor rule to calculate interest rate recommendations that would result from alternative measures of inflation and output. Differences in interest rate settings range from a minimum of 0.6 percentage points to a maximum of 3.8 percentage points.}\]
forecast values of the goal variables, rather than the current values (Clarida et al., 1999; Svensson, 2003; Orphanides and Wieland, 2008). However, it should be pointed out that some years later Rudebusch and Svensson (1999) and Orphanides and Williams (2006) do not find a significant benefit from responding to expectations out further than one year for inflation or beyond the current quarter for the output gap. Rules that respond to inflation forecasts further into the future tend to generate indeterminacy in rational expectations model (Taylor and Williams, 2010).

Second, the equal weight on inflation and output gap in the Taylor rule may be appropriate only in the case of supply-side shocks, whereas in case of demand shocks a greater weight to the output gap may be better suited. Usually all the analyses are conducted using an output gap coefficient between 0.5 and 1.0. The rationale is usually based on estimates of past behavior of the Fed, but also it is claimed that a larger coefficient is optimal in the context of DSGE models.

Third, the federal funds rate prescribed by the Taylor rule is highly sensitive to how inflation is measured. As seen above for the output gap, also different measures of the rate of change of prices can diverge significantly for long stretches, potentially providing different signals for the appropriate course of monetary policy. While in the the Carnegie Rochester paper, Taylor (1993) used the price index given by the GDP price deflator, subsequent research has used other measures like Consumer Price Index (CPI), core CPI inflation, CPI less food and energy and the Personal Consumption Expenditure (PCE) deflator. Even when a particular index is chosen, there are more choices to make, i.e. annual or quarterly. Even though the differences between these various measure could be minimal especially in the case of low and stable inflation, some authors experimented the rule with a variety of inflation measures and show a substantial variation in estimated policy parameters (Carare and Tchaidze, 2004).

Fourth, it is desirable to adopt a version of the Taylor rule that allows gradual adjustment in the natural rate of interest (Woodford, 2003). Thus, a more general version of the Taylor rule could be the following:

\[ i = \lambda i_{t-1} + (1 - \lambda) \left[ (r^* + \pi_t) + \eta(\pi_t - \pi^*) + \sigma(y_t - y^*) \right] \]  \hspace{1cm} (2.4)

where \( \lambda \) represents the degree of inertia. The equation can be rewritten as:

\[ i = \lambda i_{t-1} + (1 - \lambda) \left[ \mu + \gamma \pi_t + \gamma_y y_t \right] \]  \hspace{1cm} (2.5)

Several arguments have been put forth in favor of interest rate smoothing. In particular, the Fed would want to avoid frequent reversals in the direction of interest rate movements. These reversals may appear as mistakes to the public, thus maintaining momentum in interest rate movements will keep confidence in the central bank. Moreover, interest rate smoothing
may also be a response to the unavailability of accurate economic information and the uncertainty associated with the monetary transmission mechanism. Sack and Wieland (2000) question whether interest rate smoothing is deliberate or simply the result of monetary policy reacting to persistent macroeconomic conditions. If interest rate smoothing reflects the reaction of monetary authorities to persistent macroeconomic variables, one would expect the coefficient on the lagged interest rate to be small or insignificant. However empirical estimates of the Taylor rules find high and significant inertia (Goodhart, 1999; Rudebush, 2002; Dueker and Rasche, 2004), indicating that interest rate smoothing is deliberate.

3 Taylor rule and monetary policy after 2001

Monetary policy after 2001 has been subject to much controversy. The end of the dot-com boom and the consequent sharp decline in stock prices caused a moderate recession of the US economy between March and November. The terrorist attacks of September 11, 2001 and the invasion of Iraq in March 2003, as well as a series of corporate scandals in 2002, further clouded the economic situation in the early part of the decade. From 2000 onwards the target federal funds rate was lowered quickly in response to the 2001 recession, from 6.5% in late 2000 to 1% in June 2003 and then remained at that level for a year. In June 2004 the Fed began to raise the target rate, reaching 5.25% in June 2006 before pausing. The expansionary monetary policy of 2002 and 2003 was motivated by two main factors. First, after the recession of 2001 the GDP, which normally grows above trend in the early stages of an economic expansion, rose at an average rate of 2% in 2002 and in the first two quarters of 2003. This rate was not sufficient to affect the unemployment rate, which continued to stay above 6%. The slow recovery could be interpreted as reflecting a “capital overhang” left over from the rapid pace of investment in ITC during the boom of the late 1990s that limited both new capital investment and the need for employers to add new workers. The second factor which justifies the expansionary monetary policy was the concern about the possibility that US could experience an unwelcome decline in inflation as in Japan. The risk of approaching the zero lower bound has pushed the Fed to lower the interest rate in advance to avoid a situation in which monetary policy would be ineffective (Reifschneider and Williams, 2000; Ahearne et al., 2002).

