# The ECB monetary policy rule and inflation dispersion among EMU countries*

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First draft: May 2007
This draft: April 2009

**Abstract**

In this paper, we try to assess whether the ECB has taken into account in its monetary policy decision-making the almost large and persistent dispersion of inflation rates among EMU countries, as suggested by Jean-Claude Trichet when he argues that the ECB attributes "*a secondary role to inflation differentials when calibrating the safety margin for admissible inflation in the euro area*". We thus estimate an extended Taylor rule with additional inflation dispersion variables, paying particular attention to the robustness of our results, and using three estimation methodologies that provide complementary information about interest-rate setting in the euro area: a standard GMM framework, FIML estimates of a small semi-structural model, and finally an Ordered Probit model. Our results suggest that the ECB took the dispersion of inflation rates into account: when inflation differentials were large, the ECB seems to have been reluctant to raising its interest rate due to the fear of deflation in low-inflation countries such as Germany. Introducing an inflation dispersion indicator in the Taylor rule entails a clear cut in the coefficients associated with interest rate smoothing. This observation is perfectly in line with the conclusions of recent studies that warn against a spurious interpretation of the "smoothing parameter". The observed inertia in euro area interest rates (much higher than the one observed in the United States) may be partly explained by a significant cross-country inflation dispersion.

**Keywords:** Monetary policy ; Taylor rule ; Interest rates ; Inflation differentials ; ECB.
**JEL Classification:** E31, E52, E58.

*I am grateful to Jean-Jacques Durand, Vincent Bouvatier and participants at the 12th Conference T2M (Cergy-Pontoise - January 2008) and the 57th Congress of the AFSE (Paris - September 2008) for helpful comments.

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# 1 Introduction

Since the seminal paper from Taylor (1993), extended by significant contributions from Clarida, Gali & Gertler (1998, 2000), the evaluation of monetary policy by means of a reaction function has become a standard. A growing research on monetary policy rules has developed since then, both in a normative and a more descriptive way. The normative approach focus on the optimality conditions of different monetary policy rules in a given model of the economy, most of the time a Dynamic Stochastic General Equilibrium (DSGE) model. In this case, alternative specifications of monetary policy rules are evaluated and compared using a given "loss function", traducing the relative weights granted by the central bank to its objectives (price stability and output stabilization for example). As for the descriptive approach, it has tried to compare the observed behaviour of central bankers in their interest rate setting to the implications of a systematic Taylor-type rule.

The so-called Taylor rule has attracted particular attention since the launch of the European Monetary Union (EMU) in 1999, and many recent empirical studies, including Carstensen (2006), Fendel & Frenkel (2006), Fourçans & Vranceanu (2004, 2007), Gerdesmeier & Roffia (2004), Gerlach (2007) and Sauer & Sturm (2007), have tried to assess the relevance of the (expectations-augmented) Taylor rule for the behaviour of the European Central Bank (ECB) in its interest-rate setting. They indeed show that the ECB reacts to deviations in the future expected euro area inflation rate from its 2% target, as expected since the ECB emphasizes its primary objective of price stability. However, most empirical papers also stress the sensitivity of the ECB to real activity, as measured for example by the "output gap", even with forward-looking specifications. The output gap thus appears not only as an indicator for future inflation, but also as an autonomous objective by itself. Furthermore, empirical estimates of the ECB reaction function display a strong parameter for interest rate smoothing, often much higher than the standard values reached using U.S. data. The adjustment of the effective interest rate to the desired interest rate is thus only very partial. This finding is consistent with the observed profile of euro area interest rates since 1999: interest rates movements have been much larger and more frequent in the United States than in the euro area.

Is there a factor that may explain such a difference between the Fed and the ECB in their monetary policy decision-making? Rudebusch (2002, 2006) suggests that the "smoothing parameter" not only reflects inertia and a preference for gradualism from the Central Bank. A high smoothing parameter may also be related to the omission of important persistent influences on the actual interest-rate setting, such as serially-correlated exogenous shocks. Gerlach-Kristen (2004) adds that a very high smoothing parameter is usually the result of a misspecification of the model, *i.e.* arise from a problem of omitted variables.

Here, we propose an explanation close to those of Rudebusch (2002, 2006) and Gerlach-Kristen (2004), which is related to the very specific nature of the euro area: a Monetary Union bringing together countries that are still very different and whose cycles are still imperfectly correlated. That's why the ECB decision-making could be influenced by national considerations, for at least two reasons. Firstly, the ECB Governing Council may be reluctant to raising its interest rates if the dispersion of cyclical positions and inflation rates is very important, even when aggregate inflation rate is above target. In fact, with a quite restrictive definition of price stability ("*below, but close to 2%, in the medium-term*") and high inflation dispersion among EMU members, some countries may experience excessively low, or even negative, inflation rates. The "fear of deflation", quite clearly displayed by the Members of the Board in their speeches and in official publications by the ECB, would therefore partly explain the relative inertia of euro area interest rates since 1999. Secondly, the composition of the ECB Governing Council itself is likely to lead to national considerations in the interest-rate setting process for the euro area as a whole. Indeed, this monetary policy committee is composed of the 6 Members of the Board and 15 Governors of national Central Banks. Such an institutional framework should entail a risk that national considerations prevail in the ECB decision-making, and thus induce a lower reaction of interest rates to EMU-wide indicators, as explained by Berger & De Haan (2002). It is even more likely in the euro area since each country has one vote within the ECB Governing Council (Berger & Mueller, 2007), decisions are taken by consensus (Gerlach-Kristen, 2005) and there is no publication of the minutes from the Governing Council sessions.

In this paper, we investigate those two explanations for the influence of national considerations in the ECB decision-making, by assessing their theoretical relevance in the EMU and their potential effects in terms of interest-rate inertia. We then test those hypotheses using a standard forward-looking specification of the Taylor rule, in use since Clarida *et al.* (1998, 2000).

We thus have an objective similar to Heinemann & Huefner (2004) and Fendel & Frenkel (2008), who include respectively the median inflation rate and the dispersion of national inflation rates in Taylor-type reaction functions. But we intend to go further on three directions. Firstly, we go back to the theoretical ground for an influence of national considerations on the ECB decision-making. Secondly, we explore in details the robustness of our results for a broad range of disaggregated indicators, paying a particular attention to the respective implications of those indicators. Thirdly, we check the sensibility of our conclusions by using three alternative methodologies to estimate the ECB reaction function: a Generalized Method of Moments (GMM) framework, a Full Information Maximum Likelihood (FIML) estimator based on a semi-structural model of the euro area, and finally an Ordered Probit model for the ECB monthly decisions.

Our results show that the augmented forward-looking Taylor rule fits the data quite well: the ECB responds rather strongly to anticipated inflation (as opposed to lagged inflation). The ECB also takes the dispersion of inflation rates into account: when inflation differentials were large, the ECB seems to have been reluctant to increasing interest rates due to the fear of deflation in low-inflation countries such as Germany. The introduction of disaggregated indicators (minimum inflation rate, spread or weighted standard deviations of inflation rates for example) leads to a clear cut in the value of the parameter related to lagged interest rates. This observation is perfectly in line with the warnings from

Gerlach-Kristen (2004) and Rudebusch (2006) against a spurious interpretation of the "smoothing parameter". The observed inertia in euro area interest rates since 1999 may thus partly reflects the fact that the ECB took inflation dispersion into account.

The paper is organized as follows: Section 2 presents the Taylor rule and reviews recent estimates of interest-rate rules for the ECB. In Section 3, we describe the ECB monetary policy strategy and the role played by inflation dispersion in this strategy, as emphasized in official publications and speeches from the Members of the ECB Governing Council. Sections 4 to 6 describe the results of our estimates of an augmented forward-looking specification of the Taylor rule with additional indicators for disaggregated inflation, using successively a GMM framework, a FIML estimator of a semi-structural model of the euro area, and finally an Ordered Probit model. Section 7 concludes and provides some insights.

# 2 The Taylor rule: Standard framework and overview of the empirical literature

## 2.1 The standard framework

Since the influential paper from Taylor (1993), it has become common to describe the behaviour of a central bank as a reaction function using the short-term interest rate as an instrument, and assuming that this instrument reacts to deviations of inflation and output from their target levels. The basic Taylor rule thus takes the following form:

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

where $i_t^*$ is the desired short-term nominal interest rate, $\bar{i}$ its long-run equilibrium value[1], $\pi^*$ and $y^*$ the targets for the inflation rate and the output gap respectively (both assumed to be constant over time). The coefficients $\beta$ and $\gamma$ can be seen as the relative weights assigned by the central bank to output and inflation stabilization respectively. The $\beta$ coefficient plays a key role in the ability of the central bank to temper inflation and further in the stability of the macroeconomic system. According to the "Taylor principle", this $\beta$ coefficient must be higher than 1 for the central bank to really "drive" the inflation rate[2].

[1]The equilibrium nominal interest rate $\bar{i}$ is thus equal to the sum of the neutral real interest rate $r^*$ and the target inflation rate $\pi^*$.

[2]This "Taylor principle" has been illustrated in a wide range of theoretical models, notably by Taylor (1999), Clarida, Gali & Gertler (2000) and Woodford (2001). We can easily highlight this principle on a small macroeconomic model with three equations: an IS curve linking the output gap to real interest rates, a Phillips curve relating inflation to the output gap, and finally a Taylor rule for the central bank. In this kind of model, a shock that would push the inflation rate above target would entail a reaction of the central bank in raising its interest rates according to the monetary policy rule. If $\beta < 1$, the response is not strong enough to raise the real interest rate and thus to curb demand pressures, and inflation is

Clarida, Gali & Gertler (1998, 2000) propose a forward-looking variant of this so-called Taylor rule, which takes into account the forward-looking behaviour of central bankers[3]. In recent years, this particular specification of the Taylor rule has been used as a standard in the evaluation of monetary policy. This "expectations-augmented" policy rule can be written as:

$$i_t^* = \bar{i} + \beta(E[\pi_{t+k}|I_t] - \pi^*) + \gamma(E[y_{t+q}|I_t] - y^*) \tag{2}$$

where $E[-]$ is the expectation operator conditional on the set of information available in period t, denoted by $I_t$. If $k = 0$, we have a "contemporaneous" rule, *i.e.* the standard Taylor rule. It is a "backward-looking rule" if $k < 0$, and a "forward-looking rule" if $k > 0$.

