Interest rates, government purchases and the Taylor rule in recessions and expansions

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Abstract

In this paper we study asymmetries in the Taylor rule for the United States during the 1970-2012 period. We show that monetary authorities have been constantly concerned with excess demand in overheated periods –when the output gap is positive or the unemployment rate falls below 7 or 7.5 percent – raising the interest rate aggressively in that case. However, the Fed seems more reluctant to decrease the fund's rate during recessions. On the contrary, monetary authorities react symmetrically to inflation in booms and busts. Finally, we provide evidence that an expansionary fiscal policy does not lead to an increase in interest rates, and thus there is not necessary a "crowding-out" effect in recession.

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1 Introduction

The fiscal tightening to counter the recession still going on in many advanced economies has received a great deal of attention in recent times. Indeed, structural deficits across major advanced economies were reduced from almost 6% of GDP in 2010 to 4% in 2012, a contraction that is expected to continue in the following years. However, rather than solving the economic slack, fiscal consolidation seems to have deepened it.

In a recent paper, Blanchard and Leigh (2013) find that the effect of planned fiscal cuts had been underestimated, such that for example a fiscal expenditure reduction of 1% of GDP generally led the International Monetary Fund (IMF) to overestimate a country's subsequent growth by about a percentage point. According to their estimates, fiscal multipliers since the recession seem to have been between 0.9 and 1.7, rather than the 0.5 figure used in initial forecasts.[1] Moreover, short-term austerity in the aftermath of a severe crisis may prove more painful than thought. For instance, Auerbach and Gorodnichenko (2012) argue that the fiscal multiplier may be negative during booms, meaning that spending cuts actually raise growth while in recessions, by contrast, it could be as high as 2.5. These studies, among others, lend credence to the concern about the negative impact of austerity that now looms large in important segments of the economists' community and the society in general.

One could infer from the majority of works undertaken that the fiscal multiplier is likely to depend on a number of factors that vary both across countries and time. In particular, the literature proposes that the size of the multipliers is larger if: i) "leakages" are minimized (i.e., only a small part of the stimulus is saved or spent on imports), b) the country's fiscal position after the stimulus is sustainable and c) the monetary policy stance is accommodative (i.e., the economic authorities do not raise the interest rate when fiscal expansion is carried out).[2]

The aim of this paper is to contribute to this ongoing debate by focusing on monetary conditions and fiscal spending. To this end, we study how the monetary authorities, through Taylor-type interest rate rules, have reacted in episodes of economic slack and expansions in the United States over the 1970q1-2012q3 period. Our proposed econometric models capture two types of asymmetric Taylor rules: asymmetric reaction, and nonlinear regime-switching process; the link between in-

[1] For many years, the ample consensus was that multipliers were typically around 1, or perhaps a bit below. Moreover, others, like Alesina and Ardagna (2010), argue that fiscal consolidation may actually raise growth, even in the short run.

[2] See, for instance, Spilimbergo, et al (2009), Corsetti, et al (2012), etc.

flation, economic activity and interest rate depending on the economic cycle and the unemployment rate in the second case.

Indeed, if the central bank pursues a standard Taylor Rule, then monetary policy should function as an automatic stabilizer that works as a counterpart for fiscal policy. In conformity to this rule, spending cuts that menace to draw growth below a desired level should bring about monetary easing, which would appear to limit the size of the multiplier. Equally, the central bank has to offset, at least partially, any increase in real GDP, even if the economy is weak. Thus, the value of the fiscal-policy multiplier depends on the strength of the central bank's offsetting reaction: if the Taylor rule is operative, the nominal interest rate rises in response to an expansionary fiscal policy shock that puts upward pressure on output and inflation. In this case, the government-spending multiplier is quite modest. On the contrary, the multiplier can be much larger when monetary authorities do not increase interest rates when a fiscal expansion is accomplished.[3]

In this context, Hall (2012) advances two possible explanations, related to non-linear features of the Taylor rule, for the Auerbach and Gorodnichenko's (2012) findings related to the multiplier. He proposes that, if the multiplier is larger in economic recessions than in expansions, it is possible that: i) The response of the interest rate to the output gap is smaller during recessions or when unemployment is high and ii) The coefficient telling how much to raise the interest rate when inflation rises is smaller in recessions. These two statements imply that the Taylor rule is not effective in recessions but becomes highly important during overheating periods. They also imply that the link between the interest rate and government purchases –which in turns affects inflation and output– is stronger in booms than in busts.

The first case can arise if the central bank is highly attentive to an overheated economy and raises the interest rate aggressively in that case, but is reluctant to stimulate by cutting the rate when the economy is slack. In fact, some bank presidents (i.e. N. Kocherlakota, C. Plosser, etc.) have attributed high unemployment to structural problems, and have therefore doubted the ability of monetary policy to stimulate the economy and reduce unemployment without triggering inflation.[4]

[3]In the extreme case, the interest rate does not respond to an increase in government spending when the zero lower bound on the nominal interest rate binds. According to some macroeconomic models, this should have reduced the effectiveness of monetary policy and increased the efficacy of fiscal policy (e.g. Christiano, et al (2011)). This is so because in a deep recession, the rule may want the central bank's policy rate to be negative. When that rate has reached its lower bound of zero the Taylor rule is suspended. See Swanson and Williams (2012)

[4]For instance, Kocherlakota (2010) using a Diamond, Mortensen and Pissarides model of un-

As noticed by Hall (2012), economist rarely suggest that unemployment is low for similar reasons. Contrary to this point of view, it has been argued that during normal times the central bank in the United States is more averse to negative than to positive output gaps in part because correcting a negative output gap is thought to be more difficult than closing a positive gap (the "pushing on a string" argument).[5]

In the second case, Hall (2012) suggests that this non-linear response might occur if the central bank believes that higher inflation is more likely to be transitory in a slack economy than in a strong one. If this is the case, the Taylor rule is less operative in recessions than in expansions, explaining why the fiscal multiplier is highly important in these episodes. Another possibility is that during periods of inflation stabilization, in which monetary policy-makers are trying to build credibility up, they may be more averse to positive than to negative inflation gaps of equal size (e.g. Cukierman and Muscatelli (2008)).

