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# The Importance of the Wording of the ECB

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**Abstract**
This paper analyses the ECB communication, focusing in particular on its transparency dimension. We posit that if the ECB is transparent about its future policy decisions, then we should be able to forecast fairly well its future interest rate setting behaviour. We find that the predicting ability of the European monetary authority's words, is similar to the one implied by market-based measures of monetary policy expectations. Moreover, the ECB's wording provides complementary, rather than substitute, information with respect to economic and monetary variables.

Keywords: ECB communication, transparency, monetary policy forecast, empirical reaction function, Euribor rate curve
JEL classifications: E43, E52, E58, G14
data: Described in Appendix A of the paper

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*"The adoption of 'inflation targeting' (...) is characterized not only by public commitment to an explicit target, but also by a commitment to explain the central bank's policy actions in terms of a systematic decision-making framework that is aimed at achieving this target."*
*Michael Woodford (2003, page 3)*

## 1. Introduction

What is ECB communication about? More generally, is the ECB transparent about its future monetary policy stance? What will the level of the Repo rate be in three months from now? These are some of the questions that this paper attempts to answer.

Put another way, our goal is an analysis of ECB communications, focusing in particular on its transparency.

According to the ECB website[1], a central bank is transparent when "[it] provides the general public and the markets with all relevant information on its strategy, assessments and policy decisions as well as its procedures in an open, clear and timely manner". Therefore, we posit that if the ECB is transparent, then we should be better able to forecast its future Repo rate (the ECB's official interest rate, that is, the bid rate on its main refinancing operations). Our main findings can be summarized as follows.

First, by looking at the semantic content of the ECB President's introductory statement to the monthly press conference, we can predict fairly well the ECB near future monetary policy moves. In particular, we used the glossary constructed in Rosa and Verga (2005) to translate the qualitative information of the press conferences into quantitative variables and then we forecasted the future changes (up to a 6-month horizon) of the Repo rate as a function, either linear or non-linear, of this new ordinal measure.

Second, by carefully reading most of the ECB official documents, we identified a set of economic and monetary variables that may affect its interest rate setting behaviour. Then, we used them to estimate the ECB-specific empirical reaction function. Obviously, our null hypothesis is that if the ECB is sufficiently transparent, we can infer its underlying monetary policy rule.

Third, we compared the forecasting ability of the two methods explained above with the standard benchmark, which consists of applying the expectation hypothesis to the term structure of the Euribor rates. It turns out that words and data on economic variables are essentially complementary, rather than substitute, pieces of information to correctly predict the future Repo rate.

[1] http://www.ecb.int/ecb/orga/transparency/html/index.en.html (lastly accessed on the 31st January 2005).

Finally, the by-products of our empirical analysis are that the ECB has a real target too and that non-standard econometric techniques, such as fuzzy regression and discriminant analysis, do not perform better than standard OLS and ordinal regressions.

### 1.1 Related literature

Central bankers motivate the need for transparency for the following reasons (cf. Issing, 2005).

First, since central banks are granted the legal status of (at least instrument) independence, in order to fulfil one of the basic requirements of a democracy, that is accountability, central banks have to be transparent.

Second, transparency is a necessary ingredient to enhance the efficiency of monetary policy. Central banks can directly control only the very short-run nominal interest rates, but aggregate-spending decisions are closely related to interest rates of all maturities. Therefore, the management of financial market expectations has become a crucial instrument in the monetary authority's hands to affect the overall course of the economy. Sound credibility and good communication skills (to direct market expectations) are essential tools for the effective working of a modern central bank.

Geraats (2002) provides an excellent overview of the theoretical and empirical literature on the transparency of monetary policy.

Of course, there are many applied econometric papers that attempt to predict future monetary policy moves and to find empirical reaction functions. However, there is little previous work that attempts to directly estimate a central bank's transparency.

The papers most closely related to this one would appear to be Rosa and Verga (2005), Chevapatrakul et al. (2003) and Gurkaynak et al. (2002)[2].

Rosa and Verga (2005) construct a glossary that translates the qualitative information contained in the ECB President introductory statement to the monthly press conference into quantitative variables. Then, they use this new ordinal measure to test the common knowledge of the ECB transparency. In other words, given that the ECB is transparent, does the financial market know it? Does the ECB know that the financial

[2] In an independent work ("Interest rate setting by the ECB: words and deeds", CEPR Discussion Paper 4775, December 2004), Gerlach solved a related empirical exercise. The main differences between the contributions of his paper and ours are the following. First, we estimate a different empirical reaction function: we use both a different indicator and set of economic variables. For instance, we do not find any role for monetary aggregates when controlling for a larger set of economic variables. Second, we perform some robustness checks of our transparency results. On the one hand, we mix together words and economic variables, showing that none of them considered in isolation is a sufficient statistics to explain the ECB's behavior. On the other, we compare the forecasting ability of ECB's words and economic variables with market-based measures of monetary policy expectations.

market knows that the ECB is transparent? And so forth… Instead, in this paper we use their glossary to check the consistency between the European monetary authority's words and its future actions, that is, its future interest rate moves.

On the one hand, using (high frequency) monthly data, Chevapatrakul et al. (2003) show that the Taylor rule is a useful tool to forecast the future Bank of England interest rate setting behavior. On the other hand, they find that the information from inflation and output gap is an insufficient statistics to predict the direction of the next UK monetary authority's interest rate change compared to a wider information set that includes other economic variables such as exchange rate, labor market and factor cost information. Although in section 3 of this paper we use the same econometric approach, i.e. a generalized Taylor rule, some substantial differences remain. First, we consider the ECB reaction function from 1999 to 2004 rather than the BoE reaction function from 1993 to 2000. Second, our goal is not only to explain the European monetary authority decisions but also, and more importantly, to check the ECB's transparency. Put another way, we are interested to assess the degree of accuracy of ECB explanations about its current policy moves: by following ECB instructions, up to what extent could we reproduce its decision-making process?

Gurkaynak et al. (2002) compare the predictive power of a number of short-maturity financial instruments to measure expectations of the future course of U.S. monetary policy. We adopt their empirical framework, the (standard) expectation hypothesis applied to the term structure of the Euribor rates, to construct the benchmark we have used to assess quantitatively the transparency of the ECB.

The rest of the paper is organized as follows. In section 2, we predict future monetary policy interventions by analysing the official ECB's documents. In section 3, we try to reproduce ECB interest rate setting decisions by estimating an *ad hoc* empirical reaction function. In section 4, we present our forecasting procedure based on the expectation hypothesis applied to the term structure of the Euribor rate. In section 5, we compare the performance of our three alternative methods of forecasting. Finally, section 6 suggests some important issues left for future research and concludes. Appendix A provides both the description and the sources of the time series used in the estimations. Appendix B and Appendix C describe the methodology and discuss the results of applying the fuzzy non-linear regression and the discriminant analysis.

## 2. The ECB President press conference

The ECB, or rather its Governing Council, has conducted monetary policy since January 1999, and thus is a relatively new central bank. Nonetheless, since the very

beginning, the bank has paid a lot of attention to its announcement policy and especially to its choice of medium, form and content. For example, in order to properly communicate with the public and address the informational needs of the various target groups (i.e., politicians, academics, the press, financial markets, etc.), the ECB uses many different instruments, such as the Monthly Bulletin, the President monthly press conference (and its Questions and Answers session), the Testimony to the Committee on Monetary Affairs of the European Parliament (twice a year)[3] and frequent speeches by either its President or the members of its Governing Council.

According to the Monthly Bulletin of November 2002 (page 64), the ECB President monthly press conference and the Monthly Bulletin constitute its most important communication channels. The former is a timely tool to concisely communicate to the press the ECB Governing Council's policy relevant assessments of recent economic developments. The latter is used by the ECB not only to convey its detailed and quantitative view of the economy (thus integrating the information released by its President press conference), but also to describe its analytical framework - models, methods and indicators - that represents the basis of its decision-making process.

In this section we restrict our analysis to the semantic content of the ECB's President introductory statement to the monthly press conference in order to predict the future Repo rate. Note that although both the Editorial section of the Monthly Bulletin and the introductory statement report the same information concerning the ECB monetary policy stance, we concentrate our attention to the latter document because the former is made available to the public only with a time lag.

In exposing its opinions, the ECB has always used a very limited number of key words and strings, and employed a very standardized form of language. Moreover, thanks to the journalists' questions during the press conferences, the ECB President has further explained the meaning of some words. For instance, at the press conference of the 6th March 2003 President Duisenberg declared that: “Well, if we use the word ‘appropriate’ we expect it to remain valid for a considerable period of time”. Therefore, today it is not difficult to draw conclusions about the Bank's sentiment.

There are three main hypotheses underlying our empirical exercise.

First, the central bank's information set should not be weakly included in that of the financial markets. Romer and Romer (2000), among others, support this hypothesis by showing that central banks produce better forecasts for the economic outlook than private sector forecasters: after all, this seems very intuitive since central banks are

[3] Before March 2001, it was called either Hearing before the Committee on Economic and Monetary Affairs of the European Parliament or Speech at the Parliamentary Assembly of the Council of Europe.

usually active decision-makers and can control, at least to some extent, the future course of the economy.

