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The European Central Bank, the Federal Reserve and the Bank of England: Is the Taylor Rule a Useful Benchmark for the Last Decade?

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ABSTRACT

In this article, using a Taylor type rule, I focus on the Euro era and compare the ECB with other two central banks, the Fed and the Bank of England. A very interesting result comes out from the analysis: it seems that these central banks do not observe the inflation course before deciding on the variation of the interest rates. This result can be linked to two ideas: firstly, the use of stationary time series drops out the significance of the inflation gap; secondly, a really forward looking central bank focuses on other macroeconomic leading indicators instead of examining the inflation gap.

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Keywords: Taylor rule, European Central Bank, Federal Reserve, Bank of England.

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1 INTRODUCTION

This work makes use of a Taylor type rule to study the monetary policy of the three major central banks in the world. The main aim is to understand the usefulness of the Taylor Rule in describing the behaviour of the monetary policy. As period of analysis I have chosen the last decade because this is a period in which it is possible to directly compare the performance of the European Central Bank, the Bank of England and the Federal Reserve. This period lets us inspect the ECB during the first phase of its activity and one can compare the approach towards the monetary problems of a new established central bank with the one of other two central banks that have a very long history. Moreover, this work can be seen as a further attempt to understand if the central banks really follow a rule in order to decide the stance of the monetary policy or, at least, we can observe if a simple rule can give us some ideas of the conduct of the monetary policy. Furthermore, I decided to start the article with a visual study on the real interest rates. In so doing, with the visual and the econometric approaches, one can analyse both the path and the causes of the interest rates.

Starting from 1993, when Taylor published his work "Discretion versus policy rules in practice", there has been a large debate about the possibility that a simple rule might mimic the monetary policy of a Central Bank or another type of monetary policy-maker which used the interest rate as the key monetary policy tool.

The great simplicity of this formula and its good fit to the Federal Reserve monetary policy (Taylor applied his rule with very good results to FED monetary policy from 1987 to 1992) gave a big impulse to various strands of research focused on the implementation of this rule.

It is possible to identify three macro types of Modified Taylor Rules.

First, economists have tried to add a large number of explanatory variables (there were only two explanatory variables in the original Taylor Rule: inflation gap and output gap) in order to understand which macroeconomic variables Central Banks analyse before taking monetary policy decisions and what the economic weight of these variables is.

The other two strands have tried to change the basic structure of the Taylor Rule. In fact, Taylor used contemporaneous variables in the origin. His nominal interest rate, output gap and inflation gap all referred to the same time. So, many studies have tried to understand if this kind of formulation was really plausible. Thus, two types of Taylor Rules were created: the backward looking Taylor Rule, using real time data, and the forward looking Taylor Rule, incorporating expectations.

In the first case the independent variables are lagged with respect to the dependent one: information about macroeconomic aggregates are not immediately available and so it seemed to be correct linking the interest rate with lagged explanatory variables. In the other case economists introduced expectations on the right hand side of the Taylor Rule: Central Banks move the interest rate if future trends of the variables, that is, expectations, have a different value compared with their targets.

Given the simplicity and the validity of the formula, since 1993 many papers and articles have studied these questions - see Carare and Tchaidze (2005) for a short excursus about different types of Taylor Rule -, but the debate on the optimal type of Taylor Rule is still open. Its implementations are likely to get good results with both a backward looking rule and a forward looking one even when the study is focused on the same period and on the same policy-maker.

The recent literature seems to give a preference to using the forward looking Taylor Rule, but I think that it is always the economist that should always explain his choices and find valid economic pillars to his results.

The rest of the article is organized as follows: in the first paragraph I present a brief review of the literature related to the Taylor rule; in the second paragraph I depict the course of the real interest rate in the UK, the US and the Euro area from January 1999 to June 2008. Then I expand the analysis and show the real interest rate in the US, the UK, Germany, France and Italy from January 1984 to December 1998; in the third paragraph I present the backward and forward looking equations I use in this work; the fourth section describes the data employed in the estimations; in the fifth section I show the results of the regressions with OLS, TSLS and iterative GMM estimations; the sixth paragraph is focused on the ECB's behaviour and I try to stress the particular features of the monetary policy in the Euro area; the last section concludes the article with final remarks.

2 LITERATURE REVIEW

It is very difficult to cite the literature related to the Taylor Rule, because of its bulkiness. There are many important works on this issue and, obviously, it is impossible to refer to all of them. As a consequence, I decided to cite only the papers and the articles that I used as guidance in my own work without any claim of being exhaustive. Obviously, the work by Taylor (1993) is the seminal paper for all the contributions in this field. In that study, Taylor proposed for the first time the rule and tested its effectiveness with respect to the US Federal Reserve from 1987 to 1992. The particular feature of that article is that Taylor did not estimate the rule using econometric procedures. Starting from that study, many others have tried implementing that rule and estimating the relationship between the interest rate and some regressors.

Clarida and Gertler (1996) employed a modified Taylor Rule to study the monetary policy of the Bundesbank. In this study they used instrumental variables and examined the period from 1974 to 1993. They found that a modified Taylor rule could be useful in order to explain the behaviour of the monetary policy in Germany. Clarida, Galì and Gertler (1998) tested the Taylor Rule, using the GMM estimation in this case, for the US, Japan, Germany, Italy, France and the UK from 1979 to 1993. This study is fundamental for the use of GMM estimations with the Taylor Rule. Indeed, many following papers use the same structure given by these three economists with respect to the instrumental variables used in the regression.

Judd and Rudebusch (1998) tried to compare the monetary policy of three Fed Chairmen, Burns, Volcker and Greenspan, using a modified Taylor Rule. They found that the original Taylor Rule fits the Greenspan period very well, but they also stressed that the monetary policy of Burns was easier than the one of Greenspan and that Volcker's monetary policy was the tightest among the three chairmen.

Gerlach and Schnabel (1999) used GMM for the estimation of a Taylor Rule applied to the EMU area in the period 1990-1998 and stressed the role of inflation expectations. They also analysed other regressors, such as the Euro-Us Dollar exchange rate, the money growth and the lagged inflation, but these regressors turned out insignificant in their study.

