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### Financial instability and ECB monetary policy

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#### Abstract

This paper proposes an assessment of the monetary policy performed by the European Central Bank (ECB) and, more specifically this paper investigates to what extent the ECB monetary policy decisions were guided by financial instability signals. Our assessment is achieved by estimating a Taylor's rule, augmented by financial instability aggregate indicators. This estimate enables us, on the one hand, to compare the fitted model predictions against the observed interest rate and, on the other hand, to decompose the setup of the key rate based on these different determinants. Using a sample of data related to the Euro area, we show that financial and banking instability impact on the key interest rate setup. Consideration of instability indicators brings forward a clear improvement of the Taylor's rule, mainly for the second period of the sample. This is because, at the beginning of the ECB, instability counted for one third of the explanation of the interest rate rule, and over the recent period (starting with the last quarter of 2005, up to 2009), for more than 54%.

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## 1. Introduction

The recent global financial crisis has shaken the large consensus that previously prevailed around objectives, involvement in asset price volatility correction, and other facets of monetary policy. The financial stability was for a long time rather ignored and now it has become the main actor in monetary policy (De Gregorio, 2010).

Before the crisis, there has been a fierce debate on the role the asset prices had to play in the development of the monetary policy, taking into account the fact that volatility of asset prices can endanger the stability of a financial system and affect economic growth, as well as price stability. This debate has divided the financial economists in two categories. A commonly held view (the ‘Schwartz-hypothesis’) claims that, by always pursuing the goal of price stability, central banks will in fact better promote financial stability (Schwartz, 1995). The opposite view argues that the financial system is inherently fragile and that a central bank has occasionally to compromise its objective of price stability when financial stability is threatened (Kent and DeBelle, 1998). Practically, these studies gave birth to two research directions, developed by Bernanke and Gertler (2001), respectively by Cecchetti *et al.* (2002).

The first one, which became the dominant view, argues that central banks should not use the interest rate to influence asset prices (see García Herrero and del Río, 2003; Driffill *et al.*, 2006; Corbo, 2010). The second one considers that the central banks are responsible for financial stability and they should monitor asset prices, using the interest rate in preventing bubbles from emerging (Brousseau and Detken, 2001; Cecchetti *et al.*, 2002;).

At the same time, in the aftermath of the financial crisis, we have observed that a special role was assigned to monetary policy rules (Cecchetti and Li, 2008; Christiano *et al.*, 2008; Bauducco *et al.*, 2008; Sedghi-Khorasgani, 2010; Cúrdia and Woodford, 2010; Trecroci and Vassalli, 2010; Baxa *et al.*, 2011). However, only few studies like Granville and Mallick (2009), Blattner and Margaritov (2010) and Belke and Klose (2010) approached the monetary policy rules applied to the particular case of the Eurozone.

To fill in this gap, our paper investigates to what extent the ECB monetary policy decisions have been guided by financial instability signals. In contrast to the previous papers which have associated the financial instability only with the stock return volatility, credit boom or currency depreciation, we use aggregate financial stability indicators for financial markets, banking and foreign exchange constraints. Also, contrary to the recent papers on this topic which advance forward-looking models, we employ a backward-looking monetary policy rule which can be considered more realistic in the ECB case, due to the complexity and heterogeneity of the Eurozone<sup>1</sup>.

In order to achieve our goal, we use as starting point a standard Taylor’s rule (Taylor, 1993) that depicts by how much a central bank should change the short-term interest rate to deviations of inflation and output from their target or potential levels. We augment this rule by including financial, banking and external instability aggregate indicators. The estimation of this augmented interest rate rule allows, on the one hand, comparing the fitted model predictions against the observed interest rate and, on the other hand, decomposing the setup of the key rate based on these different determinants. This approach allows us to partially

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<sup>1</sup> Moreover, the forward-looking models recently encountered in the literature suffer from major drawbacks. As Blinder (1997) shows, the monetary policy is context- dependent and the central bankers refuse the idea of a dynamic programming. In the same time, the forward-looking models that assume rational expectations and optimize the behaviour are often seriously at odds with the data and can be accused of dynamic inconsistencies (see Estrella and Fuhrer, 2002). Additionally, the monetary policy rules which take into account the expectations do not present significant gains compared to the backward-looking rules (Fuhrer, 1997; Levin *et al.*, 2003). Moreover, the Lucas critique is empirically questionable and the forward-looking models seem to be less stable than the backward-looking ones (Rudebusch and Svensson, 2002; Estrella and Fuhrer, 2003; Rudebusch, 2005).

overcome the critique associated to the linear form of the Taylor's rule (see Blinder, 1997; Taylor and Davradakis, 2006; Castro, 2011).