In reality, central bankers are also concerned with the smoothing of their interest rate, since overly abrupt changes may create troubles in the equity and bond markets and also affect the credibility of central bankers[4]. Consequently, the path of actual short-term nominal interest rate can be modelled as a weighted average of the lagged interest rate and the desired interest rate:

$$i_t = \rho i_{t-1} + (1-\rho) i_t^* \tag{3}$$

where the parameter $\rho$ (with $0 \leq \rho < 1$) measures the degree of interest rate smoothing.

Substituting (2) into (3) and assuming that the central bank does not try to push output beyond its potential value ($y^* = 0$) yield our baseline Taylor rule:

$$i_t = \rho i_{t-1} + (1-\rho)\bar{i} + (1-\rho)\beta(E[\pi_{t+k}|I_t] - \pi^*) + (1-\rho)\gamma E[y_{t+q}|I_t] \tag{4}$$

## 2.2 An overview of the empirical literature

Empirical studies have mainly focused on the appropriateness of the Taylor rule to the monetary policy conducted by the U.S. Federal Reserve. Several studies also tried to make international comparisons. For example, Clarida *et al.* (1998) assess the fit of this kind of reaction functions to the behaviour of a set of central banks from G7 countries: their results indicate that the monetary policy conducted by the U.S. Federal Reserve, the Bundesbank and the Bank of Japan can be captured rather well by a "forward-looking" Taylor rule with a strong weight on inflation stabilization, suggesting that these

stimulated *via* the Phillips curve. If $\beta > 1$, the response of the central bank is sufficient to increase real interest rates and temper demand and inflationary pressures.

[3]Since monetary policy only affects output and inflation after several months, it is likely that central bankers focus on (expected) future inflation rather than current or past inflation.

[4]For a deeper investigation of the reasons explaining the need for interest rates smoothing, *cf.* Sack & Wieland (2000).

central banks have pursued an implicit form of inflation targeting since 1979.

The launch of the EMU has even reinforced the interest for monetary policy rules. Taylor (1999) wonders if the rule implicitly followed by the Fed could suit the euro area and thus serve as a guideline for the new European Central Bank. Faust, Rogers & Wright (2001) and Surico (2003) estimate an interest rate rule for the Bundesbank and use it as a benchmark for the monetary policy conducted by the ECB in the early months of the EMU. As for Gerlach & Schnabel (2000), Gerlach-Kristen (2003) and Gerdesmeier & Roffia (2004), they use consolidated data based on national data for the current EMU member countries before 1999, and estimate an interest rate rule for a "virtual" ECB. However, even if this methodology has the advantage of limiting the problems related to small samples, it appears as an unreliable guideline for conclusions related to the ECB monetary practice since 1999.

Finally, a number of recent empirical studies, including Fendel & Frenkel (2006), Fourçans & Vranceanu (2004, 2007), Hayo & Hofmann (2006) and Sauer & Sturm (2007), investigate the behaviour of the ECB since 1999. They demonstrate that the monetary policy conducted in the early years of the EMU (*i.e.* during Duisenberg presidency) can be modelled quite well using the expectation-augmented Taylor rule with a high degree of interest-rate smoothing. Table 1 reports a review of different Taylor rule estimations for the euro area using monthly data.

In most studies using forward-looking rules, the "Taylor principle" holds since the $\beta$ coefficient is clearly higher than 1. It is not the case with backward-looking specifications, which exhibit much lower $\beta$ estimates. This result is not really surprising, since the ECB is especially concerned with "medium-term inflation" and thus reacts to expected inflation rather than observed inflation. All estimates also show the sensitivity of the ECB to real activity, as measured by the $\gamma$ coefficient, even with forward-looking specifications. The output gap is thus not only an indicator for future inflation (as it could be the case with backward-looking rules), but also an autonomous objective by itself[5]. We must also notice that, despite many recent attempts to add other indicators in the standard formulation described in Equation (4), no other variable than inflation and the output gap turns out to be significant with forward-looking specifications. The ECB does not seem notably to have an exchange rate objective. In the same way, the oil price and asset prices may only be seen as indicators for future inflation, and thus may only be significant in contemporaneous or backward-looking rules.

[5] In the same spirit, Faust *et al.* (2001) use the estimates of a forward-looking reaction function of the Bundesbank as a benchmark to assess the ECB policy, and conclude that the ECB attaches a greater weight to the output gap and a smaller weight to inflation than the Bundesbank did.

Table 1: A review of several Taylor rules estimates for the ECB

| | Type of rule | Sample period | Estimator | $\rho$ | $\beta$ | $\gamma$ |
|---|---|---|---|---|---|---|
| **Fourçans & Vranceanu (2004)** | Contemporaneous | 1999:4-2003:10 | GMM | 0.90 | 0.84 (ns) | 0.32 |
| **Fourçans & Vranceanu (2007)** | Contemporaneous<br>*Output gap - HP filter* | 1999:1-2006:3 | OLS | 0.96 | -1.13 (ns) | 1.74 |
| **Gerdesmeier & Roffia (2004)** | Contemporaneous | 1999:1-2002:2 | GMM | 0.72 | 0.45 | 0.30 |
| **Gerdesmeier & Roffia (2005)** | Contemporaneous<br>*Ex-post data* | 1999:1-2003:3 | GMM | 0.86 | 1.52 | 1.12 |
| **Gerdesmeier & Roffia (2005)** | Contemporaneous<br>*Real-time data* | 1999:1-2003:3 | GMM | 0.99 | 0.61 | 2.14 |
| **Sauer & Sturm (2007)** | Contemporaneous<br>*Real-time data* | 1999:1-2003:10 | OLS | 0.98 | -0.27 (ns) | 3.01 |
| **Fendel & Frenkel (2006)** | Forward-looking (+12 months)<br>*Output gap - Quadratic trend* | 1999:1-2002:12 | GMM | 0.92 | 2.54 | 1.69 |
| **Fendel & Frenkel (2006)** | Forward-looking (+12 months)<br>*Output gap - Linear trend* | 1999:1-2002:12 | GMM | 0.69 | 1.43 | 0.29 |
| **Fendel & Frenkel (2006)** | Forward-looking (+12 months)<br>*Output gap - HP filter* | 1999:1-2002:12 | GMM | 0.84 | 2.00 | 0.53 |
| **Fendel & Frenkel (2006)** | Forward-looking (+12 months)<br>*Unemployment gap* | 1999:1-2002:12 | GMM | 0.95 | 4.32 | 0.65 |
| **Fourçans & Vranceanu (2004)** | Forward-looking (+6 months) | 1999:4-2003:10 | GMM | 0.84 | 2.80 | 0.19 |
| **Fourçans & Vranceanu (2007)** | Forward-looking (+12 months)<br>*Output gap - HP filter* | 1999:1-2006:3 | OLS | 0.96 | 4.30 | 1.28 |
| **Fourçans & Vranceanu (2007)** | Forward-looking (+12 months)<br>*Output gap - HP filter* | 1999:1-2006:3 | FIML | 0.95 | 3.10 | 1.57 |
| **Gerdesmeier & Roffia (2005)** | Forward-looking (+12 months)<br>*Ex-post data* | 1999:1-2003:3 | GMM | 0.81 | 0.64 | 1.44 |
| **Gerdesmeier & Roffia (2005)** | Forward-looking (+12 months)<br>*Real-time data* | 1999:1-2003:3 | GMM | 0.98 | 2.13 | 1.63 |
| **Hayo & Hofmann (2006)** | Forward-looking (+12 months) | 1999:1-2003:5 | TSLS | 0.85 | 1.48 | 0.60 |
| **Sauer & Sturm (2007)** | Forward-looking (+6 months)<br>*Real-time data* | 1999:1-2003:10 | GMM | 0.98 | 6.62 | 9.24 |

Notes: The estimates of the ECB reaction function reported in this Table refer to Equation (4). The label (ns) indicates that reported coefficients are not significant.

Finally, we must stress that the parameter $\rho$ related to lagged interest rates is most of the time very important, often much higher than 0.9. This value for the "smoothing parameter" is on average higher than the one reached on U.S. data, with a $\rho$ closer to 0.8 in estimated reaction functions for the Fed

(Clarida *et al.*, 2000; Judd & Rudebusch, 1998). Is there a factor that may explain such a difference between the Fed and the ECB in the value of the $\rho$ parameter? Rudebusch (2002, 2006) suggests that the "smoothing parameter" not only reflects inertia and a preference for gradualism from the Central Bank. A high smoothing parameter may also be related to the omission of important persistent influences on the actual interest-rate setting, such as serially-correlated exogenous shocks. Gerlach-Kristen (2004) adds that a very high smoothing parameter is usually the result of a misspecification of the model, *i.e.* arise from a problem of omitted variables. Castelnuovo (2007) show, using models in first differences, that the joint hypotheses of endogenous gradualism from the Central Bank and serially correlated exogenous shocks offer the best approximation of the euro area monetary policy.

In the next Section, we go back to the ECB monetary policy strategy and try to compare "words" and "deeds", *i.e.* to assess whether the results of recent empirical studies are in line with the official ECB strategy. Then, we propose an explanation for the differences between the ECB and the Fed in the value of the $\rho$ parameter: the effect of national considerations in the ECB decision-making.

# 3 The ECB monetary policy strategy and the role of inflation dispersion

## 3.1 The ECB monetary policy: Mission and objectives

The Maastricht Treaty defined clearly the hierarchy of objectives for the European Central Bank: the main objective of the ECB was to pursue price stability, while other objectives (mainly "*economic and social progress and a high level of employment*" as well as "*balanced and sustainable development*") were only secondary.

> "*The primary objective of the ESCB*[6] *shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies of the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2.*" - Consolidated Version of the Treaty on European Union - Article 105(1).

On 13 October 1998, the ECB announced its monetary policy strategy and made this even more explicit that price stability was its main objective. Price stability was originally defined as "*a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the euro area of below 2%*" (European Central Bank, 1999). Moreover, the ECB added that price stability was "*to be maintained over the medium term*", since monetary policy is not able to fine-tune price developments over a short horizon of few weeks or months. The ECB thus emphasized the need for monetary policy to have a forward-looking medium-term orientation. In many speeches, especially in the early years of

[6] The Treaty referred to the European System of Central Banks (ESCB) rather than to the Eurosystem since it was assumed that all EU Member States would eventually join the euro...

the EMU, the members of the ECB Governing Council emphasized that price stability was "*the best possible contribution of monetary policy to long-run growth*".