Florens, Jondeau and Le Bihan (2001), using GMM and ML estimations, estimated a reaction function for the Federal Reserve.

They employed a Taylor rule and found that the coefficients show differences in the estimates depending on whether they use the iterative or the continuous-updating GMM. The coefficients they computed with GMM estimations were indeed very large in comparison with the usual values computed in other studies.

Ball and Tchaidze (2002) used the Taylor Rule to analyse and compare two periods of the Greenspan's tenure (the old economy period 1987-1995 vs the new economy one 1995-2000). They tested the importance of the NAIRU (non-accelerating inflation rate of unemployment) as a regressor in the Taylor rule and highlighted that, using this type of regression, the rule can mimic in a good way the behaviour of Greenspan during the entire period of his presidency.

Fourçans and Vranceanu (2002) estimated different policy rules for the ECB from 1999 to 2002, using OLS and GMM. They showed that the ECB is a conservative central bank, that is the increase in the interest rate is not so big when inflation grows, and that the ECB is also focused on the real economy. Furthermore, they also found that the monetary aggregate M3 did not influence the conduct of monetary policy.

Ullrich (2003), using 2SLS, made a comparison between the Fed and the ECB from 1995 to 2002. This study used first differences to make the time series stationary. This approach is similar to the one I adopt in my study and it is important to stress that some studies on the Taylor Rule did not consider the problem of the possible presence of unit roots in the time series (on this issue see Österholm 2005). So, in order to have a robust estimation, I prefer to follow this approach and use time series in first difference in my study, as I will explain in the following pages.

Sauer and Sturm (2003) used Taylor Rule to study the ECB during the first years of the Euro era. They employed OLS and NLS and found that, with the use of expectations, the coefficient on inflation seems to comply with the Taylor principle. On the contrary, using contemporaneous data, it emerged an ECB that accommodates the changes in the inflation rate. They also stressed the poor role of the real-time industrial production data, differently from the US case.

Surico (2003) analysed the ECB monetary policy from July 1997 to October 2002. In his work he also compared the ECB with the Bundesbank and the Fed. His equation has been estimated via OLS

and GMM and it contained the usual coefficients on inflation and output together with coefficients on squared inflation and squared output. Surico used variables in level and it emerged, among the various results, that the ECB gave the same attention to inflationary and deflationary risks. As regards the output stabilization, Surico found that the behaviour of the ECB is very similar to the one adopted by the Bundesbank in a earlier period.

Clausen and Meier (2005) used the Taylor Rule (GMM estimation) in the period 1973-1998 in order to evaluate the Bundesbank monetary policy. They used different types of output gap and found that the Taylor rule mimicked "quite well" the Bundesbank monetary policy. They also found a very limited role for the monetary aggregate M3. In the end, also in this case, the Taylor rule proved a good formula to replicate the monetary policy of a central bank.

Apergis, Miller, Panethimitakis and Vamvakidis (2005) studied a model in which they inserted a Taylor-type rule. They examined forward looking and spontaneous adjustment rules, with an international view, and found that the forward looking approach gave a better contribution to macroeconomic stability. Moreover, they found that a positive inflation target gave a better result than the zero inflation target.

Carstensen (2006), using a probit model, estimated the coefficients of a rule similar to the one proposed by Taylor. He focused on the ECB from January 1999 to January 2003. In the end, he stressed that the revision of the monetary policy strategy, undertaken in 2002, did not affect the coefficients of the rule.

Rotondi and Vaciago (2007) used a Taylor-type rule and GMM estimation in order to compare the ECB and the Bundesbank monetary policies. Even in this case the coefficient on the inflation gap using the backward looking Taylor rule is lower than the one obtained with the forward looking version of the rule.

Gorter, Jacobs and de Haan (2007) tested different types of Taylor rules and focused on the comparison between Consensus data and ex-post data for the Euro area. They also tried to deeply analyse the role and the significance of the interest rate smoothing. They found an important difference in the coefficients on ex-post data in comparison with the ones on the Consensus data: the ECB's policy is stabilizing

only using the survey data (that is, the Consensus data). In this study they employed NLS.

Another interesting and recent paper by Parsley and Popper (2009), using standard and data-rich GMM, estimated three equations for the Korean economy from January 1999 to April 2008. One of these equations is a policy reaction function that resembles a Taylor rule. They use the exchange rate in the formula and often find a significant relationship between this regressor and the interest rate. Usually the exchange rate is not used in a monetary policy rule, but some of the works I cited use it and, recently, even Engle (2009) demonstrates the usefulness of introducing the exchange rate in an open-economy two-country model. Indeed, Engel affirms that the exchange rate misalignments create a loss of welfare and, so, an optimal policy has to target currency misalignments together with the inflation and output gaps.

Starting from this literature, I present an analysis based on a comparison among three areas: the Euro Area, the US and the UK. I use a threefold econometric approach (OLS, TSLS, GMM) in order to examine, through a Taylor-type rule, the monetary policy of the ECB, the Federal Reserve and the Bank of England. Furthermore, with this work, I follow both the backward and the forward looking Taylor Rule strands and try to find some empirical evidence on the ECB's behaviour from the onset of its operations, January 1999, to June 2008. The study, as I will duly explain in the following pages, uses standard OLS, TSLS and iterative GMM estimations. I adopted the OLS estimation with the backward looking formula while the TSLS and the iterative GMM were employed with the forward looking version of the Taylor rule.

It is worth noting that the rule I present in the next sections is not very similar to the one widely adopted in the literature, since problems of stationarity induced me to use the first differences of the time series. As a consequence, it is not possible to directly compare the results of this study with the ones of the dominant literature. But, in so doing, I have avoided all the possible problems linked to a spurious regression. I preferred to follow this methodology instead of having problems with the quality of my analysis.

Before introducing the equations I studied and the results obtained with the different estimations, I show, in the following paragraph, the course of the real interest rate in these three areas as a simple and

immediate indicator of the stance of monetary policy. Indeed, the real interest rate can show the strength with which central banks fought against inflation pressures. This simple vision will be useful to introduce the econometric section of this article.