Using a sample of data related to the Eurozone, we show that financial and banking instability have a negative influence on the determination of the key rate. The instability indicators counted for one third of the explanation of the interest rate rule since the creation of the ECB and, over the recent period, the financial markets and banking instability explain more than 54% of the changes in the key rate level.

The paper is organized as follows. Section 2 defines the different financial instability indicators considered in our analysis. Section 3 estimates the standard and augmented interest rate rules. Section 4 explores the importance of the macroeconomic variables and respectively of the instability indicators for the explanation of the interest rate rule. Section V contains a summary of the study and concludes.

## 2. Construction of financial instability indicators

Financial instability is assessed using aggregate indicators built-up according to the methodology used, in particular, by Illing and Liu (2003), Nelson and Perli (2005) or Gersl and Hermanek (2006) and, more recently, by the International Monetary Fund (IMF, 2008) and Blix Grimaldi (2010). The use of the financial instability aggregate indicators encompasses the advantage of making the evolution of the financial stress rely on several factors (Baxa *et al.*, 2011).

We can use different construction methods to arrive at the aggregate indicators, but their steps are similar: the selection of the individual stability/instability variables, the normalization of the values and the weighting of these comparable values, within an aggregate indicator. Under the first phase, the selected 19 individual indicators, widely used in literature, have been grouped into three categories: financial market, banking market and external constraints (see Table 1).

**Table 1. Financial instability indicators**

<i>Indicators</i>	<i>The a priori impact on instability</i>	<i>Database</i>
<i>f (financial markets indicator)</i>		
I <sub>1</sub> . Volatility of the stock index return	+	Yahoo finance
I <sub>2</sub> . Stock market capitalization (% GDP)	-	Eurostat
I <sub>3</sub> . Interest rate spread: Government bond and 3-month Euribor rate	+	Eurostat and ECB
<i>b (banks financial soundness indicator)</i>		
I <sub>4</sub> . Bank nonperforming loans to total loans	+	OECD and IMF
I <sub>5</sub> . Bank capital to assets ratio	-	OECD and IMF
I <sub>6</sub> . Bank regulatory capital to risk-weighted assets	-	OECD and IMF
I <sub>7</sub> . ROA	-	OECD and IMF
I <sub>8</sub> . ROE	-	OECD and IMF
I <sub>9</sub> . Liquid assets to total assets	-	OECD and IMF
I <sub>10</sub> . Regulatory Tier 1 capital to risk-weighted assets	-	OECD and IMF
<i>g (external constraints indicator)</i>		
I <sub>11</sub> . REER excessive depreciation or appreciation	+	Eurostat
I <sub>12</sub> . Current account deficit to GDP	+	OECD and Eurostat
I <sub>13</sub> . Short term interest rate volatility	+	OECD
I <sub>14</sub> . International reserves to imports ratio	-	Eurostat
I <sub>15</sub> . Economic sentiment indicator	-	European Commission
I <sub>16</sub> . General government deficit to GDP	+	Eurostat
I <sub>17</sub> . Public debt to GDP	+	Eurostat
I <sub>18</sub> . Loans (% change)	+	OECD
I <sub>19</sub> . Credits to deposits ratio	+	OECD

Their impact on financial instability is described in most of the previously cited studies, but their inclusion in one or another category is open to discussion. However, the choice of these three categories was made according to the IMF (2008). The data covering the period 1999:q1 up to 2011:q1<sup>2</sup> are quarterly data.

Financial instability can be associated either with a high value, or with a poor value of the indicators (depending upon their impact on the instability). For example, instability is characterized by a high non-performing loans ratio (NPL) and, at the same time, by a low level of the return on assets (ROA).

Under the second phase, the values of each indicator corresponding to all the Eurozone member states are normalized based on the following technique:

