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 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 promptly to inflation, especially in busts, when the interest rate is reduced. 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 decrease that is forecast to rise 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 the links between 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 inflation, economic activity and interest rate depending on the unemployment rate in the second case.

[1] Estimates of fiscal multipliers are all over the map. 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.

Indeed, if the central bank pursues a standard Taylor Rule, then monetary policy should function as an automatic stabilizer. 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 the nominal interest rate is not sensitive to increases in government spending.[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. In particular, 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 when unemployment is high. These two statements imply that the Taylor rule is not operative in recessions but becomes highly important during overheating periods. Therefore, the Taylor rule ties the interest rate directly to government purchases but the tie is stronger when unemployment is low than when it is high.

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. 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).[4]

In the second case, Hall (2012) suggests that this non-linear response might occur if the

[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, Blinder (1997) stated that "In most situations the central bank will take far more political heat when it tightens preemptively to avoid higher inflation than when it eases preemptively to avoid higher unemployment". See also Cukierman and Gerlach (2003).

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 inoperative in recessions, 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 idea is that, in normal circumstances, a government spending expansion stimulates output and inflation. The standard belief is that this leads to an increase in interest rates, which 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 is stronger when unemployment is low.

The empirical literature tends to give 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. 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) rely on a quadratic loss function of the central bank and a nonlinear Phillips curve. They propose 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) suggest that the 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 very aggressive and markedly asymmetric monetary policy 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.

A serious drawback from most of the previous studies is that their results are based on the output gap obtained by filtering the data –mainly the Hodrick-Prescott filter– and rarely provide results based on an alternative measure (see Dolado, et. al (2005), Shin, et. al (2012), etc). However, given that estimates of the output gap are highly imprecise, it is important to assess whether the estimated regression coefficients and subsequent policy conclusions are sensitive to the method of detrending output. In addition, the literature mainly focuses 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. However, deviations of the output around its potential are arguably an equally important feature leading to an asymmetric reaction function.

In this context, we go further than the previous literature by capturing Taylor type rules in slack and overheating episodes. We consider two alternative definitions of the output gap and show that the results are highly sensitive to these measures. Considering data from the Congressional Budget Office (CBO), we provide evidence that the Fed has engaged in very aggressive monetary policy in case of excess demand –in overheating periods–. On the contrary, results relying on the HP filter indicate that monetary authorities are more concern with negative output gaps than with positive gaps. In both cases, our results show that since Greenspan's tenure the Fed often acted passively in relation to inflation in overheating periods. Finally, we show that if an expansionary fiscal policy takes place in recession times –when the unemployment is high– it does not lead to interest rate increases.

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 the same economic 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:

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

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 $i^* = 2\%$, $\pi_t^* = 2\%$ 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:

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

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 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 $t-1$ and ρ is the adjustment speed or smooth parameter. Given that expectations are unobserved, the standard approach is to substitute $E_t \pi_{t+h}$ with the actual value π_{t+h}. If h is equal to 0, Eq. (3) is already a forward-looking specification because inflation is not observed contemporaneously (Orphanides (2001)). The estimation in this case can be performed directly by OLS.

In addition, we also consider the baseline forward-looking rule with $h = 4$. Since the current interest rate shock is likely to affect future inflation in this case, the OLS procedure provides biased estimators, whereas GMM provides a consistent estimation procedure. This technique requires identifying relevant instrument variables, strongly correlated with RHS variables, but uncorrelated with innovations. In this case, we assume that the central bank's information set at time t are four lagged values of interest rate, inflation and output gap. These instruments are plausibly correlated with future inflation.

The literature has detected shifts in the preferences of the Fed regarding inflation and output growth. In particular, it is usually claimed that 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)). Therefore, we define a "preference symmetry test" by means of a Wald test for the null hypothesis that $\widehat{\delta_\pi}$ equals $\widehat{\delta_y}$ in equation (3). Instead, if the monetary policy is more concern with inflation that with economic growth, the $\widehat{\delta_\pi} > \widehat{\delta_y}$. On the contrary, if the Fed is dominated by growth-oriented policies, then $\widehat{\delta_\pi} < \widehat{\delta_y}$.