Regarding the tie between interest rates and government purchases, the mainstream idea is that, in normal circumstances, a government spending expansion stimulates output and, therefore, inflation. The standard mechanism is that monetary authorities increase interest rates which, in turn, reduces current consumption and investment demand, limiting the multiplier. This implies that the higher the link between interest rates and government spending, the lower the multiplier. It follows that if the fiscal multiplier is higher in recessions than expansions, then the interest rate-government purchases tie must be stronger when unemployment is low.

The empirical literature gives some support to a nonlinear feature of the Taylor rule. For instance, Martin and Milas (2004) find that positive inflation gaps attract a more aggressive response than negative gaps in the UK. Also for the UK and allowing the interest rate instrument to experience three regimes depending on whether inflation is above, below, or inside a band around the target level, Taylor and Davradakis (2006) show that the standard Taylor rule becomes active once expected inflation is significantly above its target. Rabanal (2004) provides evidence that the Federal Reserve places much more weight on inflation stabilization in expansions, while it shifts its focus to output stabilization in recessions. Dolado, et. al (2005) conclude that European central banks have systematically responded more strongly to positive than negative inflation and output gaps but they do not find evidence of nonlinearity in the USA. Similarly, Shin, et. al (2012) provide evidence that the

employment, attributes unemployment to a skills or geographical "mismatch". This is the same as claiming that unemployment is mostly "structural".

[5]See Blinder (1997), Cukierman and Gerlach (2003), Doyle and Falk (2010), etc.

Fed has acted in a linear fashion in the long-run but that its interest rate response to inflationary shocks has been more rapid than in the case of disinflationary shocks.

This literature also insists that there are temporal changes in the policy reaction function, perhaps driven by changes in the mandate of the central bank or in the nature of the economy. For instance, Shin, et. al (2012) conclude that the Volcker administration engaged in aggressive and markedly asymmetric monetary policies due to the high level of inflation at the time. On the contrary, much of Greenspan's tenure and the early period under Bernanke were characterized by growth-fostering policies in a framework that often acted passively in relation to inflation.

Most of the previous studies on nonlinear Taylor rules focus on deviations of inflation from target or the response of interest rate to inflationary shocks versus disinflationary shocks as the relevant factors leading to asymmetric reactions in the Taylor rule. Nonetheless, deviations of the output around its potential are arguably an equally important feature leading to an asymmetric reaction function. Moreover, the majority of these studies are based exclusively on the output gap obtained by filtering the data –mainly the Hodrick-Prescott filter– (see Dolado, et. al (2005), Shin, et. al (2012), etc), which is criticized for being highly imprecise. It is also common in this literature to estimate the Taylor rule with actual values for inflation and output gap –which is information not available at the time those decisions were made– and the General Method of Moments (GMM), thus potentially introducing inefficiency and even bias.

In this context, we go further than the previous literature by capturing Taylor type rules in slack and overheating episodes. Instead of a filtered Hodrick-Prescott series to obtain the output gap, we consider the output gap from the Congressional Budget Office (CBO). We also rely on forecast real-time data, which is the data that the Fed uses to decide on their actions. Since forecasts are known to the policymaker with certainty, they are probably more appropriate than the revised data usually employed.[6]

We provide evidence that the Fed has engaged in a very aggressive monetary policy in case of excess demand (in overheating periods).[7] However, our results show

[6]Orphanides (2001) shows that estimated rules that respond to the forecasts of inflation and the output gap provide a better description of policy than rules specifying a response to the lagged or within-quarter counterparts of these variables.

[7]A positive output gap means that the economy is operating above its capacity to maintain a level of production on a sustained basis owing to excess demand. A negative gap means that there is excess supply –spare capacity or slack in the economy– due to weak demand.

that the Fed acts equally in relation to inflation in overheating and slack periods. In contrast to other studies, we do not find evidence that since Greenspan's tenure the Fed follows growth-fostering agenda and acts passively in relation to inflation. Finally, we show that if an expansionary fiscal policy takes place in recession times –when the output gap is negative or the unemployment is high– it does not lead to increases in the interest rate.

This paper is organized as follows. Section 2 introduces the methodology and describes the data set. Section 3 presents the results and the discussion. Finally, section 4 concludes.

2 Methodology

In this section, we propose two alternative models to identify the Taylor rule in overheating and slack episodes. We then present a simple model to capture the interest rate-government purchases link under these episodes. Finally, we describe the data set.

2.1 Econometric strategy

Our first proposed model allows us to test the proposition that the central bank is more attentive to overheated periods, and therefore it raises the interest rate aggressively, but it is reluctant to stimulate by cutting the rate when the economy is slack. In this case, the asymmetry depends on the sign of the output gap.

