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Abstract

The Taylor rule constitutes the main tool policy makers rely on to guide monetary policy. In simple words, the rule is a reaction function that determines the short-term interest rate, which responds in the baseline specifications to changes in the inflation gap and the output gap. Since the original paper of Taylor (1993), a large debate has taken place in the literature regarding what the best performing rules are. This paper attempts to analyze the recent literature on the Taylor rule and in particular two important extensions proposed in the last decades: first, we consider whether financial variables should be included in the Taylor rule; second, we analyze the inclusion of the long-term interest rate. From this analysis, we contribute to the understanding of the main monetary policy tool used by any Central Bank and debate whether we find potential variables to extend it.

Keywords: Inflation - Interest rates - Output - Taylor rule - Taylor principle
JEL: E50, E52, E58

1 Introduction

The work of Taylor (1993) has inaugurated a prolific line of research that explores the behavior of the Central Bank and the response of short-term interest rates to different variables. In the original paper, Taylor attempts to approximate the actual movements of the interest rate carried out by the Federal Reserve and proposes a monetary policy rule by which the short-term interest rate responds to movements in the price level and the real income. The basic Taylor rule is given by a function of the following type:

$$i_t = r + \pi^* + \alpha_1(\pi_t - \pi^*) + \alpha_2 y_t \tag{1}$$

where i_t is the short-term interest rate; π^* is the inflation rate target set by the monetary authority; r is the equilibrium or natural real interest rate; π_t is the inflation rate, and y_t is the output gap, both at time t. Finally, α_1 and α_2 are positive policy parameters chosen by the Central Bank defining the relative weight given to deviations in inflation and output with respect to the targets set by the monetary authority.

In simple words, the Taylor rule constitutes a reaction function that tells us that the Central Bank will increase (decrease) the short-term interest rate whenever the rate of inflation or the output gap are above (below) the targets. The parameters α_1 and α_2 describe the importance that the monetary authority assigns to each deviation. Taylor (1993) emphasized that this kind of rule would stabilize inflation only if the weight assigned to the inflation gap was larger than the unity. Otherwise, an inflation increase would lead to a reduction in the real interest rate, pushing inflation even further. This policy implication came to be known as the "Taylor principle", constituting the basic premise for central bankers to follow.