Equation (3) is based on the assumption that both excess demand and excess supply 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 $(y_t - y_t^*)$ by its decomposition into positive and negative components in Equation (3). Considering for simplicity of exposition the case where $E_t\pi_{t+h} = \pi_{t+h} = \pi_t$, we get to the following asymmetric extensions of the Taylor rule:

$$i_t = \alpha + \rho i_{t-1} + \delta_\pi \pi_t + \delta_y^+ y_t^+ + \delta_y^- y_t^- + \epsilon_t \quad (4)$$

where all the variables were previously defined and $y_t^+ + y_t^- = y_t - y_t^*$ by definition. Note that y_t^+ (y_t^-) takes positive (negative) values when the output gap is positive (negative), and 0 otherwise. Hence, the estimated δ_y^+ coefficient will be positive and significant if we expect the interest rate to increase in economic expansions. Equally, the coefficient $\widehat{\delta^-}$ 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 $\widehat{\delta_y^+} = \widehat{\delta_y^-}$ In Equation (4). If $\widehat{\delta_y^+} > \widehat{\delta_y^-}$, then there is an asymmetry where positive values of the output gap have higher impact on the interest rate than negative gaps. In this case, this linear equation with a break point is an approximation of a convex function. On the contrary, if $\widehat{\delta_y^+} < \widehat{\delta_y^-}$, then the asymmetry implies that the central bank has systematically responded more strongly in recession times.

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 parts, 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 the economy should behave in this simplistic fashion. If monetary authorities dismiss small deviations of the output with respect to its potential but react actively for large enough demand pressures, 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:

$$i_t = \alpha + \phi_1 i_{t-1} + \delta_\pi \pi_t + \delta_y (y_t - y_t^*) + \left[\delta_\pi^* \pi_t^* + \delta_y^* (y_t - y_t^*)\right] \times f(r_{t-i}; \xi, c) + \epsilon_t \quad (5)$$

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:

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

Equation (5) allows the coefficient telling how much to raise the interest rate when inflation or the output gap 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 nonlinearity: since we are interested on the reaction of the interest rate in slack and overheated episodes, we consider the lagged unemployment rate. That is, we define slack (overheating) as the response arising when the previous period's unemployment rate is above (below) 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 state of the labour market.[5]

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 $\widehat{\delta_y}$ and $\widehat{\delta_\pi}$ in the first regime (when $f=0$), and $\widehat{\delta_y+\delta_y^*}$ and $\widehat{\delta_\pi+\delta_\pi^*}$ in the second regime (when $f=1$). Indeed, whereas the elasticity in a linear model is constant and equal to $\widehat{\delta_y}$ and $\widehat{\delta_\pi}$ 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:

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

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

1. $H_0:\delta_\pi+\delta_\pi^*=\delta_y+\delta_y^*$: preference symmetry in slack periods
2. $H_0:\delta_\pi=\delta_y$: preference symmetry in overheating periods
3. $H_0:\delta_y=\delta_y+\delta_y^*$: regime output gap symmetry
4. $H_0:\delta_\pi=\delta_\pi+\delta_\pi^*$: regime inflation symmetry

In addition, if $\widehat{\delta_y}$ is not significant but $\widehat{\delta_y}+\widehat{\delta_y^*}$ is positive and significant, Eq. (5) allows to estimate the unemployment level at which the monetary authorities react to demand or inflation pressures. For instance, if the central bank believes that higher inflation is more likely to be transitory in a slack economy than in a strong one, then $\widehat{\delta_\pi} > \widehat{\delta_\pi}+\widehat{\delta_\pi^*}$.