In the baseline Taylor rule, the central bank is assumed to set the level of the nominal short-term interest rate as a function of the rate of inflation and output gap:

$$i_t = i^* + \theta(\pi_t - \pi^*) + \gamma(y_t - y_t^*) \quad (1)$$

where i_t denotes the Federal funds rate, π_t and $(y_t - y_t^*)$ are the inflation rate and the output gap, respectively, i^*, is the target for the short-term nominal interest rate and π^* is the target level of inflation. In his seminal article, Taylor assumes that i^* = 2%, π_t^* = 2% and that the rate of growth of potential output is time-invariant at 2.2%. Moreover, Taylor notes that the output and inflation gaps enter the central bank's reaction function with equal weights of 0.5.

The parameters π^* and i^* in equation (1) can be combined into a single constant term $\mu = i^* - \theta\pi^*$ leading to the following equation:

$$i_t = \mu + \eta_\pi \pi_t + \eta_y (y_t - y_t^*) \tag{2}$$

The previous static rule is likely to be mis-specified owing to the omission of dynamic terms. In particular, Clarida, et. al (2000) emphasize the possibility that the interest rate adjusts gradually to achieve its target level. In this case, the actual observable interest rate is assumed to partially adjust to the target.

In addition, if the central bank sets the level of the interest rate as a function of expected inflation, the policy rule is known to be "forward-looking". A number of authors claim that the forward-looking reaction function is consistent with the observed behavior of central banks (e.g. Clarida, Galí, and Gertler (2000), etc). Most central banks explicitly claim that they do not only consider past or current economic conditions, but they also include economic forecasts in their macroeconomic conditions statement. Therefore, a large number of recent studies estimate the following more general specification, which incorporates the expected inflation rate and the degree of interest-rate smoothing:

$$i_t = \alpha + \rho i_{t-1} + \delta_\pi E_t(\pi_{t+h}) + \delta_y (y_t - y_t^*) + \epsilon_t \tag{3}$$

where ρ is the adjustment speed or smooth parameter, h is the horizon of the central bank with respect to inflation and E_t denotes the mathematical expectation conditional to the information set containing all variables dated $t-1$. The nonlinear least square (NLS) coefficients on expected inflation and the actual output gap may be computed as $\beta_\pi = \delta_\pi/(1-\rho_i)$ and $\beta_y = \delta_y/(1-\rho_i)$.

Note that even for the case of a contemporaneous Taylor rule (with $h = 0$), none of the right hand side variables of Eq. (3) are observable in real time due to data collecting lags. Therefore expectations of them need to be formed (Nikolsko-Rzhevskyy (2011)). Instead, several authors propose to eliminate unobserved forecasts from the expression by rewriting Eq. (3) in terms of realized variables, implicitly treating the expectation sign E as being a rational expectation of the future (e.g. Clarida, Galí, and Gertler (2000), Dolado, Maria-Dolores, and Naveira (2005), Taylor and Davradakis (2006), etc). Since the current interest rate shock is likely to affect future inflation, there is and endogeneity problem and the OLS procedure provides biased estimators in this case. In practice, the forward-looking Taylor rule is estimated by GMM, relying on statistical criteria to choose instruments. However, this may result in failure of identification or weak instruments (Dees, Pesaran, Smith, and Smith (2009)). Moreover, the realized values of inflation are not available to policymakers in real-time and, therefore, are not part of the information set. Finally, the realized values of inflation are the effect of the Fed's policy, not the cause

(Nikolsko-Rzhevskyy (2011)).

In this paper, we rely on actual real-time inflation forecasts instead. As suggested by Orphanides (2004), a significant advantage of using real-time forecasts rather than the actual inflation rates is that all regressions could be estimated using OLS, and there is no need to resort to using GMM. The reason is that since real-time inflation forecasts for $t+h$ do not incorporate any ex-post information, there is no endogeneity, and thus OLS (or NLS) can be used to estimate Eq. (3).

In addition, the literature has detected shifts in the preferences of the Fed regarding inflation and output growth. For instance, it is usually claimed that during the pre-Greenspan period –mainly during the so-called Great Moderation– the Fed became predominantly concerned with inflation and largely neglected the output gap. On the contrary, under the leadership of Greenspan and Bernanke, the Fed has not adhered to the Taylor principle in a consistent fashion but has reacted strongly to the output gap (e.g. Shin, et. al (2012)). In order to test if these shifts are significant, we define a "preference symmetry test" by means of a Wald test for the null hypothesis that $\widehat{\beta_\pi} = \widehat{\beta_y}$ in the NLS coefficients of equation (3). If the monetary policy is more concern with inflation that with economic growth, then $\widehat{\beta_\pi} > \widehat{\beta_y}$. On the contrary, if the Fed is dominated by growth-oriented policies, then $\widehat{\beta_\pi} < \widehat{\beta_y}$.