$$I_{ijc}^n = \frac{I_{ijc} - I_{ic}^{\min}}{I_{ic}^{\max} - I_{ic}^{\min}}$$

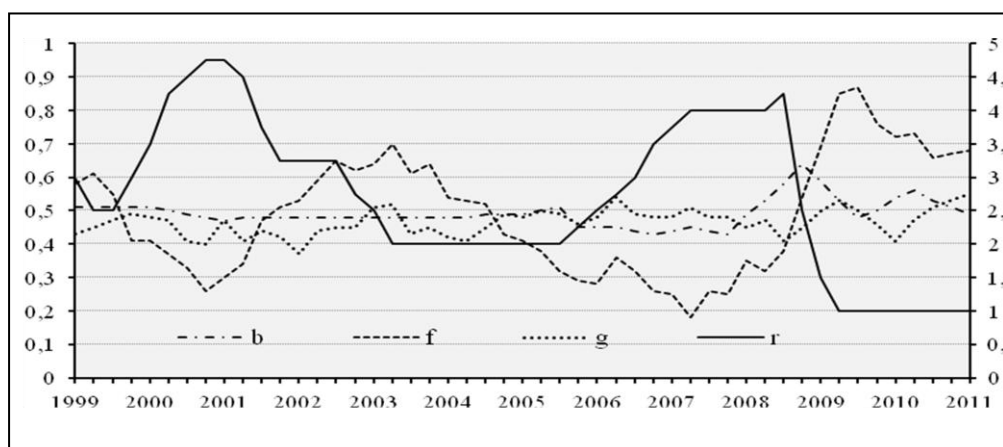
where:  $I_{ijc}$  represents the indicator  $i$  for the period  $j$  for the country  $c$ , and  $I_{ic}^{\min}$  and  $I_{ic}^{\max}$  stand for the values corresponding to the weakest, respectively to the strongest manifestation of instability,<sup>3</sup> recorded by the indicator  $i$  over the analysed period in the country  $c$ .  $I_{ijc}^n$  is the normalized value of the individual indicator. This normalization procedure allows obtaining indicators defined over the interval [0;1].

During the third phase, the normalized values  $I_{ij}^n$  of each individual instability indicator at the Eurozone level are obtained using the average of the normalized indicators' values for each country. Afterwards, the composite indicators of the financial markets, banking markets and external constraints instability (listed in Table 1) at the Eurozone level, are defined by the simple arithmetic means of the normalized values of the corresponding indicators:

$$f = \frac{\sum_{i=1}^3 I_{ij}^n}{3}; \quad b = \frac{\sum_{i=4}^{10} I_{ij}^n}{7} \quad \text{and} \quad g = \frac{\sum_{i=11}^{19} I_{ij}^n}{9}$$

Figure 1 mirrors the evolution of these indicators (f, b and g) together with the key rate ( $r$ ) trend.

**Figure 1. Instability indicators and key rate**



Note: the key rate  $r$  is measured on the left scale and the instability indicators on the right scale.

<sup>2</sup> The missing quarterly data have been computed based on a linear interpolation of the corresponding annual or bi-annual data.

<sup>3</sup> Thus, for an indicator affected by the sign '+' in Table 1,  $I_{ic}^{\min}$  corresponds to the minimum value of the indicator  $I_{ijc}$  and  $I_{ic}^{\max}$  to its maximum value. For an indicator affected by the sign '-', as for example the ROA,  $I_{ic}^{\min}$  corresponds to the maximum value of the indicator  $I_{ijc}$  and  $I_{ic}^{\max}$  to its minimum value.

We observe the existence of an opposite evolution of these instability indicators as compared to the monetary policy rate. For example, over the recent period (financial crisis of 2008), the ECB has decreased its key rate, whereas the financial and banking instability indicators experienced an ascending rise.<sup>4</sup> During the period before 2008, the banking instability indicator seems relatively stable and, consequently, it does not explain the key rate variations. Unlike this indicator, the financial market instability indicator appears to be much more volatile. Thus, financial instability decreases towards the end of the years '90 and at the beginning of the years 2000, a situation which corresponds to a period when the ECB had increased its rate. Subsequently, financial instability progressively increases up to 2004, with the ECB reducing its key rate over that period. Afterwards, financial instability experienced a decrease between 2003 and the beginning of 2008, as the ECB started to increase its key rate at the end of 2005. Financial and banking indicators therefore seem to encompass a certain explanatory power in respect to the key rate.

### 3. Assessment of the ECB's monetary policy by means of the Taylor's rule

We estimate a Taylor's rule in order to determine whether, besides the price stability objective and the activity stability objective, the ECB takes into account the financial instability when defining its monetary policy decisions. To reach our purpose, we first estimate a standard Taylor's rule, and afterwards we proceed with a rule augmented by financial instability indicators.

#### 3.1. Estimation of the standard Taylor's rule

The starting point of the empiric analysis is the standard Taylor's rule:

$$r_t = \bar{r} + \alpha\pi_t + \beta gdp_t + \varepsilon_t \quad (1)$$

where:  $\varepsilon_t$  is an error term introduced in order to take into account the variations of the interest rate  $r_t$  (key rate) which are not explained by the equation.

We have used quarterly data (end-of-quarter values) and the time framework covers the period starting with the first quarter of 1999 up to and including the first quarter of 2011, more precisely a sample made up of 49 observations. The interest rate used in the analysis is the value of the main refinancing rate observed at the end of each quarter. The term  $\pi_t$  stands for the Eurozone inflation rate considered as a deviation from the 2% target. The term  $gdp_t$  represents the Eurozone Gross Domestic Product (GDP) growth rate<sup>5</sup>, that is, the deviation from the long term growth rate.<sup>6</sup> The constant  $\bar{r}$  of Equation 1 designates the long-term interest rate value (when inflation is equal to its target, and the growth rate is equal to its average).