Second, the monetary authority should not face a severe time-inconsistency problem (cf. Barro and Gordon, 1983). In other words, when the incongruence of preferences between the central bank and the private sector is not too large, there is no incentive for the central bank to misrepresent its private information.

Third, the public should understand the language used by the monetary authority.

We can synthetically rephrase the three assumptions above by stating that if the central bank releases *new*, *true*, and *clear* information (cf. Winkler, 2000), then the public should pay attention to it. Note that if at least one of these assumptions is not satisfied, our empirical exercise will be meaningless.

The glossary (reported) in Table 1 (see Rosa and Verga (2005) section three for further details about its construction) is employed to rank the words used in speeches into an ordered scale of numbers representing the degree of risk to price stability. We have thus transformed all the ECB President's statements into something suitable for statistical analysis.

Our assigned value of risk, *Index*, to each ECB monetary policy announcement is reported in Table A1 of Appendix A. Recall that this *Index* is a summary statistics of the ECB Governing Council view about both the future prospects of inflation and real activity in the Euro area. In fact, in accordance with the Maastricht Treaty (which established the European Union and, as a by-product, the European System of Central Banks), the ECB has both a nominal (i.e., inflation) and real (i.e., output growth) objective[4]. However, note that the latter ECB goal is subordinated to the achievement of the former: more formally, ECB preferences can be represented by a lexicographic utility function with price stability and economic growth being respectively its first and second argument.

Therefore, the words about real activity become relevant only when there are no inflation risks.

We estimate the following equation for the period January 1999-June 2004:

$$R_{t+m} - R_t = \alpha + \beta Index_t + \varepsilon_t \qquad (1)$$

[4] Article 105 states: "The primary objective of the ESCB shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Community with a view to contributing to the achievement of the objectives of the Community as laid down in Article 2 [i.e., sustainable economic growth]".

where $R_{t+m}$ stands for the Repo rate in force within $m$ months from today ($t$). $\alpha$ is a constant and $\varepsilon$ stands for a zero-mean noise term uncorrelated with *Index*.

We consider only the days of the ECB Governing Council meetings. Although the ECB Governing Council meets twice a month, since November 2001 the Repo rate could be changed only at its first meeting. Both to be consistent over time and to have (more or less) monthly data (and thus monthly-frequency forecasts), for the period January 1999 – October 2001 we have considered only the first meeting of every month. Moreover, overall we have 56-57 observations (cf. Table A1), since in August there is no ECB Governing Council meeting (and thus no press conference). Finally, for simplicity, we have assumed that each meeting takes place every 30 days.

Note that by construction the econometrician's information set contains only one element, which is a summary of the information released in the most recent ECB President press conference.

In order to have a straightforward interpretation of our empirical results we have used Ordinary Least Squares (OLS) estimation with HAC-t statistics. Since it is not the most appropriate econometric technique, below we will explore some alternative econometric methods, such as ordered probit (in section 5) and fuzzy regression (in Appendix B).

Table 2 reports the estimations of equation (1) coefficients for $m = 1,\ldots, 6$. As ex-ante expected, $\beta$ is always positive and statistically significant. Thus, the probability of future monetary policy interventions (namely, a change in the Repo rate) is an increasing function of the absolute value of *Index*. For example, if today the ECB President says that "it is imperative to contain upward pressure to price stability", then the Repo rate on average will increase by about 50 basis points within the next three months.

$\alpha$ turns out to be always negative and sometimes significant at the 5% level: this seems to indicate that $\beta$ is downward distorted. In other words, to have an unbiased *Index*, we need to slightly scale down the degree of risk reported in Table 1, but at the same time still preserving its relative ranking. Hence, for instance, the word "appropriate" should be associated to a negative number. This can be easily rationalized by recalling the ECB objectives postulated by the Maastricht Treaty: when there are no risks to price stability, the European monetary authority should achieve sustainable economic growth, and, thus, should be inclined to an expansionary monetary policy. However, note that the distortion of $\beta$ is small. In fact, by estimating a constrained version of (1), with $\alpha = 0$, the $R^2$ drops (obviously, since now the estimation becomes a constrained minimization problem), but not substantially.

## 3. Economic and monetary variables and ECB's interest rate forecasts

Taylor (1993) showed that the U.S. Federal Reserve monetary policy at the beginning of the nineties responded to the U.S. output gap and inflation rate. Put another way, it was possible to reproduce the Fed interest rate decisions by looking at the behaviour of those economic variables.

Several papers (among others, Gerlach-Kristen (2003) and Ullrich (2003)) have recently provided evidence that the Taylor rule explains quite well also the ECB's past and current interest rate setting behaviour. Nonetheless, in its Monthly Bulletin of October 2001 (page 50), the ECB stated that "the use of any of these rules [such as Taylor's one], even if only as benchmarks, would in many circumstances be misleading and not contribute to a better understanding of monetary policy. Thus, there is no convincing alternative to explaining monetary policy decisions in a way that corresponds closely to the internal framework of analysis underlying the central bank's decision-making process". Hence, on the one hand, a simple Taylor rule approach to monetary policy would contradict what the Bank itself says. On the other hand, even if we agree with the Bank's opinion that monetary policy is too complicated to be represented by a simple formula, we are also convinced that its main features are known to its officials and do not change too much over time. Therefore, some kind of rule can be submitted to empirical analysis, since, after all, the ECB's behaviour is not random.

In order to detect the economic and monetary variables that the ECB seems to consider more relevant for its policy decisions, we examined all official documents in which the ECB explained the reasons for its various interventions.

To give a broad idea of the variables that are involved, we report in Table A2 a simple (we have just used a counting rule) list of economic and monetary indicators cited by the ECB in its Monthly Bulletin and its President monthly press conference. However, note that some variables are mentioned to emphasize that they are not important for the monetary policy decisions. For instance, in the Monthly Bulletin of December 2001 (page 5) it is stated: "When comparing current monetary developments with the reference value for the rate of growth of M3, it should be kept in mind that the reference value is a medium term concept. In particular, temporary deviations of M3 from levels in line with its long-term determinants are not unusual (…). Such temporary deviations do not necessarily have implications for future price developments".

Obviously, if the ECB is transparent, we could reproduce its interest rate setting decisions by identifying the *right* set of economic and monetary variables.

We have estimated the following regression again for the period January 1999-June 2004:

$$R_{t+m} - R_t = \alpha + \boldsymbol{X}_t\boldsymbol{\beta} + \varepsilon_t \qquad (2)$$

where $\boldsymbol{\beta}$ is a column vector of regression coefficients and $\boldsymbol{X}_t$ is the row of time t observations of the matrix whose columns correspond to either a monetary or an economic time series.

Again, as in section 2, we have used OLS estimation to simplify the interpretation of the regression results. However, in Appendix C, in order to check the robustness of our empirical conclusions, the discriminant analysis was applied as a statistical forecasting model. Moreover, to allow a direct comparison with the findings of the previous section we have considered the same monthly observations: the information set used to estimate (2) is clearly different and disjointed from the one used to estimate (1), nonetheless we have considered the availability of data at the same dates *t*s.

Note that for each variable at *t*, the analysis has considered only the values that were really available (Orphanides, 2001). In other words, we estimate real-time empirical reaction functions: we have used the (preliminary and incomplete) data that are contained in the financial market information set at *t*, rather than final and revised macroeconomic data.

It turns out that the most important variables are the following:

1. The present rate of inflation (more precisely, the Harmonized Index of Consumer Prices), $INFL_t$. Although the ECB tries to act in advance, the higher current inflation is, the more likely an increase in its official interest rate will be.
2. The current Repo rate, $Repo_t$. Monetary policy rules or reaction functions usually exhibit a very slow partial adjustment of the policy interest rate[5]. Moreover, if the official interest rate is already high (low), a further increase (decrease) is less likely.
3. The rate of growth of industrial prices (net of energy and unprocessed food prices), $INFLN_t$. Given HICP, an upward intervention is more probable if this index – a sort of measure of core inflation – is growing fast.
4. The real annual growth rate of the Euro compared with the US Dollar (measured in US$ needed to buy 1 €), $gE_t$. For instance, an appreciation of the Euro reduces the risk of inflation and thus a decrease of the ECB official interest rate is more likely. Note that since in the period 1999-2004 the difference between European and

[5] A survey of the main reasons for policy inertia or interest rate smoothing behaviour by central banks can be found in Gerlach-Kristen (2004, page 1) and Rudebusch (2002, footnote 17).

American inflation has been approximately constant, we could have used the nominal (rather than the real) appreciation / depreciation of the Euro against the US Dollar.

5. The level and annual growth of GDP and industrial production (utilized capacity), respectively $GDP_t$, $gGDP_t$, $PROD_t$, $gPROD_t$. We expect that a reduction in the ECB official interest rate is more likely when both economic growth is low and there are no upward inflation risks.
6. The "economic sentiment indicator", $SENT_t$. The reasons to include this index in our regression specifications are the same as the ones mentioned in the previous point. But the sentiment indicator has three main advantages[6]. First, its data are available before those of GDP and industrial production. Second, it seems to anticipate these real variables. And, third, it is less volatile than them.

Other variables, such as wages, oil prices and monetary aggregates, turned out to be not relevant when the variables mentioned above were already taken into account in our empirical analysis.