3 THE TRENDS OF THE INTEREST RATES

In order to examine the role of monetary policy in dampening and controlling the trend of the inflation rate, an examination of the movements of the real interest rate is of primary importance. This simple indicator can reveal the behaviour of the central banks and their approach towards inflation pressures. For this reason, in this paragraph I present a simple visual analysis of the movements of the real interest rate in three areas: the Euro area, the US and the UK. More precisely, I calculated the real interest rate in these three areas from January 1999 to June 2008 in order to compare these three central banks during the first ten years of the Euro.

Moreover, I move another step further by calculating the real interest rate from January 1984 to December 1998 in the US, the UK, Germany, France and Italy. In this way one can build a twofold analysis: a comparison among the ECB, the Fed and the Bank of England during the last decade and a comparison among the ECB and the pre-existing national central banks.

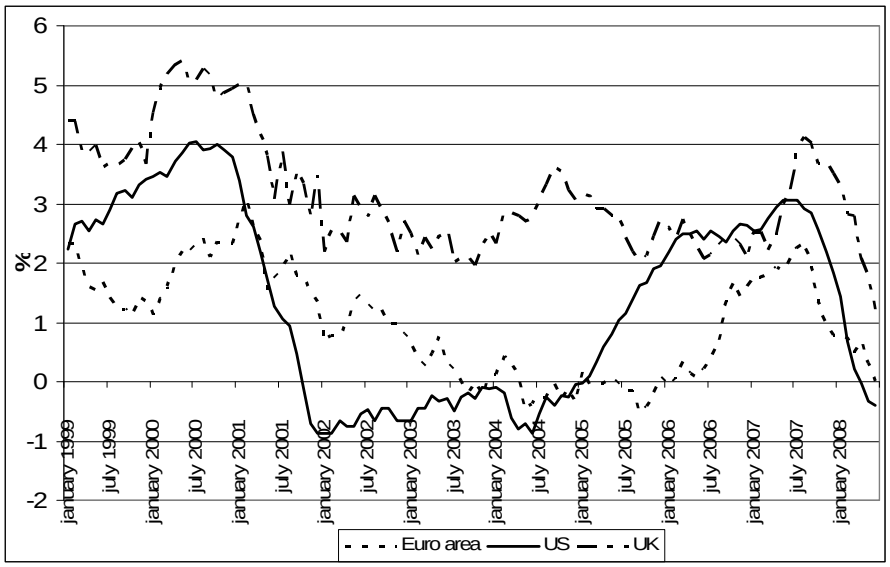
Obviously, the movements of the real interest rate are linked with the global situation that a central bank has to face and so this fact can reduce the importance of the intertemporal comparison. But I think that this approach, although simple and probably limited, can help us draw some important preliminary judgements on this issue. Indeed, the period examined is that of the "Great Moderation". During this period the central banks faced a quite good climate in terms of both (moderate) price dynamics and (high) growth. This can help us in the comparison. Except for national and temporary shocks (for example in Italy and in the UK in first years of the nineties, or in the US in 2001), the twenty-four years of the sample represent an exceptionally good period for the central banks. As a consequence it is possible to compare their behaviours over time.

Figure 1 shows the first part of the analysis. We can observe the trend of the real interest rate in the Euro area, the US and the UK. The real interest rate is given by the difference between the monthly average of

the overnight rate and the monthly inflation rates. I used data taken from the OECD and Eurostat websites.

It is widely known that these central banks have a different approach. For example, the ECB has an explicit inflation target while the Federal Reserve has an implicit target. Furthermore, they have different inflation rates as targets of their monetary policy. As a consequence, in order to build a precise graph, I used the HICP (all items) for the Euro area, the core inflation (CPI, all items less energy and food) for the US and the CPI (all items) for the UK. These are the inflation rates that those three central banks use as their targets. The lines depicted in the figure show the difference between these inflation rates and the respective overnight interest rates.

Figure 1. Real interest rate in the Euro area, the US and the UK, January 1999 - June 2008



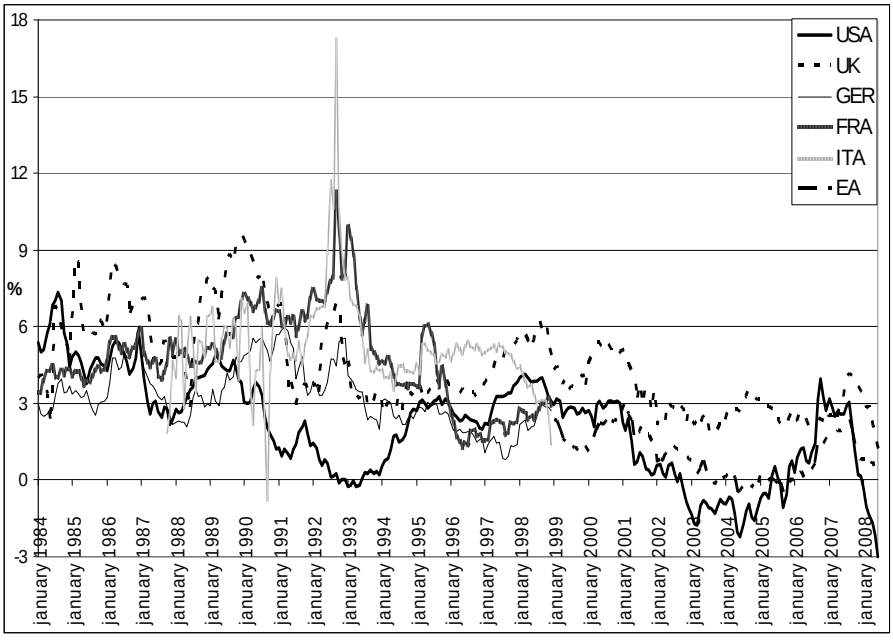
Source: Personal calculations using Eurostat, Bank of England and Bureau of Labor Statistics data.