Although macroeconomic conditions certainly warranted accommodative

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4 In the same period the Fed accompanied the low policy rates with many statements about its intention in the subsequent periods. For example, in August 2003 the Fed announced that the policy was likely to remain accommodative for a “considerable period” whereas in May 2004, a month before the increase of the target rate, the Fed suggested that the long phase of expansionary policy was close to conclusion (FOMC, August 2003; FOMC, January 2004).
policies from 2001 onwards, the question remains whether policy was more expansive than necessary. Taylor (2007) argued that the federal funds rate fell below the prescribed Taylor rule rate from mid-2002 to mid-2006 and he identified precisely in this deviation - which was as large as three percentage points for a considerable period - the cause of the housing price bubble, the build-up of financial imbalances and thus of the Great Recession (Taylor, 2010; 2011). Taylor argued that this deviation reflects clearly a change in the policy regime. However, this conjecture is rejected by Bernanke (2010). He criticized Taylor on the fact that he used realized rather than forecasted inflation. He showed that using forecast instead of realized CPI the gap between the actual and prescribed interest rates narrowed considerably.

Nevertheless, if we analyze in detail Bernanke’s answer, we note that he is unable to respond appropriately to criticisms made by Taylor. Figure 3 and Figure 4 plot the implied federal funds rate with the realized CPI inflation and with the forecast one-year-ahead CPI inflation. It is simple to note that the results are very similar. When the output gap is set $\gamma_y = 0.5$, the federal funds rate is below the prescribed Taylor rule rate throughout the considered period. On the contrary, if $\gamma_y = 1.0$ the difference is not so large, but the federal funds rate is below the prescribed Taylor rule in all but two quarters from 2002:Q2 to 2005:Q3.

Perhaps to better explain the discrepancy between the statements of Taylor and those of Bernanke there is something else. Actually a better analysis could be obtained by changing the inflation indicator. As we mentioned before, the economic literature has never been particularly careful to define precisely which inflation variable would be better to use in the Taylor rules. Indeed, when we come to policy prescriptions, it is not clear what particular measure should be used. Kohn (2007) argued that the Fed policy closely followed a Taylor rule if the core Personal Consumption Expenditure (PCE) deflator, rather than the CPI, is used to measure inflation.

Let us do a simple numerical analysis of these statements. Data on nominal GDP and thus on inflation measured by the GDP deflator were published by the Fed of Philadelphia web site. One-to-four quarter ahead internal Fed inflation forecasts are available on the Greenbook. Although the forecasts are not publicly available after 2005, there is a close enough fit between Greenbook and Survey of Professional Forecasters (SPF) forecasts so that the data can be spliced together. Other real time inflation measures are the CPI and the core PCE deflator. The data on the Fed funds rate are freely available and we use the (annualized) quarterly effective rate published by the Federal Reserve Board. The real-time output gaps are available only until the end of 2005, but the Congressional Budget Office (CBO) publishes real-time potential GDP estimates that can be combined with real-time output gap. Following Poole (2007) I construct the missing output gaps by using actual and potential GDP estimates for the previous quarter.

With these data I was able to reconstruct a reliable database. Figure 5
illustrates the prescribed interest rate with inflation measured by the realized core PCE deflator, the output gap from the Greenbook until 2004:Q4 and the CBO thereafter, and an output gap coefficient of 0.5. While the actual federal funds rate is below the prescribed Taylor rule rate from 2002 to 2005, the gap is much narrower than with headline CPI inflation, typically around one rather than three percentage points. An even closer fit can be found using core PCE inflation and an output gap coefficient of 1.0 where, with only minor deviations, the prescribed and actual rates nearly coincide from 2001:Q2 to 2004:Q4.