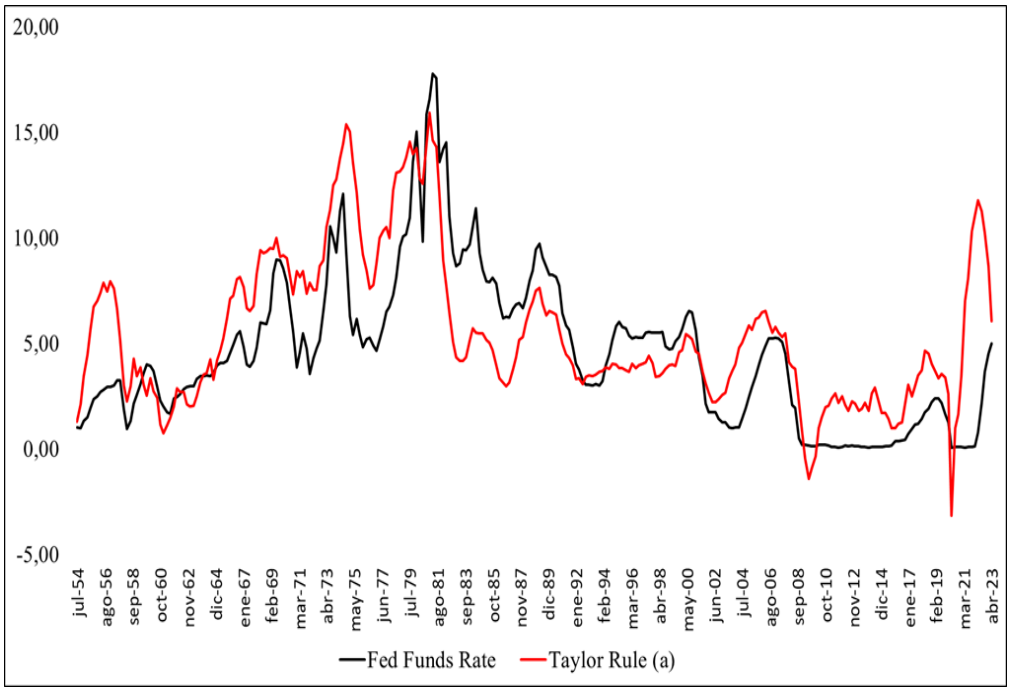

Figure 1: Evolution of the Fed Funds rate and the Taylor Rule

[1]

In Figure 1 it may be observed the evolution of the Fed Funds rate along with the Taylor Rule. It may be appreciated that the Fed Funds rate not only follows the trend suggested by the rule during the period ending around the second oil shock in 1979, but it is also systematically higher than this latter at least until the beginning of the 1990s. Instead, in the years previous to the shock, during the 1960s and 1970s, it seems to be quite straightforward that the Fed Funds rate is practically always below the rate suggestes by the Taylor rule. Some authors, as for instance, Clarida et al. (1999), affirm that this violation of the Taylor principle was the reason behind the Great Inflation of the 1970s.

In order to reduce inflation, the Federal Reserve tightened monetary policy until around the end of the 1980s more than suggested by the Taylor principle. This period coincided with Paul Volcker serving as the chairman of the Federal Reserve Board (1979-1987), during which the weight given to inflation stabilization was clearly dominant, with the US economy experiencing two recessions attributed to the aggressive tightening of monetary policy -see, e.g., Goodfriend and King (2005)-. During the Great Moderation period (1984m1-2007m12) the performance was again erratic. The Fed Funds rate moved slightly above the rule in part of the 1990s, and below in the 2000s. This latter period of low interest rates gave place to a large discussion debating whether the Federal Reserve had had direct responsibility in creating the asset price bubble that burst in 2008 and triggered the financial crisis and the Great Recession -on the origins of the financial crisis, see, e.g., Baily et al. (2008)-. In the aftermath of the crisis, interest rates remained way below the suggested ones by the Taylor principle in a period in which monetary policy faced the constraint of the zero lower bound. Indeed, the Fed Funds rate hit zero in a low inflation environment and remained at that level until around 2014.

A simple analysis of Figure 1 leaves the feeling that the Taylor rule is able to reproduce the general behavior of the Fed Funds rate in a fairly accurate way, but still showing better performance in some periods than in others. Is this a consequence of the variables included in the reaction function? Would it be possible to improve the fit of the rule? What other variables could or should be included? An extensive literature has been developed around the Taylor rule, suggesting and testing different variables, such as financial variables, exchange rate variables, etc., presenting in general mixed results. The scope of this work is to explore some of the main options tested in recent times and come up with some relevant policy implications that could serve as a guide for policy makers.

In Section 2 we present some of the main extensions of the Taylor rule proposed in recent years, many of them as a direct consequence of the re-thinking of the monetary policy that took place as a result of the financial crisis. In particular, we focus on two kind of variables: financial variables and the long-term interest rate. In the Section 3 we leave place for discussion and some concluding remarks.

2 Extensions

Since its first appearance, the Taylor rule has immediately gained popularity in the field of monetary economics and became a practical tool to guide monetary policy. Just a few years after the original paper of Taylor (1993), some important works, like Svensson (1997), showed that the Taylor rule constituted an optimal policy if the preferences of the Central Bank were given by a quadratic intertemporal loss function, the short-term interest rate was the control variable and the economy was described by a Philips curve and an IS-LM curve.