On 8 May 2003, the Governing Council presented an internal evaluation of its monetary policy strategy and announced a clarification of this strategy with a new definition of price stability, more precise and more "symmetric". In addition to the previous definition, the Governing Council added that "*the ECB aims to maintain the inflation rate below, but close to, 2% over the medium term*" (European Central Bank, 2003b). This clarification was partly motivated by the need to preserve a sufficient margin against deflationary risks, and also by the existence of an upward bias in the statistical measure of inflation (related to the so-called Boskin effect). We will see later on that this clarification of the definition of price stability was also motivated by the implications of inflation differentials between EMU countries.

To reach its primary objective of price stability, the ECB Governing Council adopted a "two-pillar strategy". This strategy included "*a prominent role for money, as signalled by the announcement of a reference value for the growth of a broad monetary aggregate*" on the one hand, and "*a broadly-based assessment of the outlook for future price developments and the risks to price stability in the euro area as a whole*" on the other hand (European Central Bank, 1999). The monetary pillar, seen as the legacy of the Bundesbank, was used to assess long-run price changes, in the view that inflation is mainly a monetary phenomenon in the long run. The second pillar was made up of a wide range of financial and economic indicators, used to assess shorter-run inflation: it included especially output growth, unemployment, measures of the output gap, fiscal policies, the evolution of wages, exchange rates, asset prices, the oil price,...The ECB has confirmed and clarified its strategy in its evaluation outcome published in May 2003. The two-pillar strategy has been kept, but with a precision on the cross-checking of information and a switch in those two pillars: monetary developments (assessed especially using the broad money aggregate M3) have become the second pillar, relabelled as "monetary analysis", and serves as an indicator for medium- to long-run inflationary trend. The previous second pillar has become the first one, labelled as "economic analysis", and is used to assess inflationary pressures over the short- to medium-term.

## 3.2 The dispersion of national inflation rates and the fear of deflation

The ECB looks at aggregate economic conditions in the euro area for the conduct of its monetary policy, which is designed for the euro area as a whole. It stresses the lack of instruments at its disposal to offset cyclical differences between the EMU members, including differences in inflation rates. However, national differences in inflation rates are a potential source of concern for the ECB, for several reasons. Firstly, the existence of huge inflation differentials may imply that the single monetary policy could be too lax for some countries but simultaneously too tight for others. Secondly, a common monetary policy could push lower-inflation countries within the euro area towards deflationary levels in the presence of important inflation dispersion.

The clarification made on May 2003 by the ECB regarding its definition of price stability ("*below, but close to 2% over the medium term*") was partly motivated by the implications of inflation differentials and the risk for lower-inflation countries to face excessively low or even negative inflation rates.

> "[...] *it has been argued that the ECB's monetary policy should aim to achieve over the medium-term an inflation rate for the area as a whole that is high enough to prevent regions with structurally lower inflation rates from having to meet the costs of possible downward nominal rigidities or entering periods of protracted deflation. According to all available studies, a rate of inflation below but close to 2% for the euro area also provides a sufficient margin in this respect.*" - European Central Bank (2004), p. 54.

Since the revision of its monetary policy strategy in May 2003, the ECB has many times argued that inflation differentials are an important part of its economic analysis, as emphasized in an official report devoted to inflation differentials[7]:

> "*The ECB's monetary policy strategy attributes a secondary role to inflation differentials when calibrating the safety margin for admissible inflation in the euro area.*" - European Central Bank (2003a), p. 6.

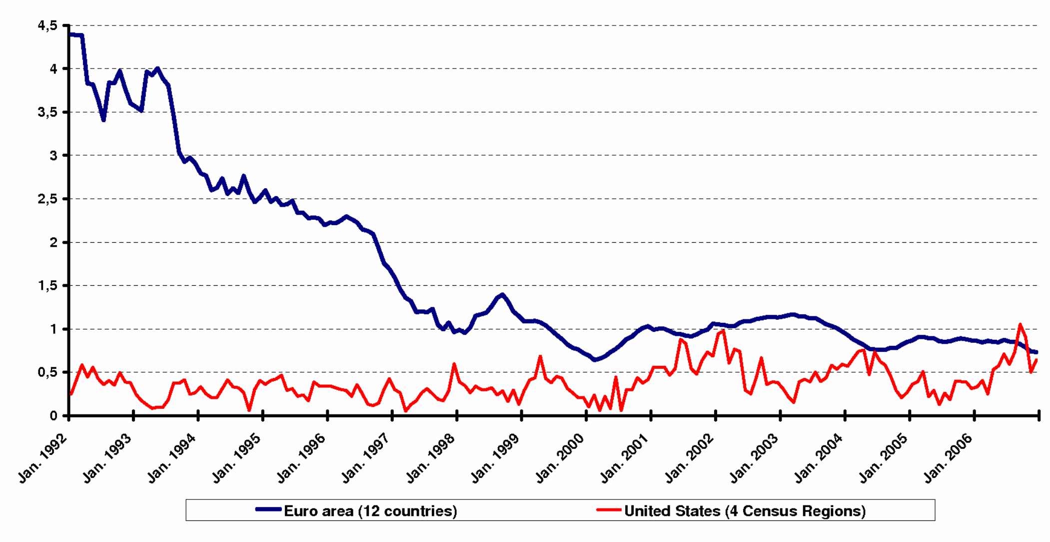
It thus appears clearly that the ECB is closely monitoring inflation dispersion among euro area countries, and this may be reflected in its interest rate setting: the ECB should be more reluctant to raising its inflation rate when the dispersion of inflation rates is already rather high, since it may lead one or several low-inflation countries to a dangerous deflation situation.

We shall notice that inflation dispersion slightly increased after the launch of the EMU in 1999, and the unweighted standard deviation of euro area inflation rates has remained around one percentage point most of the time since then, as can be seen on Figure 1. This figure also shows that inflation dispersion is still slightly higher in the euro area than in the United States[8], a much older Monetary Union of a comparable size, which can provide a useful benchmark. This rather high level of inflation dispersion in the euro area may partly explain the observed inertia of interest rates in the EMU compared to the United States. Figure 2 indeed shows that the movements in interest rates were less frequent and of a smaller extent in the EMU than in the United States.

[7]The main conclusions drawn in this official report have been published in the ECB Monthly Bulletin (European Central Bank, 2005)

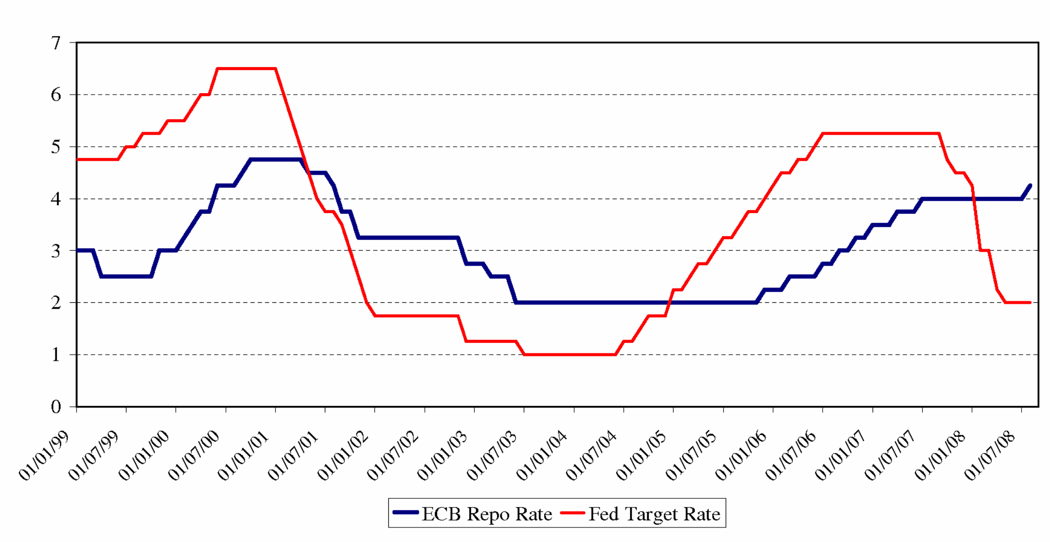
[8]Figure 1 displays the evolution of the unweighted standard deviation for the inflation rates of the 4 U.S. Census Regions (*Northeast*, *Midwest*, *South* and *West*).

Figure 1: Inflation dispersion in the euro area and the United States




*Notes:* the dispersion indicator is the unweighted standard deviation of inflation rates (in percentage points). *Sources:* monthly data from EUROSTAT and the U.S. Bureau of Labour Statistics.

Figure 2: ECB and Fed main interest rates




## 3.3 The composition of the ECB Governing Council and the role of the median inflation rate

As the U.S. Federal Reserve and the former Bundesbank, the ECB is a two-tier Central Bank: its Governing Council is made up of the 6 members of the Executive Board on the one hand, and the Presidents of national Central Banks (15 Presidents since January 2008 and the entry of Malta and

Cyprus in the EMU) on the other hand. Unlike the Fed's institutional framework, each President of a national Central Bank has a permanent seat in the ECB Governing Council and holds one vote in the ECB decision-making process[9]. The weight of national representatives is thus very high within the ECB Governing Council, since they hold 15 votes over 21 (*i.e.* more than 70% of all votes). Consequently, the likelihood of a predominance of national considerations on the ECB's interest rate decisions is relatively large.

The possibility that the vote of the Governors of national Central Banks may be influenced by national considerations is indeed grounded from a theoretical point of view, as explained by Heinemann & Huefner (2004). If the independence of those national representatives is not perfect, national governments may try to influence them (for popularity and re-election motivations in particular). Those behaviours would clearly open the door to a regional bias in the ECB decision-making. However, such a regional bias may also emerge even when assuming that the Governors of national Central Banks are perfectly independent with respect to national Governments. It is in fact likely that the public opinion and its perceptions of the ECB monetary policy influence the members of the Governing Council. Since each national Central Bank's representative is confronted with the public opinion and the media of its own country, he may have a "national" representation of the perception of the ECB monetary policy. That's why national considerations should matter more than the "euro-area wide" public opinion in the votes of the Governors of national Central Banks.

Several empirical papers indeed highlight the influence of national considerations among the monetary policy committees of the U.S. Fed or the former Bundesbank. Meade & Sheets (2005) analyse the votes of the members of the U.S. FOMC and show that individual decisions from the representatives of regional Central Banks are clearly influenced by regional considerations, especially regional inflation and unemployment rate. Interestingly, Meade & Sheets (2005) also note that the decisions from the members of the Board of Governors located in Washington are also affected by the economic situation of Washington ... As for the former Bundesbank, Berger & De Haan (2002) show that the votes of the representatives of the German *Landër* within the Deutsche Governing Council (*Zentralbankrat*) were largely related to regional considerations, especially concerning regional inflation and growth rates[10].