In order to avoid collinearity, particularly strong among the real variables, four synthetic indices for utilized capacity and economic growth were calculated. The first one, $CAP_t$, is the mean value of the (normalized) residuals of GDP, industrial production and "economic sentiment indicator" from their (Hodrick-Prescott) filtered values, and it is a sort of utilized capacity index. Since the data about GDP and industrial production are published with a lag, we have constructed another index, $CAPF_t$. In it, the missing data of $GDP_t$ and $PROD_t$ were estimated on the basis of the "economic sentiment indicator", which is published only with one-month delay. This index is more useful than an analogous one in which only the data actually available were considered. Other two indices, $gREAL_t$ and $gREALF_t$, were derived in the same manner as $CAP_t$ and $CAPF_t$, but they were based on $gGDP_t$, $gPROD_t$ and $gSENT_t$.

Table 3 reports the regression results of the following specification of (2):

$$R_{t+m} - R_t = \alpha + \beta_1(Repo_t - INFL_t) + \beta_2(INFL_t - INFLN_t) + \beta_3 CAPF_t + \beta_4 gE_t + \varepsilon_t \qquad (2')$$

The coefficients of all variables ($\beta$s) have their ex-ante expected sign. In deciding its interest rate setting decisions, the ECB takes into account the level of inflation together with its causes, and the real sector conditions. Moreover, the presence of $gE$ in the right-hand side (RHS) of (2') implies that the ECB also considers the

[6] Using EuroCOIN data (available at http://www.cepr.org/data/EuroCOIN, lastly accessed on the 31st January 2005), instead of $Sent_t$, does not affect our overall estimation results.

effects of the exchange rate channel of the monetary transmission mechanism in terms of both net external demand and import prices (cf. Ball, 1999).

$\beta_1$ is always negative and significantly different from zero: hence, the short-run real interest rate is a mean-reverting process.

*CAPF* can be interpreted as a forward-looking monthly output gap proxy, and its coefficient is significantly positive, as economic theory suggests.

Finally, note that the ECB reacts strongly to core inflation ($-\beta_2$), but less vigorously to a more general HIPC ($\beta_2 - \beta_1$).

In terms of adjusted $R^2$, the model seems to represent the ECB's interest rate setting behaviour fairly well, especially for a forecasting horizon between 3 and 5 months.

The role of forecasts on inflation and GDP is critical in estimating (2). Since ECB's own forecasts are available only twice a year (too little for our empirical purposes), we have used the Survey of Professional Forecasters (SPF) data. Nonetheless, if we include them in the RHS of (2'), their coefficient is never significantly different from zero. This can be explained by the fact that SPF data are constructed on the maintained hypothesis that the ECB will act in order to achieve its target (i.e., an inflation level somewhat below 2% in the medium term). Hence, the information that Professional Forecasters convey lose a great deal of their relevance and are often misleading.

Finally, note that we have included no lags of the regressors $\boldsymbol{X}_t$ in the specification of (2). In other words, we have implicitly assumed that a Markovian process governs the evolution of $\boldsymbol{X}_t$. It is clearly a simplification. However, the regressors' coefficients of many lags turned out to be not significantly different from zero once we include them in (2) (regression results not reported).

## 4. Euribor rates term structure

In this section we evaluate econometrically the ability of financial market interest rates to capture expectations for the future course of the ECB monetary policy over different time horizons. In particular, we first review the empirical framework underlying the derivation of the forecasting equations. And then we proceed to the estimation of the parameters of the interest rate forecasting regressions.

Most short-run interest rates are closely related to short-run expectations about future monetary policy moves: this relationship arises because financial intermediaries can potentially choose between different short-term financial strategies.

The Euribor rate is the interest rate in force in the interbank market and clearly if banks are good forecasters of the future ECB monetary policy, then the Euribor rate

should anticipate the Repo movements[7]. This hypothesis is confirmed by Figure 1, which contains the plot of the Repo rate in the sample period together with the one-month and six-month Euribor rate: they almost overlap!

Both the absence of arbitrage opportunities and the ability of borrowers to resort to different lenders imply that the financial cost $r_{t,k}$ to borrow money on the interbank market for $k$ months starting at day $t$ is equivalent to the expected cost of borrowing from the central bank again from day $t$ to day $t+k$ *months*, up to a risk premium $\gamma$ (returns in excess of the risk-free rate). Hence,

$$r_{t,t+k} = E_t\left[\prod_{j=0}^{k-1}(1+R_{t+j})-1\right]+\gamma \qquad (3)$$

where the notation is the same as before.

Equation (3) can be theoretically motivated by relying on standard asset pricing formulas, and specifically to the stochastic pricing kernel (see, for example, Campbell et al. (1997), chapter 8 and 10)[8].

In the empirical literature is often assumed that $\gamma$ is time-invariant and this assumption is also known as the expectation hypothesis. We have deferred the discussion about the implications of allowing predictable time-varying risk premia in the conclusion.

In order to derive the specification of the interest rate forecasting regression, we can rearrange (3) as:

$$\bar{R}_{t,k} = \alpha + \beta r_{t,k} + \varepsilon_t \qquad (4)$$

where $\bar{R}_{t,k}$ is defined as $\left[\prod_{j=0}^{k-1}(1+R_{t+j})-1\right]$ and $\varepsilon_t$ stands for a stochastic zero-mean forecast error, $\bar{R}_{t,k}$ - $E_t$ $[\bar{R}_{t,k}]$, which is uncorrelated with all available information at time $t$.

Obviously, under the maintained hypotheses of both no arbitrage opportunities and constant risk premia, we should find that $\beta$ equals 1 and $\alpha$ equals $-\gamma$.

[7] Note that market expectations about the ECB future monetary policy can also be proxied by the futures contract on the Euribor (Bernoth and von Hagen, 2004). Nevertheless, our main results continue to hold: in fact, Euribor rates of return on futures contracts are highly positively correlated to the underlying Euribor implicit rates of return.

[8] Note that in the ECB case $\gamma$ contains also an econometrically indistinguishable transaction cost component. Borrowing from the central bank is more costly than borrowing from the interbank market since in the first situation the loan is backed by the deposit of a security collateral whose rate of return is lower that the one granted by the market.

Phillips-Perron cointegration tests (not reported here for reasons of space, but available from the authors upon request) reject the unit root hypothesis for the first differences of Euribor interest rates, but not for their levels. Moreover, the cointegration Johansen estimations confirm that every couple of interest rates is cointegrated with a slope equal to 1. However, note that the non-stationarity of the data may disappear as more observations for the euro area become available, since interest rates are likely to be stationary in large samples.

If we estimate directly (4), then we are going to find the cointegrating vector (a long-run relationship), rather than the coefficients of the short-run interest rate forecasting regression. To avoid this econometric problem, we stochastically detrend (it is a common practice) both sides of (4):

$$\bar{R}_{t,k} - R_t = \alpha + \beta (r_{t,k} - R_t) + \varepsilon_t \qquad (5)$$

The parameters α and β have the same interpretation as before, but the $R^2$ statistic now measures the fraction of changes in the Repo rate explained by the Euribor rate curve.

If we are interested in predicting the Repo rate over some interval beginning at some point in the future, we can easily extend (5) as follows:

$$\bar{R}_{t+k,t+k+n} - R_t = \alpha + \beta (r_{t,t+k,n} - R_t) + \varepsilon_t \qquad (6)$$

where $r_{t,t+k,n}$ stands for the (implicit) Euribor rate quoted on day $t$ for an interbank loan for $n$ months starting at day $t+k$ *months*.

Again the coefficients α and β have the same interpretation as before but the $R^2$ statistic now measures the ability of the Euribor rate to forecast changes in the Repo rate from its current level to its average level over some interval in the future.

Table 4 reports our estimations of (6) for the period January 1999-June 2004 when $n = 1$ and $k = 1, \ldots, 6$. In all regressions, the Wald test of the expectation hypothesis (i.e., $\beta = 1$) is never rejected. Therefore, we decided to estimate (6) with the constraint $\beta = 1$, that is:

$$\bar{R}_{t+k,t+k+n} - r_{t,t+k,n} = \alpha + \varepsilon_t \qquad (7)$$

Note that in this formulation $-\alpha$ represents the risk premium: it is both positive (always statistically different from zero) and increasing over time.

The $R^2$ of the constrained estimation is just slightly lower than before, confirming that the above restriction is almost slack. Moreover, $R^2$ is an hump-shaped function of *k*, reaching its maximum, 0.71, at *k = 4*.

The intuition of this result is that forecasting the exact timing of European monetary policy intervention is a difficult job for the market: in fact, $R^2$ reaches its minimum level for the one-month prediction (*k = 1*) of the Repo rate. Since for our purposes (when *k* is larger than 2) a change of the Repo rate of 50 basis points (bps) all at once in one meeting is equivalent to a change of 25 bps in two consecutive meetings[9], we observe that as *k* increases, $R^2$ increases as well. However, this flexibility property of the prediction is outweighed for large forecasting horizons *(k* longer than *4*) by the higher environmental uncertainty.

Finally, note that the findings of Table 4 are broadly consistent with older studies on market predictability of ECB policy decisions, such as Perez-Quiros et al. (2002) and Ross (2002): financial markets forecast quite well future ECB monetary policy moves.