Globally speaking, the graph suggests that during the last years these Central banks did not adopt a so tight monetary policy. The Bank of England had the highest real interest rate during almost the entire period. In this case, the real interest rate lies within a narrow range, from 2 to 5 per cent, in almost all the sample. On the contrary, the Fed moved the real interest rate in an ampler way, from 4 to -1 per

cent. It is important to notice that the Fed adopted a very expansive monetary policy from the end of 2001 to the end of 2004, with a negative real interest rate during this period.

The ECB has had a mixed strategy: it has moved the real interest rate in a range similar to the one of the BoE, but it always had a lower rate than the BoE, more similar to the one of the Fed. We can even observe a period of negative real interest rate from the first half of 2004 to the end of 2006. For the ECB, the range goes from -0.5 to 3 per cent. It is of great importance noticing that during two periods (from February 1999 to January 2001 and from February 2005 to January 2008) the ECB had the lowest real interest rate.

Figure 2. Real interest rate in the US, the UK, the Euro Area, Germany, France and Italy, January 1984 - June 2008.



Source: Personal elaboration using OECD and EUROSTAT data.

This international comparison suggests that the ECB did not implement a very tight monetary policy during the last decade. So, the first finding is that the direct role of the monetary policy in dampening and controlling the inflation rate, through the use of the interest rate as the main tool, is probably softer than we could typically expect.

Over the longer period, from January 1984 to June 2008, figure 2 shows the real interest rate (overnight rate minus CPI in all the cases) for the US, the UK, the Euro area, Germany, Italy and France. Obviously, the figure shows the real interest rate of the Euro area from January 1999 ahead and the real interest rate of Germany, France and Italy from January 1984 to December 1998. Even in this case I use monthly data.

The figure suggests that the BoE usually has a tighter monetary policy in comparison with the other nations. The central banks of Italy and France adopted a tighter monetary policy than the UK but only for a limited period.

With the onset of the Euro, the monetary policy of this area probably changed. Indeed, it seems that the national central banks adopted a tighter monetary policy during their life in comparison with the one chosen by the ECB during these first years of its activity. Clearly, the ECB faces a different economic environment and different economic pressures but it seems that during the Euro era monetary policy has been easier than in the previous years.

Indeed, the crucial feature of this analysis is that monetary policy during the Euro era has not been particularly tight both historically and internationally. This is only a simple descriptive analysis but it suggests anyhow that the trend of the real interest rate cannot easily explain the low inflation rate the Euro area experienced. As a consequence, this preliminary study indicates we should deepen the analysis on monetary policy in search of some other more robust explanations.

This is what I will present in the following pages: an econometric study on the monetary policy using a Taylor-type rule.

4 ECONOMETRIC SPECIFICATION

In this section I present the equations I estimate and the data I use for the regressions. It is worth noting that a large part of the literature often assumes the stationarity of the time series used in the Taylor Rule. Furthermore, many papers do not treat this argument at all - see Österholm (2005) for a criticism of these issues. In my work I analyse this issue in depth before starting with the econometrics in order to exclude the possibility of spurious regressions. The results of the ADF, Phillips-Perron and KPSS tests on the time series leave no doubt. Unit roots are present in some of the time series I should use in my analysis

following the traditional form of the Taylor rule. For example, the monthly average of the overnight interest rate time series features a unit root in the three areas that I analyse (the Euro area, the US and the UK). The same problem surfaces in other time series (for example in the inflation gaps, or in the exchange rates). As a consequence, in order to estimate the same equation for the three areas and avoid errors in the estimations I decided to use the first difference form for all the equations and for all the time series. In this way I eliminated the possibility of spurious regressions, even if the value of the coefficients is completely different from the one obtained with the original Taylor rule. This is a problem if one wants to compare the analysis of these pages with other works, but in this way we are sure that the significance of the relationships is not linked to the presence of the unit roots.

After this procedure, all the time series I employ in this study are stationary (see table 10 for the results of the tests). The results clearly highlight the absence of a unit root.

But this procedure has changed the structure of the Taylor rule. The formula proposed by Taylor in 1993 is similar to the following one:

$$i_t = \beta_1 + \beta_2 \Pi_t^{gap} + \beta_3 x_t^{gap} + \beta_4 z_t + \varepsilon_t \qquad (1)$$

where the dependent variable, the interest rate, i_t, is regressed on a constant, an inflation gap Π_t^{gap}, an output gap x_t^{gap} and other regressors z_t. The formula of my study is different because, as I said, I employ time series in first difference.

The first equation I estimate, the baseline version, is the following one:

$$\Delta i_t = \beta_1 + \beta_2 \Delta \Pi_{t-1}^{gap} + \beta_3 x_{t-1}^{gap} + \beta_4 \Delta e_{t-1} + \beta_5 \Delta i_{t-1} + \varepsilon_t \qquad (2)$$

where i_t is the day to day interest rate, Π_{t-1}^{gap} is the inflation gap in period t-1, x_{t-1}^{gap} is the output gap in period t-1, e_{t-1} is the log of the exchange rate index in period t-1 and Δ denotes series in first difference.

This equation is backward looking, since we have lagged independent variables in the right hand side of the equation. I estimated this equation through OLS and it represents the first step of my analysis. The two fundamental differences, in comparison with the original rule,

are the use of the first differences and the lags on the right side of the formula.

This type of formula and the OLS estimation represent the basic way to estimate a Taylor rule. This approach is very elementary even if it is used in literature, especially in the more dated papers.

In order to expand and deepen the analysis I estimated another formula. The crucial role that the expectations have in the literature induced me to also use a more complex approach. Indeed, I estimated a forward looking rule in order to compare the results of the two methodologies. In this case I use both the TSLS and the iterative GMM estimations. The TSLS is used in some studies and it gives the same results of the standard GMM approach under normal conditions. The iterative GMM is not so widespread in the literature but I decided to use it in order to have a further comparison and evaluate the different results (Florens, Jondeau and Le Bihan (2001) used the two-step GMM and the iterative GMM in order to compare the different results and highlight their properties).