All in all, it appears that the composition of the ECB Governing Council is likely to generate a

[9]Within the U.S. Federal Open Market Committee (FOMC), each of the 7 members from the Board of Governors has one vote, but the Presidents of regional Banks only have 5 votes in total, with a rotation scheme (a rotation among the 11 regional Fed, the Bank of New York being the only one to have a permanent seat).

[10]We must notice that the empirical analyses from Meade & Sheets (2005) and Berger & De Haan (2002) are based on the examination of individual votes from the members of the U.S. FOMC or the former *Zentralbankrat*, published in the detailed minutes from the sessions of the Federal Reserve and the Bundesbank. Since the individual votes of the members of the ECB Governing Council are kept secret, a direct evaluation of the effect of national considerations in the decisions of national Central Banks' representatives is impossible in the euro area. That's why we aim at providing in the next Sections an indirect test of those potential effects through the estimates of a Taylor rule with national indicators for the ECB monetary policy decisions.

regional bias in the decisions related to interest rate setting, and may also induce a smaller reactivity of the ECB to aggregate indicators from the euro area, as noted by Berger & De Haan (2002). This is all the more probable that each country has the same weight in the ECB voting system (Berger & Mueller, 2007), decisions need to be reached by "consensus" (Gerlach-Kristen, 2005), and there is no publication of the minutes from the Governing Council sessions[11].

Have the decisions of the ECB regarding the interest rate setting really been affected by national considerations, as suggested by the dominance of national representatives in its Governing Council, since the launch of the EMU in 1999? Has the ECB taken into account the quite large dispersion of national inflation rates and acted to avoid deflation situations in specific countries, as explained in the previous Subsection? Could this partly explain the significant inertia of euro area interest rates? The following three sections, dedicated to the estimation of an interest rate rule for the ECB using three different and complementary approaches, should shed light on those issues.

# 4 GMM estimates of an augmented reaction function

## 4.1 Empirical framework

An empirical variant of our reference interest rate rule described in (4) may be written as:

$$i_t = \alpha_1 + \alpha_2.i_{t-1} + \alpha_3.(E[\pi_{t+k}|I_t] - \pi^*) + \alpha_4.E[y_{t+q}|I_t] + \varepsilon_t \tag{5}$$

where the dependant variable is a proxy for the target short-term nominal interest rate, namely the monthly average of EONIA (*Euro OverNight Index Average*), the overnight interest rate in the euro area. $\pi_t$ is the inflation rate, calculated as the annualised growth rate of the Harmonized Index of Consumer Price (HICP) of the euro area from one month to the same month of the previous year. $y_t$ is an indicator for real activity and cyclical positioning. We use the industrial output gap, measured as the monthly deviation of the Industrial Production Index (IPI) from a trend calculated using the Hodrick-Prescott filter with a smoothing parameter set to 14 400 (standard value for monthly data)[12]. A detailed description of the series and data sources is provided in Appendix A.

[11] The reform of the ECB voting system adopted by the European Council of March 21, 2003, which modified Article 10.2 of the Eurosystem's statutes, may incidentally be viewed as an admission by the ECB of the risk of a regional bias: to limit a further rise in the relative weight of national Central Banks representatives induced by the enlargement of the euro area to new EU Members, a rotation scheme was introduced. This system would include a rotation of votes among two or three group of countries (depending on the total number of EMU countries) and would limit to 15 the number of votes given to Governors of national Central Banks.

[12] We also made the estimates with two alternative proxies: the deviation of the IPI growth rate from the over-the-period average (equal to 1.57%, with a growth rate computed from one month to the same month of previous year) on the one hand, and the "unemployment gap" measured as the monthly deviation of the unemployment rate from a trend calculated using the Hodrick-Prescott filter. It appears that using such alternative detrending methods yield qualitatively similar results, which is in line with several recent empirical studies such as Fendel & Frenkel (2006) and Hayo & Hofmann (2006).

The regression coefficients can be related to implied coefficients in Equation (4) in the following form: $\alpha_1 = (1-\rho)\bar{i}$ ; $\alpha_2 = \rho$ ; $\alpha_3 = (1-\rho)\beta$ and $\alpha_4 = (1-\rho)\gamma$.

Finally, $\varepsilon_t$ is an error term that captures stochastic disturbances (*i.e.* pure monetary policy shocks) denoted as $\varepsilon_t^{MP}$, as well as expectation errors in forward-looking rules:

$$\varepsilon_t \equiv \varepsilon_t^{MP} - (1-\rho)(E[\pi_{t+k}|I_t] - \pi_{t+k}) - (1-\rho)(E[y_{t+q}|I_t] - y_{t+q}) \tag{6}$$

We also study an augmented specification of our empirical model (5) where we include an indicator $X_t$ for the dispersion of national inflation rates among the EMU countries. Our baseline indicator is the unweighted standard deviation of 12-months inflation rates among the twelve euro area countries.

In this case, our augmented empirical model is:

$$i_t = \alpha_1 + \alpha_2.i_{t-1} + \alpha_3.(E[\pi_{t+k}|I_t] - \pi^*) + \alpha_4.E[y_{t+q}|I_t] + \alpha_5.E[X_{t+l}|I_t] + \varepsilon_t \tag{7}$$

with $\alpha_5 = (1-\rho)\omega$.

## 4.2 Results from GMM estimates

The major problem when working with contemporaneous and even more with forward-looking specifications is the likely correlation between those contemporaneous or forward-looking variables and the error term, which leads to biased estimates of the related coefficients. These variables need therefore to be instrumented. Traditional instrumental variable methods, such as Two-Stage Least Squares (TSLS), are thus sometimes used to estimate Taylor rules. However, they are also problematic since they require normality, non-autocorrelation and homoskedasticity of the error terms.

That's why we carry out our estimates using the Generalized Method of Moments (GMM) estimator, which accounts for potential endogeneity biases as well as non-spherical disturbances. This technique nests many common estimators such as OLS or TSLS and does not require any information about the exact distribution of the error terms: the normality assumption underlying Least Squares estimators is not required any more[13]. The only required assumption that must be satisfied is the orthogonality condition: the instruments should be uncorrelated with the residual term. Good instruments should also be highly correlated with our right-hand side variables.

With regard to the choice of our instruments, we refer to the monetary policy strategy presented by the ECB, as described in the previous Section. For the estimation of our forward-looking spec-

[13] Hamilton (1994) emphasizes this crucial feature of the GMM methodology: "*The key advantage of GMM is that it requires specification only of certain moment conditions rather than the full density*" (p. 409).

ifications of the Taylor rule, we use the lagged values of the dependent and independent variables and lagged values of some indicators that are supposed to convey information about future inflation according to the ECB's "two-pillar strategy": the lagged values of the "money gap"[14], the monthly average of the euro/dollar exchange rate and the oil price expressed in euros. The exact count and choice of instruments is reported below each Table.

We specifically use here the two-step efficient GMM estimator (Hansen, 1982; Hansen & Singleton, 1982). Standard errors for coefficient estimates are computed using the procedure defined by Newey & West (1987) who propose a consistent estimator in case of both heteroskedasticity and autocorrelation of unknown form (*i.e.* HAC covariance).

GMM estimators also allow us to test the quality of instruments since we use more instruments than there are variables to be instrumented. Here, we report the Hansen-Sargan test, which is a test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid instruments (*i.e.* they are orthogonal to the error term), and that the estimated model is correctly specified (excluded instruments are correctly excluded from the estimated equation). Under the null, the test statistic is distributed as chi-squared in the number of overidentifying restrictions. We also explore the issue of weak instruments[15]. We look at Shea's "partial R-squared" in the first stage (a measure of instrument relevance that takes intercorrelations among instruments into account) and also at the F-stat form of the Cragg-Donald statistic in the first stage regression, as suggested by Stock, Wright & Yogo (2002) to test for the presence of weak instruments. The null hypothesis is that the equation is only weakly identified, *i.e.* that instruments do not contribute much to explaining the instrumented variables. In our regressions, "partial R-squared" are always higher than 0.75 in the first stage regressions and the Cragg-Donald statistic does not indicate any weak instruments problem.

Baseline results for GMM estimates are reported in Table 2. The estimated rule is a forward-looking specification with 6-month ahead inflation rates and output gaps ($k = q = 6$)[16]. The estimation of the standard Taylor rule with interest rate smoothing (Column 1) yield parameter estimates that are perfectly in line with previous findings, synthesized in Table 1. The implied $\beta$ coefficient, associated to inflation stabilization, is clearly greater than unity, suggesting that the Taylor Principle holds. As documented in Section 2, the $\gamma$ coefficient is really high (higher than 3), suggesting that the ECB follows a real "output stabilization objective", loosing its monetary policy when growth is expected to be breathless and tightening it when output growth is likely to take off. However, the instantaneous

[14]The "money gap" is constructed as the deviation of the 12-month growth rate of the monetary aggregate M3 from its reference value 4.5%.

[15]Recent researches, including Stock *et al.* (2002) indeed show that the use of weak instruments can lead to substantial biases in GMM estimators and also in test statistics, even in large samples.

[16]Most empirical studies focusing on the euro area show that at least six months are necessary for a change in monetary policy to having significant effects on output and inflation. Even more time may perhaps be required. Nevertheless, we retain a six-month lead in our forward-looking specification given our short time period. Fourçans & Vranceanu (2004) also opt for this rather low number of leads. Sauer & Sturm (2007) estimate the ECB monetary policy rule with a 3-month lead, while Ullrich (2003) retains a 12-month lead.

reaction of the ECB to expected deviations of inflation *and/or* output from their target is much more limited, since the smoothing parameter $\rho$ is really high (0.97).