Another piece of evidence that the prescribed interest rate depends more on the use of PCE instead of CPI inflation than on the use of forecast instead of realized inflation is provided by Figure 6, which is identical to Figure 5 except that realized core PCE inflation is replaced by forecast PCE inflation. With an output gap coefficient of 0.5, the gap between the prescribed and actual rates is narrow and, with a coefficient of 1.0, the prescribed and actual rates are very close between 2002:Q1 and 2004:Q4.

This evidence leads us to conclude that the accusation of Taylor that the Fed implemented a less rule-based monetary policy is not particularly robust. At least until 2005, the U.S. central bank does not seem to have deviated very much from the practice of the previous decades and from the recommendations of most macroeconomic theory and models. The debate between Taylor and Bernanke seems to be the result of theoretical and empirical misunderstandings relating to the choice of the indicators of inflation and output that accompany the implementation of monetary policy rules in the last twenty years. But if the “Great Deviation” mentioned by Taylor does not seem to be reflected in the data, there is another “Great Deviation” that received less attention and that we will try to analyze in the next section.

4 The Fed and the Natural Rate of Interest: the authentic Great Deviation

If the comparison made in the previous section may help to clarify whether the Fed followed the original Taylor rule, it does not allow us to clarify if the Fed’s monetary policy was actually too expansive or not. In order to evaluate the stance of monetary policy we should investigate the gap between the market real rate of interest and the natural rate. Despite being a fundamental concept in both traditional monetary theory and in its most recent advances (Woodford, 2003; Trautwein and Zouache, 2009), it is still not clear what the natural rate of interest really is and what is meant with this variable. For the Classics, the natural rate was the real rate that equated

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5 The inflation forecasts are from Orphanides and Wieland (2008) through 2006:Q4 and from the SPF thereafter.
savings and investment. Further, this rate also stabilized the general price level and should be equal to the marginal product of capital. But as Amato (2005) points out, even Knut Wicksell defined the natural real interest rate in at least three different ways: the marginal productivity of capital, the interest rate that equates saving and investment, and the interest rate consistent with price stability. Of course, this does not necessarily imply that those definitions are inconsistent with each other, but there is no reason to draw an equality sign between these objects, so that they should be treated as three different natural rates definitions (Laidler, 1991, p.130). On the other hand, today’s definitions differ from those described above. In micro-based models the natural rate is defined as the flexible price equilibrium level of the real rate. According to another popular definition, the natural rate is equal to the real rate that stabilizes inflation, i.e. the so-called Non-Accelerating Inflation Rate of Interest (NAIRI).

With regard to the Fed, even if there is no single definition of the natural rate of interest, there is clearly a common view of this concept. Roger W. Ferguson Jr., a former Vice Chairman of the Board of Governors of the Fed system, defined the natural rate of interest⁶ as “the level of the real federal funds rate that, if allowed to prevail for several years, would place economic activity at its potential and keep inflation low and stable” (Ferguson, 2004, p. 2). On the other hand Janet Yellen, the current Vice Chairman of the Fed, states that “[...] policy can be deemed natural when the federal funds rate reaches a level consistent with full employment of labor and capital resources over the medium run”. This is a definition that is very similar to that give by Alan Greenspan. Indeed in his Humphrey Hawkins testimony to Congress in May 1993, Greenspan stated that the equilibrium interest rate is “[...] the real rate level that, if maintained, would keep the economy at its production potential over time. Rates persisting above that level, history tells us, tend to be associated with slack, disinflation, and economic stagnation”. On the contrary rates below that level are associated “[...] with eventual resource bottlenecks and rising inflation, which ultimately engenders economic contraction. Maintaining the real rate around its equilibrium level should have a stabilizing effect on the economy, directing production toward its long-term potential” (Greenspan, 1993).

It is also clear that the Fed sees the natural rate of interest as a variable that can change over time. For this reason there is not much confidence in