The following formula visualizes the second equation I estimated:

$$\Delta i_t = \beta_1 + \beta_2 \mathrm{E}_t(\Delta \Pi^{gap}_{t+k} \mid \Omega_t) + \beta_3 \mathrm{E}_t(x^{gap}_{t+k} \mid \Omega_t) + \beta_4 \mathrm{E}_t(\Delta e_{t+k} \mid \Omega_t) + \beta_5 \Delta i_{t-1} + \varepsilon_t \quad (3)$$

In this case $\mathrm{E}_t(\Delta \Pi^{gap}_{t+k} \mid \Omega_t)$ represents the expectation at time t of the inflation gap t+k periods ahead, $\mathrm{E}_t(\Delta x^{gap}_{t+k} \mid \Omega_t)$ is the expectation of the output gap and $\mathrm{E}_t(\Delta e_{t+k} \mid \Omega_t)$ is the expectation of the exchange rate. Ω_t represents the set of the available information at time t. The other symbols have the same meaning of the previous formula. In this case, it is straightforward to observe that the formula is completely forward looking. I substitute the lagged independent variables of the equation 2 with their respective expectations.

The instruments used for the estimations are the same both for the TSLS and for the iterative GMM. I followed the mainstream literature, even though, I introduced some changes. I employed a constant and the lagged independent variables together with other variables as instruments. To be more precise, I used as instruments a constant, lags 1 to 6, lag 9 and lag 12 of the exchange rate and interest rate, lags 2 to 7, lag 9 and lag 12 of the inflation gap, output gap and commodity prices. The use of different lags in comparison with a large part of the

literature (see Clarida, Galì and Gertler, 1998) for the inflation gap, the output gap and the commodity prices, is motivated by the fact that these variables are not immediately calculated and so I decided not to use the lag 1 within the set of available information at time t. In other words, I use a slightly different set of instrumental variables in order to make the estimations more realistic. For these three variables I employ lags 2 to 7 instead of lags 1 to 6. It is a very slight change, but I decided to employ it because in this way one can mimic more precisely the way in which the policy makers form their expectations. Moreover, I followed the critique by Orphanides (1997) which underlined the problems related to the use of contemporaneous independent and dependent variables in the original Taylor rule. In his study he focused on the US case during the period 1987-1992 (the same period analysed by Taylor, 1993) and showed the differences that emerged using contemporaneous or real time data. In so doing, he stressed the limits of the original formulation of the Taylor rule and recommended to be more cautious in the choice of the right timing for the variables. As a consequence, following his teaching I try to use this different set of instruments to make the estimations more reliable.

5 THE DATA

Before showing the results of the three types of estimations, it is useful to analyse in depth the data I used for my study.

As regards the inflation gap, I used the annual rate of change of the HICP published by Eurostat for the Euro area, the core inflation for the US (CPI, all items less food and energy published by the Bureau of Labor Statistics) and the CPI (all items, published by the UK government) for the UK. In all the cases the gap is referred to a 2 per cent threshold. In the case of the US, this ceiling is not explicit but there is a common view about the importance of this threshold for the core inflation. Then, given the lack of stationarity, I calculated the monthly variation of the inflation gap and employed this series in the regressions.

For the output gap, I employed the Hodrick-Prescott (HP) filter on the industrial production index time series (data from OECD for the three areas) and then I calculated the difference between the actual data and the trend obtained through the HP filter: $x_t^{gap} = 100*[\log(IPt) - \log(IP*)]$.

Where IPt is the actual series of the industrial production and IP* is the time series calculated through the HP filter. The output gap series calculated in this way are stationary.

As regards the exchange rate, I employed different exchange rates to have an ampler inspection. I used the "broad" and the "narrow" nominal effective exchange rates, published by the Bank for International Settlements, and one bilateral exchange rate for each nations: the Euro-US dollar for the Euro area, the Pound Sterling-US Dollar for the UK and the US Dollar-Euro for the US. All these time series are published by Eurostat. In this case I used the monthly percentage variation of the exchange rates in my estimations.

The interest rate, as I said before, is the monthly average of the overnight interest rate (data published by Eurostat for the three areas) and in the estimations I used the monthly variation.

For the commodity price, used as an instrument, I used an index, in dollars, published by the International Monetary Fund. In this case I used the US dollar-Euro and the US dollar-Pound Sterling exchange rates to transform the time series of the commodity prices for the Euro area and the UK cases. In all the cases I employed the first difference of the log of the series.

As regards the possibility to use a mixed frequency approach, there are some limits that induced me not to test this methodology in this work, even if I think that it could be useful for a future deeper analysis. First of all, the only regressor that has a high frequency is the bilateral exchange rate. The other regressors are all on a monthly basis. But, given the fact that the study is focused on the behavior of the central banks, I don't think that the boards are alert in following the daily fluctuations of the exchange rate. They are probably more focused on the trend of the exchange rate rather than on the increases/decreases that a currency shows everyday. Furthermore, these short term fluctuations are often linked to speculation and the central bankers are instead focused on the medium to long term course of the variables. As a consequence, I think that in this case the monthly mean can be quite good as regressor.

Moreover, in this study, like in many others, the dependent variable is the monthly mean of the overnight rate. Even in this case there are three points that limit the use of a mixed frequency approach. Firstly, we are referring to the dependent variable. If I had decided to employ

the daily value of the overnight rate I should have modified the structure of the equation and found daily regressors instead of the monthly data I used. Second, I used the monthly mean of the overnight rates as a proxy of the rates established by the central banks because these rates are discrete variables and, as a consequence, they are not so good for econometric purpose. Third, the use of the daily value of the overnight rate is probably more useful to study the interbank money market instead of the monetary policy. For these reasons I decided not to employ or test this methodology in this article. I have probably lost some of the available information contained in the bilateral exchange rates, the only regressor with high frequency that I could have employ, but I wanted to mimic the real behavior of the central banks with my approach and this fact persuaded me to follow this type of structure. In sum, the mixed frequency approach can represent a valuable tool for a future deeper analysis in this field, but I think that it is necessary a previous watchful study in order to overcome the problems that I have just mentioned.