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

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

[5] We could equally rely on the output gap as transition variable. The advantage of the unemployment rate is that it is an observable variable available for policy making.

where i_t and g_t are the interest rate and the (log) public spending, 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 cases. Then, the two regimes can be interpreted as extreme recessionary periods (i.e. when the unemployment rate is above the threshold and great expansions (in the opposite case). 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: $H_0 : \widehat{\theta_i} > \widehat{\theta_i} + \widehat{\theta_i^*}$. On the contrary, if the link is stronger in slack episodes that during expansions, then $H_0 : \widehat{\theta_i} < \widehat{\theta_i} + \widehat{\theta_i^*}$.

2.2 Data description

Quarterly data were collected for the United States for the 1970:1-2012:3 period. The inflation rate is the annual rate of growth of the consumer price index obtained from the OECD's economic Outlook. The interest rate corresponds to the Federal Funds rate from the IMF (series 60b). Government expenditure is the current expenditure of the Federal Government, provided by Bureau of Economic Analysis (BEA). We used the unemployment rate supply by the OECD as transition variable in Equations (9) and (11). All the variables are seasonally adjusted.

We pay special attention to the definition of the output gap. 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 compare rigorously the output gap obtained from a Hodrick Prescott filter (HP) with an output gap measure constructed by the Congressional Budget Office (CBO).

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 (see figure 1). In opposition, the output gap obtained with the Hodrick Prescott (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) and then started to recover. By 2011q4 the HP output gap was already back to positive numbers whereas the CBO estimate indicates still excess supply by the end of 2012.

Moreover, structural breaks are smoothed over by the HP filter. This implies that the filter moderats a break when it occurs, spreading its effect forwards and backwards over several years. This may be appropriate if a break occurs gradually over time but is problematic in the case of large discrete changes in output levels due to sudden demand or supply shocks (Giorno, Richardson, Roseveare, and van den Noord (1995)).

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 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 and thus it can be interpreted as the level of output that is consistent with stable inflation. On the negative side, the CBO's model uses some parameters –as the the coefficients on labor and capital in the production function– that are imposed rather than econometrically estimated.

Even though our prefer measure is the CBO's estimate and thus it constitutes our benchmark output gap, throughout the results we carefully assess the similarities and differences of the results obtained with the two measures of the output gap.

3 Empirical Results

Table 1 presents the estimated coefficients of the symmetric and asymmetric Taylor rules (Equations 3 and 4) for the 1970q1-2012q4 period. The table also provides the results for the 1970q1-2008q3 and 1988q1-2012q3 subperiods.

We distinguish these subperiods because the empirical literature on monetary policy rules has been typically concerned about structural breaks in the Taylor rule, with an emphasis in the pre- and post-Greenspan years (before and after 1988). This literature usually insists that since Greenspan's chairmanship 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). In addition, we conduct the same analysis without the recent years when policy rates reached their zero lower bound (since December 2008). According to many macroeconomic models, this should have greatly reduced the effectiveness of monetary policy and increased the efficacy of fiscal policy (e.g Christiano, et.al (2011), Farhi and Werning (2012), etc.)

The symmetric models based on the CBO output gap show that the monetary policy response has been weak, with the Fed raising the funds rate just 0.1% in response to a 1%

Figure 1: **Output gap: difference between actual output and potential output from a Hodrick Prescott filter and the CBO estimate**