Table 2: Forward-looking Taylor rule - GMM estimates (1999:1-2006:12)[a]

| | **(1)** | **(2)** | **(3)** |
|---|---|---|---|
| Constant | 0.066 | 0.259 | **0.357** |
| | (1.52) | (1.63) | (2.10)** |
| $i_{t-1}$ | **0.972** | **0.854** | **0.772** |
| | (58.39)*** | (8.91)*** | (7.28)*** |
| $E[\pi_{t+6}\|I_t] - \pi^*$ | **0.093** | **0.328** | **0.224** |
| | (3.39)*** | (2.17)** | (2.41)** |
| $E[y_{t+6}\|I_t]$ | **0.090** | **0.087** | **0.104** |
| | (6.60)*** | (6.06)*** | (7.04)*** |
| Median | | -0.121 | |
| inflation rate (t+6) | | (-1.39) | |
| Standard deviation of | | | **-0.437** |
| inflation rates (t+6) | | | (-2.83)*** |
| **Structural parameters** | | | |
| $\rho$ | **0.972** | **0.854** | **0.772** |
| $\beta$ | **3.385** | **2.241** | **0.982** |
| $\gamma$ | **3.259** | **0.595** | **0.455** |
| $\omega$ | | -0.824 | **-1.918** |
| Adjusted $R^2$ | 0.9809 | 0.9754 | 0.9754 |
| Hansen J-test[b] | [0.2328] | [0.4263] | [0.8752] |
| Number of observations | 90 | 90 | 90 |

[a] We report the results reached using the two-step GMM estimator with the Newey & West (1987) correction. $t$-statistics are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level respectively. Instruments are the lagged interest rates, HICP inflation rate and the output gap (first and second lags), as well as lags of the "money gap", exchange rate variations and the growth rate of oil prices (first and second lags). In Columns (2) and (3), we also add among the instruments the first and second lags of the median inflation rate or the standard deviation of national inflation rates.

[b] *p-value* of the Hansen-Sargan test for the null hypothesis of valid instruments.

When we add our baseline indicator of inflation dispersion in this forward-looking Taylor rule (Column 3), those results are clearly different: the smoothing parameter is lower than 0.8, closer to the estimates reached for the U.S. Federal Reserve with similar forward-looking Taylor rules. It thus seems that the very high value of the smoothing parameter in standard forward-looking rules are partly the result of a problem of omitted variable, as suggested by Rudebusch (2002), Gerlach-Kristen (2004) and Castelnuovo (2007). This omitted variable is likely to be inflation dispersion among euro area countries. The coefficient associated to the unweighted standard deviation of national inflation rates is indeed highly significant and negative. This result, in line with Fendel & Frenkel (2008), suggests that the ECB is more reluctant to raising its inflation rate when the dispersion of inflation rates is already rather high, since it may lead one or several low-inflation countries to a dangerous deflation situation: this negative situation can thus be seen as a reflection of the ECB's "fear of deflation", as announced on May 2003 when clarifying its monetary policy strategy.

We shall note that this conclusion is rather robust to the introduction of alternative inflation dispersion indicators instead of the unweighted standard deviation. Table 8 reported in Appendix B display the results of the GMM estimates of our augmented forward-looking reaction function with four alternative indicators: a weighted standard deviation (using the official weights defined each year by the ECB for the construction of the HICP)[17], the spread between the average of the three highest and the average of the three lowest[18], a quadratic form of the unweighted standard deviation of inflation rates[19], and finally the minimum inflation rate within the EMU. Notably, the ECB seems to be more reluctant to increasing its interest rate when the minimum inflation rate is already low[20].

On the other hand, Column (2) of Table 8 indicates that the median inflation rate does not play a particular role in the ECB interest rate setting when working with a forward-looking specification of the Taylor rule. This conclusion casts some doubt on our hypothesis of national considerations in the ECB decision-making due to the composition of the ECB Governing Council.

However, it must be noted that estimates of forward-looking Taylor rules using a GMM framework (*i.e.* assuming rational expectations of the Central Bank from the set of information available in real-time) have been widely criticized, for several reasons: on the one hand, those estimates may be very sensitive to the precise choice of the instruments (Gerdesmeier & Roffia, 2004)[21]. On the other hand, estimates assuming rational expectations are a potential source of problems on small samples, especially concerning the end of the period (Carstensen, 2006).

That's why we also use survey data for the expectations related to inflation and the output gap, as it is increasingly usual in estimations of forward-looking rules (Heinemann & Huefner, 2004; Gerlach, 2007; Sauer & Sturm, 2007). More precisely, we use data from the Poll of Forecasters tabulated in *The Economist*[22]. The results are reported in Table 3.

[17]This indicator is intended to take into account possible weighting schemes for the fear of deflation: central bankers may be more reluctant to increasing interest rates when Germany is close to deflation than when Luxembourg do . . .

[18]This spread is less sensitive to outliers than the "simple spread" between the highest and lowest inflation rates. The results are however very close, while less significant, if we use this simple spread.

[19]This quadratic form accounts for potential non-linearity in the ECB's reaction to inflation dispersion, as suggested by Fendel & Frenkel (2008).

[20]We investigate another possibility by replacing the inflation dispersion indicator by the German inflation rate, suggesting that the ECB is specifically concerned with German inflation when setting its interest rate. Results indicate that the coefficient on German inflation is not significant: the ECB is thus trying to control aggregate inflation and monitoring inflation dispersion, but not specifically German inflation. The same result is of course reached if we include French, Italian or Spanish inflation in our forward-looking Taylor rule.

[21]As for our results reported in Table 2, they prove to be robust to small changes in the precise set of instruments, as long as the changes only concern the selection and lags of additional instruments (money gap, euro/dollar exchange rate and the oil price). However, the results are quite sensitive to the lag selection for the lagged explaining variables (inflation rate and output gap).

[22]The data and construction of our survey indicators are presented in Appendix A.

Table 3: Taylor rule with survey data - GMM estimates (1999:1-2006:12)[a]

| | (1) | (2) | (3) |
|---|---|---|---|
| Constant | **0.211** | 0.245 | 0.125 |
| | (3.52)*** | (2.10)** | (1.04) |
| $i_{t-1}$ | **0.924** | **0.930** | **0.913** |
| | (39.03)*** | (33.90)*** | (22.83)*** |
| $E[\pi_{t+12}\|I_t] - \pi^*$ | **0.156** | **0.175** | **0.122** |
| | (2.60)** | (2.23)** | (1.91)* |
| $E[y_{t+12}\|I_t]$ | **0.164** | **0.153** | **0.182** |
| | (5.31)*** | (3.39)*** | (3.70)*** |
| Median | | -0.019 | |
| inflation rate (t+6) | | (-0.37) | |
| Standard deviation of | | | **-0.108** |
| inflation rates (t+6) | | | (-2.52)** |
| **Structural parameters** | | | |
| $\rho$ | **0.924** | **0.930** | **0.913** |
| $\beta$ | **2.056** | **2.494** | **1.392** |
| $\gamma$ | **2.159** | **2.181** | **2.083** |
| $\omega$ | | -0.275 | **-1.234** |
| Adjusted $R^2$ | 0.9822 | 0.9822 | 0.9831 |
| Hansen J-test[b] | [0.1811] | [0.1305] | [0.2914] |
| Number of observations | 96 | 96 | 96 |

[a] We report the results reached using the two-step GMM estimator with the Newey & West (1987) correction. *t*-statistics are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level respectively. Instruments in Column (2) and (3) are the lagged interest rates, HICP inflation rate and the output gap (first and second lags), as well as lags of the "money gap", exchange rate variations and the growth rate of oil prices (first and second lags). We also add among the instruments the first and second lags of the median inflation rate or the standard deviation of national inflation rates.

[b] *p-value* of the Hansen-Sargan test for the null hypothesis of valid instruments.

The main conclusions are very close to those reached assuming rational expectations from the ECB as in Table 2. The reactions of the ECB to expected inflation and the output gap (structural parameters $\beta$ and $\gamma$) are very similar, and the ECB is also influenced by the level of inflation dispersion (Column 3). On the other hand, the median inflation rate doesn't seem to impact in the ECB decisions. Table 9 reported in Appendix B also suggests that the minimum inflation rate plays a key role in the interest-rate setting. It thus reinforces our hypothesis that the ECB pays attention not to push lower-inflation countries towards deflation.

# 5 Lessons from FIML estimates of a small semi-structural model of the euro area

GMM estimates of interest rate rules may be criticized on the ground that central bankers use an implicit model of the economy to set their interest rate, not only expected future values for the inflation and the output gap. Single-equation methods do not take into account potential reactions of future inflation and output to modifications in the interest rate setting. That's why we also estimate in this Subsection a small macroeconometric model of the euro by using a Full Information Maximum Likelihood (FIML) estimator, as suggested by Clausen & Hayo (2005) and Fourçans & Vranceanu (2007). The model is close to the Hybrid New-Keynesian model used notably by Angeloni & Ehrmann (2007) for studying the transmission of inflation differentials in the euro area[23]. It is made up of the forward-looking Taylor rule (with or without the indicator for inflation dispersion), a Hybrid New-Keynesian Phillips Curve and a Hybrid IS Curve. The Phillips curve relates current inflation to lagged inflation, expected future inflation and the output gap. As for the IS curve, it links the current output gap to lagged output gap, expected output gap and the real interest rate.

Our small model can thus be written in the following empirical form[24]:

$$\begin{aligned} i_t &= \alpha_1 + \alpha_2.i_{t-1} + \alpha_3.\pi_{t+12} + \alpha_4.y_{t+6} + \varepsilon_{1,t} \\ \pi_t &= b_1 + b_2.\pi_{t-1} + b_3.\pi_{t+6} + b_4.y_t + \varepsilon_{2,t} \\ y_t &= c_1 + c_2.y_{t-1} + c_3.y_{t+3} + c_4.(i_t - \pi_{t+12}) + \varepsilon_{3,t} \end{aligned} \tag{8}$$

We also use an augmented specification of this small semi-structural model to test our two hypotheses of national considerations in the ECB reaction function. We thus add another indicator $X_t$, that is alternatively the median inflation rate or the dispersion of national inflation rates, in our baseline model:

$$\begin{aligned} i_t &= \alpha_1 + \alpha_2.i_{t-1} + \alpha_3.\pi_{t+12} + \alpha_4.y_{t+6} + \alpha_5.X_t + \varepsilon_{1,t} \\ \pi_t &= b_1 + b_2.\pi_{t-1} + b_3.\pi_{t+6} + b_4.y_t + \varepsilon_{2,t} \\ y_t &= c_1 + c_2.y_{t-1} + c_3.y_{t+3} + c_4.(i_t - \pi_{t+12}) + \varepsilon_{3,t} \end{aligned} \tag{9}$$

[23]However, we have a euro area-wide model, not a disaggregated one like Angeloni & Ehrmann (2007). We must also notice that, unlike Fourçans & Vranceanu (2007), we use Hybrid specifications for the IS and Phillips Curves instead of backward-looking versions, since it seems to be more consistent with our forward-looking Taylor rule.