Equation (3) is based on the assumption that both excess demand –when the GDP is above its potential level– and excess supply –when it is below– affect the interest rate proportionally (but with different sign). If this is not the case, an asymmetric regime reaction can be captured by defining two dummy variables, D_1 and D_2, that take the value of 1 when the output gap is positive or negative, respectively, and 0 otherwise. We then identify two asymmetric variables in the following way:

$$y_t^+ = (y_t - y_t^*) \times D_1$$
$$y_t^- = (y_t - y_t^*) \times D_2$$

In the previous setting, y_t^+ captures excess demand and y_t^- excess supply. We can now replace $(y_t - y_t^*)$ in Eq. (3) by its decomposition into positive and negative components in Equation (3). This provides the following asymmetric extensions of the Taylor rule:

$$i_t = \alpha + \rho i_{t-1} + \delta_\pi E_t(\pi_{t+h}) + \delta_y^+ y_t^+ + \delta_y^- y_t^- + \epsilon_t \qquad (4)$$

where all the variables were previously defined and $y_t^+ + y_t^- = y_t - y_t^*$ by definition. The NLS estimates in this case are computed as $\beta_\pi = \delta_\pi/(1-\rho_i)$, $\beta_y^+ = \delta_{y^+}/(1-\rho_i)$

and $\beta_y^- = \delta_{y^-}/(1-\rho_i)$. Note that y_t^+ (y_t^-) takes positive (negative) values when the output gap is positive (negative), and 0 otherwise. Hence, the estimated β_y^+ coefficient will be positive and significant if monetary authorities raise the interest rate to cool the economy off in economic expansions. Equally, the coefficient $\widehat{\beta_y^-}$ will be also positive if the Fed reduces the funds rate due to economic slack.

A "regime symmetry test" can then be carry out with a Wald statistic testing the null hypothesis that $\widehat{\beta_y^+} = \widehat{\beta_y^-}$ in Equation (4). If $\widehat{\beta_y^+} > \widehat{\beta_y^-}$, then there is an asymmetry where positive values of the output gap entail The Fed to reacts more aggressively than in the case of negative gaps. On the contrary, if $\widehat{\beta_y^+} < \widehat{\beta_y^-}$, then the asymmetry implies that the central bank has systematically responded more forcefully in recessions.

Despite its interest, there are some limits regarding the previous asymmetric model. Indeed, to this point we have decomposed the output gap into its positive and negative components, with a zero threshold value delineating the positive and negative changes. This simple approach has an intuitive appeal and provides estimation results that may be easily interpreted, particularly in relation to expansionary or recessionary periods of the business cycle. Indeed, the output gap is conceptually appealing because it is an important determinant of inflation developments. According to the previous equations, a positive output gap implies an overheating economy and upward pressure on inflation and interest rates. By contrast, a negative output gap implies a slack economy and downward pressure on inflation.

Nevertheless, there is little reason to believe that monetary authorities behave in this simplistic fashion. If the Fed dismiss small deviations of the output with respect to its potential but react actively when demand pressures are large enough, defining slack and overheating episodes on the base of a zero threshold would be misleading. Our second econometric model employs a non-zero threshold and therefore avoids the previous drawback. In this case, the Taylor rule is specified as follows:

$$i_t = \alpha + \rho_1 i_{t-1} + \delta_\pi E_t(\pi_{t+h}) + \delta_y(y_t - y_t^*) + \left[\delta_\pi^* \pi_t^* + \delta_y^*(y_t - y_t^*)\right] \times f(r_{t-i}; \xi, c) + \epsilon_t \quad (5)$$

where $f(s;\xi,c)$ is the transition function, ξ is the speed of transition, r is the transition variable and c denotes the threshold that divides between regimes. The function $f(r_{t-i};\xi,c)$ is a first-order logistic function with two regimes associated with small and large values of the transition variable relative to the threshold.[8] The

[8]The other candidate transition function is an exponential function, which is characterized by

logistic function takes the following form:

$$f(r_{t-i};\xi,c) = 1 - \frac{1}{1+\exp(-\xi(r_{t-i}-c))} \tag{6}$$

Equation (5) allows the coefficient telling how monetary authorities increase the interest rate when inflation or the output gap –or both– rise to vary according to a conditioning information set, contained in r_{t-i}. The variables entering this information set depend on the model that generates the non-linearity: since we are interested on the reaction of the interest rate in slack and overheated episodes, we consider the lagged output gap. Thus, we define slack (overheating) when the previous period's output gap is below (above) a threshold value. This choice builds on the evidence that most of the decisions are based on the state of the business cycle in the last (observed) quarter. Eq. (5) has an intuitive appeal as it provides a simple means of modelling the dependence of aggregate economic activity, inflation and the short term interest rate nexus on the economic cycle.[9]

Given that the function $f(r_{t-i};\xi,c)$ is continuous and bounded between 0 and 1, depending on the realization of the transition variable, the slope of the Taylor rule will be specified by a continuum of parameters. In the two extremes –when the transition variable reaches its lower and upper values– the estimated coefficients are $\widehat{\beta_y}$ and $\widehat{\beta_\pi}$ in the first regime (when $f=0$), and $\widehat{\beta_y+\beta_y^*}$ and $\widehat{\beta_\pi+\delta_\pi^*}$ in the second regime (when $f=1$). Thus, whereas the elasticity in a linear model is constant and equal to $\widehat{\beta_y}$ and $\widehat{\beta_\pi}$ in equation (3), in model (5) the elasticity varies in time according to the value of the transition function. In particular, the elasticity at time t is defined as a weighted average of the estimated parameters as follow:

$$\frac{\partial i_t}{\partial(y_t-y_t^*)} = \widehat{\beta_y} + \widehat{\beta_y^*} \times f(r_{t-i};\xi,c)$$
$$\frac{\partial i_t}{\partial(\pi_t-\pi_t^*)} = \widehat{\beta_\pi} + \widehat{\beta_\pi^*} \times f(r_{t-i};\xi,c)$$

Based on the previous nonlinear model, we can test for both preferences and regime symmetry with the following array of hypothesis tests:

1. $H_0 : \widehat{\beta_\pi+\beta_\pi^*} = \widehat{\beta_y+\beta_y^*}$: preference symmetry in slack periods

symmetric dynamics in the two extreme regimes. Once the null hypothesis of linearity is rejected, we determine whether the logistic or the exponential function should be used with an auxiliary regression and a test sequence. These tests are available from the author upon request.

