4. FINANCIAL STABILITY AND MONETARY POLICY: A REDUCED-FORM MODEL FOR THE EURO AREA[1]

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Abstract

This paper is related to the growing academic literature on monetary policy and financial stability. In the first part, we propose a review of the literature on the subject, describing both theoretical and empirical models. In the second part, based on Filardo's approach, we construct a reduced-form model for the Euro Area, addressing the need to include the financial stability objective into the ECB monetary policy decisions. The purpose of the paper is to see whether the ECB decisions can be improved if policymakers systematically react to financial instability signals. The novelty of the paper is the introduction of an aggregate financial instability index in the augmented Taylor's rule that is a part of the proposed model. Our results show that, since the ECB setup until nowadays, the monetary policy decisions were influenced by the financial instability level, as indicated by the optimal policy rate. However, at the beginning and at the end of the analysed interval, we observe a discrepancy between the real key rate and the proposed optimal policy rule. More precisely, for the period 1999-2001, the model shows that the optimal rate ranged bellow the key rate, fact which shows that the ECB has intentionally fixed its initial interest rate to a much higher level in order to strengthen its credibility. In the same line, in 2009 the ECB should have decreased the key rate below the level of 1% to better overcome the lack of liquidity on the market. Our results also show that, towards the end of the analysed period (2010-2011), the ECB should have considerably increased the key rate to respond to inflation threats.

Keyword: financial stability, monetary policy, ECB, reduced-form models, Taylor rule

JEL Classification: C51, E52

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I. Introduction

Studying the link between monetary policy and financial stability is a challenging subject, due to the fact that the specialists' points of view differ considerably and its complexity cannot be ignored. This work became more difficult in the case of the Euro Area, where a single monetary policy must attain different individual objectives.

In the last years, the literature focused on the role which must be played by the monetary policy in the correction of asset price volatility. Given that the interest rate is the primary tool used by central banks in achieving their goals, the policy-makers' decisions were naturally modelled by an interest rate rule of the type proposed by Taylor. A multitude of models describing optimal policy rules emerged in this area and grew more and more sophisticated, starting with the reduced form models, continuing with the general equilibrium models and arriving at the time-varying models, the newest category. Each of them presents advantages and inconveniences.

After the burst of the financial crisis, a common view in the literature was that the asset price volatility cannot be considered as an equivalent of financial instability. There are many potential sources of financial disequilibrium, including the increased volatility of real and financial assets. Moreover, the central banks must be actively involved in achieving the financial stability goal.

In this context, we propose a simple reduced-form model based on Filardo's (2000) approach, which allows us to indetify an optimal monetary policy rule for the ECB. The model is composed of three equations describing the output, the inflation and the financial instability. A Taylor rule augmented with a financial instability index is introduced into the model. The preferences of the central bank are represented in a loss function intended to reduce the variability of price level, output gap and financial instability.

The main difference of our work in respect to the above-mentioned study consists in the financial instability equation, which is constructed on the basis of an aggregate instability index and not on that of asset price volatility. The advantage of such an index resides in the fact that it represents a more complex analysis of the instability level, approached in its dynamics (Baxa *et al.*, 2011). First, it approximates the evolution of financial stress caused by different factors and, thus, it is not limited to one specific type of instability. Second, the inclusion of additional variables into the instability or stress index does not affect the evolution of the indicator. Third, the composition of the indicator allows for breaking down the reactions of the central bank with respect to different stress sub-components.

Another contribution of our paper as compared to Filardo (2000) consists in the modification of the loss function, from which we have eliminated the interest rate variability, introducing instead the financial instability index variability. Moreover, we applied the proposed method, not to the FED case, but also to the ECB case. The Euro Area case is more complex and difficult, due to the fact that we must construct an instability index for all the EMU members and a single monetary policy must react to financial instability, considering the individual financial system as a whole. Our results show that the ECB key interest rate was close to the calculated optimal policy rate, apart from the beginning and the end of the analysed time interval. These results can be associated with the need for increasing credibility immediately after the ECB setup and with a lack of strong monetary policy reaction during the crisis.

The rest of the paper presents the theoretical debates on the relation between monetary policy and financial stability (section II), the review of the theoretical and empirical models on the topic (section III), a reduced-form model for the Euro area (section IV) and the conclusions of the study (section V).

II. Monetary Policy and Financial Stability: Literature Review

Financial stability was for a long time rather ignored and now it has become the main actor in monetary policy (De Gregorio, 2010). For example, a study made by the Central Bank Governance Group shows that none of the considered central banks had a clearly articulated financial stability objective that was an explicit part of their formal monetary policy objective. However, according to the same study, a reconsideration of the mandates of central banks in the field of financial stability is necessary (BIS, 2011).

Nevertheless, the involvement of the monetary policy in financial stability was not commonly accepted by the academic community and by practitioners. Here comes to mind the old and well-known Tinbergen principle[3], which says that we must have at least as many instruments as objectives. This triggered an intense debate which lasted for almost two decades and which discussed the role that the monetary policy could play in assuring financial stability.