⁶The concepts “neutral real interest rate”, “natural real interest rate” and “equilibrium real rate” are sometimes used interchangeably in the literature and also during the FOMC. They do differ, however. The natural rate is the rate of interest at which investment and savings are equal, whereas the neutral rate is that at which there are no evident inflationary pressure (Amato, 2005). Curiously, the only one to justify in some way the use of one of these terms is Ferguson, who admits to prefer the last one because “by using the word equilibrium it reminds us that it is a concept related to the clearing of the markets” (Ferguson, 2004, p.2).
the literature that derives the natural rate by taking averages of the actual real rate observed over long period of times. An estimate derived from long-run observations may not be relevant to policy for two main reasons. First, economic conditions during the policy-relevant period might differ from the average conditions during the observation period. Second, the economy changes in ways that tend to limit the relevance of historical observation for policymaking. Indeed “the value of the natural rate depends on the strength of spending - that is, the aggregate demand for US produced goods and services. Aggregate demand, in turn, depends on a number of factors. These include fiscal policy, the pace of growth in our main trading partners, movements in asset prices, such as stocks an housing, that influence the propensity of households to save and spend, the slope of the yield curve, which determines the level of the long-term interest rates associated with any given value of the federal funds rate and the pace of technological change, which influences spending” (Yellen, 2005). Thus, all the estimations of the level of the natural rate can widely depend on the type of measure and the prevailing and projected economic conditions. In other words, for the Fed the natural rate of interest is a forward-looking notion and all the variables that contribute to build a macroeconomic forecast are relevant to estimate it.

In the late Nineties, as evidence mounted that trend productivity growth had increased, the issue of the natural rate of interest became even more important\(^7\). All the member of the Board were concerned that maintaining Taylor’s fixed 2% natural rate would lead to an overly stimulative policy. In particular, the previous President of the Federal Reserve of Richmond Alfred Broaddus said that “an increase in trend productivity growth means that the real short rate need to rise. [...] The reason is that households and business would want to borrow against their perception of higher future income now in order to increase current consumption and investment before it’s actually available. The Taylor rule does not give any attention to that kind of real business cycle reason for a move in rates” (FOMC, June 1999, pp. 99-100).

Quantitative measures of the equilibrium real rate of interest are a regular input in the monetary policy debate at the Federal Reserve, as demonstrated by the fact that a chart with a range of estimates of it is included in most published Bluebooks at least since May 2001. These estimates are given by the use of model FRB/U.S. model - i.e., the staff’s large-scale econometric model of the U.S. economy - and the predictions about the equilibrium rate depend on a very broad array of economic factors, some of which take the form of projected values of the model’s exogenous variables. In order to understand if the Fed really used these estimates in defining its monetary policy, let us embed these measures of the natural rate, which we

\(^7\)This may reflect also the very low U.S. private savings ratio, and the sharp surge in the U.S. government deficit and debt ratio.
denote by $\hat{r}^*_t$, in a class of policy rules of the form:

$$\tilde{r}_t = \hat{r}^*_t + \pi_t + \eta(\pi_t - \pi^*) + \sigma(y_t - y^*)$$ (4.1)

and let us set the two policy coefficient at $\eta = \sigma = 0.5$ as suggested by Taylor. Figure 7 depicts the gap between the implied federal funds rate $\tilde{r}_t$ - given $\hat{r}^*_t$ - and the effective Fed funds rate $i_t$ in the case of present and forecast CPI. In both cases, especially in the interval 2002:Q1-2006:Q2, the gap is always negative. In other words, the Fed seems to have systematically set an interest rate lower than what it should have done according to the Taylor rule, given the natural rate of interest estimated by itself. The statistical analysis of these policy errors - i.e., the difference between the effective rate $i_t$ and the implied rate $\tilde{r}_t$ - seems to confirm this impression. Using the database presented in the previous section, we test the hypothesis that the error term $\varepsilon_t$ is autocorrelated. The equation that we estimate is thus a first-order autoregressive process AR(1):

$$\varepsilon_t = \phi_0 + \phi_1 \varepsilon_{t-1} + u_t$$ (4.2)

under the null hypothesis $H_0: \phi_1 = 0$, namely that there is no autocorrelation. From Table 1 it can be noticed that this hypothesis is rejected both in the case in which the monetary policy rule is based on the original parameters of Taylor and in the case in which the output-gap coefficient is fixed at a higher level ($\sigma = 0.75$). In the former case, estimation errors appear to move around a drift $\phi_0$ that is slightly negative and statistically significant. Unfortunately we have too few observations to conduct a reliable test on the average of the errors. However, in the time-interval considered, the errors are all negative, therefore their average will definitely be different from zero.