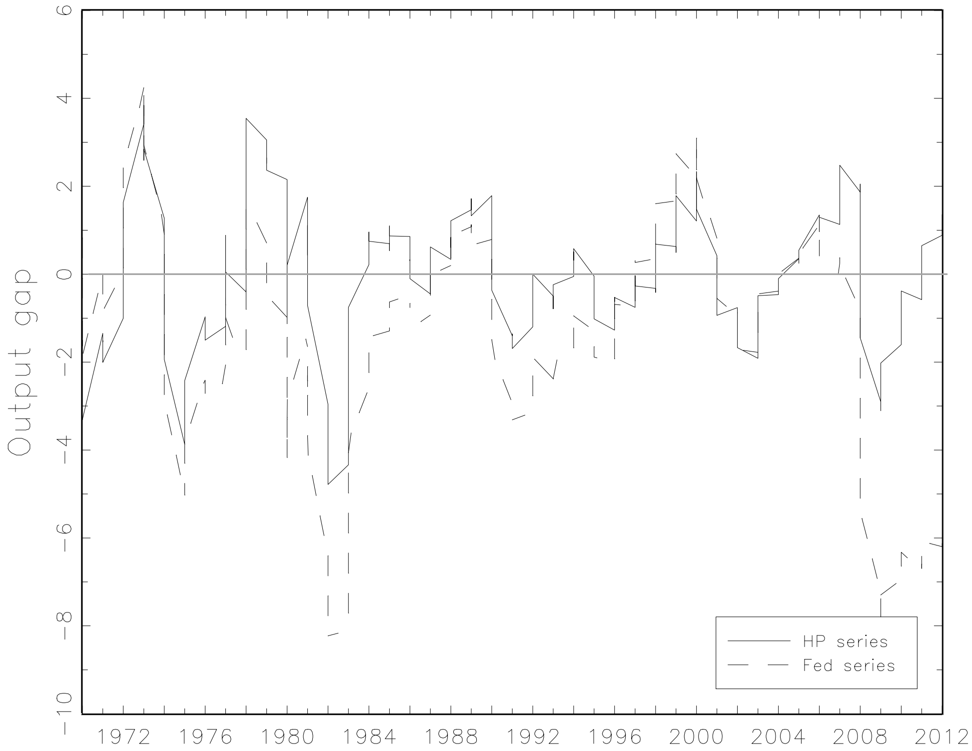


Table 1: **Output gap and inflation elasticities in symmetric and asymmetric Taylor rules**

Elasticity	OLS estimates $E_t\pi_{t+h} = \pi_t$ 1970q1-2012q3	1970q1-2008q3	1988q1-2012q3	GMM estimates $E_t\pi_{t+h} = \pi_{t+4}$ 1970q1-2012q3	1970q1-2008q3	1988q1-2012q3
Symmetric						
Inflation	0.114	0.115	0.011	0.122	0.133	−0.001
	(3.04)	(2.89)	(0.23)	(3.06)	(3.65)	(−0.00)
Output gap CBO	0.110	0.155	0.071	0.096	0.151	0.063
	(4.03)	(4.08)	(3.05)	(3.70)	(4.32)	(2.86)
Preferences symmetry test	0.958	0.452	0.052	0.560	0.714	0.005
Inflation	0.084	0.098	−0.042	0.081	0.106	−0.080
	(2.33)	(2.54)	(−0.83)	(2.39)	(3.45)	(−1.67)
Output gap HP	0.249	0.264	0.130	0.230	0.267	0.154
	(5.62)	(5.52)	(2.77)	(5.36)	(5.73)	(2.79)
Preferences symmetry test	0.007	0.010	0.035	0.010	0.006	0.007
Asymmetric						
Inflation	0.115	0.116	0.020	0.103	0.114	0.022
	(3.07)	(2.91)	(0.43)	(3.10)	(3.85)	(0.73)
Positive output gap CBO	0.231	0.201	0.174	0.259	0.212	0.153
	(2.32)	(1.95)	(2.21)	(3.25)	(2.53)	(2.66)
Negative output gap CBO	0.083	0.140	0.053	0.066	0.136	0.045
	(2.42)	(2.60)	(1.99)	(2.53)	(3.19)	(1.77)
Regime symmetry test	0.207	0.654	0.048	0.036	0.479	0.037
Inflation	0.088	0.106	−0.062	0.065	0.087	−0.123
	(2.38)	(2.67)	(−1.21)	(1.99)	(3.11)	(−1.84)
Positive output gap HP	0.209	0.186	−0.018	0.294	0.272	−0.045
	(2.17)	(1.82)	(−0.22)	(2.59)	(2.42)	(−0.44)
Negative output gap HP	0.281	0.330	0.286	0.182	0.244	0.311
	(3.51)	(3.64)	(3.40)	(2.94)	(3.61)	(3.32)
Regime symmetry test	0.789	0.389	0.029	0.475	0.856	0.038