## 5. A comparison of the three alternative methods of forecasting

Our previous analysis has shown that ECB's statements on the risk to price stability, a set of economic variables that the Bank considers important for its goals, and the term structure of Euribor rates convey useful information on the future behaviour of its official interest rate.

Table 5 reports the corrected classification of the sign of the predicted interest rate changes[10] by using an ordered probit (Vanderhart, 2000) as econometric tool and three different set of regressors, respectively given by the *Index* about the ECB perceived risk to European price stability (cf. section 2), real-time economic variables (cf. section 3) and the Euribor term structure (cf. section 4). Diebold and Kilian (2001) have shown that the $R^2$ of the OLS regression provides a good measure of the forecasting ability of future interest rate changes. Note that our qualitative conclusions would not substantially change if we used the goodness of fit reported in Table 2, 3 and 4 (i.e., by using the standard Least Squares of the exact predicted Repo rate change),

[9] There are two other possible explanations for this counterintuitive phenomenon. On the one hand, our sample size is small and *k = 1* case may be due simply to a "bad" time series realization and thus it is not a systematic finding. On the other, the risk premium is more volatile for short maturities. And, in this case, market liquidity conditions become relatively more important as a determinant of the corresponding rate of return. Therefore, there is a further error component in the estimation, with the consequence of worsening the fit of the regression.

[10] The function sign ($\Delta Repo_t$) takes value 1 when $\Delta Repo_t = \{0.25,0.5\}$, 0 when $\Delta Repo_t = \{0\}$ and -1 when $\Delta Repo_t = \{-0.25,-0.5\}$.

rather than the corrected classification of the ordered probit estimation about the predicted sign of the Repo rate change.

As expected, and except in one isolated case (i.e., using *Index* as explanatory variable for the one-month forecast of the sign of the Repo change[11]), the market-based measures of future monetary policy moves, proxied by the implicit Euribor rate, represent an upper bound on the ability of statistical models to forecast future changes in the Repo rate. This finding supports the classical view that prices incorporate all available information. And as Rudebusch (1998), among others, once underlined, this is due to the flexibility of market forecasts in processing and then incorporating new information. Evans (1998) confirms this fact for the U.S. Fed fund rate. In particular, he found that although real-time Taylor rules describe quite well the Fed reaction function, their corresponding forecasts have a standard deviation that is 50 percent larger than the implied forecasts from the Fed funds futures market contracts.

Moreover, note that in no case our estimates make large forecasting errors, that is suggest future increases in the Repo rate when the actual movements were downward, or vice versa.

A second result stemming from Table 5 is that ECB words provide better and more comprehensive information than economic variables in order to predict the ECB future behavior. A natural question arises: is the semantic content of the ECB President's introductory statement to the monthly press conference a sufficient statistics to summarize all the hard information contained in the economic data?

Table 6 provides a quantitative answer by predicting the Repo change using both ECB words and economic variables as right-hand side regressors. On the one hand, the coefficient of *Index* is always positive and significantly different from zero. On the other, the coefficients of some economic variables, such as the short-run real interest rate or the core inflation, remain significant and with the right sign. Therefore, words are complementary to (rather than a substitute for) numbers. And to enhance ECB transparency both documents, i.e. press conference and Monthly Bulletin, are needed.

Third, and not surprisingly, Table 5 shows that the forecasting ability of all three set of regressors decreases more or less monotonically over time: it is more difficult to predict the Repo rate in force in six months from now rather than the Repo level that will be decided in next month's Governing Council meeting.

[11] However, note that the efficiency of market-based measures of ECB monetary policy expectations has increased over time. More specifically, by restricting the sample period to January 2002-June 2004 (regression results not reported), the Euribor rate turns out to be always the best predictor of the sign of the future changes of the Repo rate. In other words, at the beginning of the ECB's life, there were some arbitrage opportunities, which were not exploited by the market. Obviously, this last claim is true provided that the glossary of Table 1 has been constructed in real-time and not with the hindsight.

## 6. Conclusions

In this paper we show that nowadays bankers are not boring at all (cf. Lambert, 2004). In particular, ECB communications can convey useful information about the short-run dynamics of the Repo rate. In other words, this paper develops a new methodological approach to study central banks' interest rate setting behaviour by looking at the precise wording that has been used. Moreover we found that the ECB is transparent, and therefore its words are usually followed by consistent facts.

Alternatively, and more prosaically, this paper can be reinterpreted as both proposing and comparing three different methods to forecast the ECB's official interest rate. The first alternative analyses the semantic content of the ECB President's statements at the monthly press conference. With the second method we try to detect the main economic and monetary variables that drive the ECB's interest rate setting behaviour. And, finally, we look at the term structure of the Euribor rates. Note that even if we found that all these alternatives are useful in forecasting official interest rate movements, they are not equivalent, and, above all, they convey different information. Hence, the optimal forecasting strategy consists in combining all these methods (Billio et al., 2000): predictions are more reliable when they are similar.

Of course, some important issues are not considered in this paper and deserve further study.

In section 4 we have made the implicit assumption that the risk premium on Euribor contracts (proxied by -α) is constant over time. Piazzesi and Swanson (2004) show that for the period 1988-2003 (sixteen years) excess returns on U.S. federal funds futures have been time-varying and, more specifically, strongly countercyclical. Moreover, they found that excess returns could be well predicted by macroeconomic indicators. Therefore, they conclude that futures-based measures of the future path of monetary policy should be adjusted to account for these variable excess returns (see in particular Figure 6 in their paper). Is this also true for the European case? We have tentatively tried to replicate their exercise by regressing (OLS with HAC standard errors) the risk premium for various maturities (defined as $\bar{R}_{t+k,t+k+1} - r_{t,t+k,1}$ in our notation) on a constant and a vector of variables known to financial markets at time t (regression results not reported). The constant turns out to be always positive and significantly different from zero. While the regressor coefficients on employment growth and financial business cycle indicators such as corporate bond spreads were systematically insignificantly different from zero. Perhaps, either our sample (six and a half years) is too short to investigate this issue or we have not identified the right set of explanatory variables.

In order to adequately capture the effects of U.S. monetary policy on asset prices, Gurkaynak et al. (2004) found that at least two factors are required. They interpret the first one as the current federal funds target rate and the second one as the future path of policy, which is closely associated with FOMC announcements. It would be interesting to qualify their claim that words speak at least as loud as actions. Does the semantic content (that is, the strength) of the words that the central bank has used matter? And our tentative answer is an unconditional "Yes, it does": not only is important that the ECB speaks, but also what it says!

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***Table 1.*** *– Glossary of ECB's official statements and their ranking*

| ECB's main statements: the most important keywords | Degree of risk |
|---|---|
| Imperative that upward pressure to be contained – Essential short-term movements of inflation do not become protracted and translate into second round effects – [We assure that] price stability in the euro area will be maintained – [We assure that ECB will] take appropriate action if and when required – Risks [to price stability] are upward (upside) – The risks to price stability are confirmed - Vigilant (vigilance) – Alert – Assessed continuously – Close monitored. – Continuous close attention | +3 |
| Both confident and vigilant - Good however vigilant - Downward risks have receded further | +2 |
| The downside risks have disappeared – Somewhat less favourable – Upward pressure remain contained – rather balanced – Mixed signals – Uncertainty – [Price perspectives are] less satisfactory but further evidence is needed | +1 |
| Appropriate – Favourable – Compatible – Consistent – In line – Balanced – No strong pressures either upward or downward – Absence of significant pressures either upwards or downwards | 0 |
| Upward risks to price stability have diminished [even if not fully disappeared] – Improvement [in inflation risks] – Inflationary pressures have further diminished (or: are lower) – Favourable, but there are some [downside] risks – Appropriate but remain downside risks – Balanced but monitor closely all [downside] factors | -1 |
| Consistent, but carefully monitor all [downside] risks to economic growth – Monitor carefully all [downside] factors relevant to economic growth – Downside risks are still relevant – Economic slowdown is still cause for concern – Downside risks are not vanished | -2 |
| [Strong] downside risks for economic activity – Monitor closely the downside risks to economic growth. | -3 |

NOTE: This table is borrowed from Rosa and Verga (2005).