Clarida et al. (1999) extended the model by incorporating rational expectations, which came to be the typical way to model expectations in monetary models. In addition, they showed that the rule fitted the behavior of monetary authorities in other countries other than the United States. Other efforts have been made trying to extend the two-equation model. In early times, for instance, it is possible to find contributions such as those of Ball (1999), Engel and West (2002), and Ullric (2003), in which the nominal exchange rate is included. In addition, we can also find many attempts to break the assumption of the quadratic loss function. In this latter case, the first papers date from the end of the 1990s and the beginning of the 2000s, and we find Chadha and Schellekens (1999), Kim et al. (2003), and Surico (2004), among others.

There are two interesting lines of extensions that we explore in this paper. Firstly, the literature around the Taylor rule has been enriched after the Great Recession, due to the need to consider whether financial variables should be included inside the monetary policy rule. Secondly, a vast literature has been developed around the relationship between short-term interest rates and long-term interest rates. In this latter case, we have to remember that the Central Bank can only affect short-term interest rates, hence the understanding of the link between short-term and long-term interest rates is key for the transmission of monetary policy.

2.1 The Taylor rule after the Great Recession

In recent years, more specifically after the 2008 crisis, many proposals have aimed at including financial variables in the Taylor rule. As a response to the financial crisis, the Federal Reserve strongly eased monetary policy and drove interest rates to zero. The irruption of the zero lower bound (2008Q4-2015Q4) constituted a problem for policy makers, since when the interest rate hit zero, the

Federal Reserve was unable to follow the Taylor principle when managing monetary policy. This motivated researchers to discuss the potential effect of including financial and liquidity management variables in the Taylor rule.

We could say that there are two prominent strands of literature in this matter. On the one hand, as stated in Kockerols and Kok (2019), it seems that the dominant approach in the aftermath of the crisis, is the one supporting the idea that monetary policy should not consider financial stability variables. Indeed, the idea behind this literature is that macroprudencial policy is much more effective in doing so than monetary policy, and the costs of pursuing financial stability using monetary policy exceed the benefits. On the other hand, there's a large body of literature supporting the idea of "leaning against the wind", which basically means that monetary policy should somehow respond to financial variables, and not only to inflation and output, especially when the risk of facing financial bubbles is high. As stated in Brunnermeier (2014), leaning against the wind is a non-trivial operation that heavily depends on the timing (early interventions are preferred), and strength (it should be not too weak nor to strong).

However, the most accepted view in the post-crisis period continued to be that monetary policy should not "lean against the wind" and macroprudencial policy should be used instead. As a matter of fact, some relevant works suggest that the former strategy may carry along counterintuitive results, increasing financial fragility instead of reducing it. In this line of analysis, Korinek and Simsek (2016) affirm that an increase in interest rates derive in an increase of household indebtedness and financial instability.

Beyond the theoretical debate between the "leaning against the wind" supporters and non-interventionists, we find in practice that the behavior of most monetary authorities might not be guided only by a typical Taylor rule. Yagihashi (2011), for example, supports the idea that the Fed, even before the Great Recession, when deciding monetary policy, took into consideration credit channel conditions. As stated by this latter, the credit channel is "the monetary policy transmission mechanism through the supply of loanable funds". In the literature, it is quite common to find a definition of the credit channel given by difference in the returns between a risky asset and a safe asset. Taylor (2008), for instance, proposes to use the spread between the LIBOR at 3 month maturity and an index of overnight Federal Fund rate, also at 3 month maturity. Yagihashi, instead, works with "slow-moving variables" and estimates an extended Taylor rule, finding variables such as net worth capital ratio to be economically and statistically significant.

Franceschi (2021) include financial and liquidity variables and also shows that the Fed has paid attention to these variables during the last decades. By measuring liquidity as the spread between risk-free liquid assets and less liquid assets, Franceschi finds that financial conditions enter into the consideration of the Fed when carrying out monetary policy. Hence, it is possible to find that the Fed consistently deviates from the Taylor principle when estimating the rule without financial and liquidity considerations. However, deviations vanish when including proxy variables for liquidity and giving more weight to financial liquidity.