6 RESULTS

The analysis I have done tries to compare, as I have pre-announced, three economic areas: the Euro area, the US and the UK. In so doing, it is possible to highlight the particular features of the Euro area.

In the following pages I will firstly show the backward looking estimations and then I will employ the forward looking version of the rule.

6.1 Backward looking, OLS

The following tables show the estimation of the equation 2. In this case I employ the OLS estimation.

Tables 1, 2 and 3 respectively show the results using, as regressors, the broad NEER, the narrow NEER and the bilateral exchange rates previously mentioned. In the tables I show the value of the coefficients, their significance, the R2 statistics, the Durbin Watson test, the results of the White test and the maximum value of the Variance Inflation Factors (VIF).

The first important things to analyse are the coefficients on the inflation gap. These coefficients are not statistically different from zero in the three areas and with the three different exchange rates used. It

seems that the relationship between the interest rate and the inflation gap is no longer present using this specification of the formula.

Table 1. OLS, robust standard error, January 1999 - June 2008; Dependent variable: day to day rate. Exchange rate: broad NEER

	EA	US	UK
β_1	0.006	-0.002	-0.014
β_2	-0.064	-0.077	-0.081
β_3	2.648***	-1.349	2.548
β_4	-2.170**	1.443	4.565***
β_5	0.167	0.720***	-0.466***
adj R^2	0.120	0.498	0.210
DW	2.12	2.29	1.99
Test	9.96	16.23	15.00
White	pv: 0.764	pv: 0.299	pv: 0.377
V.I.F.	<1.12	<1.04	<1.06

Notes: *, **, *** : significant at ten, five and one percent level.

As regards the coefficient on the output gap, we can observe a significant coefficient, at one percent level, for the Euro area, but insignificant coefficients in the other two nations. We got the same result using the different exchange rates. In this case the ECB seems to be more alert on the information coming out from the real economy in comparison with the other central banks.

Moreover, a more mixed result comes out with the coefficient on the exchange rate: in the Euro area this coefficient is always statistically different from zero and it has the right sign. It is bigger in the first two cases (broad and narrow NEER) than in the case of the Euro-US Dollar exchange rate; in the US this coefficient has always the wrong sign and only the bilateral exchange rate is significant; for the UK, the exchange rate is always highly significant but with the wrong sign. Even in this case, the ECB seems to observe the fluctuations of the exchange rate as an indicator for the pace of the monetary policy.

At the end, the lagged dependent variable is highly significant in the US and the UK in all the three cases, but it is not significant in the Euro area.

The values of the statistics shown in the tables highlight that there are no problems of autocorrelation, heteroskedasticity or collinearity.

Indeed, the Durbin Watson tests show values around 2, the White tests show the absence of heteroskedasticity and the VIFs have a very little value.

Table 2. OLS, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: narrow NEER

	EA	US	UK
β_1	0.005	-0.002	-0.012
β_2	-0.064	-0.080	-0.080
β_3	2.735***	-1.360	2.502
β_4	-2.160**	0.766	4.546***
β_5	0.165	0.721***	-0.464***
adj R^2	0.117	0.496	0.211
DW	2.11	2.30	2.00
Test	10.65	16.43	14.27
White	pv: 0.712	pv: 0.287	pv: 0.429
V.I.F.	<1.14	<1.04	<1.05

Notes: *, **, *** : significant at ten, five and one percent level.

Table 3. OLS, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: bilateral rate

	EA	US	UK
β_1	0.006	-0.000	-0.019
β_2	-0.063	-0.087	-0.092
β_3	2.567***	-1.272	2.014
β_4	-1.320**	1.387**	2.757***
β_5	0.169	0.713***	-0.463***
adj R^2	0.119	0.517	0.209
DW	2.07	2.32	1.97
Test	9.33	15.63	15.76
White	p v:0.809	p v:0.335	p v: 0.328
V.I.F.	<1.1	<1.04	<1.04

Notes: *, **, *** : significant at ten, five and one percent level.

These results show a different approach of the three central banks: the ECB seems to be more alert on information about the economy (output gap) and exchange rates, while in the other cases (the Fed and the BoE) these coefficients are not significant or they have the wrong

sign. But the most interesting result is the one linked with the inflation gap coefficients. With this specification of the Taylor rule it seems that the central banks do not observe the fluctuation of the inflation gap before deciding about the variations of the interest rate. Obviously, in these cases all the time series are stationary and so the lack of this linkage is really interesting for a real insight of the central banks behaviour.

This first step has highlighted different results in comparison with the literature. The inflation gap is not significant and this is really strange for central banks that have an explicit or implicit inflation target. The Fed has no significant policy coefficients (except for one case, but with the wrong sign). Only the smoothing parameter is significant in the three estimations. The situation for the BoE is not so different from the US case.

These results are surprising but one has to be cautious: this is the backward looking approach and before drawing a definitive conclusion it is wise to also observe the forward looking results.

6.2 Forward looking, TSLS

As I have previously said, in order to deepen the analysis I also use a forward looking version of my rule. I estimate equation 3 through TSLS and iterative GMM. In this section I show the TSLS estimation results. Tables 4, 5, 6 illustrate the estimated coefficients, the R2 and the Durbin Watson statistics. Even in this case I employ three different exchange rates as regressors (broad and narrow NEER and a bilateral exchange rate).

The results are not so different from those obtained with the OLS-backward looking approach.

Indeed, the coefficient on the inflation gap is statistically different from zero in only one case (in the US with broad NEER). In the other cases we find no significant coefficient. So, even using the expectations, the situation does not change. It seems that the central banks I analysed in this study do not observe the course of the inflation gap before deciding on the interest rate variations. Obviously, this result is quite surprising.

As regard the coefficient on the output gap, the situation is similar to the previous one. The coefficient is statistically different from zero and with the right sign in the Euro area, but in the other two areas this

coefficient is not significant at all. Again, using the expectations, the ECB seems to be focused on the course of the real economy, that is the industrial production.