***Table 2.*** *– Prediction of the Repo change using ECB words*

| | | Meetings of the Governing Council after: | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
| $\alpha$ free | $\alpha$ | -0.021 | -0.053 | -0.083 | -0.101 | -0.117 | -0.146 |
| | Pr($\alpha$=0) | 0.156 | 0.042 | 0.036 | 0.058 | 0.128 | 0.143 |
| | $\beta$ | 0.072 | 0.112 | 0.156 | 0.199 | 0.231 | 0.256 |
| | Pr($\beta$=0) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $R^2$ | 0.434 | 0.474 | 0.570 | 0.605 | 0.524 | 0.477 |
| | Adj. $R^2$ | 0.424 | 0.465 | 0.561 | 0.598 | 0.515 | 0.467 |
| $\alpha$ =0 con-straint | $\beta$ | 0.070 | 0.109 | 0.151 | 0.192 | 0.223 | 0.246 |
| | Pr($\beta$=0) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $R^2$ =Adj.$R^2$ | 0.421 | 0.436 | 0.512 | 0.550 | 0.477 | 0.424 |
| Observations | | 56 | 56 | 56 | 57 | 57 | 56 |

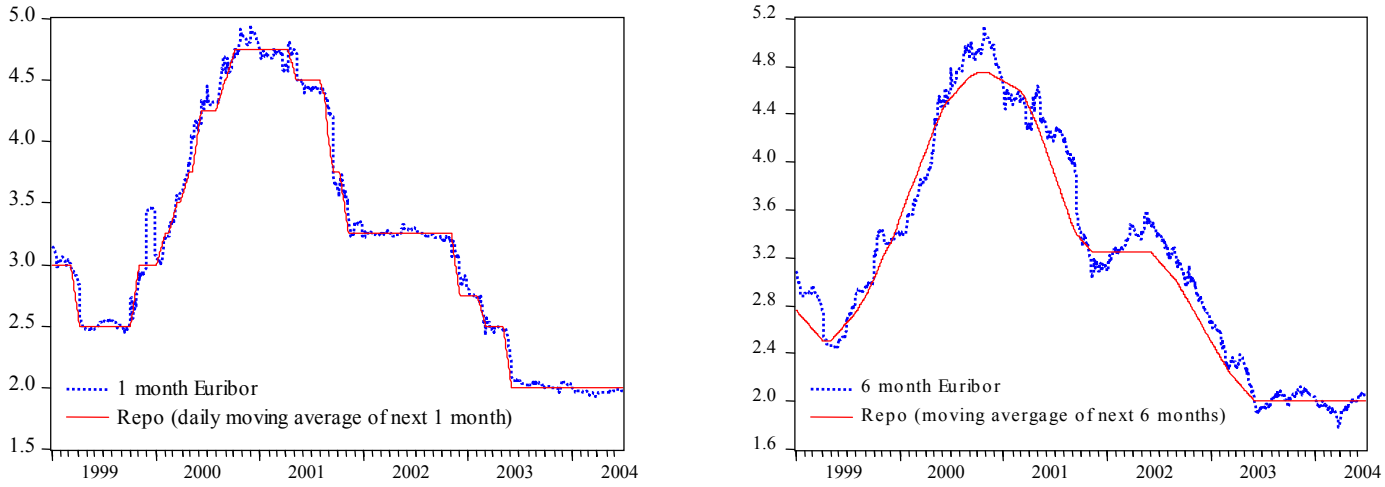
NOTE: Monthly observations on days of ECB Governing Council meetings, January 1999 – June 2004. The econometric method is Ordinary Least Squares with HAC-t statistics (Heteroskedasticity - Consistent standard errors). The independent variable is the mean of Risk ( (min+max) / 2 reported in Table A1).

***Table 3.*** *– Prediction of the Repo change using real-time economic variables*

| | Meetings of the Governing Council after: | | | | | |
|---|---|---|---|---|---|---|
| | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
| *Constant* | 0.276<br>(0.004) | 0.413<br>(0.001) | 0.577<br>(0.000) | 0.773<br>(0.001) | 1.074<br>(0.002) | 1.222<br>(0.006) |
| *Repo-INFL* | -0.143<br>(0.001) | -0.233<br>(0.000) | -0.319<br>(0.000) | -0.388<br>(0.000) | -0.514<br>(0.000) | -0.607<br>(0.000) |
| *INFL-INFLN* | -0.099<br>(0.038) | -0.150<br>(0.010) | -0.228<br>(0.010) | -0.336<br>(0.014) | -0.475<br>(0.022) | -0.515<br>(0.036) |
| *CAPF* | 0.118<br>(0.002) | 0.203<br>(0.003) | 0.308<br>(0.007) | 0.364<br>(0.009) | 0.409<br>(0.015) | 0.366<br>(0.040) |
| *gE* | -0.007<br>(0.000) | -0.010<br>(0.008) | -0.013<br>(0.020) | -0.017<br>(0.011) | -0.025<br>(0.004) | -0.033<br>(0.003) |
| $R^2$ | 0.324 | 0.372 | 0.465 | 0.439 | 0.450 | 0.418 |
| Adj. $R^2$ | 0.271 | 0.323 | 0.423 | 0.395 | 0.407 | 0.372 |
| Observations | 56 | 56 | 56 | 57 | 57 | 56 |

NOTE: Monthly observations on days of ECB Governing Council meetings, January 1999 – June 2004. The econometric method is Ordinary Least Squares with HAC-t statistics (Heteroskedasticity - Consistent standard errors). p-value in brackets.

***Figure 1.*** *- Repo and Euribor rates*




NOTE: The sample is January 1999-June 2004, daily data. In order to have a sensibile plot, the median value of the risk premium together with the implicit cost of borrowing from the central bank , defined as $\overline{R}_{t+k,t+k+1} - r_{t,t+k,1}$ with $k = 0$ and $5$ (the notation is the same as before), is subtracted from the Euribor implict rate.

***Table 4.*** *– Prediction of the Repo change using the Euribor rate*

| | | Meetings of the Governing Council after: | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
| β free | α | -0.124 | -0.188 | -0.229 | -0.266 | -0.307 | -0.383 |
| | Pr(α=0) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | β | 0.823 | 0.934 | 0.963 | 1.079 | 1.111 | 1.135 |
| | Pr(β=0) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $R^2$ | 0.458 | 0.517 | 0.639 | 0.714 | 0.662 | 0.603 |
| | Adj. $R^2$ | 0.448 | 0.508 | 0.632 | 0.708 | 0.655 | 0.598 |
| Wald test (β=1) F statistics | | 0.237 | 0.634 | 0.793 | 0.526 | 0.494 | 0.523 |
| β = 1 con-straint | α | -0.148 | -0.199 | -0.236 | -0.251 | -0.283 | -0.349 |
| | Pr(α=0) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | $R^2$=Adj.$R^2$ | 0.437 | 0.514 | 0.638 | 0.710 | 0.655 | 0.595 |
| Observations | | 56 | 56 | 56 | 57 | 57 | 56 |

NOTE: Monthly observations on days of ECB Governing Council meetings, January 1999 – June 2004. The econometric method is Ordinary Least Squares with HAC-t statistics (Heteroskedasticity - Consistent standard errors).

***Table 5***. *– Corrected classification in %*

| | Meetings of the Governing Council after: | | | | | |
|---|---|---|---|---|---|---|
| | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
| Index | 87.5 | 75 | 69.6 | 71.9 | 66.7 | 67.8 |
| Economic variables | 80.3 | 64.3 | 69.6 | 68.4 | 66.7 | 66.1 |
| Euribor rate | 85.7 | 82.1 | 82.1 | 87.7 | 71.9 | 71.4 |
| Observations | 56 | 56 | 56 | 57 | 57 | 56 |

NOTE: Monthly observations on days of ECB Governing Council meetings, January 1999 – June 2004. The dependent variable is the sign of the change in the Repo rate. The econometric method is ML – Ordered Probit (Quadratic hill climbing).

***Table 6.*** *– Prediction of the Repo change using both ECB words and real-time economic variables*

| | Meetings of the Governing Council after: | | | | | |
|---|---|---|---|---|---|---|
| | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
| *Constant* | 0.103<br>(0.154) | 0.172<br>(0.064) | 0.257<br>(0.079) | 0.281<br>(0.116) | 0.517<br>(0.031) | 0.539<br>(0.067) |
| *Repo-INFL* | -0.071<br>(0.032) | -0.131<br>(0.003) | -0.182<br>(0.014) | -0.184<br>(0.036) | -0.283<br>(0.015) | -0.327<br>(0.010) |
| *INFL-INFLN* | -0.038<br>(0.282) | -0.068<br>(0.138) | -0.119<br>(0.085) | -0.164<br>(0.042) | -0.281<br>(0.021) | -0.276<br>(0.073) |
| *CAPF* | -0.014<br>(0.727) | 0.009<br>(0.856) | 0.053<br>(0.507) | -0.009<br>(0.919) | -0.013<br>(0.900) | -0.142<br>(0.261) |
| *gE* | -0.002<br>(0.241) | -0.003<br>(0.298) | -0.004<br>(0.444) | -0.003<br>(0.630) | -0.009<br>(0.357) | -0.014<br>(0.218) |
| *Index* | 0.081<br>(0.000) | 0.122<br>(0.000) | 0.159<br>(0.000) | 0.229<br>(0.000) | 0.260<br>(0.000) | 0.314<br>(0.000) |
| $R^2$ | 0.516 | 0.565 | 0.663 | 0.711 | 0.672 | 0.659 |
| Adj. $R^2$ | 0.468 | 0.522 | 0.630 | 0.682 | 0.640 | 0.625 |
| Observations | 56 | 56 | 56 | 57 | 57 | 56 |

NOTE: Monthly observations on days of ECB Governing Council meetings, January 1999 – June 2004. The econometric method is Ordinary Least Squares with HAC-t statistics (Heteroskedasticity - Consistent standard errors). p-value in brackets.

# Appendix A – Data

For details on Euribor, see http://www.euribor.org/html/content/euribor_tech.html.