To explain the fact that the Fed has systematically fixed the short-term interest rate at a lower level than it should have done following the Taylor rule, some accusers focus on the role of a discretionary monetary policy. It is assumed that Alan Greenspan, setting a low federal funds rate and through low-inflation expectations, has sought to directly influence the long-term interest rate. The central idea of this view is that Greenspan was convinced to be able to push down long-term interest rate not just by directly purchasing long-term securities - as Keynes argued in his Treatise on Money - but by creating expectations that future short-term interest rates will be

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8Note that, while maintaining both the policy coefficients and the variables unchanged, the gap between $i_t$ and $\tilde{r}_t$ is entirely due to an error in the estimate of the natural rate of interest by the Fed.

9I also estimated the equation with two delays AR(2) - i.e, $\varepsilon_t = \phi_0 + \phi_1 \varepsilon_{t-1} + \phi_2 \varepsilon_{t-2} + u_t$ - but in both cases the coefficient $\phi_2$ was not statistically significant.

10I conducted a Z-test on the mean, under the null hypothesis that it is equal to zero $H_0 : \mu_\varepsilon = 0$. Not surprisingly, in both cases this hypothesis is rejected.
low\textsuperscript{11}. The unhortodox mistake would be that the natural rate is not influenced by monetary policy and that it was the short-term interest rate to have to adapt to the long-term one. We do not know whether this was really Greenspan’s intention or not. Looking \textit{ex-post} at what has happened over that period, it seems that this conjecture is not supported by the data. Indeed the long-term rate has not been closely correlated with the contemporaneous short-term policy rate. Time series of the short-term and the long-term rate have been shown to have quite different statistical properties, but there is of course some correlation. Between 1971 and 2002, the federal funds rate and the long-term rate moved in lockstep. The correlation between them was a tight 0.85 (Greenspan, 2009). Nevertheless the link between the two interest rates is unlikely to be constant. Rather, it seems to be time-variant. There have been many periods when there has been no apparent relationship. Andrews (1993) showed that the relationship between Treasury yields and the funds rate changed in the late 1980s and diminished to insignificance between 2002 and 2005. During the monetary policy tightening of 2004-2005 the US government yield did not rise at all (Rosenburg, 2007): this was the famous \textit{Greenspan conundrum}\textsuperscript{12}. Thornton (2012) says that the change in the relationship between the federal funds rate and the 10-year yields occurred when the FOMC began using the fund rate as a policy target rather than an operating target as it had previously done. The use of the federal funds rate as a policy instrument caused the funds rate to be determined by monetary policy consideration and not by economic

\textsuperscript{11}This argument refers to the old debate about the so-called “Classical Dichotomy”, i.e. if the natural rate of interest is assumed to be independent of nominal phenomena including the money rate of interest or not. In this second case, the real economy would lack an anchor and would be affected by hysteresis and monetary policy would have permanent real implications via its influence on the natural rate of interest. In this context estimates of Taylor rules in which empirical proxies for the natural rate are assumed to be exogenous, would be misspecified (Clarida et al., 1999)

\textsuperscript{12}For some critical remarks on the fact that the long-term rate had continued to fall even after the Fed had started to gradually increase the federal funds rate see Turner (2013).
fundamentals as before. The long-term interest rate was unaffected by this change and continued to be determined by economic fundamentals. This is an instance of the so-called Goodhart’s Law, which states that any observed statistical regularity will tend to collapse once pressure is placed upon it for control purposes.

However, the debate about the responsibilities of the Fed is likely to overlook an important element. The hypothesis that the U.S. central bank has implemented a discretionary monetary policy seems not to have an empirical counterpart if we change the inflation indicator. Also in this case, if in equation (4.1) we use PCE deflator instead CPI inflation, the result would be very different (Figure 8). The effective federal funds rate follows more closely the implied rate, given the natural rate estimated by the Fed. Setting the output-gap policy coefficient to 0.7 the performance improves further. The difference between the two curves is slight and random. If we replicate the same test we have done with equation (4.2), we obtain two important results summarized in Table 2. The first is that the parameters are not statistically significant and thus there seems to be no-autocorrelation between the errors. The second is that, by conducting a Z-test on the mean of the errors, the null hypothesis $H_0 : \mu_\varepsilon = 0$ is not rejected. Therefore the gap between theoretical and observed interest-rate seem to be serially uncorrelated with zero-mean, i.e. the errors follow a white noise process.