[24]The exact specification of this small model (especially the selection of lags for forward-looking indicators) is the one that provides the better fit to the data.

Results are reported in Table 4. It appears that FIML estimates of the interest rate rule coefficients are globally in line with the GMM estimates documented in the previous Section. In Column (1), we display the results for the standard forward-looking Taylor rule, which are very close to those reached with GMM estimates: the $\beta$ coefficient, associated to inflation stabilization, is clearly greater than unity, suggesting that the Taylor Principle holds. The $\gamma$ coefficient is also significant, suggesting that the ECB has a secondary objective of output stabilization. Finally, the smoothing parameter $\rho$ is again very high (close to 0.95), as with GMM estimates.

The inclusion of the median inflation rate (Column 2) or the unweighted standard deviation of national inflation rates (Column 3) has the same effects than those highlighted using GMM estimates: the smoothing parameter $\rho$ is clearly lower than in the standard Taylor rule (closer to 0.9). This observation suggests once again that the very high value for interest-rate smoothing reached in most empirical papers focusing on the ECB may be the result of the omission of an important serially-correlated variable related to national considerations. More precisely, the ECB seems to react strongly to a rise in the standard deviation of national inflation rates: a 0.1 percentage-point increase of this indicator should entail a long-run cut in the interest rate of nearly 0.3 percentage-point (as revealed by the structural parameter $\omega$ in Column 3).

Those results seem to be quite robust in the choice of the indicator for national inflation dispersion, as indicated in Table 10 reproduced in Appendix B. Once again, the minimum inflation rate appears to influence the ECB interest-rate setting, suggesting that the ECB may try not to push low-inflation country towards deflation.

We shall finally notice that our estimates of the hybrid Phillips Curve and IS Curve are consistent with most empirical analyses using an aggregate model of the euro area, such as Sahuc (2002) and Smets (2003). Backward-looking parameters thus play a dominant role with respect to forward-looking components, both for inflation (suggesting a high degree of inflation persistence in the euro area) and the output gap. As expected, our estimates display a significant effect of the output gap on inflation through the Phillips Curve, and also a clear impact of the real interest rate on output through the IS Curve.

Table 4: A hybrid model with a forward-looking Taylor rule - FIML estimates (1999:1-2006:12)

| | (1) | (2) | (3) |
|---|---|---|---|
| **Forward-looking Taylor rule.** ***Dependent variable:*** $i_t$ | | | |
| Constant | -0.144 | 0.131 | 0.150 |
| | (-0.819) | (0.792) | (0.803) |
| $i_{t-1}$ | **0.948** | **0.900** | **0.899** |
| | (36.277)*** | (41.286)*** | (40.992)*** |
| $\pi_{t+12}$ | **0.137** | **0.120** | **0.108** |
| | (2.178)** | (2.023)** | (1.657)* |
| $y_{t+6}$ | **0.055** | **0.071** | **0.054** |
| | (3.298)*** | (4.416)*** | (3.371)*** |
| Median inflation rate | | **0.122** | |
| | | (3.580)*** | |
| Standard deviation of | | | **-0.290** |
| inflation rates | | | (-2.231)** |
| *Adjusted* $R^2$ | *0.9792* | *0.9822* | *0.9805* |
| **Hybrid Phillips Curve.** ***Dependent variable:*** $\pi_t$ | | | |
| Constant | **0.467** | **0.545** | **0.495** |
| | (2.034)** | (2.352)** | (2.079)** |
| $\pi_{t-1}$ | **0.865** | **0.833** | **0.856** |
| | (10.128)*** | (11.024)*** | (10.546)*** |
| $\pi_{t+6}$ | -0.081 | -0.087 | -0.086 |
| | (-0.655) | (-0.740) | (-0.684) |
| $y_t$ | **0.052** | **0.059** | **0.054** |
| | (1.716)* | (1.883)* | (1.724)* |
| *Adjusted* $R^2$ | *0.7725* | *0.7722* | *0.7726* |
| **Hybrid IS Curve.** ***Dependent variable:*** $y_t$ | | | |
| Constant | -0.134 | -0.125 | -0.133 |
| | (-1.259) | (-1.161) | (-1.238) |
| $y_{t-1}$ | **0.478** | **0.488** | **0.480** |
| | (4.847)*** | (4.786)*** | (4.753)*** |
| $y_{t+3}$ | **0.401** | **0.393** | **0.399** |
| | (5.036)*** | (5.050)*** | (5.011)*** |
| $i_t - \pi_{t+12}$ | **0.135** | **0.125** | **0.134** |
| | (1.930)* | (1.993)* | (1.996)* |
| *Adjusted* $R^2$ | *0.6895* | *0.6890* | *0.6894* |
| **Structural parameters from the forward-looking Taylor rule** | | | |
| $\rho$ | **0.948** | **0.900** | **0.899** |
| $\beta$ | **2.635** | **1.200** | **1.069** |
| $\gamma$ | **1.058** | **0.710** | **0.535** |
| $\omega$ | | **1.220** | **-2.871** |
| *Number of observations* | *84* | *84* | *84* |

# 6 An Ordered Probit approach for modelling interest rate changes

GMM and FIML estimates of our augmented reaction function were using the monthly average of the EONIA as the monetary policy instrument of the ECB. For large samples, this is likely to be a good approximation, since the ECB clearly controls the overall path of the overnight rate. However, there are temporary deviations of the EONIA from the rate of the Main Refinancing Operations (MRO) directly under the ECB control, and those deviations are rather hard to explain, as noted by Carstensen (2006). Therefore, the use of the EONIA interest rate may have entailed an additional noise in our regressions, especially on a small sample as ours. That's why we want to check our results in this Section using directly the ECB MRO rate. Since this rate is always set at multiples of 25 basis points, a simple regression model for continuous dependent variable would not be appropriate. We thus use an Ordered Probit model that is designed for "censored" dependent variables[25].

Let $i_t$ denote the effective repo rate and $i_t^T$ the "target" repo rate for the Governing Council. Those two rates may differ since the ECB only sets its MRO rate as a multiple of 25 basis points. As in the previous Sections, we denote respectively $\pi_t$ and $y_t$ the inflation rate and the output gap, while $X_t$ is a vector of other variables that are supposed to influence the ECB monetary policy decisions. The expression for the target level of the interest rate is thus:

$$i_t^T = c + \alpha_\pi E[\pi_{t+k}|I_t] + \alpha_y E[y_{t+q}|I_t] + \alpha_X E[X_{t+l}|I_t] \qquad (10)$$

Assuming that the ECB proceeds to a gradual adjustment of the actual interest rate, as in Judd & Rudebusch (1998), we get the following dynamic expression for the desired interest rate $i_t^*$:

$$\Delta i_t = i_t^* - i_{t-1} = \lambda_0(i_t^T - i_{t-1}) + \lambda_1 \Delta i_{t-1} + \varepsilon_t \qquad (11)$$

where the constant is omitted and $\varepsilon_t$ is a residual. This Equation implies that interest rates changes should be distributed continuously. However, as the ECB sets interest rates in steps, only discrete changes are observed. Combining Equations (10) and (11) and incorporating the fact that the ECB sets its interest rate in steps yield the following expression:

$$i_t^* - i_{t-1} = \tilde{\alpha}_\pi E[\pi_{t+k}|I_t] + \tilde{\alpha}_y E[y_{t+q}|I_t] + \tilde{\alpha}_X E[X_{t+l}|I_t] - \lambda_0 i_{t-1} + \lambda_1 \Delta i_{t-1} + \varepsilon_t \qquad (12)$$

with $\tilde{\alpha}_i = \alpha_i \lambda_0$. $i_t^*$ may therefore be defined as a latent unobserved variable.

[25] Ordered Probit models are increasingly popular for the estimation of Central Bankers reaction functions. Examples of their diffusion include Gali *et al.* (2004), Heinemann & Huefner (2004), Carstensen (2006), Ullrich (2006) and Gerlach (2007).

We do not observe the variations of this latent variable, but only the effective changes in the MRO rate by steps of 25 basis points, which depend on where the latent variable is relative to a set of threshold values $\mu_i$:

$$
\begin{aligned}
\Delta i_t &= -0.50\% && \text{if} \quad i_t^* - i_{t-1} \leq \mu_1 \\
\Delta i_t &= -0.25\% && \text{if} \quad \mu_1 < i_t^* - i_{t-1} \leq \mu_2 \\
\Delta i_t &= 0\% && \text{if} \quad \mu_2 < i_t^* - i_{t-1} \leq \mu_3 \\
\Delta i_t &= +0.25\% && \text{if} \quad \mu_3 < i_t^* - i_{t-1} \leq \mu_4 \\
\Delta i_t &= +0.50\% && \text{if} \quad \mu_4 < i_t^* - i_{t-1}
\end{aligned}
\qquad (13)
$$

Finally, the number of 25-basis-point cuts and 50-basis-point increases in the interest rate has been very limited since 1999, as indicated in Table 5. That's why we decide, like Heinemann & Huefner (2004), not to discriminate between the extent of increase or decrease Our Ordered Probit model thus display only three modalities: -1 (a cut in the MRO rate), 0 (no change) and +1 (an increase of the MRO rate).