Daily data on Euribor interest rates ($r_{t,k,n}$ for $k = 1, \ldots, 6$) are downloadable from the Treasury Management database website, http://www.tmpages.com/tmp55.htm, and, in particular, on the page of "EurIBOR: Comprehensive history from National Bank of Belgium and TMP: EONIA and EurIBOR (all terms)". Note that Euribor interest rates with maturity of two months or more are referred to the day after the ECB Governing Council meeting

Data on $REPO_t$, $INFL_t$, $INFLN_t$, $gE_t$, $PROD_t$, $GDP_t$, $gPROD_t$, $gGDP_t$, *Unemployment* can be found in the "Euro area statistics" section of the Monthly Bulletin available at http://www.ecb.int/pub/mb/html/index.en.html

$gE_t$ can be downloaded from the ECB website http://www.ecb.int/stats/exchange/eurofxref/html/index.en.html

$CAP_t$, $CAPF_t$, $gREAL_t$, $gREALF_t$ are derived from our computation on ECB data.

$E_t[gGDP_{t+1\text{year}}]$, $E_t[gGDP_{t+2years}]$, $E_t[INFL_{t+1year}]$, $E_t[INFL_{t+2years}]$ are obtained from the Survey of Professional Forecasters, downloadable from http://www.ecb.int/stats/spf/spf.html#hist

Remember that in order to estimate the ECB empirical reaction function at time t, we have used the (preliminary and incomplete) data that are contained in the financial market information set at t, rather than final and revised macroeconomic data.

$SENT_t$ and its associated $gSENT_t$ can be downloaded at http://europa.eu.int/comm/economy_finance/indicators/business_consumer_surveys/bcsseries_en.htm. For more information about this index, see http://europa.eu.int/comm/economy_finance/indicators/business_consumer_surveys/userguide_en.pdf.

*MSCI Index – Euro Credit Corporate Spread* is our proxy for the corporate bond spread used in section 6.

All websites were last accessed on January 31st 2005.

The data set is available from the authors upon request.

***Table A1***. *– ECB President announcements about future monetary policy moves*

| Date | Risk | min | max |
|---|---|---|---|
| | | | |
| 07/01/1999 | 0 | 0 | 0 |
| 04/02/1999 | -1 | -2 | -1 |
| 04/03/1999 | -2 | -3 | -2 |
| 08/04/1999 | -1 | -1 | -1 |
| 06/05/1999 | 0 | 0 | 0 |
| 02/06/1999 | 0 | 0 | 0 |
| NA | | | |
| NA | | | |
| 09/09/1999 | 2 | 2 | 3 |
| 07/10/1999 | 3 | 3 | 3 |
| 04/11/1999 | 2 | 2 | 2 |
| 02/12/1999 | 2 | 2 | 2 |
| | | | |
| 05/01/2000 | 2 | 2 | 2 |
| 03/02/2000 | ? | ? | ? |
| 02/03/2000 | 3 | 3 | 3 |
| 13/04/2000 | 3 | 3 | 3 |
| 11/05/2000 | 3 | 3 | 3 |
| 08/06/2000 | 2 | 2 | 3 |
| 06/07/2000 | 3 | 3 | 3 |
| NA | | | |
| 14/09/2000 | 3 | 3 | 3 |
| 05/10/2000 | 2 | 2 | 2 |
| 02/11/2000 | 2 | 2 | 3 |
| 14/12/2000 | 3 | 3 | 3 |
| | | | |
| NA | | | |
| 01/02/2001 | 1 | 1 | 2 |
| 01/03/2001 | 1 | 1 | 1 |
| 11/04/2001 | -1 | -1 | 0 |
| 10/05/2001 | -1 | -1 | -1 |
| 07/06/2001 | -1 | -1 | -1 |
| 05/07/2001 | -1 | -1 | -1 |
| NA | | | |
| 30/08/2001 | -1 | -2 | -1 |
| 11/10/2001 | -2 | -2 | -2 |
| 08/11/2001 | -1 | -1 | -1 |
| 06/12/2001 | 0 | 0 | 0 |

| Date | Risk | min | max |
|---|---|---|---|
| | | | |
| 03/01/2002 | 0 | 0 | 0 |
| 07/02/2002 | 0 | 0 | 0 |
| 07/03/2002 | 0 | 0 | 0 |
| 04/04/2002 | 0 | 0 | 0 |
| 02/05/2002 | 1 | 1 | 1 |
| 06/06/2002 | 1 | 1 | 1 |
| 04/07/2002 | 1 | 1 | 1 |
| NA | | | |
| 12/09/2002 | -3 | -3 | -2 |
| 10/10/2002 | 0 | -1 | 0 |
| 07/11/2002 | -3 | -3 | -3 |
| 05/12/2002 | -2 | -2 | -1 |
| | | | |
| 09/01/2003 | -3 | -3 | -2 |
| 06/02/2003 | -3 | -3 | -2 |
| 06/03/2003 | -1 | -2 | -1 |
| 03/04/2003 | 0 | -1 | 0 |
| 08/05/2003 | -3 | -3 | -2 |
| 05/06/2003 | -1 | -2 | -1 |
| 10/07/2003 | 0 | -2 | 0 |
| NA | | | |
| 04/09/2003 | 0 | -2 | 0 |
| 02/10/2003 | 0 | 0 | 0 |
| 06/11/2003 | 0 | 0 | 0 |
| 04/12/2003 | 0 | 0 | 0 |
| | | | |
| 08/01/2004 | 0 | 0 | 0 |
| 05/02/2004 | 0 | 0 | 0 |
| 04/03/2004 | 0 | 0 | 0 |
| 01/04/2004 | 0 | 0 | 0 |
| 06/05/2004 | 0 | 0 | 0 |
| 03/06/2004 | 1 | 1 | 1 |

NOTE: January 1999 - June 2004. We report the degree of risk to price stability of each ECB President press conference: its construction is based on Table 1. Min-Max stands for a sort of confidence interval. Note that we have considered only the first press conference of each month.
We have highlighted in grey all the observations we have not used in the forecasting regressions. In particular:
- we were not able to codify the press conference of 03/02/2000 because the wording of the ECB President referred to the past and thus was not forward-looking.
- NA when the press conference did not take place.
- we consider both December 1999 (Millennium effect) and September 11$^{th}$ 2001 (terrorist attack) exceptional events.

***Table A2**. – Economic and monetary variables featuring in the ECB official documents*

| | Monthly Bulletin | | | | | Press Conference | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1999** | **2000** | **2001** | **2002** | **Total** | **1999** | **2000** | **2001** | **2002** | **Total** |
| **Economic Variables** | | | | | | | | | | |
| Growth of euro area real GDP | 12 | 12 | 12 | 12 | 48 | 2 | 9 | 7 | 9 | 27 |
| Expected real GDP growth | | | | | NA | 3 | 7 | 5 | 2 | 17 |
| Economic activity in the Euro area | | | | | NA | 0 | 6 | 5 | 3 | 14 |
| HICP | 12 | 12 | 12 | 12 | 48 | | | | | NA |
| Expected consumer price inflation | | | | | NA | 2 | 2 | 3 | 2 | 9 |
| Capacity utilisation | 2 | 4 | 2 | 0 | 8 | 0 | 3 | 2 | 0 | 5 |
| Investment / Consumption decision in the Euro area | | | | | NA | 1 | 3 | 6 | 4 | 14 |
| Industrial / Consumer confidence | 9 | 9 | 10 | 7 | 35 | 3 | 9 | 3 | 6 | 21 |
| Industrial production | 5 | 4 | 1 | 0 | 10 | | | | | NA |
| Fiscal policy | 5 | 9 | 11 | 7 | 32 | 5 | 6 | 2 | 3 | 16 |
| Employment | 9 | 12 | 10 | 9 | 40 | 1 | 7 | 3 | 7 | 18 |
| Wages | 8 | 12 | 12 | 12 | 44 | 1 | 6 | 9 | 7 | 23 |
| Energy prices | 11 | 9 | 10 | 9 | 39 | 5 | 5 | 5 | 4 | 19 |
| Oil price | 9 | 12 | 9 | 7 | 37 | 4 | 8 | 7 | 9 | 28 |
| Raw material prices | 3 | 0 | 0 | 0 | 3 | | | | | NA |
| Services prices | 6 | 1 | 3 | 4 | 14 | 4 | 1 | 0 | 4 | 9 |
| Consumer prices | 4 | 6 | 1 | 0 | 11 | 0 | 5 | 7 | 7 | 19 |
| Producer prices | 2 | 6 | 3 | 2 | 13 | 0 | 1 | 2 | 1 | 4 |
| Food prices | 8 | 3 | 9 | 10 | 30 | 6 | 3 | 7 | 6 | 22 |
| World / USA economy | 11 | 9 | 8 | 11 | 39 | 5 | 8 | 8 | 2 | 23 |
| Forecast of world growth | | | | | NA | 5 | 7 | 0 | 0 | 12 |
| Exchange rate | 11 | 12 | 6 | 5 | 34 | 1 | 9 | 6 | 3 | 19 |
| | | | | | | | | | | |
| Government bond yields | 1 | 3 | 2 | 0 | 6 | | | | | NA |
| Bond yields | 10 | 9 | 6 | 3 | 28 | 6 | 7 | 5 | 1 | 19 |
| Yield curve | 5 | 6 | 1 | 0 | 12 | 0 | 0 | 3 | 0 | 3 |
| Nominal interest rate | 3 | 3 | 1 | 3 | 10 | | | | | NA |
| Real interest rate | 2 | 0 | 1 | 0 | 3 | | | | | NA |
| Short-term interest rate | 7 | 1 | 6 | 4 | 18 | | | | | NA |
| Long-term interest rate | 6 | 5 | 7 | 0 | 18 | | | | | NA |
| Interest rates | | | | | NA | 5 | 0 | 1 | 3 | 9 |
| Liquidity | | | | | NA | 3 | 2 | 3 | 11 | 19 |
| | | | | | | | | | | |
| **Monetary Variables** | | | | | | | | | | |
| M3 | 12 | 12 | 12 | 12 | 48 | 11 | 12 | 10 | 11 | 44 |
| M1 | 1 | 3 | 2 | 6 | 12 | | | | | NA |
| Credit growth | 5 | 4 | 2 | 0 | 11 | | | | | NA |
| c/c deposit growth | 3 | 0 | 0 | 0 | 3 | | | | | NA |
| Loans to private sector | 9 | 12 | 10 | 11 | 42 | 11 | 12 | 10 | 10 | 43 |
| Deposit with agreed maturity < 2 years | 3 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 1 |
| Credit to general government | 2 | 1 | 1 | 0 | 4 | 1 | 0 | 0 | 0 | 1 |
| Uncertainty in stock market | 0 | 0 | 4 | 7 | 11 | 0 | 0 | 2 | 4 | 6 |
| Financial conditions / developments | | | | | NA | 1 | 3 | 5 | 10 | 19 |