Even when empirical applications demonstrate that the Fed may consider financial variables when deciding the short-term interest rate, the general feeling in the literature is that this should not be necessary if macroprudential regulations were well designed. Indeed, some consensus on the financial crisis origins would suggest that the road to the crisis was paved by the limited financial regulations and not by the absence of financial variables in the Taylor rule.

2.2 The relationship between short-term and long-term interest rates

A rich line of literature has worked around the connection between short and long-term interest rates, arguing that bond rates naturally incorporate information on inflation expectations. In this debate, we can also find two types of literature, depending on the direction of the causality under consideration. One strand is devoted to the analysis of the effect of the short-term interest rate on the long-term interest rate, where it is possible to find works such as that of Iwata (2010). This literature came to be of particular interest as a direct consequence of the 2008 crisis, especially as the zero lower bound became a constraint for the conducting of monetary policy. In general, there was some agreement on the fact that monetary policy would still be operative when approaching the zero lower bound if long-term interest rates were positive, since monetary policy would be transmitted through the channel of the long-term interest rate. Interestingly, Bernanke and Blinder (1992) suggest that the spread between the Federal Funds rate and a long-term bond rate is a good indicator of the stance of monetary policy.

In this paper, however, the concern is about the converse relationship, this is, the causality going from long-term to short-term interest rates. This is a long-dated line of research, with applications

appearing already in the end of the 1990s, concerned about the effects of including the long-term rate into the Taylor rule. What would be the effect on the short-term interest rate of a shock on the long-term interest rate? Would it be possible to incorporate the long-term interest rate into the Taylor rule? What should be the sign of the coefficient accompanying it?

Favero and Bagliano (1998) evaluate VAR models designed to analyze the transmission mechanism of monetary policy and check the effect of the omission of the long-term interest rate. When they include it, they find that shocks that increase the long-term interest rate also increase the short-term interest rate. Gerlach-Kristen (2003) present an alternative Taylor rule where the role for the long rate is key, affirming that agents typically see the long-term interest rate as a proxy for long run inflation. They also estimate a positive effect of the long-term rate on the short-term. These results were validated in the beginning of the 2000s by McCallum (2005), who assumes that in the policy rule the long-term interest rate has a positive sign.

A contrasting result is found in Casellina and Uberti (2008), where the long-term interest rate is negative correlated to the short-term interest rate. The model arrives to such an opposite result by working with some particular extensions: First, in the line of Clarida et al. (1999), the output gap depends on expected inflation and expected output gap; second, observed output is assumed to depend on the long-term interest rate; third, like in Ball (1999), inflation and the observed output are related through the exchange rate. On its part, the exchange rate is related to the equilibrium of the long-term interest rate and to the inflation rate.

The work of Wölfel and Weber (2017) attempts to identify the main variables for the Fed's reaction function, and using a Bayesian model averaging (BMA), shows that Fed does not only consider the usual targets (inflation, unemployment and output gap), but also takes into account other variables. More precisely, all models tested found a relevant role for the long-term interest rate, validating all of them a positive sign for the coefficient. This is clearly in line with most of the literature on the subject, though it is at odds with the aforementioned results of Casellina and Uberti (2008).