Thus, the mistake made by the Fed is not a proper policy error. The U.S. central bank appears to have applied with sufficient diligence all the requirements of the Taylor rule, given its estimates of natural interest rate. The real problem is that the latter was wrong. Sadly, though, estimates of the natural rate are often very elusive and imprecise. Policy makers have repeatedly expressed their skepticism about the ability of obtaining precise estimates of the natural rate (Blinder, 1998; Ferguson, 2004). However, this variable is part of the Taylor rule and should be derived in some way.

---

Table 2 Errors with PCE inflation, Test of autocorrelation

<table>
<thead>
<tr>
<th></th>
<th>Taylor coefficients</th>
<th>Higher output-coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi_1$</td>
<td>0.0625</td>
<td>0.365</td>
</tr>
<tr>
<td></td>
<td>(0.258)</td>
<td>(0.218)</td>
</tr>
<tr>
<td>$\phi_0$</td>
<td>-13.26</td>
<td>0.0190</td>
</tr>
<tr>
<td></td>
<td>(12.75)</td>
<td>(0.111)</td>
</tr>
<tr>
<td>Observations</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.004</td>
<td>0.157</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*p < 0.01  **p < 0.05  ***p < 0.1

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13 Also in this case I have estimated an AR(2) model and the result is that the coefficient $\phi_2$ was not statistically significant.
Because of the difficulty associated with properly defining the natural rate of interest, the latter is often obtained by way of approximations of observable variables. A good proxy for the natural rate of interest is usually identified in the 10-year bond yield on risk-free assets (Beenstock and Ilek, 2010; Gerlach and Moretti, 2011). From 1980 to 2007 this variable has shown a downward trend (Figure 1). In particular, from that time forward, it has been low, well below its historical averages. As Greenspan noted during his testimony before the Congress in July 2004, two distinct but overlapping developments appear to be at work in explaining the low level of long-term interest rate: a longer-term trend decline in bond yields and an acceleration of that trend over the period. This trend is perplexing on both macroeconomic and microeconomic grounds. The macroeconomic paradox is that the fall to a very low level in the past few years has occurred when the potential growth rate of the global economy has risen and when investment in the emerging economies has been strong, i.e. when theoretically the natural rate would have to increase. The microeconomic paradox is that the decline in the real rate has occurred even though the volatility of long-term rates has actually risen. This is the opposite of what one would expect, since normally investors would require some compensation for holding a more volatile asset (Watson, 1999).

This decline in the long-term interest rate can be ascribed to expectations of lower inflation and of a reduced risk premium resulting from less inflation volatility due to the substantially increased production capacity.

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14 For a detailed survey of the literature on this point see Amato (2005).
In addition, Greenspan thought that the declining long-term yields reflected “an excess of intended saving over intended investment” (Greenspan, 2005b). On this point the most widely accepted explanation of low-term rates is the Bernanke’s thesis of the global “saving glut” (Bernanke, 2005). A decisive contribution to this phenomenon was the tectonic shift in the early 1990s by much of the developing world from heavy emphasis on central planning to increasingly dynamic, export-led market competition. The result was a surge in growth in China and a large number of other emerging market economies that led to an excess of global intended savings relative to intended capital investment. According to the IMF, the marginal propensity to save in developing Asia has been above 40% for almost a decade and in the years before the sub-prime crisis of 2007, it rose to 55%. At the same time, investment ratios also rose, but by less. That ex-ante excess of savings propelled global long-term interest rates progressively lower between early 2000 and 2005. That decline in long-term interest rates across a wide spectrum of countries statistically explains - and is the most likely major cause of - real estate capitalization rates that declined and converged across the globe, resulting in the global housing price bubble.

Whatever is the explanation of the decreasing trend in the natural rate, it should be stressed that, since 2001, we observed a persistent wedge between a proxy of the natural interest rate $\hat{i}$ and the Fed’s estimate of the equilibrium rate $\hat{i}^*$ (Figure 2). The gap appears to be systematic and persists until the end of 2005. Also in this case we check if the errors are really systematic
or not. The results of the regression - similar to that we have seen with equation (4.2) - are presented in Table 3. The autocorrelation coefficient is positive and highly significant both if we consider the constant term $\phi_0$ and if we omit it. Moreover, with a simple test, we can see that the null hypothesis $H_0 : \phi_1 = 1$ is not rejected. Therefore the gap between AAA Corporate Bond Yield and Fed’s estimate natural rate composes a difference-stationary stochastic process. It is a random walk without drift that can be represented as follows:

$$
\varepsilon_t = \varepsilon_0 + \sum_{i=0}^{t-1} u_{t-i} \quad (4.3)
$$

Far from being purely random, the error in the estimate of the natural rate is therefore the result of a systematic error of the central bank. The FRB/US econometric model used by the Fed underestimated from the beginning the value of the equilibrium rate. For this reason, since 2001, we observe a substantial gap between the two rates, and this initial error $\varepsilon_0$ - net of minor random deviations $u_t$ - has remained basically unchanged until 2005.