In addition, we should note that, by their construction, the end of period macroeconomic data are observable when the ECB has to make its interest rate decision. This means that the central banker observes the  $\pi_t$  and the  $gdp_t$  in order to determine the  $r_t$ . Thus, there is no

<sup>4</sup> It is more difficult to see on this figure the existence of a connection between the indicator  $g$  and the key rate.

<sup>5</sup> The inflation and production data are of the same type: it is about the annual growth rate, price index and GDP, computed each quarter (compared to the same period of the previous year).

<sup>6</sup> It is not about real output gap. In practice, the central banks work in real time with observable data, namely the growth rate. The output-gaps estimation is very uncertain and it is always subject to important corrections several quarters after the publication of the output gaps in real time. Besides, certain authors have rigorously highlighted the danger of using precarious macroeconomic data which can bring the monetary policy to cause the pro-cyclical effects, rather than counter-cyclical ones (Orphanides, 2003).

endogeneity problem. The key rate can affect the future values of  $\pi_t$  and  $gdp_t$  (this is the final target of the monetary policy), but not the present values which are exogenous.<sup>7</sup>

The results of the estimation performed with the Taylor's rule (equation 1) are listed in Table 2.

The  $R^2$  emphasizes the fact that only a third of the key rate variations are explained by those of the inflation rate and growth rate, revealing that other more important variables can explain the monetary policy. The Fisher's statistic is, however, high, the associated critical probability being negligible and indicating that the regression is significant at the global level. At the individual level, the estimated parameters have the expected sign and they are all significant.

### 3.2. Estimation of the augmented Taylor's rule

The growth and the inflation obviously stand for significant determinants of the interest rate rule, but the weakness of the  $R^2$  of the standard Taylor's rule suggests that other explanatory variables have to be identified. As a consequence, we have added to the model, different financial instability (financial market, banking and external constraints) indicators, noted  $f_t$ ,  $b_t$  and  $g_t$ , respectively.

These instability indicators are all clearly (negatively) correlated with the key rate ( $\rho_{rf} = -0.75$ ,  $\rho_{rb} = -0.33$ ,  $\rho_{rg} = -0.38$ ), thus implying an important explanation of the interest rate. Financial and banking indicators are mutually correlated one with the other ( $\rho_{fb} = 0.45$ ), indicating a partially common evolution, whereas the third indicator is poorly correlated with the two other indicators ( $\rho_{gf} = 0.10$ ,  $\rho_{gb} = -0.07$ ).

Nevertheless, these instability indicators may cover most of the influence of the inflation rate and of the growth rate, to the extent to which the inflation and the output are influenced by the credit conditions and by the cost of the capital. A part of the variations of the financial instability indicators only mirrors the variations of the standard macroeconomic indicators, generating a multicollinearity<sup>8</sup> situation (the six correlations of the macroeconomic variables with the instability indicators vary between -0.10 and -0.63, the financial markets instability indicator being particularly correlated with the output and the inflation).

In order to solve this problem, it is convenient to reduce the instability indicators to their 'pure' component, eliminating the correlations with the macroeconomic variables. We have thus constructed corrected indicators, noted with  $fc_t$ ,  $bc_t$  and  $gc_t$ , which measure the residual instability, that is not already contained by the macroeconomic indicators. Such indicators encompass the advantage of being in agreement with the 'judgment' variables invoked by Svensson (2003) in order to explain the gap between the real interest rate and the forecasts provided by the interest rate rule.

These orthogonalized instability indicators are obtained by means of the regression of different indicators on the macroeconomic variables  $\pi_t$  and  $gdp_t$ . The corrected indicators are, in this case, represented by the standardized errors of these regressions.<sup>9</sup> These errors are

<sup>7</sup> For information, the average value of the growth rate of the sample is 1.51 while the average value of their inflation reaches 2.02 (considering the centered inflation rate or the deviation from the 2% target brings forward no difference). The average value of the key rate is 2.71, and it varies between 1 and 4.75.

<sup>8</sup> The two most important 'condition index' reach the values 25 and respectively 49, denoting a multicollinearity level that cannot be ignored, according to Belsey *et al.* (1980).