NOTE: January 1999 – December 2002. The table reports economic and monetary variables cited at least once in a given issue of the ECB President introductory statement to the monthly press conference and in the ECB Monthly Bulletin (Editorial section). From January 1999 to December 2002 there have been 48 issues of the Monthly Bulletin and 44 press conferences held by the ECB President took place (either at the beginning or at the middle of the month). Exceptional (one-time) events (such as the 11$^{th}$ September 2001 terrorist attack, Kosovo conflict, UMTS auction, etc.) have not been reported. NA stands for not applicable.

## Appendix B – Fuzzy regression

In this Appendix we use non-linear fuzzy logic (Zadeh, 1965) to empirically investigate the relationship between the independent variable *Index* introduced in section 2 and the future changes of the Repo rate.

Fuzzy logic is a generalization of conventional (Boolean) logic: it allows the elements of a fuzzy set to have different grades of membership in [0,1], rather than in {0,1}.

Given the approximate (fuzzy) mode of reasoning, the theory of fuzzy logic is well suited to model human decision-making, and in particular lexical uncertainty (i.e., linguistic imprecision).

On the one hand, the ranking of Table 1 is strongly affected by Rosa and Verga's personal judgment. For example, another researcher could have interpreted the string "upward pressure remain contained" as +2 or 0 and not necessarily as +1. On the other, its scale is ordinal: the only meaningful information conveyed by it consists of the relative order among different words, and not by their distance.

Given the nature of the problem, does the fuzzy regression procedure improve the model's fit with respect to OLS estimations? Moreover, could we get some additional information about the underlying relationship between *Index* and future Repo changes?

Before answering these questions, we briefly review the fuzzy estimation technique.

First, we generated the membership values $u_{it}$ for each $Index_t$ with respect to cluster $i$ by using the Fuzzy C-Means (FCM) Clustering algorithm (cf. Giles et al., 2000, page 8 and 9). In particular, in our case, since the sample size is small, we imposed three partitions: upward risk (U), no risk (N) and downward risk (D) to price stability, initially centred at 1.5, 0, and –1.5 respectively. Then we applied the FCM algorithm[12]:

a) We generated a new partition of the data by assigning its observation to its closest cluster centre.
b) We calculated new cluster centres as the centroids of the clusters.
c) We iterated a) and b) until the cluster partitions got stable.

Our resulting $u_{it}$ have been reported in Table B1. Of course, when $Index_t$ is equal to $Index_{t+s}$, then $u_{it} = u_{it+s}$. It is interesting to see that when $Index_t < -1.5$ or $Index_t > 1.5$,

[12] The program written by the authors is available upon request.

the corresponding $u_{it}$ is different from the canonical basis of $\Re^3$ (respectively given by (1,0,0) or (0,0,1))

Second, we constructed three different sets by looking at the highest membership degree of each $Index_t$. Then, we estimated by OLS the following equation:

$$R_{t+m} - R_t = \alpha_i + \beta_i Index_{it} + \varepsilon_{it} \qquad for\ i \in \{U,N,D\} \text{ and } m = 1, \ldots, 6 \qquad \text{(B1)}$$

Finally, by combining the first two steps, we have:

$$E_t[R_{t+m}] - R_t = \sum_{i \in \{U,N,D\}} u_{it}\left(\alpha_i + \beta_i Index_{it}\right) \qquad for\ m = 1, \ldots, 6 \qquad \text{(B2)}$$

Table B2 reports the fuzzy estimation coefficients. Since by construction the shape of the relationship is allowed to change from set to set, overall the estimation becomes non-linear. And, therefore (obviously), the $R^2$ reported in Table B2 is always higher than the corresponding $R^2$ computed by using standard OLS estimation (cf. Table 2).

Figure B1 plots the expected future Repo changes implied by (either unconstrained or constrained) OLS and fuzzy regression.

When *m* is greater than *1*, the shape of the fuzzy relationship between Index and expected Repo changes is quite similar. Nevertheless, note that the magnitude of the expected reaction of future Repos to a given ECB word is increasing in *m*, especially when the absolute value of *Index* is large. Thus, it seems that the ECB follows the Brainard's (1967) principle: because of uncertainty, it prefers to make small and gradual policy changes rather than a single large one.

Therefore, on the one hand, when the absolute value of *Index* is large, the use of fuzzy regression methods (with respect to plain OLS) produces clearer results, by emphasizing the persistency of the ECB's monetary policy. However, on the other hand, when the absolute value of *Index* is small, the fuzzy estimation results are more ambiguous to interpret that the corresponding OLS estimates. Perhaps, the fuzzy regression results do not fully capture that when the value of *Index* is near zero, the expected future ECB policy moves are flat, but with a lot of variance.

***Table B1.*** *– Degree of membership* $u_{it}$

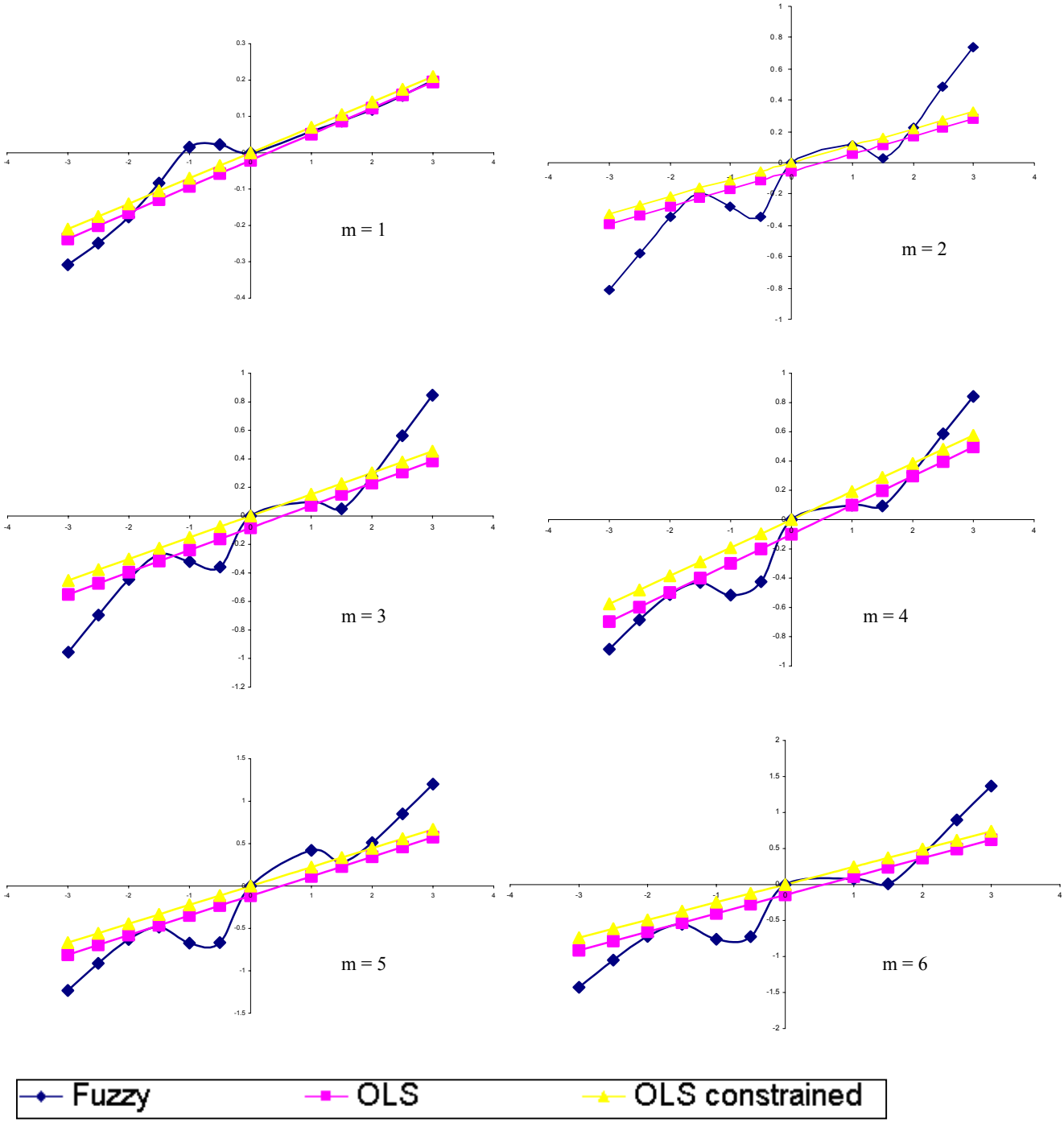
| | Downward | No Risk | Upward |
|---|---|---|---|
| 3 | 0.082 | 0.184 | 0.735 |
| 2.5 | 0.051 | 0.131 | 0.818 |
| 2 | 0.019 | 0.058 | 0.923 |
| 1.5 | 0 | 0 | 1 |
| 1 | 0.031 | 0.194 | 0.775 |
| 0 | 0 | 1 | 0 |
| -0.5 | 0.19 | 0.762 | 0.048 |
| -1 | 0.775 | 0.194 | 0.031 |
| -1.5 | 1 | 0 | 0 |
| -2 | 0.923 | 0.058 | 0.019 |
| -2.5 | 0.818 | 0.131 | 0.051 |
| -3 | 0.735 | 0.184 | 0.082 |