Table 5: Calendar of changes in the ECB interest rate (January 1999 - December 2006)

| **Date of change** | **Rate change** | **New level** | **Duration in weeks** |
|---|---|---|---|
| 9 April 1999 | - 0.50 | 2.50 | 29 |
| 5 November 1999 | + 0.50 | 3.00 | 13 |
| 4 February 2000 | + 0.25 | 3.25 | 6 |
| 17 March 2000 | + 0.25 | 3.50 | 6 |
| 28 April 2000 | + 0.25 | 3.75 | 6 |
| 9 June 2000 | + 0.50 | 4.25 | 12 |
| 1 September 2000 | + 0.25 | 4.50 | 5 |
| 6 October 2000 | + 0.25 | 4.75 | 31 |
| 11 May 2001 | - 0.25 | 4.50 | 16 |
| 31 August 2001 | - 0.25 | 4.25 | 3 |
| 18 September 2001 | - 0.50 | 3.75 | 7 |
| 9 November 2001 | - 0.50 | 3.25 | 56 |
| 6 December 2002 | - 0.50 | 2.75 | 13 |
| 7 March 2003 | - 0.25 | 2.50 | 13 |
| 6 June 2003 | - 0.50 | 2.00 | 131 |
| 6 December 2005 | + 0.25 | 2.25 | 13 |
| 8 March 2006 | + 0.25 | 2.50 | 14 |
| 15 June 2006 | + 0.25 | 2.75 | 8 |
| 9 August 2006 | + 0.25 | 3.00 | 9 |
| 11 October 2006 | + 0.25 | 3.25 | 9 |
| 13 December 2006 | + 0.25 | 3.50 | 13 |
| 14 March 2007 | + 0.25 | 3.75 | 13 |
| 13 June 2007 | + 0.25 | 4.00 | 56 |
| 9 July 2008 | + 0.25 | 4.25 | 13 |

The results reached using this Ordered Probit model are reported in Table 6. Since we consider a forward-looking specification of our model and can not simply assume rational expectations for the

ECB as we did in our baseline GMM estimates, we use the survey data provided by *The Economist* and described above. The main results are perfectly in line with those discussed in the previous two Sections with both GMM and FIML methodologies. As expected, aggregate HICP inflation and the output gap are key determiners in the ECB decisions related to interest rate setting. Our results also point out that the interest rate *level* influence the ECB decisions: the Governing Council may be more inclined to increasing its key interest rate when it is initially rather low, and conversely to cut it when the initial level is rather high. On the other hand, the parameter on the *lagged change* in the interest rate isn't significant whatever the specification, suggesting that a change in the key interest rate would not influence the decision of the Governing Council for the following month.

The inclusion of the unweighted standard deviation of national inflation rates (Column 3) does not entail major changes on those baseline results, though slightly improving the fit of the model. This dispersion indicator is once again highly significant and reveals the role of national considerations on the ECB's decisions relative to interest rates changes[26]. However, Column (2) of Table 6 suggests that the median inflation rate does not play a specific role.

Table 7 displays the marginal effects for each variable and specification. The marginal effects are the change in the probability of each modality (-1, 0 and +1, *i.e.* respectively decrease, no change and increase in the MRO rate) for a one-unit change (a one-percentage-point change in our case) in the explanatory variable (calculated for mean values of explanatory variables). The computation of marginal effects thus allows us to interpret and compare the impact of small changes of each variable on the voting decision. For example, it appears that a one-percentage-point increase in the expected output gap reduces the probability of a cut in the interest rate by 0.103 and increases the probability for a tightening of monetary policy by 0.209, if we refer to our preferred specification (3) with the standard deviation of inflation rates. Interestingly, a one percentage-point increase in this dispersion indicator raises the probability of a cut in interest rates by 0.063, and reduces the probability of an increase in interest rates by 0.129.

[26]This conclusion seems to be quite robust in the choice of the indicator for national inflation dispersion, as indicated in Table 11 reproduced in Appendix B.

Table 6: Forward-looking Taylor rule - Ordered Probit estimates (1999:1-2006:12)

| | (1) | (2) | (3) |
|---|---|---|---|
| $i_{t-1}$ | **-0.938** | **-0.790** | **-0.868** |
| | (-4.11)*** | (-2.82)*** | (-3.16)*** |
| $\Delta i_{t-1}$ | -0.188 | -0.215 | -0.187 |
| | (-0.50) | (-0.55) | (-0.49) |
| $E[\pi_{t+12}\|I_t]-\pi^*$ | **1.985** | **2.507** | **2.003** |
| | (2.47)** | (2.52)** | (2.42)** |
| $E[y_{t+12}\|I_t]$ | **1.771** | **1.469** | **1.620** |
| | (4.31)*** | (2.63)*** | (3.39)*** |
| Median inflation rate | | 0.529 | |
| | | (0.91) | |
| Standard deviation of | | | **-0.997** |
| inflation rates | | | (-2.64)*** |
| Pseudo $R^2$ | 0.2441 | 0.2507 | 0.2477 |
| Number of observations | 95 | 95 | 95 |

Notes: We report the results reached using an Ordered Probit model with Huber-White corrected standard deviation. $z$-statistics are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level respectively.

Table 7: Forward-looking Taylor rule - Marginal effects from the Ordered Probit

| | (1) | | | (2) | | | (3) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Prob(y=...) | | | Prob(y=...) | | | Prob(y=...) | | |
| | -1 | 0 | 1 | -1 | 0 | 1 | -1 | 0 | 1 |
| $i_{t-1}$ | **0.062** | 0.064 | **-0.125** | 0.048 | 0.052 | **-0.100** | **0.055** | 0.057 | **-0.112** |
| | (1.97)** | (1.57) | (-3.68)*** | (1.62) | (1.59) | (-2.92)*** | (1.66)* | (1.59) | (-2.99)*** |
| $\Delta i_{t-1}$ | 0.012 | 0.013 | -0.025 | 0.013 | 0.014 | -0.027 | 0.012 | 0.012 | -0.024 |
| | (0.51) | (0.46) | (-0.50) | (0.57) | (0.51) | (-0.56) | (0.50) | (0.45) | (-0.49) |
| $E[\pi_{t+12}\|I_t]-\pi^*$ | **-0.130** | -0.135 | **0.265** | **-0.153** | -0.164 | **0.318** | **-0.127** | -0.131 | **0.258** |
| | (-2.02)** | (-1.22) | (2.21)** | (-1.98)** | (-1.22) | (2.26)** | (-1.98)** | (-1.22) | (2.26)** |
| $E[y_{t+12}\|I_t]$ | **-0.116** | -0.120 | **0.237** | **-0.090** | -0.096 | **0.186** | **-0.103** | -0.106 | **0.209** |
| | (-2.28)** | (-1.47) | (3.68)*** | (-1.73)* | (-1.41) | (2.60)*** | (-1.90)* | (-1.48) | (3.15)*** |
| Median | | | | -0.032 | 0.035 | 0.067 | | | |
| inflation rate | | | | (-0.90) | (0.73) | (0.88) | | | |
| Standard deviation of | | | | | | | **0.063** | 0.065 | **-0.129** |
| inflation rates | | | | | | | (1.66)* | (0.54) | (-2.63)*** |

Notes: The marginal effects in each category sum to zero (Heinemann & Huefner, 2004).

# 7 Conclusion

In this paper, we have tried to assess whether national considerations matter in the ECB monetary policy decision-making. We investigate two hypotheses that may provide some grounds for an influence of national inflation rates in the interest-rate setting within a Monetary Union. On the one hand, the ECB Governing Council may have been reluctant to raising its interest rates when the dispersion of cyclical positions and inflation rates was very important, even with aggregate inflation above target. We highlighted that the clarification of the ECB monetary policy strategy announced on May 2003, with a new definition of price stability, was indeed partly motivated by the implications of inflation differentials and the risk for lower-inflation countries to face excessively low or even negative inflation rates. On the other hand, the composition of the ECB Governing Council itself is likely to lead to national considerations in the interest-rate setting process for the euro area as a whole, since this monetary policy Committee is made up of the 15 Presidents of national Central Banks and the 6 members of the Board.

We investigate those two hypotheses using the standard framework given by forward-looking Taylor rules in use since Clarida *et al.* (1998, 2000). Our results highlight the significant role played by cross-country inflation dispersion in the ECB interest rate setting, and this result is robust to the dispersion indicator used in our augmented Taylor rule. It also appears that the ECB reacts quite strongly to an expected future deviation of the inflation rate from its 2% target: in our augmented forward-looking Taylor rule, it appears that a deviation of future inflation above target by one percentage-point would imply a reaction of the ECB raising its interest rate by about 1.5 percentage-point. The ECB also smoothes its intervention in the money market, but the effective adjustment represents between 8 and 15% of the desired change in interest rate when an indicator of inflation dispersion is added to the Taylor rule, whereas it could be less than 4% when considering the standard Taylor rule.

It thus appears that the observed inertia in euro area interest rates (much higher than the one observed in the United States) may be partly explained by a significant cross-country inflation dispersion: the ECB should have been more reluctant to raising its interest rates, even if aggregate inflation was most of the time above the 2% target, since it should have lead low-inflation countries (such as Germany) to a dangerous deflation situation. Now that Germany has escaped from this fear of deflationary pressures, the ECB should be less reluctant to increasing its interest rates, as suggested by the four consecutive 0.25 point increases in the ECB interest rates between October 2006 and June 2007.

Future researches should focus on the optimality of an interest rate rule including an inflation dispersion indicator for the ECB in a theoretical macroeconomic model including a specific loss function for the Central Bank.

# Appendix A: Data

## Interest rates

For GMM and FIML estimates, we use the monthly average of the EONIA (*Euro OverNight Index Average*). Data are extracted from the *OECD Main Economic Indicators*. As for the Ordered Probit modelling, we use the rate of Main Refinancing Operations (MRO), which is the key interest rate of the ECB. Data are provided on the ECB Website:
http://www.ecb.int/stats/monetary/rates/html/index.en.html

## Inflation rates

The aggregate inflation rate for the euro area is computed as the 12-month growth rate of the Harmonized Index of Consumer Prices (HICP). This series is not adjusted for seasonality and is extracted from the *OECD Main Economic Indicators*.

Inflation forecasts are based on data published by the newspaper *The Economist*. Those forecasts, tabulated each month since 1994, are calculated as the means of the forecasts from a Pool of Forecasters. It must be noted that those data are only annual average inflation rates for the current and following year, not true 12-month inflation forecasts. To convert these forecasts into monthly moving figures, we follow Gerlach (2007) and Sauer & Sturm (2007): the 12-month inflation forecast is the weighted average of the forecasts for the current and the following year, where the respective weights are $x/12$ and $(12-x)/12$, $x$ being the number of remaining months in the current year. To illustrate, the expected rate of inflation in March ($x = 9$) is computed as $9/12$ of the expected rate of this year and $3/12$ of the expected rate of inflation for next year.

## Output gap measures

Our baseline proxy for the output gap is the monthly deviation of the Industrial Production Index (IPI) from a trend calculated using the Hodrick-Prescott filter with a smoothing parameter set to 14 400 (standard value for monthly data). We also made the estimates with two alternative proxies: the deviation of the IPI growth rate from the over-the-period average (equal to 1.57%, with a growth rate computed from one month to the same month of previous year) on the one hand, and the "unemployment gap" measured as the monthly deviation of the unemployment rate from a trend calculated using the Hodrick-Prescott filter. Seasonally-adjusted IPI and unemployment data are extracted from the *OECD Main Economic Indicators*.