<sup>9</sup> We have standardized the residues by splitting them with their standard deviation in order to be able to more easily compare the instability-indicators estimated coefficients.

afterwards used in the augmented Taylor's rule. We then estimate the new augmented interest rate rule:

$$r_t = \bar{r} + \alpha\pi_t + \beta gdp_t + \gamma_f fc_t + \gamma_b bc_t + \gamma_g gc_t + \varepsilon_t \quad (2)$$

The orthogonalization of the financial instability indicator entails several advantages. First, the constant term  $\bar{r}$  retrieves an interpretation in terms of long-term interest rate. In fact, in the long run, the inflation rate is equal to its target, the growth rate reaches its average value, and the orthogonalized instability indicators are equal to their average value which is null. In the long run,  $r_t = \bar{r}$ , which simplifies the interpretation of the augmented equation. Then, as these indicators are orthogonalized with respect to the macroeconomic variables, we can clearly decompose the interest rate rule into one macroeconomic component and one component related to the consideration of the financial instability. The global importance of the instability indicators can be accurately quantified at the level of the regression. The results of the equation 2 are listed in Table 2.

Once the instability indicators have been orthogonalized, the constant term, the inflation rate and the output parameters retrieve their values estimated using Equation 1, these values being positive and significant. The parameter related to the banking instability is not significant and this result cannot be put on the shoulders of a multicollinearity<sup>10</sup> problem. As the indicators are standardized, the comparison between the values of the parameters makes possible the observation that reveals the fact that the banking instability indicator has a much more feeble effect as compared to the others.

A comparison with the results of the estimation performed using the standard interest rate rule (equation 1) highlights the idea that the consideration of the instability indicators brings forward an additional explanation, which cannot be neglected, as half of the key rate variations are explained by the instability indicators (the value of  $R^2$  doubles).

However, the explanatory value (the  $R^2$ ) of the Equation 2 still remains poor, which in fact is not surprising inasmuch as the key rate shows a very powerful inertness,<sup>11</sup> as seen in Figure 1. This strong idleness of the interest rate rule has caused the specialists introduce the interest rate lag as explanatory variable.

### 3.3. Estimation of the augmented interest rate rule with partial adjustment

The  $r_t^{LT}$  is the notation for the estimated values of the long term interest rate using the standard interest rate rule.  $r_t^{LT}$  is the interest rate established by the ECB and which can be considered as non-inertial at the beginning of its existence. Based on the assumption of a partial adjustment, the interest rate effectively set by the central banker is the following:

$$\begin{cases} r_0 = r_0^{LT} + \varepsilon_0 \\ r_t = \rho r_{t-1} + (1-\rho)r_t^{LT} + \varepsilon_t \quad \forall t \geq 1 \end{cases}$$

with:  $r_t^{LT} = \bar{r} + \alpha\pi_t + \beta gdp_t + \gamma_f fc_t + \gamma_b bc_t + \gamma_g gc_t$

The partial adjustment of the interest rate rule introduces an auto-regressive term into the equation, which was missing during the first observation. In fact, the first observation of the model corresponds to the setup of the ECB, and the first interest rate,  $r_0$ , fixed under the direction of Duisenberg, was chosen with the lack of any inertness, as at that time the ECB had no history which might trigger it.

<sup>10</sup> The corrected indicators are correlated among them, but quite poorly.

<sup>11</sup> In case of half of the considered quarters, there was no change with respect to the interest rate as compared to the previous quarter.

It is possible to estimate the previous model by a procedure consisting of the maximization of the partial likelihood, which is purely the OLS estimator under the assumption of normal errors.

Actually, the equation  $r_t = \rho r_{t-1} + (1-\rho)r_t^{LT} + \varepsilon_t$ , when considered separately, defines a linear model:

$$r_t = \rho r_{t-1} + k + a\pi_t + bgdp_t + c_f fc_t + c_b bc_t + c_g gc_t + \varepsilon_t \quad \forall t \geq 1 \tag{3}$$

where:  $k = (1-\rho)\bar{r}$ ,  $a = (1-\rho)\alpha$ ,  $b = (1-\rho)\beta$ ,  $c_f = (1-\rho)\gamma_f$ ,  $c_b = (1-\rho)\gamma_b$  and  $c_g = (1-\rho)\gamma_g$

The estimators  $\hat{\rho}, \hat{k}, \hat{a}, \hat{b}, \hat{c}_f, \hat{c}_b, \hat{c}_g$  naturally lead to the following parameters of interest:

$$\hat{r} = \frac{\hat{k}}{1-\hat{\rho}}, \hat{\alpha} = \frac{\hat{a}}{1-\hat{\rho}}, \hat{\beta} = \frac{\hat{b}}{1-\hat{\rho}}, \hat{\gamma}_f = \frac{\hat{c}_f}{1-\hat{\rho}}, \hat{\gamma}_b = \frac{\hat{c}_b}{1-\hat{\rho}}, \hat{\gamma}_g = \frac{\hat{c}_g}{1-\hat{\rho}}.$$

The results of equation 3 are also listed in Table 2.