***Table B2.*** *– Fuzzy estimation using ECB words*

| | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
|---|---|---|---|---|---|---|
| $\alpha_D$ | 0.233 | - | - | - | - | -0.555 |
| | (0.000) | - | - | - | - | (0.000) |
| $\beta_D$ | 0.211 | 0.129 | 0.180 | -0.234 | 0.263 | - |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | - |
| $\alpha_N$ | - | - | - | - | - | - |
| | | - | - | - | - | - |
| $\beta_N$ | - | 0.833 | 0.833 | 0.833 | 1.500 | 1.500 |
| | | (0.000) | (0.000) | (0.009) | (0.000) | (0.000) |
| $\alpha_U$ | -0.142 | -0.280 | -0.367 | -0.381 | -0.455 | -0.776 |
| | (0.005) | (0.019) | (0.006) | (0.004) | (0.018) | (0.014) |
| $\beta_U$ | 0.114 | 0.215 | 0.277 | 0.317 | 0.375 | 0.524 |
| | (0.001) | (0.000) | (0.001) | (0.000) | (0.001) | (0.001) |
| Fuzzy OLS $R^2$ | 0.553 | 0.566 | 0.613 | 0.613 | 0.572 | 0.545 |
| Observations | 56 | 56 | 56 | 57 | 57 | 56 |

NOTE: January 1999 – June 2004, monthly observations. p-value in brackets. – stands for a regression coefficient constrained to be zero, since in the unconstrained estimation turned out to be not statistically significant. The estimator is OLS with HAC-t statistics. The independent variable is the mean of Risk ( (min+max) / 2 reported in Table A1).

***Figure B1.*** *– Estimation of expected future Repo changes using Index (Fuzzy Vs OLS)*




NOTE: The sample is January 1999-June 2004, monthly data. The lines represent expected future Repo changes, $E_t[R_{t+m}] - R_t$, using *Index* as independent variable.

# Appendix C – Discriminant analysis

This Appendix[13] first reviews the methodology of the discriminant analysis (cf., for example, Klecka, 1980) and then applies it to forecast the sign of the future Repo changes using the same economic variables identified in section 3.

Let $\mathbf{X}$ denote the $n \times k$ matrix of $n$ observations and $k$ regressors. Each observation can be classified into P groups: in our analysis, there are three groups, which correspond to the sign of the Repo change. Note that the partition of the groups is given and does not depend on the subjectivity of the researcher.

The main goal consists in discriminating a new observation into one of the P groups, given the value taken by its $k$ regressors. More precisely, the discriminant analysis classifies the new observation $\mathbf{x}^*$ ($k \times 1$ vector) into the group that minimizes the following criterion function:

$$p \in \text{argmin}_h \, (\mathbf{x}^* - \mathbf{m_h})'\mathbf{V}^{-1}(\mathbf{x}^* - \mathbf{m_h}) \quad \text{for } h = 1, \ldots, P \qquad \text{(C1)}$$

where $\mathbf{m_h}$ ($k \times 1$ vector) stands for the vector of means of all regressors in each group, and $\mathbf{V}^{-1}$ is the inverse of the variance-covariance matrix of $\mathbf{X}$.[14] As standard in multivariate statistics, it is sometimes recommended to use the standardized matrix $\mathbf{Z}$ rather than directly $\mathbf{X}$, and in this case $\mathbf{V}$ stands for the correlation (variance-covariance) matrix associated to $\mathbf{X}$ ($\mathbf{Z}$).

Since it is difficult to ascertain whether a case is clearly a member of its correct group, in our analysis we have used a stochastic version of (C1). In this case, the output is a conditional (on the regressors realization) probability that indicates how likely each case is of being a member of a given group. Note that to compute these posterior probabilities, prior probabilities need to be assumed.

When the number of regressors is large relative to the number of observations (not true in our analysis), then it is useful to extract some latent factors in order to identify what mostly distinguishes one group from the other. In particular, the matrix $\mathbf{V}$ can be decomposed in the sum of $\mathbf{V_W}$ (variance-covariance matrix within the groups) and $\mathbf{V_B}$ (variance-covariance matrix between the groups). And our goal is to find the Fischer discriminant function $\mathbf{y} = \mathbf{Xa}$, where $\mathbf{a}$ ($k \times 1$ vector) is such that:

[13] This Appendix was written by Giulio Campanini, a member of the Department of Economics at the University of Parma.

[14] Note that when $\mathbf{V}=\mathbf{I_k}$ (i.e., the regressors are uncorrelated), the criterion function collapses to the Euclidean distance.

$$\mathbf{a} \in \text{argmax}_{\mathbf{a}} \, (\mathbf{a'V_B a})/(\mathbf{a'V_W a}) \quad \text{s. to} \quad \mathbf{a'a} = 1 \qquad \text{(C2)}$$

More generally, we want to find the eigenvectors (canonical variables) of the matrix $(\mathbf{V_W})^{-1}\mathbf{V_B}$. Note that the eigenvalues are a direct indicator of the discriminant capacity of the associated function.

Therefore, this last procedure (C2) can be interpreted as a form of principal components analysis and aims to reduce a large number of regressors to a few linear combinations of them, chosen to capture as much of the variation (and discriminant capacity) in the regressors as possible.

To avoid an overly optimistic estimate of the success of the classification, it is usually better to use a cross-validation procedure, which employs one sample to compute the classification functions and another sample (drawn from the same population) to estimate the proportion misclassified. Below we will use the leave-on-out cross-validation method, which consists of two steps. First, we delete a case (test sample) and then we compute linear classification functions on the remaining n-1 cases (training or learning sample). Second, we use these linear classification functions to classify the deleted case into one of the P groups. The procedure is repeated for the remaining n-1 cases, and the proportion of the correctly classified cases among those deleted is used to estimate the hit rate of the classification procedure.

Table C1 reports the corrected classification of the sign of the predicted interest rate changes by using the discriminant analysis as econometric tool. Before discussing the results, it is important to keep in mind that by using a different set of regressors (with respect to *Repo*, *INFL*, *INFLN*, *CAPF*, *gE*) the fit of the model could have been better. In particular, note that often a statistical model with fewer regressors (thus more parsimonious) is more useful to classify new cases than one with more variables.

Our main finding is that once we exclude the 1-month forecasting horizon the discriminant analysis slightly improves the percentage of correctly classified cases with respect to the ordinal probit regression (cf. Table 5 third row). However, the magnitude of the forecasting error sometimes turned out to be larger: in fact, in few cases, our estimates suggest future increases in the Repo rate when the actual movements were downward or vice versa.

***Table C1.*** *– Corrected classification in % using the cross-validation criterion*

| | Meetings of the Governing Council after: | | | | | |
|---|---|---|---|---|---|---|
| | 1 month | 2 months | 3 months | 4 months | 5 months | 6 months |
| Economic variables (a) | 76.8 (0) | 66.1 (0) | 73.2 (1) | 71.9 (0) | 73.7 (1) | 73.2 (5) |
| Economic variables (b) | 51.8 (0) | 67.9 (0) | 75 (1) | 75.4 (1) | 73.7 (2) | 71.4 (4) |
| Observations | 56 | 56 | 56 | 57 | 57 | 56 |

NOTE: January 1999-June 2004, monthly observations. In brackets we report the number of cases where a downward change in Repo was forecasted and turned out to be upward (or vice versa). (a) when prior probabilities are given by the realized relative frequency of cases. (b) when prior probabilities are equal. The leave-on-out cross-validation criterion has been used.

In conclusion, overall the forecasting ability of non-standard econometric techniques, such as fuzzy regression and discriminant analysis, is not much better than the one of plain OLS and ordinal regressions. Nonetheless, they sometimes provide additional and complementary information about the underlying relationship under investigation.

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