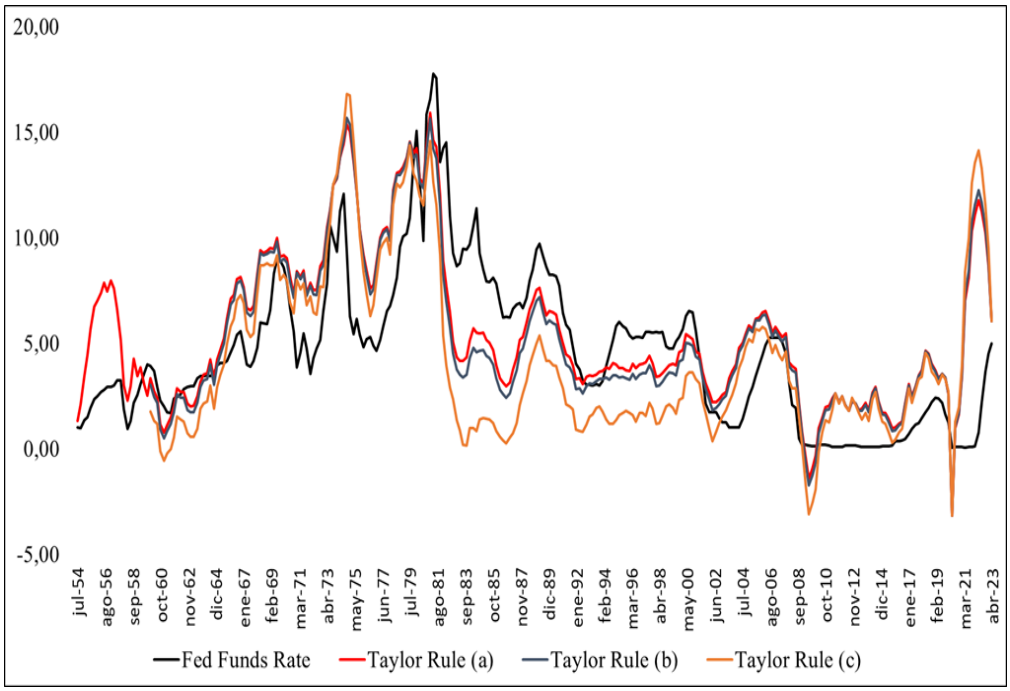

Figure 2: Evolution of the Fed Funds rate and the Taylor Rule

[2]

In Figure 2, a simple exercise is carried out. The long-term interest rate is included in an otherwise typical Taylor rule. In this case, the long-term interest rate is included with a negative sign, as in Casellina and Uberti (2008).

As shown in Table 1, the correlation coefficients between the Fed Funds rate and the Taylor rule worsen when the long-term interest rate is included with a negative sign. It is possible to observe that these results hold across the different sub-periods since the 1960s until these days. This

would suggest that, a priori, in order to include the long-term interest rate with a negative sign, the assumptions made in Casellina and Uberti are not trivial.

Taylor Rule	(a)	(b)	(c)
1960-1984 (pre-Great Moderation)	0.70	0.66	0.49
1984-2007 (Great Moderation)	0.68	0.65	0.52
1960-2023 (Full sample)	0.57	0.48	0.13

Table 1: Correlation coefficients between the Fed Funds rate and the Taylor Rule

[3]

What if the long-term interest rate enters the Taylor rule with a positive sign? Interestingly, even when at first sight it is not possible to find big differences between Figure 3 and Figure 2, the correlation between the Taylor rule and the Fed Funds rate improves considerably. This suggests that the Federal Reserve actually considers in some way the long-term interest rate when setting the policy rate. Once again, it is straightforward to note that these results are consistent across different time spans.