[9] Even though the output gap as transition variable is our benchmark case, we rely also on the unemployment rate. The results in this case are presented in the appendix.

2. $H_0 : \widehat{\beta_\pi} = \widehat{\beta_y}$: preference symmetry in overheating periods

3. $H_0 : \widehat{\beta_y} = \widehat{\beta_y + \beta_y^*}$: regime output gap symmetry

4. $H_0 : \widehat{\beta_\pi} = \widehat{\beta_\pi + \beta_\pi^*}$: regime inflation symmetry

Finally, we analyze the link between the interest rate and public spending through the following equation:

$$i_t = \alpha_i + \theta_i i_{t-1} + \theta_g \Delta g_{t-1} + \left[\theta_g^* \Delta g_{t-1} \times f(r_{t-i}; \xi, c)\right] + \epsilon_t \tag{7}$$

where g_t represents public spending in logarithms, Δ is the first difference operator and ϵ_t are the uncorrelated errors. Note that we consider the lagged government spending to tackle the endogeneity problem between the interest rate and fiscal spending as well as the lagged endogenous variable to allow for a dynamic adjustment.

The transition function $f(r_{t-i}; \xi, c)$ In Eq. (7) is defined as in the previous nonlinear Taylor rule. Then, the two regimes can be interpreted as extreme recessionary periods and great expansions. Equally, we can test if the tie between the interest rate and government purchases is strong in expansions and weak in slack by testing the null hypothesis that $\widehat{\theta_i} > \widehat{\theta_i + \theta_i^*}$. On the contrary, if the link is stronger in slack episodes that during expansions, then $\widehat{\theta_i} < \widehat{\theta_i + \theta_i^*}$.

2.2 Data description

Quarterly data for the period 1970:1-2012:3 were collected for the United States. The interest rate corresponds to the Federal Funds rate from the IMF (series 60b). Government expenditure is the current expenditure of the Federal Government, supplied by Bureau of Economic Analysis (BEA). All the variables are seasonally adjusted.

We pay special attention to the definition of the right-hand side variables in the Taylor rule. Indeed, it is now largely accepted that the use of ex-post data can distort the picture when trying to analyse monetary policy reaction functions (e.g. Orphanides (2001), Orphanides (2004), Molodtsova, et. al. (2008), Nikolsko-Rzhevskyy (2011), etc). For instance, Orphanides (2001) suggests that, instead of running the regressions on the data available at the time of the study, i.e. revised data, forecast real-time data should be used. By doing so, the researcher would be using the same information set as the central bank did at the time of the decision. By this means, more correct inference should be produced. Another gain from real-time data is that, since inflation forecasts for $t + h$ in Eq. (3) do not incorporate any ex-post information, there is no endogeneity, and thus OLS can be employed.

In this paper, we use inflation (GDP deflator and consumer price index based inflation) and unemployment forecasts from the Survey of Professional Forecasters, provided by the Federal Reserve Bank of Philadelphia. Contrary to the Greenbook inflation forecasts, which is the other alternative for real-time forecast data, the SPF is available for our entire period. Since we are interested in detecting shifts in the preferences of the Fed regarding inflation and output growth, considering a long sample is important.[10]

The correctness of the output gap is also important in policy rules. Indeed, it is well know that there are difficulties associated with the measurement of potential output. Therefore, readings on the state of excess demand are inherently imprecise. Given these difficulties, we rely on the output gap measure constructed by the Congressional Budget Office (CBO). Since the CBO is the data that the Fed uses to decide on their actions, it is probably a better measure than the filtered Hodrick-Prescott series usually employed in the literature.

Let us focus on the differences between the two measures of the output gap. On the one side, the Hodrick-Prescott is a two-sided filter. Running the filter up to the end point of data will tend to result in the trend being too close to the last data point. By losing observations or losing the ability to identify the trend, it performs poorly at the beginning or end of a sample period. Therefore, the HP filter will tend to underestimate trend output growth for the current period – the recent recession–. For instance, in 2008q1 — when the US economy was already in recession for most people – the output gap measure constructed by the CBO shows something close to a 1.5 percentage point negative output gap. In opposition, the output gap obtained with the HP filter indicates a positive output gap close to 2 percentage points. Both the HP filter and the CBO estimates reached their minimums in 2009Q3 but by very different magnitudes (-2.9 and -7.8 percentage points respectively). By 2011q4 the HP output gap was already back to positive numbers whereas the CBO estimate indicates a GDP below its –excess supply– even by the end of 2012.[11]

On the other side, the CBO's estimate is based on a growth model to calculate potential output. Unlike the HP filter, the CBO's method benchmarks their trend

[10]The Greenbook data are not available before late 1980s and for the last 5 years due to the Greenbook publication lag.

[11]Note that to mitigate the end of sample problem when using two-sided filters such as the HP filter, Watson (2007) suggests fore- and -back-casts GDP using an AR model, prior to applying the filter. This is, however, beyond the scope of the present paper.

to measures of capacity. One important advantage of using this growth-accounting framework is that it looks explicitly at the supply side of the economy (i.e. it considers capacity utilization in the economy) and thus it can be interpreted as the level of output that is consistent with stable inflation. Moreover, the HP filter was not introduced in the literature until the 90s. Therefore, it is hard to claim that those gaps could have been used by policy makers in the 70s. Because of its previous advantages compared to the commonly used filtered series, we use the CBO's estimate.