Notes: (1) t-statistics are given in parentheses; (2) The symmetry test presents the probability for the null hypothesis: $H_0 : \delta_y^+ = \delta_y^+$ in Eq. (4).

increase in the output gap or in the inflation rate in the short-run. The results also show symmetry in the Fed's preferences regarding its objectives of inflation and growth at least until 2008. However, in accordance with the previous literature, since 1988 the Fed became predominantly concerned with growth and largely neglected inflation. It is very important to remark the sensitivity of our results to the output gap measure. Indeed, the Taylor rule using the HP filter estimate indicates that monetary authorities have been constantly more concern with growth than inflation.

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 pre-Greenspan period. Just as in the symmetric case, the results from the HP filter differ from those with the CBO estimate, indicating that if one considers the HP filter, the Fed is more concern with correcting a negative output gap than a positive one since 1988.

We then explore how the interest rate reacts in boom and bust periods without imposing a zero threshold in the estimations. In this case, our propose model has the interesting advantage to endogenously determine the threshold unemployment rate that defines overheating and recession episodes, compelling 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. However, when the economy is overheating (for an unemployment rate below 7.5% or even lower according to the GMM estimation), the Fed is more cautious with demand pressures and increases rapidly the interest rate in response to a positive output gap.

As in the previous model, the regime symmetry test shows to 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– 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 higher when unemployment is low than when it is high. If higher government expenses are translated into higher inflation, this second result would imply, in turn, a higher multiplier during expansions.

It is important to distinguish how much of these combined effects are a result of the financial crises and the adoption of the zero lower bound for nominal rates since the last quarter of 2008. As seen, for the 1970q1-2008q3 period, the Fed has reacted symmetrically towards inflation and growth objectives during slack episodes. Equally, during recessions the interest rate decreases (increases) about 0.2% in response to a 1% increase (decrease) in the output gap. However, periods of low unemployment (i.e. overheated episodes) lead monetary authorities to have asymmetric preferences, responding mainly by increasing the interest rate to a positive output gap. Even though the results from CBO data and the HP filter differ in some aspects, both specifications indicate that in overheating periods, demand pressures tend to prompt stronger interest rate increases than inflation.

Nevertheless, since 1988 the Fed has shown little concern for inflation in its reaction function both in slack and overheating periods. Moreover, according to the GMM estimation, monetary authorities have followed an accommodating monetary policy stance, with interest rates declining even as inflation rises. In opposition, our results indicate that monetary authorities are especially reactive to demand pressures by increasing the interest rate when the economy is overheating.

Our finding that the reaction of Fed has been less active in slack periods than during booms contradicts recent studies claiming that the Fed pursues a growth fostering agenda since Greenspan's times (Shin, et. al (2012)). Indeed, we provide evidence that the Federal Reserve is no more averse to negative than to positive output gaps (i.e. there is no evidence of the "pushing on a string" argument). 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.

Another possible explanation for our different findings is the definition of the output gap. Indeed, according to the HP series, monetary authorities have reacted strongly to the output gap in recessions. On the contrary, the Fed has not shown any reaction to overheated episodes. Remember, however, that the HP filter can severely underestimate the real state of the economy during the recent crises.

Figure 2 shows the estimated elasticities for inflation and the output gap derived from the nonlinear model according to the OLS estimate and with the CBO data. The estimated elasticities from the whole period and for the 1970q1-2008q4 sub-period show high inflation concerns in the mid-seventies, early eighties and between 1992 and 1993. These dates coincide with lower output gap preferences from the Fed. 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. Effectively, the central bank is highly attentive to an overheated economy and raises the interest rate aggressively in that case, but is more reluctant to stimulate by cutting the rate when the economy is slack.