Table 4. TSLS, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: broad NEER

	EA	US	UK
β_1	0.005	-0.001	-0.008
β_2	0.021	0.371*	0.045
β_3	2.152**	-1.829	5.274
β_4	-1.814	1.763	1.931
β_5	0.134**	0.747***	-0.488***
adj R^2	0.031	0.543	0.227
DW	2.20	2.13	1.96

Notes: *, **, *** : significant at ten, five and one percent level.

The situation is mixed when we analyse the exchange rates. In this case, the broad NEER is not significant in the three regions, and it has the right sign only in the Euro area. The narrow NEER is significant in the Euro area and it has the right sign, but this coefficient is not statistically different from zero in the other two nations. The bilateral exchange rate is highly significant in the Euro area, again with the right sign, and it is slightly significant in the US, but in this case with the wrong sign.

Table 5. TSLS, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: narrow NEER

	EA	US	UK
β_1	0.007	0.000	-0.007
β_2	0.011	0.306	0.044
β_3	2.270**	-1.705	5.073
β_4	-2.469*	1.671	1.605
β_5	0.126	0.751***	-0.488***
adj R^2	0.024	0.540	0.225
DW	2.22	2.15	1.95

Notes: *, **, *** : significant at ten, five and one percent level.

The Durbin Watson statistics are always near 2.

In sum, the situation with the forward looking approach and TSLS estimations is not so different from the one depicted with the backward looking rule. Indeed, even in this case the ECB seems to be the unique central bank that has a focus on the real economy and on the fluctuations of the exchange rates (but I am not affirming that ECB controls the exchange rate). The other estimations, for the FED and the BoE, do not show significant coefficients. The last thing to notice is the lack of significance for the coefficient on the inflation rate, as previously mentioned.

Table 6. TSLS, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: bilateral rate

	EA	US	UK
β_1	0.007	0.001	-0.015
β_2	0.003	0.281	0.092
β_3	1.914*	-1.579	5.279
β_4	-1.391**	1.371*	2.408
β_5	0.150	0.739***	-0.484***
adj R^2	0.025	0.526	0.213
DW	2.25	2.19	1.95

Notes: *, **, *** : significant at ten, five and one percent level.

6.3 Forward looking, iterative GMM

The last estimation is carried out through the iterative GMM. In this case it is useful to give some details in order to fully explain the set-up I used.

Firstly, the weighting matrix (W) employed in this case is an identity matrix (I). Given the nature of the iterative GMM, the matrix W is recalculated several times until convergence is achieved. So, the use of the identity matrix for the first step of the iteration does not create problems for the robustness of the results.

Moreover, I used the kernel of Bartlett and the software by default calculates HAC (heteroskedasticity and autocorrelation consistent) estimations. So, the coefficients do not incorporate these possible problems.

In tables 7, 8 and 9 I show the value of the estimated coefficients together with the J-test.

The J-test, or test for over-identifying restrictions, has the correct specification of the model as null hypothesis. The results of the Hansen's J-test are always positive: in all the cases it is not possible to reject the null. As a consequence the models tested in this section are "valid".

The values of the coefficients are, in some cases, very surprising.

In the Euro area case, the coefficient on the inflation gap is now significant but it has the wrong sign in the three cases. This result is deeply different in comparison with the TSLS and OLS estimations, in which the coefficient on the inflation gap has never been significant. The output gap is significant in the first and third specifications (with the broad NEER and with the Euro-US dollar exchange rate) and it has the right sign. The smoothing parameter is now significant for the first time in the Euro area case. As regards the exchange rates, the broad and narrow NEER are not significant, while the euro-US dollar exchange rate remains significant and with the right sign.

Table 7. iterative GMM, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: broad NEER

	EA	US	UK
β_1	0.012**	0.010***	0.016*
β_2	-0.152***	-0.029	-0.005
β_3	1.216***	-0.697	5.950***
β_4	-0.537	1.229*	3.707**
β_5	-0.173***	0.694***	-0.697***
J-test	20.02 pv:0.98	18.86 pv:0.99	20.38 pv:0.98

Notes: *, **, *** : significant at ten, five and one percent level.

As regards the US, the exchange rate is significant in two cases (broad NEER and bilateral exchange rate) but with the wrong sign. The smoothing parameter and the constant are significant, but the other coefficients are not statistically different from zero. In this case the estimation is similar to the previous ones. The Taylor rule estimated with US data shows a Federal Reserve that does not care about inflation and the real economy.

Table 8. iterative GMM, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: narrow NEER

	EA	US	UK
β_1	0.003	0.007**	0.018*
β_2	-0.109***	-0.019	0.023
β_3	0.509	-0.252	-4.203***
β_4	0.461	0.567	-3.697**
β_5	-0.170***	0.568***	-0.636***
J-test	19.29 pv:0.98	18.35 pv:0.99	19.96 pv:0.98

Notes: *, **, *** : significant at ten, five and one percent level.

For the UK the situation is mixed: the constant and the smoothing parameter are always significant; the inflation gap is significant in the last case only and it has the right sign; the other coefficients (output gap and exchange rate) give strange results: the output gap is statistically different from zero in the three cases, but it has the right sign only in the first regression; the exchange rate is significant in the three equations and it has the right sign in the last two regressions (narrow NEER and bilateral exchange rate).

Table 9. iterative GMM, robust standard error, January 1999-June 2008; Dependent variable: day to day rate. Exchange rate: bilateral rate

	EA	US	UK
β_1	0.015***	0.007**	0.020**
β_2	-0.120***	-0.020	0.361***
β_3	0.916**	-0.763	-3.279***
β_4	-0.547**	0.585**	-2.133**
β_5	-0.119***	0.573***	-0.474***
J-test	20.45 pv: 0.98	18.58 pv:0.99	21.21 pv:0.97

Notes: *, **, *** : significant at ten, five and one percent level.

The estimations with the iterative GMM have given mixed results: we find more coefficients with significant values but they often have the

wrong sign. The situation is not extremely different from that depicted in the previous tables.