**Table 2. Results of the estimations**

	equation 1			equation 2			equation 3		
	coeff.	t-stat.	p-values	coeff.	t-stat.	p-values	coeff.	t-stat.	p-values
$r_{t-1}$							0.81	14.86	< 0.0001
c	2.70	19.74	< 0.0001	2.70	26.89	< 0.0001	0.48	3.10	0.0030
$\pi_t$	0.54	2.69	0.0099	0.54	3.66	0.0016	0.07	1.03	0.3110
gdp <sub>t</sub>	0.15	2.01	0.0505	0.15	2.74	0.0156	0.13	5.72	< 0.0001
fc <sub>t</sub>				-0.56	-5.28	< 0.0001	-0.10	-1.97	0.0550
bc <sub>t</sub>				-0.07	-0.63	0.5300	-0.09	-2.16	0.0360
gc <sub>t</sub>				-0.34	-3.34	0.0017	-0.04	-0.96	0.3410
R <sup>2</sup>	0.33			0.66			0.94		
F	11.19		0.0001	16.77		< 0.0001	123		< 0.0001

The explanatory power of the model (the R<sup>2</sup>) has significantly increased as compared with that of the previous model. Taking into account the strong inertness of the key rate, it is not surprising to see the term of autocorrelation gaining so much importance in the statistic explanation of its dynamics. We can otherwise observe that all the estimated parameters present the expected sign and they are significant, except for the parameters  $\hat{b}$  (inflation effect) and  $\hat{c}_g$  (external constraints effect). Moreover, the comparison of the financial instability estimated parameters shows that the effect of financial instability is of the same importance as that of banking instability, the impact of the third parameter being two times weaker.

The model can also be used to explain the first observation. In this case we obtain:

$\hat{r}_0 = \hat{r}_0^{LT} = 2.37$ , a value that has to be compared with the initial observed value,  $r_0 = 3$ . These results are in accordance with the idea that the ECB has intentionally fixed its initial interest rate to a much higher level in order to strengthen its credibility.

#### 4. The importance of the macroeconomic variables and respectively of the instability indicators for the explanation of the interest rate rule

Acknowledging the fact that  $r_0 = r_0^{LT} + \varepsilon_0$ , the model  $r_t = \rho r_{t-1} + (1-\rho)r_t^{LT} + \varepsilon_t$  can be rewritten as:

$$r_t = \rho^t r_0^{LT} + (1-\rho)[r_t^{LT} + \rho r_{t-1}^{LT} + \dots + \rho^{t-1} r_1^{LT}] + \varepsilon_t + \rho \varepsilon_{t-1} + \dots + \rho^{t-1} \varepsilon_1 + \rho^t \varepsilon_0 \quad \forall t \geq 0$$

For the entire  $z_t \in \{\alpha\pi_t, \beta gdp_t, \gamma_f fc_t, \gamma_b bc_t, \gamma_g gc_t\}$ , we can then determine the part of the interest rate explained by the trajectory of  $z_t$ , noted with  $p(z_t)$ , as being:



$$\begin{cases} p(z_0) = z_0 \\ p(z_t) = \rho^t z_0 + (1-\rho)[z_t + \rho z_{t-1} + \dots + \rho^{t-1} z_1] \end{cases} \quad \forall t \geq 1$$

Besides, as  $\bar{r} = p(\bar{r}) = \rho^t \bar{r} + (1-\rho)[\bar{r} + \rho \bar{r} + \dots + \rho^{t-1} \bar{r}]$ , we can rewrite the interest rate:

$$r_t = \bar{r} + p(\alpha\pi_t) + p(\beta gdp_t) + p(\gamma_f fc_t) + p(\gamma_b bc_t) + p(\gamma_g gc_t) + \eta_t \quad \forall t \geq 0 \quad (4)$$

where:  $\eta_t = \varepsilon_t + \rho\varepsilon_{t-1} + \dots + \rho^{t-1}\varepsilon_1 + \rho^t\varepsilon_0$

We consider the predicted interest rate value given by:

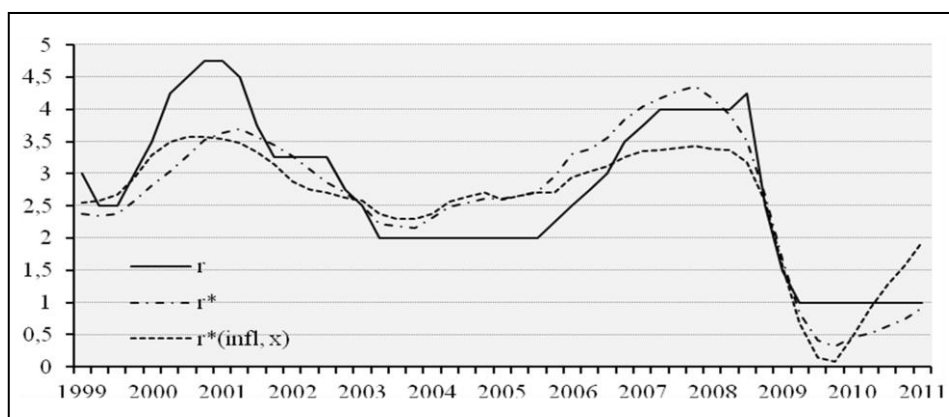
$$r_t^* = \hat{r} + p(\hat{\alpha}\pi_t) + p(\hat{\beta}gdp_t) + p(\hat{\gamma}_f fc_t) + p(\hat{\gamma}_b bc_t) + p(\hat{\gamma}_g gc_t) \quad \forall t \geq 0 \quad (5)$$

This predicted value does not require us to know the past interest rate, but instead, we need information about the whole chronicle of the components  $z_t \in \{\alpha\pi_t, \beta gdp_t, \gamma_f fc_t, \gamma_b bc_t, \gamma_g gc_t\}$ .

The importance of equation 5 resides in enabling a decomposition of the key-rate determination depending upon different interest variables. Outlining the diagrams corresponding to the different components  $p(z_t)$ , we can see the way in which different variables have impacted upon the interest rate. We have to clearly understand what these  $p(z_t)$  components point at. In fact, having in mind the inertness of the interest rate rule, the  $z_t$  variations do not trigger instantaneous repercussions on the interest rate. They become partly effective on the subsequent values of  $r_t$ . All at once, at each moment  $t$ , the rate  $r_t$  is affected not only by the present value of  $z_t$  (whose variation has partial repercussions), but also by the past values of  $z_t$  whose variations become effective little by little. The component  $p(z_t)$  gathers all these present and past effects in order to measure the part of the key rate which is determined by the trajectory of  $z_t$ . The predicted value resulting out of Equation 5 thus explains the interest rate depending on the present and past adjustments of different  $z_t$  variables.

The evolution of the fitted model, in parallel with the observed interest rate, is presented in Figure 2. As the model in equation 5 does not verify the variance analysis equation, taking into account the nature of the errors, the calculation of  $R^2$  is sensitive to the methodology. If we consider the  $R^2$  as the square of the coefficient of the correlation between  $r_t$  and  $r_t^*$ , we thus obtain  $R^2 = 0.77$ .

**Figure 2. The ‘reduced’ normative predictor  $r^*(\pi, gdp)$ , the complete normative predictor  $r_t^*$  and the observed rate  $r_t$**



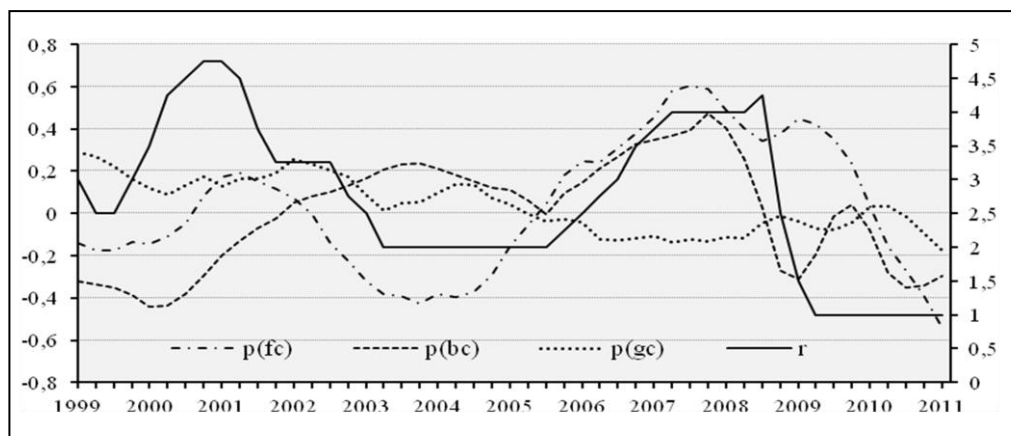
We can see in Figure 2 that, at the beginning, the interest rate set by the ECB reached a level above that recommended by the rule, as we have previously explained. The ECB subsequently raised its interest rate during the first two years after its constitution, increasing the gap with the predicted value; afterwards, the ECB decreased the rate more or less correctly over a period of about 18 months, before initiating a late increase. The ECB kept increasing its interest rate up to the third quarter of 2008, when it should have had already started its reduction. It did not decrease the rate up to the level required by the rule, lingering at a threshold of 1%, whereas the rule would have required a drop of the rate around 0.32 during the last quarter of 2009.