For survey data estimates, we use an indicator of expected real GDP growth in the coming twelve months, calculated on the basis of the information contained in *The Economist* Poll of Forecasters. Monthly data are constructed as for expected inflation data, with a weighted average of the forecasts for the current and the following year. We also made the estimates using an alternative indicator for expected real activity, constructed from the *Economic Sentiment INdicator* (ESIN) developed by the European Commission, as suggested by Gerlach (2007). The results are very close to those reached with the data from *The Economist*.

## Other aggregate indicators for the euro area

The "money gap" is constructed as the deviation of the 12-month growth rate of the monetary aggregate M3 from its reference value 4.5%. Our exchange rate indicator is the 12-month growth rate of the euro/dollar exchange rate. Those data are extracted from the *OECD Main Economic Indicators*. Finally, we use the 12-month growth rate of the crude oil price (*brent spot price*) in euros, taken from the U.S. Department of Energy (*Energy Information Administration*).

## National inflation indicators

National inflation rates are constructed as 12-month growth rates of the HICP, with data extracted from the *OECD Main Economic Indicators*.

# Appendix B: Robustness checks

Table 8: Robustness checks - GMM estimates of a forward-looking Taylor rule (1999:1-2006:12)[a]

| | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Constant | 0.056 | **0.488** | **0.209** | **0.361** |
| | (1.13) | (2.29)** | (2.55)** | (2.08)** |
| $i_{t-1}$ | **0.835** | **0.740** | **0.822** | **0.778** |
| | (8.80)*** | (6.62)*** | (7.39)*** | (7.34)*** |
| $E[\pi_{t+6}\|I_t] - \pi^*$ | **0.186** | **0.278** | **0.150** | **0.213** |
| | (2.75)*** | (2.58)** | (1.97)* | (2.34)** |
| $E[y_{t+6}\|I_t]$ | **0.113** | **0.105** | **0.106** | 0.104 |
| | (7.92)*** | (6.58)*** | (7.30)*** | (7.08)** |
| Minimum | **0.095** | | | |
| inflation rate (t+6) | (1.72)* | | | |
| *Spread* of | | **-0.252** | | |
| inflation rates (t+6) | | (-2.10)** | | |
| Weighted standard deviation | | | **-0.348** | |
| of inflation rates (t+6) | | | (-2.02)** | |
| Quadratic form of the | | | | **-0.109** |
| std.dev. of inflation rates (t+6) | | | | (-1.81)* |
| **Structural parameters** | | | | |
| $\rho$ | **0.835** | **0.740** | **0.822** | **0.778** |
| $\beta$ | **1.132** | **1.070** | **0.842** | **0.958** |
| $\gamma$ | **0.683** | **0.403** | **0.597** | **0.469** |
| $\omega$ | **0.578** | **-0.968** | **-1.956** | **-0.489** |
| Adjusted $R^2$ | 0.9786 | 0.9723 | 0.9783 | 0.9759 |
| Hansen J-test[b] | 0.6626 | 0.9727 | 0.7198 | 0.8799 |
| Number of observations | 90 | 90 | 90 | 90 |

[a] We report the results reached using the two-step GMM estimator with the Newey & West (1987) correction. $t$-statistics are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level respectively. Instruments are the lagged interest rates, HICP inflation rate and the output gap (first and second lags), as well as lags of the "money gap", exchange rate variations and the growth rate of oil prices (first and second lags). We also add among the instruments the first and second lags of the indicator of inflation dispersion.

[b] *p-value* of the Hansen-Sargan test for the null hypothesis of valid instruments.

Table 9: Robustness checks - GMM estimates of a Taylor rule with survey data (1999:1-2006:12)[a]

| | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| Constant | **0.228** | **0.243** | **0.235** | **0.212** |
| | (3.55)*** | (2.31)** | (3.74)*** | (2.22)** |
| $i_{t-1}$ | **0.892** | **0.928** | **0.929** | **0.924** |
| | (24.81)*** | (30.80)*** | (32.35)*** | (28.90)*** |
| $E[\pi_{t+12}\|I_t] - \pi^*$ | **0.138** | **0.158** | **0.154** | **0.155** |
| | (2.37)** | (2.59)** | (2.40)** | (2.59)** |
| $E[y_{t+12}\|I_t]$ | **0.194** | **0.156** | **0.157** | **0.164** |
| | (5.57)*** | (3.43)*** | (4.07)*** | (3.69)*** |
| Minimum | **0.062** | | | |
| inflation rate (t+6) | (2.67)** | | | |
| *Spread* of | | -0.019 | | |
| inflation rates (t+6) | | (-0.32) | | |
| Weighted standard deviation | | | -0.054 | |
| of inflation rates (t+6) | | | (-0.48) | |
| Quadratic form of the | | | | -0.001 |
| std.dev. of inflation rates (t+6) | | | | (-0.02) |
| **Structural parameters** | | | | |
| $\rho$ | **0.892** | **0.928** | **0.929** | **0.924** |
| $\beta$ | **1.279** | **2.197** | **2.154** | **2.045** |
| $\gamma$ | **1.790** | **2.164** | **2.198** | **2.163** |
| $\omega$ | **0.572** | -0.263 | -0.751 | -0.008 |
| Adjusted $R^2$ | 0.9828 | 0.9822 | 0.9822 | 0.9822 |
| Hansen J-test[b] | 0.1369 | 0.1490 | 0.1165 | 0.1508 |
| Number of observations | 96 | 96 | 96 | 96 |

[a] We report the results reached using the two-step GMM estimator with the Newey & West (1987) correction. *t*-statistics are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level respectively. Instruments are the lagged interest rates, HICP inflation rate and the output gap (first and second lags), as well as lags of the "money gap", exchange rate variations and the growth rate of oil prices (first and second lags). We also add among the instruments the first and second lags of the indicator of inflation dispersion.

[b] *p-value* of the Hansen-Sargan test for the null hypothesis of valid instruments.

Table 10: Robustness checks - FIML estimates of a hybrid model with a forward-looking Taylor rule (1999:1-2006:12)

| | (1) | (2) | (3) |
|---|---|---|---|
| **Forward-looking Taylor rule.** ***Dependent variable:*** $i_t$ | | | |
| Constant | -0.020 | 0.057 | 0.124 |
| | (-0.094) | (0.307) | (0.756) |
| $i_{t-1}$ | **0.885** | **0.901** | **0.902** |
| | (21.185)*** | (37.806)*** | (43.662)*** |
| $\pi_{t+12}$ | **0.092** | **0.112** | **0.127** |
| | (2.259)** | (1.695)* | (2.025)** |
| $y_{t+6}$ | **0.057** | **0.051** | **0.069** |
| | (3.323)*** | (2.953)*** | (4.310)*** |
| Minimum | **0.148** | | |
| inflation rate | (1.968)** | | |
| Weighted standard deviation | | **-0.272** | |
| of inflation rates | | (-1.700)* | |
| *Spread* of | | | **-0.089** |
| inflation rates | | | (-2.995)*** |
| *Adjusted* $R^2$ | *0.9813* | *0.9803* | *0.9806* |
| **Hybrid Phillips Curve.** ***Dependent variable:*** $\pi_t$ | | | |
| Constant | **0.459** | **0.471** | **0.511** |
| | (1.840)* | (1.983)** | (2.236)** |
| $\pi_{t-1}$ | **0.852** | **0.857** | **0.854** |
| | (9.299)*** | (9.994)*** | (10.996)*** |
| $\pi_{t+6}$ | -0.065 | -0.076 | -0.092 |
| | (-0.487) | (-0.591) | (-0.770) |
| $y_t$ | **0.053** | **0.052** | **0.055** |
| | (1.692)* | (1.692)* | (1.774)* |
| *Adjusted* $R^2$ | *0.7727* | *0.7727* | *0.7725* |
| **Hybrid IS Curve.** ***Dependent variable:*** $y_t$ | | | |
| Constant | -0.133 | -0.135 | -0.129 |
| | (-1.230) | (-1.267) | (-1.194) |
| $y_{t-1}$ | **0.479** | **0.477** | **0.488** |
| | (4.648)*** | (4.772)*** | (4.801)*** |
| $y_{t+3}$ | **0.399** | **0.402** | **0.390** |
| | (5.037)*** | (5.026)*** | (4.966)*** |
| $i_t - \pi_{t+12}$ | 0.134 | 0.136 | 0.129 |
| | (1.489) | (1.522) | (1.464) |
| *Adjusted* $R^2$ | *0.6894* | *0.6895* | *0.6890* |
| **Structural parameters from the forward-looking Taylor rule** | | | |
| $\rho$ | **0.885** | **0.901** | **0.902** |
| $\beta$ | **0.800** | **1.131** | **1.296** |
| $\gamma$ | **0.496** | **0.515** | **0.704** |
| $\omega$ | **1.287** | **-2.747** | **0.908** |
| *Number of observations* | *84* | *84* | *84* |

Table 11: Robustness checks - Ordered Probit estimates of a forward-looking Taylor rule (1999:1-2006:12)

| | **(1)** | **(2)** | **(3)** | **(4)** |
|---|---|---|---|---|
| $i_{t-1}$ | **-1.607** | **-0.850** | **-0.828** | **-0.872** |
| | (-4.52)*** | (-3.14)*** | (-3.20)*** | (-3.17)*** |
| $\Delta i_{t-1}$ | -0.151 | -0.200 | -0.217 | -0.186 |
| | (0.38) | (-0.51) | (-0.55) | (-0.48) |
| $E[\pi_{t+12}\|I_t] - \pi^*$ | **1.823** | **2.140** | **1.845** | **1.994** |
| | (2.32)** | (2.48)** | (2.17)** | (2.42)** |
| $E[y_{t+12}\|I_t]$ | **2.468** | **1.544** | **1.596** | **1.629** |
| | (4.82)*** | (3.09)*** | (3.66)*** | (3.42)*** |
| Minimum | **1.161** | | | |
| inflation rate | (3.01)*** | | | |
| *Spread* of | | **-0.614** | | |
| inflation rates | | (-1.88)* | | |
| Weighted standard deviation | | | **-1.887** | |
| of inflation rates | | | (-2.46)** | |
| Quadratic form of the | | | | **-0.245** |
| std.dev. of inflation rates | | | | (-1.71)* |
| Pseudo $R^2$ | 0.2753 | 0.2506 | 0.2554 | 0.2474 |
| Number of observations | 95 | 95 | 95 | 95 |

Notes: We report the results reached using an Ordered Probit model with Huber-White corrected standard deviation. $z$-statistics are in parentheses. *, ** and *** denote significance at the 10%, 5% and 1% level respectively.

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