Given the availability of the data, we estimate three periods: i) From 1970 to 2012, using the forecasted GDP deflator, ii) From 1981 to 2012 using the forecasted CPI, and iii) From 1988 to 2012 –the Greenspan's and Bernanke's mandates– with the forecasted CPI.

3 Empirical Results

Table 1 presents the estimated NLS coefficients of the symmetric and asymmetric Taylor rules (Equations 3 and 4) for the whole period. The table also provides the results for the 1980q1-2012q3 and 1988q1-2012q3 subperiods. We distinguish 1988q1-2012q3 because the empirical literature on monetary policy rules insists that since Greenspan's chairmanship (1988) and with the occurrence of the Great Moderation, monetary policy shifted focus from inflation to output growth (e.g Clarida, et al (2000), Shin, et. al (2012), etc).

The symmetric models presented in table 1 show that the monetary policy response to the output gap has been weaker than to inflation, with the Fed raising the funds rate just 0.7% in response to a 1% increase in the output gap, compared to an increase 1.7% for the case of the inflation rate. The results also show that the symmetry in the Fed's preferences regarding its objectives of inflation and growth cannot be accepted. Moreover, contrary to previous studies, our results show that since 1988 the Fed has not neglected inflation. Neither monetary authorities have been particularly more interested in economic growth.

Turning to the asymmetric specification, we observe that positive and negative output gaps are weighted differently by the Fed. Indeed, the results show that monetary authorities have responded more strongly to positive than negative output gaps, although the difference is not significant for the whole period.

We then explore how monetary authorities react in boom and bust periods, with-

Table 1: **Output gap and inflation elasticities in symmetric and asymmetric Taylor rules**

	1970q1-2012q3	**1980q1-2012q3**	**1988q1-2012q3**
Symmetric			
Inflation GDP	1.773 (8.77)	–	–
Inflation CPI	––	2.166 (10.45)	2.058 (7.45)
Output gap	0.793 (4.42)	0.488 (5.05)	0.562 (6.15)
Preferences symmetry test	0.004	0.000	0.000
Asymmetric			
Inflation GDP	1.786 (8.91)	–	–
Inflation CPI	–	2.260 (12.53)	2.189 (9.31)
Positive output gap	1.570 (2.75)	1.326 (3.53)	1.501 (4.73)
Negative output gap,	0.617 (3.15)	0.339 (3.50)	0.357 (3.87)
Regime symmetry test	0.134	0.019	0.002

Notes: (1) The symmetric equation corresponds to: $i_t = \alpha + \rho i_{t-1} + \delta_\pi E_t(\pi_{t+h}) + \delta_y(y_t - y_t^*) + \epsilon_t$; (2) The asymmetric equation corresponds to $i_t = \alpha + \rho i_{t-1} + \delta_\pi E_t(\pi_{t+h}) + \delta_y^+ y_t^+ + \delta_y^- y_t^- + \epsilon_t$; (3) The table reports the NLS estimates: $\widehat{\beta_y} = \widehat{\delta_\pi}/(1-\widehat{\rho i})$ and $\widehat{\beta_y} = \widehat{\delta_y}/(1-\widehat{\rho i})$ in the symmetric equation and $\widehat{\beta_y} = \widehat{\delta_\pi}/(1-\widehat{\rho i})$, $\widehat{\beta_y^+} = \widehat{\delta_y^+}/(1-\widehat{\rho i})$; $\widehat{\beta_y^-} = \widehat{\delta_y^-}/(1-\widehat{\rho i})$ in the asymmetric equation; (4) t-statistics are given in parentheses; (5) The preference symmetry test presents the probability for the null hypothesis: $H_0 : \widehat{\beta_\pi} = \widehat{\beta_y}$ in the symmetric equation; (7) The regime symmetry test presents the probability for the null hypothesis: $H_0 : \widehat{\beta_y^+} = \widehat{\beta_y^-}$ in the asymmetric equation.

out imposing a zero threshold in the estimations. In this case, our proposed model has the interesting advantage to endogenously determine the threshold output gap that defines overheating and recession episodes, compelling monetary authorities to react asymmetrically. The results for the whole period, presented in table 2, show that policy-makers have a higher concern for inflation than growth in slack episodes. This result is confirmed when the trigger variable is the unemployment rate (see table 4 in the appendix). However, when the economy is overheating, the Fed is equally cautious with inflation and excess demand, increasing rapidly the interest rate in both cases.

The regime symmetry test shows two important facts. The first one is that the response of the interest rate to the output gap is weaker during recessions –or when unemployment is high (see table 4)– than during expansions. The fact that the central bank is reluctant to stimulate by cutting the rate when the economy is slack could, in part, explain why the fiscal multiplier is higher in recessionary periods. On the contrary, the second fact implies that the coefficient telling how much to raise (or to reduce) the interest rate when inflation rises (or decreases) is symmetric in slack and overheated periods.[12] If higher government expenses are translated into higher inflation, this second result would imply, in turn, a similar multiplier in expansions and recessions.

The results also confirm that even since 1988 the Fed has been highly concerned with inflation both in slack and overheating periods. In opposition, our findings indicate that the Fed is especially reactive to demand pressures and strongly increases the interest rate when the economy is overheating.