5 Safer monetary policy: adaptive rule

To be honest, we can not say with certainty that the gap between the Moody’s Seasoned AAA Corporate Bond Yield and the forecast equilibrium rate by the Fed has been caused by estimation errors. It may be that the Fed has estimated and published periodically in its Bluebook the equilibrium real rate, but then it has decided to use another set of indicators that have not been reported anywhere. For example, in a letter to Jim Saxton, the Chairman of the Fed warned that “the reliance on a single summary measure such as a natural rate of interest would be unwise as a strategy for formulating monetary policy. Rather, a full consideration of current and prospective
economic developments, and of the risks to the outlook, is essential for the conduct of monetary policy” (Greenspan, 2005b).

However it is not clear what should be the reliable policy indicators for the former governor of the Fed. If the trend of the “safe” corporate bonds was a conundrum, same doubts were expressed by Greenspan on the use of the yield spread between the Fed funds rate and the 10-year bond yield. Despite the importance of a yield spread for monetary policy recognized by classical economists like Wicksell and Thornton and also by recent research of the Federal Reserve Bank of New York (Estrella, 2005), Greenspan does not seem to make much reference to this indicator in the choice of policies to be adopted15. In fact, he declared that the yield spread “ [...] is no longer useful as a leading indicator to the extent that it was” (Greenspan, 2005a).

To support his position Greenspan cited the case of the 1992-94 biennium in which the yield curve narrowed sharply even as the economy was entering the longest sustained expansion of the postwar period. With this he sought to demonstrate that a flattening of the yield curve is not a foolproof indicator of future economic weakness. In fact, many factors can affect the slope of the yield curve, and these factors do not all have the same implications for the future output growth. Economic theory identifies three basic factors that affect the slope of the yield curve: the current level of the real funds rate relative to the long run level, the level of near-term inflation expectations relative to expected inflation at longer horizons and the level of near-term risk premiums relative to risk premiums at longer horizons. Much statistical analysis indicates that the first factor is the key component from which the yield curve slope derives much of its predictive power for future GDP growth, while the connection with the two other factors is far less certain and likely to depend on economic circumstances. Greenspan was very clear on these points: “A rise in near-term inflation expectations above long-term inflation expectations would tend to flatten the yield curve and might also signal a prospective weakening in aggregate demand. This configuration in inflation expectations might reflect adverse supply factors that have pushed up inflation expectations in the near term but that are expected to dissipate over time. In this case, the flattening of the yield curve might be a signal of an improving inflation picture that could also be accompanied by a favorable outlook for economic growth” (Greenspan, 2005b). Regarding the connection between output growth and risk premiums, Greenspan argued that “ [...] a fall in distant horizon risk premiums would flatten the yield curve and might signal a weakening in economic activity. [...] But it is also possible that a decline in the risk premiums could be a sign that investors are generally more willing to bear risk. In this case, a flattening of the yield curve [...] could be an indicator of an easing in financial conditions that would stimulate future

15 Nevertheless the Conference Board conducts an ongoing evaluation of these indicators and especially thorough, major reevaluation of the composite was made in July 2005.
economic activity” (Greenspan, 2005b).

Therefore, according to the former governor of the Fed, the problem of lack of knowledge of the natural variables can not be solved with the use of proxies. These may have some descriptive value *ex-post*, but can not be used to determine the monetary policy decisions. Greenspan’s considerations are consistent to what some economists have said for long (Orphanides and Williams (2002b); Mazzocchi (2013)): the central bank, due to the presence of imperfect information, could set a wrong target on some variables. The idea that the central bank may sooner or later realize that the target set is wrong is not so obvious. Real and nominal variables are continuously hit by shocks and it may be not so easy to take a correction. As long as there is a gap between the short-term interest rate and the natural rate of interest, the economy is on an unsustainable and potentially explosive intertemporal path.