The importance of the instability indicators can be observed if we were to recalculate the predicted values taking into account only the output and the inflation, as presented in Fig. 2.

The influence of the instability indicators can, in particular, be felt starting with the last quarter of 2005, when the instability requires that the key rate increase more strongly and more quickly than suggested by the macroeconomic variables. We see that the macroeconomic variables do not explain, by themselves, the important increase of the interest rate which started in the last quarter of 2005, and which ended in the third quarter of 2008 (including the third quarter of 2008). In addition, we see that towards the end of the period, without considering the instability indicators, the interest rate rule would have dictated an even more significant decrease of the interest rates, actually suggesting a quasi-null rate for the last quarter of 2009, before anticipating a sharp rise of the interest rates (almost 2% for the first quarter of 2011). Therefore, the consideration of the instability indicators obviously improves the quality of the model over the second period of the sample.

Moreover, it is also interesting to decompose the effects of different instability, which are depicted in Figure 3.

**Figure 3. The key rate and the different financial instability indicators**



Note: The key rate is measured on the right axis and the instability indicators are on the left axis.

First, we see that the indicator  $gc$  has a quite reduced contribution to the key-rate evolution, which explains the fact that it is weakly significant. With respect to the two other indicators, their evolution follows rather closely that of the  $r_t$ . However, we can observe that the first period recording the increase of the interest rate (1999-2001) has preceded the period when the financial and banking instability increased. The analysis of  $r^*(\pi, gdp)$  in Figure 2, points out that the initial increase of the interest rates results from the macroeconomic conditions of the period. The instability rise subsequently contributes to pursuing and accentuating this increase. Afterwards, for the following four years, the financial instability and the banking instability evolved in the opposite sense, meaning that their effects on the monetary policy are offset. Starting with the second quarter of 2002 up to the third quarter of

2005, the average of  $p(\gamma_f fc_t) + p(\gamma_b bc_t)$  reaches -0.05, namely the fifth of the *tick* (25 bp) practiced by the central bank, thus representing a negligible quantity, a situation which indicates that the macroeconomic factors have, over the respective period, essentially explained the monetary policy (in Figure 2, the two curves  $r^*$  and  $r^*(\pi, gdp)$  are practically overlaid). Further on, it clearly seems that the central bank has begun to increase its rate starting with the moment when both financial and banking instability started to increase (beginning with the fourth quarter of 2005). Then, towards the end of the period, the drop of the banking instability ordered the reduction of the interest rate, with the ECB keeping its key rate at 1%, whereas the financial instability experienced a sharp fall off.

If we decompose the formation of the fitted model  $r_t^*$ , it turns out that the macroeconomic component  $p(\alpha\pi_t) + p(\beta gdp_t)$  explains 65% of the rate variations, while the component  $p(\gamma_f fc_t) + p(\gamma_b bc_t) + p(\gamma_g gc_t)$  explains the remaining 35%, both of which still represent a third of the interest rate rule explanation. Over the period covering the last quarter of 2005 up to the first quarter of 2009, the instability indicators explain more than 54% of the predicted value  $r_t^*$ .

## 5. Conclusions

The recent financial crisis has highlighted two important aspects. The first shows the fact that central banks decisions must be formulated based on monetary policy rules, avoiding thus being discretionary. The second refers to the importance central banks should pay to financial imbalances. As a result, the recent literature has focused on the monetary policy rules which integrated financial instability elements.

Nevertheless, the association of financial instability only with the asset price volatility, credit boom or currency depreciation is quite limited. In addition, the use of more and more complex and forward-looking models did not entail the expected quality improvements, on contrary. Moreover, the monetary policy rules augmented with instability indicators were insufficiently approached in case of the Eurozone, due to the difficulty to estimate the financial instability level and to the high degree of heterogeneity.

To overcome these limitations, this paper assesses the monetary policy implemented by the ECB since its organization and, more precisely, it analyses to what extent its monetary policy decisions were guided by financial instability signals. This assessment is performed having as starting point a standard Taylor's rule, which assigns two objectives to the monetary policy: price stability and real activity stability, which we augment by including aggregate instability indicators (financial market, banking and external constraints). This approach allows us to compare the fitted model estimations with the observed data and to see the influence of the different key rate determinants.

Using a sample of data related to the Eurozone, we show that financial and banking instability have a negative influence on the determination of the key rate. The consideration of the instability indicators clearly improves the quality of the monetary rule, in particular over the second period of the sample retained for the analysis, because the consideration of the instability counts for one third of the explanation of the interest rate rule since the creation of the ECB, and for more than 54% over the recent period (starting with the last quarter of 2005 up to 2009).

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