Our evidence that the Federal Reserve is less averse to negative than to positive output gaps contradicts recent studies claiming that the Fed pursues a growth fostering agenda since Greenspan's times (Shin, et al (2012)). At this respect, there are two "technical" features that may explain the different results. First, if monetary authorities have asymmetric regime preferences, as it seems to be the case, previous studies may be severely biased due to their inability to accurately capture the different responses elicited from positive and negative output gaps. Second, the definition of the output gap and the inflation expectations is also important. Indeed, most of the literature on non-linear Taylor rules is based on HP filter based output gap. Remember, however, that the HP filter can severely underestimate the real state of the economy during the recent crises. This literature also considers revised data for inflation instead of actual real-time inflation forecasts.

Rather, we believe that the Fed has show higher interest to cool off an overheating economy than to stimulate recoveries. This may be related to pessimistic views about what monetary policy can accomplish to combat downturns. Indeed, in a recent article, Romer and Romer (2012) suggest that pessimistic views about the effectiveness and costs of expansionary actions have played a major role in limiting the Fed's moves over the last few years. Because recessions and particularly unemployment are seldom seen as "structural" by policy makers, they worry that monetary policy actions will do little good and that they could cause inflation, distortions in financial markets and losses on the Fed's portfolio. Inflation, instead, seems to be taken more seriously. For instance, at the end of the 1970s, Volcker, concluded that monetary policy absolutely could reduce inflation, leading the Fed to raise interest rates to historic highs. The recession that followed was hard, but inflation did come down (Romer and Romer (2012)).

[12] When considering the unemployment rate, inflation receives more attention when unemployment is low than when it is high.

It is also important to outline the constraint on monetary policy in busts arising from the fact that nominal interest rates cannot be negative, i.e. the zero-bound problem. Indeed, when monetary authorities follow a relatively low inflation target, there is a lower bound that prevent larger decreases in rates to tackle the problem in busts before the zero bound becomes binding.[13] Under this circumstances, it is not easy for a central bank to restore full employment when an economic slump occurs.

Figure 1 shows that the preference of the Fed regarding how much to react to inflation has remained practically unchanged throughout the period. On the contrary, demand pressures tend to prompt stronger interest rate increases in overheating periods.[14] Indeed, the estimated elasticity shows equally inflation concerns both in booms and busts. This is not the case of the output gap elasticity. Note that the years preceding the crises –at least since the beginning of the 2000's and just before 2008– monetary authorities were highly concern with the output gap and demand pressures derived from a relatively low unemployment rate. In turn, policy-makers have been more cautious about adjusting interest rates since 2008.

Finally, based on the simple model presented in Eq.(7), we explore the relationship between interest rates and government purchases in recessions and expansions. From the results, shown in table 5, it is clear that the interest rate increases with government expenditures exclusively in overheated periods –when the output gap is above -1.8 or unemployment rate is below 7.5%–. Moreover, since 1988, monetary authorities seem to follow an accommodating monetary policy stance, with interest rates declining even as the government spending rises in times of bust. This implies that an expansionary fiscal policy does not increase interest rates and thus not necessary reduces investment spending in recession times. If the increased public borrowing does not 'crowds out' private spending when unemployment is high, it follows that the fiscal multiplier is likely to be larger when there is a great deal of slack.

[13]The Federal Reserve calls two-percent inflation a "longer-run goal".

[14]In order to save space, we only present the elasticities obtained from the whole period.

Table 2: **Estimated elasticities in slack and overheated episodes**

	Slack economy	**Overheated economy**	***Regime symmetry***	**Threshold output gap**
1970q1-2012q3				
Inflation GDP	1.909 (6.75)	1.761 (4.38)	0.786	-0.6
Output gap	0.530 (2.24)	2.166 (3.47)	0.010	-0.6
Preference symmetry test	0.000	0.614		
1980q1-2012q3				
Inflation CPI	2.185 (10.80)	2.203 (4.11)	0.973	0.9
Output gap	0.390 (3.92)	1.207 (1.70)	0.058	0.9
Preference symmetry test	0.000	0.095		
1988q1-2012q3				
Inflation CPI	2.038 (9.12)	2.334 (10.10)	0.168	-1.0
Output gap	0.274 (2.85)	1.267 (5.77)	0.001	-1.0
Preference symmetry test	0.000	0.001		

Notes: (1) The estimated equation is $i_t = \alpha + \rho_1 i_{t-1} + \delta_\pi \pi_t + \delta_y (y_t - y_t^*) + \left[\delta_\pi^* \pi_t^* + \delta_y^* (y_t - y_t^*)\right] \times f(r_{t-i}; \xi, c) + \epsilon_t$; with the output gap as transition variable; (2) The table reports the NLS estimates: $\widehat{\beta_y} = \widehat{\delta_\pi}/(1-\widehat{\rho i})$ and $\widehat{\beta_y + \beta_{y*}} = \widehat{\delta_y}/(1-\widehat{\rho i}) + \widehat{\delta_{y*}}/(1-\widehat{\rho i}) \times f(\bullet)$ for the output gap and $\widehat{\beta_\pi} = \widehat{\delta_\pi}/(1-\widehat{\rho i})$ and $\widehat{\beta_\pi + \beta_{\pi*}} = \widehat{\delta_\pi}/(1-\widehat{\rho i}) + \widehat{\delta_\pi *}/(1-\widehat{\rho i}) \times f(\bullet)$ for slack and overheated episodes, respectively; (3) t-statistics are given in parentheses; (4) The regime symmetry test presents the probability for the null hypothesis: $H_0 : \widehat{\beta_y} = \widehat{\beta_y} + \widehat{\beta_y^*}$ and $H_0 : \widehat{\beta_\pi} = \widehat{\beta_\pi + \beta_\pi^*}$; (5) The preference symmetry test presents the probability for the null hypothesis: $H_0 : \widehat{\beta_y} = \widehat{\beta_\pi}$ and $H_0 : \widehat{\beta_\pi + \beta\pi*} = \widehat{\beta_y + \beta y*}$