The presence of different values is not so strange. In other works, some of these have been previously cited, the use of different estimation methodologies produced very different values of the coefficients. But, notwithstanding this fact, it is possible to draw some conclusions on the basis of the estimated data.

7 THE CENTRAL BANKS' BEHAVIOUR

This complex study sheds a critical light on the role of monetary policy. Many works have studied the movements of the inflation rate during the last decades and, at the same time, it is well known the role of monetary policy as a possible explanation of the Great Moderation (as regards the Great Moderation see, for example, Bernanke 2004; Giannone, Lenza and Reichlin 2008; Melick and Galati 2006; Rogoff 2003; while for an analysis of the inflation processes see Angeloni, Aucremanne and Ciccarelli 2006; Angeloni, Aucremanne, Ehrmann, Galì, Levin and Smets 2004; Assenmacher-Wesche and Gerlach 2006; Berck 2000; Borio and Filardo 2007; Cecchetti and Debelle 2005; Cogley and Sargent 2001). The interesting feature is that the result given by the estimations presented in this article is a little bit surprising, if we remember the key role of central banking in the theoretical framework of the Great Moderation.

In fact, I found that the coefficients on the inflation gap were insignificant in my regressions. This means that the decisions on the interest rate course are not linked with the fluctuations of the inflation gap. Obviously, this is a very strange picture for central banks that have to anchor the inflation rate around the target, especially for the ECB and the BoE that have an explicit target. I think that this result reduces the role of the central banks in guiding and anchoring the inflation rate during the last decades. Furthermore, this result would suggest that these monetary policies might have led to an unstable inflation process. And this is at odds with the mandate of the central banks. For the ECB, we have observed a focus on the real economy and on the fluctuations of the exchange rates, but this result cannot cover the lack of attention on the inflation process.

In other words, the study has highlighted a very low direct attention of the three central banks towards their main targets and, as a consequence, the conclusion is that it is not possible to ascribe to these

authorities a crucial role in dampening and guiding the inflation course.

In sum, it is possible to hold that, using stationary time series, the result obtained via the Taylor rule reduces the presumed key role of the central banks as prominent figures in the context of the low and stable inflation. As a consequence, that result, the low inflation, is probably linked to other global economic features.

8 CONCLUSIONS

In this article I have used a modified Taylor rule to examine the monetary policy of the European Central Bank, the Federal Reserve and the Bank of England during the last years (from January 1999 to June 2008). The purpose of this article was to find a possible linkage between the monetary policy and the stable course of the inflation, especially in the Euro area. The international comparison was useful in order to highlight the particular features of the central banks I analysed.

The lack of stationarity in some time series induced me to use the first difference of the data in order to avoid the presence of spurious regressions. In so doing, I transformed the original Taylor rule and I obtained results that are not directly comparable with the main literature in this field of research. I used three different methodologies for the estimation of the rule: OLS for the backward looking version and TSLS and iterative GMM for the forward looking specification. I introduced slight changes in the formula and in the instruments used as set of information in the forward looking set-up.

The estimations have showed some interesting, and a little bit surprising, results.

Firstly, the coefficient on the inflation gap has been always insignificant or with the wrong sign. This means that the variation of the interest rate is not linked with the variation of the inflation gap. This result has been valid both with the backward looking and the forward looking approach. This feature is the most surprising one of this work: the three central banks of the study do not care about the course of the inflation gap.

As regards the output gap, the ECB seems to be alert toward this indicator while the other two central banks do not show, in many cases, significant coefficients. In this case it is possible to assert that

the ECB shows a certain degree of attention toward the economic growth as indicator of possible threats for the stability of the inflation.

I obtained a similar result with the exchange rates. In this case the regressions with the Euro area data show that the ECB observes the trend of the exchange rates. In details, I used both a broad and a narrow version of the NEER (by BIS) and the Euro-Us dollar bilateral exchange rate and I found that the coefficients on these exchange rates are often significant both with the backward looking and the forward looking formulas. For the other central banks, the role of the exchange rate is extremely limited.

These results cannot shed more light on the stability of the inflation rate in the Euro area, in the US or in the UK . We have observed a not so direct approach toward the inflation gap. The ECB, even if it shows a more active behaviour in comparison with the Fed and the BoE, does not seem to be really aggressive against the inflation course. This finding can lead to two different ideas: one is that probably the stability of the inflation is linked with other economic factors. I gave an idea on this issue in a previous work [not cited to protect the anonymity]; the second is that the standard Taylor rule has two problems: firstly, the use of time series in level probably produces spurious regressions; secondly, my analysis highlighted that the central banks probably examine other macroeconomic-indicators. That is, a pure forward looking approach induces the central banks to focus on leading indicators instead of observing the realized or expected inflation. This can open a new strand of research: a Taylor rule without the inflation gap as regressor.

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APPENDIX

Table 10. Unit root tests; Phillips Perron: H0: unit root. KPSS: H0: stationary

	Phillips Perron	KPSS
Δ dtd US	-4.811***	0.1066
Δ dtd UK	-15.364***	0.1940
Δ dtd EA	-9.852***	0.1315
Δ infl. gap US	-10.720***	0.0786
Δ infl. gap UK	-10.117***	0.2855
Δ infl. gap EA	-9.539***	0.1383
Output gap US	-2.912**	0.1332
Output gap UK	-5.463***	0.1557
Output gap EA	-3.663***	0.1960
Δ Broad NEER US	-8.246***	0.5045**
Δ Broad NEER UK	-10.025***	0.2519
Δ Broad NEER EA	-7.625***	0.2292
Δ Narrow NEER US	-8.121***	0.3045
Δ Narrow NEER UK	-10.032***	0.2082
Δ Narrow NEER EA	-7.592***	0.3977*
Δ Euro/USD exchange rate	-7.781***	0.3830*
Δ Pound/ USD exchange rate	-9.371***	0.2193
Δ Commodity US	-9.541***	0.2396
Δ Commodity UK	-9.663***	0.1609
Δ Commodity EA	-8.790***	0.1277

Notes: *, **, *** : significant at ten, five and one percent level. KPSS test without trend. PP and KPSS: lags 12.