As Orphanides and Williams (2002b) show, a rule that does not make use of natural variables - or proxies of them - and conversely employs only observed macroeconomic variables may allow a reliable stabilization policy. To address this issue, we can simply assume the following feedback rule:

\[
i_t = \lambda i_{t-1} + (1 - \lambda) \left[ i_{t-1} + \gamma_\pi (\pi_t - \pi^*) + \gamma_y (y_t - y_{t-1}) \right]
\] (5.1)

This rule introduces three important elements. First, it allows for inertial behavior in setting interest rates, \( \lambda > 0 \), which proves particularly important for policy analysis in models with strong expectational channels (Woodford, 2003). Second, it allows the policy response to the evolution of the effective output rather than the output-gap. Third, the natural rate of interest, instead of acting as an “anchor” of the system (as stated in the New Neoclassical Synthesis models), becomes a sort of “hidden attractor” and it does not appear explicitly in the rule.

It is interesting to note that the use of this type of rule between 2000 and 2007 would have guaranteed a trend of short-term interest rate very close to the long term rate. Following Kozicki (1999) and Rudebush (2002) we set the smoothing parameter \( \lambda = 0.8 \). If we use the policy coefficients suggested by Taylor - namely \( \gamma_\pi = 1.5 \) and \( \gamma_y = 0.5 \), the performance of the short-term nominal interest rate, while remaining consistently below the trend of the long-term rate, would have avoided the huge gap actually observed in that period (Figure 9). However, a better performance would have taken place with a lower inflation coefficient or considering only the dynamics of the output (Figure 10-11).

6 Conclusions

The Taylor rule has undoubtedly influenced the debate about monetary policy over the last 20 years. Economists everywhere recognize the Taylor
rule’s importance in monetary policymakers’ decisions. The transcript from the FOMC meetings include several references to the rule (Kahn, 2012). However, the fact that Taylor rule has been referred to in the policy meetings does not necessarily imply that it has had a significant influence on the decisions.

The most common way to analyze the importance of the Taylor rule is simply to consider the correlation between the original Taylor rule and the actual federal funds rate. Based on this approach Taylor (2010) argues that the Fed followed the Taylor rule quite closely until around 2002. After that, he argues that the Fed abandoned the Taylor rule and moved to a more discretionary monetary policy. He sees the large deviation from the Taylor rule between 2002 and 2006 as a policy mistake that contributed to the buildup of financial imbalances and the subsequent crisis. Bernanke (2010) replied to Taylor by showing that a forward-looking Taylor rule would have implied an interest rate closer to the actual one. Nevertheless this explanation does not seem entirely satisfactory.

In this paper we have seen that there are essentially two elements that can justify the Fed’s monetary policy: the use of a different indicator of inflation - the PCE instead of the CPI - and the use of its own estimates of the natural rate of interest. Based on this empirical evidence it has been possible to identify the “true” Great Deviation, namely the one between the Fed’s estimate of the natural rate of interest and the rate inferred from the performance of the long-term safe securities. This wedge was systematic and substantially constant throughout the period that we considered. This evidence seems to confirm all the doubts that the economic literature has placed on the reliability and accuracy of the estimates of natural variables. Conversely, policy errors of the Fed, i.e. the gap between the effective federal funds rate and the rate implied by the Taylor rule, were marginal and completely random. The main message is thus that the error is not in the application of monetary policy rule, but in the rule itself.

These results confirm two important conclusions obtained in determining a robust monetary policy. The first is that the key element that eventually determines whether a rule is good or bad are not the parameters but the crucial piece of information about the natural rate of interest. A Taylor rule is not able to produce good results if the central bank is misinformed about this variable. On the contrary, monetary policy rules relying upon timely and precise knowledge of the natural rate of interest are destabilizing, allowing macroeconomic imbalances to grow. The second result is that, unless we can be highly confident that central banks are better (perfectly) informed than the market about the natural rates, adaptive rules, using step-by-step adjustment of the interest rate with respect to the different observable conditions in the economy are preferable.
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Figure 3 Effective Funds Rate and Implied rate with CPI inflation, 2002:Q1 - 2007:Q4

Figure 4 Effective Funds Rate and Implied rate with forecast CPI inflation, 2002:Q1 - 2007:Q4
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