Table 3: **Linear and nonlinear estimated coefficient for government purchases in slack and overheated episodes. Transition variable: output gap**

	Slack economy	Overheated economy	Symmetry test	Threshold value
1970q1-2012q3	−0.053 (−1.60)	0.088 (3.42)	0.000	-1.8
1988q1-2012q3	−0.049 (−2.87)	0.031 (1.34)	0.000	-0.3

Notes: (1) The estimated equation is $i_t = \alpha_i + \theta_i i_{t-1} + \theta_g \Delta g_{t-1} + \left[\theta_g^* \Delta g_{t-1} \times f(r_{t-i}; \xi, c)\right] + \epsilon_t$; (2) t-statistics are given in parentheses.

4 Concluding remarks

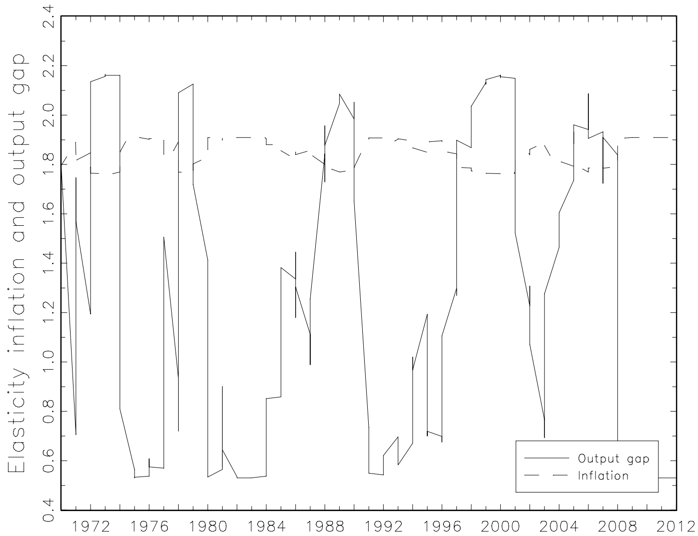
According to recent empirical evidence, fiscal multipliers are substantially larger during recessions than expansions (Auerbach and Gorodnichenko (2012)). Given the close link between the multiplier and the conduct of monetary policy, we investigate if asymmetries in Taylor type policy rules are one of the reasons explaining this finding.

Indeed, when central banks follow a Taylor Rule, multipliers are relatively small. However, when monetary policy is accommodative (i.e. the interest rate is kept constant) then the multiplier is greater. Thus, we should expect moderate responses of the interest rate to the output gap and the inflation rate during recessions or when unemployment is high.

This paper demonstrates that the first one of this statements rings true. Moreover, monetary authorities are highly concern with excess demand –when the output gap is positive or the unemployment rate is below 7 to 7.5 percent– and raise the interest rate aggressively in that case but are more reluctant to decrease the fund's rate during recessions. This way to conduct monetary policy reflecting concerns over economic overheating remains even during Greenspan's and Bernanke's mandates, largely known to be "growth oriented". One of the reasons that may explain this is that policy makers see what monetary policy could accomplish in recessions as limited and costly in terms of inflation or even confidence. Moreover, in times of busts and when authorities follow a low inflation target, monetary policy is also constraint by the zero-lower bound. However, monetary authorities react to the inflation equally in booms and busts. This implies that the second hypothesis is not verified by our results.

Finally, we show evidence that an expansionary fiscal policy does not lead to increases in the interest rates if it is carried out in recession. Thus, we could infer that fiscal expenditure not necessarily reduces investment spending. This result is important because it implies that there is not a "crowding-out" effect if fiscal expansions is accomplished in recessions. On the contrary, fiscal consolidation may prove more painful than thought.

Figure 1: **Elasticity inflation and output gap in nonlinear Taylor rule**



5 Appendix

Table 4: **Estimated elasticities in slack and overheated episodes. Threshold variable: unemployment rate**

	Slack economy	**Overheated economy**	***Regime symmetry***	**Threshold unemployment**
1970q1-2012q3				
Inflation GDP	0.839 (2.60)	1.720 (7.46)	0.008	7.5
Output gap	0.758 (2.78)	1.652 (4.44)	0.040	7.5
Preference symmetry test	0.716	0.864		
1980q1-2012q3				
Inflation CPI	2.646 (14.33)	1.879 (9.60)	0.102	7.6
Output gap	0.652 (4.99)	0.911 (6.90)	0.134	7.6
Preference symmetry test	0.000	0.000		
1988q1-2012q3				
Inflation CPI	1.502 (5.72)	2.524 (11.70)	0.000	6.9
Output gap	0.023 (0.21)	1.002 (7.21)	0.000	6.9
Preference symmetry test	0.000	0.000		

Notes: (1) See table 2

Table 5: **Linear and nonlinear estimated coefficient for government purchases in slack and overheated episodes. transition variable: unemployment rate**

	Slack economy	Overheated economy	Symmetry test	Threshold value
1970q1-2012q3	−0.024 (−1.07)	0.070 (2.69)	0.000	7.5
1988q1-2012q3	−0.027 (−1.28)	−0.038 (−0.109)	0.798	5.7

Notes: See table (3)

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