Table 2: **Linear and nonlinear estimated elasticities in slack and overheated episodes**

	OLS estimates, $E_t\pi_{t+h} = \pi_t$				GMM estimates, $E_t\pi_{t+h} = \pi_{t+4}$			
	Slack economy	Overheated economy	Regime symmetry	Threshold value	Slack economy	Overheated economy	Regime symmetry	Threshold value
1970q1-2012q3								
Output gap CBO	0.113 (2.84)	0.261 (5.95)	0.012	7.4	0.047 (0.83)	0.262 (2.20)	0.030	6.9
Inflation	0.216 (4.40)	0.095 (2.56)	0.009	7.4	0.233 (3.92)	0.143 (2.52)	0.225	6.9
Preference symmetry test	0.030	0.003			0.001	0.322		
Output gap HP	0.317 (3.51)	0.354 (6.50)	0.724	7.5	0.085 (1.46)	0.459 (4.29)	0.005	7.4
Inflation	0.205 (4.55)	0.034 (0.94)	0.000	7.5	0.237 (2.68)	0.010 (0.21)	0.009	7.4
Preference symmetry test	0.198	0.000			0.031	0.000		
1970q1-2008q3								
Output gap CBO	0.264 (3.25)	0.286 (5.78)	0.816	7.5	0.350 (3.08)	0.434 (6.15)	0.585	7.4
Inflation	0.298 (5.00)	0.076 (1.85)	0.001	7.5	0.429 (6.25)	0.050 (1.21)	0.000	7.4
Symmetry test	0.599	0.001			0.436	0.000		
Output gap HP	0.559 (4.86)	0.359 (6.49)	0.122	7.5				
Inflation	0.309 (5.95)	0.038 (1.02)	0.000	7.5				
Preference Symmetry test	0.014	0.000						
1988q1-2012q3								
Output gap CBO	0.108 (4.62)	0.329 (4.53)	0.001	5.0	0.079 (2.29)	0.529 (3.96)	0.004	5.1
Inflation	−0.039 (−0.92)	−0.039 (−0.92)	0.230	5.0	−0.052 (−1.11)	−0.234 (−3.06)	0.030	5.1
Symmetry test	0.075	0.076			0.083	0.000		
Output gap HP	0.232 (3.47)	0.048 (0.54)	0.085	5.5	0.289 (3.59)	−0.009 (−0.05)	0.049	5.4
Inflation	−0.047 (−0.91)	−0.069 (−1.10)	0.592	5.5	−0.102 (−0.33)	−0.117 (−1.77)	0.965	5.4
Preference Symmetry test	0.004	0.367			0.064	0.623		

Notes: (1) t-statistics are given in parentheses; (2) The symmetry test presents the probability for the null hypothesis: $H_0 : \widehat{\delta_y} = \widehat{\delta_y} + \widehat{\delta_y^*}$ and $H_0 : \widehat{\delta_\pi} = \widehat{\delta_\pi} + \widehat{\delta_\pi^*}$ in Equations (5) and (**??**), respectively.

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 3, it is clear that the interest rate increases with government expenditures exclusively in overheated periods –when the unemployment rate is below 7.5%–. 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.

Table 3: **Linear and nonlinear estimated coefficient for government purchases in slack and overheated episodes**

	Slack economy	Overheated economy	Symmetry test	Threshold value
1970q1-2012q3	−0.024 (−1.07)	0.070 (2.69)	0.000	7.5
1970q1-2008q3	−0.032 (−1.23)	0.072 (2.56)	0.000	7.6
1988q1-2012q3	−0.027 (−1.28)	−0.038 (−0.109)	0.798	5.7

Notes: (1) $\widehat{\gamma}$ is the estimated elasticity in the lower regime (when trend inflation is below the threshold level $\widehat{c}$) in Equation (5); (2) $\widehat{\gamma}+\widehat{\gamma^*}$ is the estimated elasticity when $g = 1$ in Equation (5); (3) t-statistics are given in parentheses.