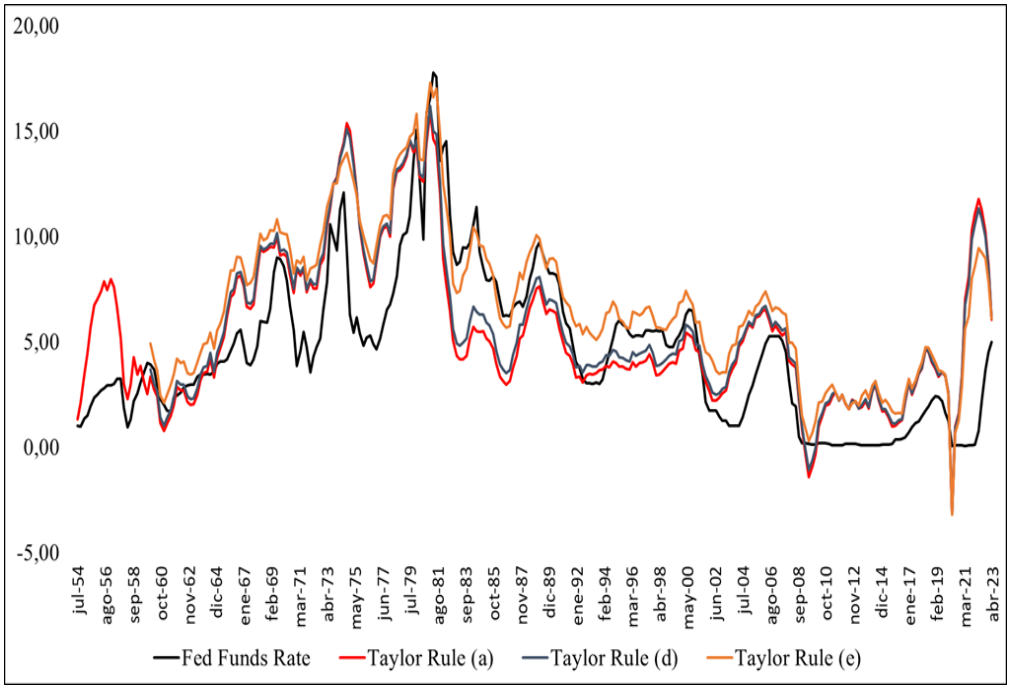

Figure 3: Evolution of the Fed Funds rate and the Taylor Rule

[4]

Taylor Rule	(a)	(b)	(c)
1960-1984 (pre-Great Moderation)	0.70	0.74	0.86
1984-2007 (Great Moderation)	0.68	0.71	0.83
1960-2023 (Full sample)	0.57	0.66	0.86

Table 2: Correlation coefficients between the Fed Funds rate and the Taylor Rule

[5]

3 Discussion and concluding remarks

After thirty years of the work of Taylor (1993), we are still searching for the right reaction function to conduct monetary policy. The literature on this matter is vast and almost impossible to cover

thoroughly. During the last three decades, an important debate took place -still takes place- around the possible need to expand the Taylor rule and incorporate new variables into the reaction function. This line of research is key, with clear policy implications, and related directly to the search for the best practices to guide monetary policy.

The literature does not seem to have reached definitive results. However, it seems that the progress it experienced allows us to at least come up with some policy implications based on the minimum agreements reached. Of course, it is completely out of discussion the fact that inflation (or the inflation gap) should be part of the Taylor rule. Even when some monetary authorities care exclusively for inflation, it is almost out of the debate that the output gap should be included as well. What other variables would improve the conducting of monetary policy? The list to analyze is long, and in this paper we revisit the main works on the Taylor rule focused on two particular possible extensions, which experienced a prominent place in the literature in recent years: first, we analyze whether the inclusion of financial variables, in the light of the 2008 financial crisis, is become a must for any Central Bank; second, we study the effect of including long-term interest rates. Periods of turmoil in which the role of monetary policy is in the spotlight, as the last financial crisis, are evidently prolific in opening the discussion on which variables could eventually become good candidates to enter the Taylor rule.

The debate on whether to include financial variables inside the Taylor rule or not has been an appealing line of research with two clear positions: on the one hand, those favoring the idea of intervention -the so-called "leaning against the wind" supporters-, and, on the other, those favoring the idea of non-intervention, assuming that policy makers should rely on macroprudential policies to ensure financial stability. Overall, an extensive analysis of the main literature seems to suggest that the latter would be the correct approach, while the first gained popularity during the first years after the crisis, and lost part of the appeal in recent times.

When we center the analysis on the long-term interest rate, the debate seems to be again puzzling, but the literature ruling in favor of including the long-term interest rate in the Taylor rule is overwhelming. The debate appears when checking the relationship between the short and the log-term interest rate inside the reaction function. While more empirical work is still needed, the literature seems to support the idea that the Federal Reserve usually takes into account the long-term interest rate when setting the Fed Funds rate, and the relationship between both variables would be positive for simple policy rules but might be negative when using more sophisticated ones.

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