4 Concluding remarks

According to recent empirical evidence, fiscal tightening in times of recessions can be highly counterproductive in terms of economic growth. This implies that fiscal multipliers are substantially larger during recessions than expansions. 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 that fiscal shocks have a larger impact when the affected country is in recession.

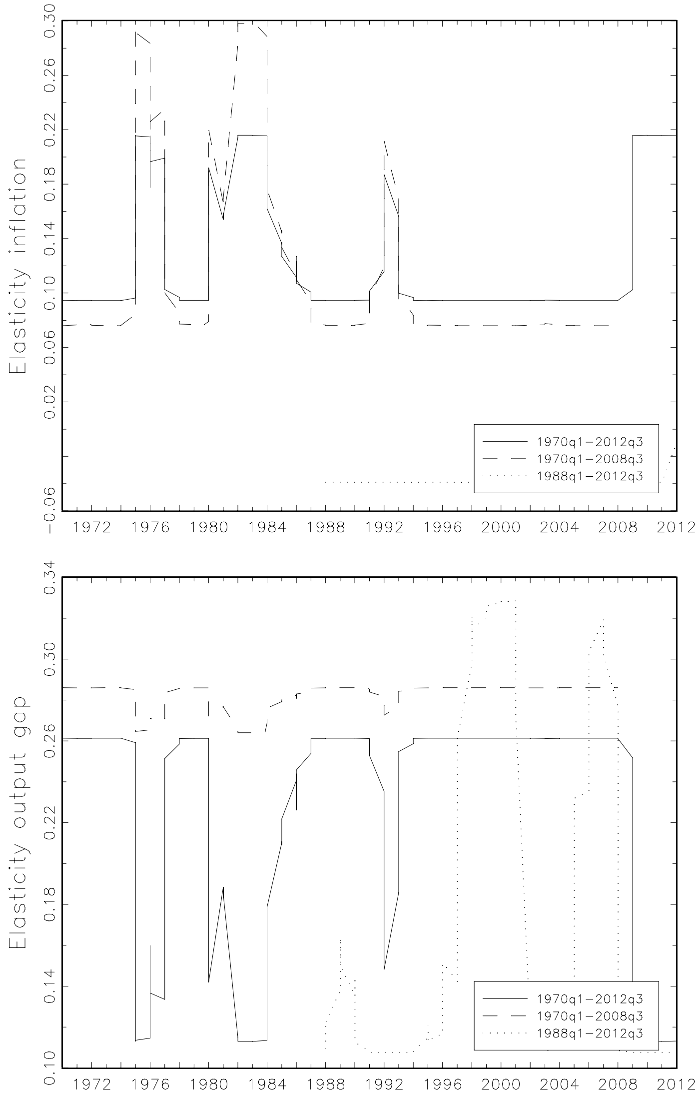
When central banks follow a Taylor Rule then multipliers are relatively small. However, when monetary policy is accommodative (i.e. the interest rate is kept constant) then the multiplier is greater. Thus, we should expect moderate responses of the interest rate to the output gap and the inflation rate 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 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". However, since the interest rate reacts to the inflation especially in busts, the second hypothesis is not verified by our results.

We also show evidence that an expansionary fiscal policy –higher government expending– does not increase interest rates and thus not necessary reduces investment spending in recession times.

Finally, it is important to remark that differences in output gap estimates can be significant and sometimes lead to spurious results or even very different policy conclusions. Indeed, with the CBO estimate of the output gap a positive gap prompts the Fed to cool the overheating economy by raising policy rates by two times more than a negative output gap prompts monetary stimulus. Quite the opposite, a Taylor rule estimated with a HP filter indicates that policy makers have been constantly concerned in recession times. Because of modelling uncertainty, it is essential that policy evaluations are based on robust alternative assumptions.

Figure 2: **Elasticity inflation and output gap in OLS estimation**



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