This debate, as Brousseau and Detken (2001) show, has divided the financial economists into two categories. A commonly held view argues that the financial system is inherently fragile and that a central bank has to compromise occasionally its objective of price stability when financial stability is threatened (Kent and Debelle, 1998). The opposite view (the “Schwartz hypothesis”) claims that, by always pursuing the goal of price stability, central banks will in fact best promote financial stability (Schwartz, 1995). Practically, these studies gave birth to two research directions, developed by Bernanke and Gertler (2001), and by Cechetti *et al*. (2002), respectively. An important number of papers have emerged afterwards continuing the same lines as these predecessors. They all analyse the connection between monetary policy and the asset prices.

These two schools of thought approach the issue of whether the central bank should try to influence or not the asset prices. The first one, which is well represented by the present and former Chairmen of the US Federal Reserve, argues that central banks should not use the interest rate to influence asset prices. Several studies supporting this position were published by García Herrero and del Río (2003) and they showed that the focus of the central bank objectives on price stability reduced the likelihood of a banking crisis. In the same line, Driffill *et al*. (2006) claim that the interest rate

[3] Tinbergen was the first winner of the Nobel Prize for economics (Schoenmaker and Wierts, 2011).

smoothing may be both unnecessary and undesirable and may lead to the indeterminacy of the economy's rational expectations equilibrium. Lately, Corbo (2010) shows that the monetary policy rate is a blunt instrument that is not well-suited to resolve distortions in the financial system.

The second school of thought takes the view that asset prices are often subject to bubbles and crashes. These can have strong pro-cyclical effects and can also affect the stability of financial markets. Since central banks are responsible for financial stability, they should monitor asset prices and try to prevent the emergence of bubbles (that invariably lead to crashes). In this view, the use of the interest rate is seen as effective in preventing bubbles from emerging. Practically, Cecchetti *et al*. (2002) have argued in favour of a more proactive response of monetary policy to asset prices. They agree with Bernanke and Gertler that the monetary authorities would have to make an assessment of the bubble component in asset prices, but take a more optimistic view of the feasibility of this task. Representative studies here are those of Brousseau and Detken (2001), which find that optimal monetary policy should explicitly react to fears of financial instability.

The entire debate focuses on the asset price volatility, which is however not equivalent to financial instability. In addition, discussions are held about the trade-off between the two objectives of the central banks – price stability and financial stability – presenting it rather as a conflict between these objectives. However, this proves not to be a conflict, but rather a change in priorities, as shown by Brousseau and Detken (2001). A trade-off between the two objectives exists when changing relative weights in the utility function will lead to an optimal policy, which eventually achieves more of one objective and less of the other, while a conflict would highlight the incompatibility between them. In other words, the present financial crisis put forward the need to give up, in the short run, one objective in favour of the other, but the direct inflation targeting strategies adopted by most of the central banks in the last period could be an impediment connected with the involvement of the monetary policy in the assurance of stability.

The contradiction between the two schools of thought emerges from the debate focused on the asset price volatility. On the one hand, the need to involve the monetary policy in the correction of financial disequilibrium is emphasized and, on the other hand, the incapacity to detect speculative bubbles and, thus, implicitly, the inefficiency of the monetary policy is invoked beside the risk to which the central bank exposes itself to and the possible failure of the price stability objective.

Indeed, one of the measures used for studying financial instability is asset price behaviour. Yet, this approach is limitative. First, the central bank has to prevent the occurrence of any type of financial crisis, not only of those generated by asset price bubbles. Second, in many economies the interest rate smoothing could be inefficient in the attempt to correct asset price imbalances. Third, the tools used for financial assets and for the real assets prices might differ. Last, but not least, the financial asset prices represent a serious problem only for the economies with an extremely developed capital market, but the identification of a general method to measure instability must not resume in all situations to asset prices.

III. Models of the Relation between Financial Stability and Monetary Policy

There is a wide variety of models describing the relation between monetary policy and asset prices[4]: in one category we can find backward and forward looking models, in another category we distinguish between regime switching and state-space models and finally, in a third category we find reduced-form models, dynamic stochastic general equilibrium models (DSGE)[5] and time varying models. An important part of the studies focus on the augmented Taylor rule in order to analyse this relation. We will further on briefly describe the reduced-form models, the DSGE models and the time-varying models. Practically, we present an evolution of the models approaching the relation between financial stability and monetary policy.

3.1. The Reduced-Form Models

In this section we briefly describe the characteristics of these models (for more details see Appendix 1).

One simple model in this category is that proposed by Filardo (2000). The model comprises three key components: 1) a system of equations describing the key aspects of the macroeconomic background[6], 2) a monetary policy interest rate equation, and 3) preferences of the central bank. The monetary rule which closes de model is an augmented Taylor rule with asset prices.

Filardo (2001) revised this model. He assessed the advantages of an asset price augmented monetary rule to see whether the central bank is capable or not to distinguish if the asset price trend is due to its fundamentals or to speculative actions. Like in 2000, the model is completely autoregressive, but in this case, the asset prices have a fundamental (F) and a speculative (B) component. The model is composed of three blocks of equations: the output and inflation block, the asset price inflation block and the monetary policy block.

Two alternative monetary policy rules are evaluated. The first alternative corresponds to a monetary authority that does not respond to asset price inflation. This rule is consistent with conventional Taylor-type rules. The second alternative corresponds to a monetary authority that responds to overall asset price inflation. The results show that the desirability of using asset price information critically depends on the monetary authority's preference for interest rate smoothing and the variability of asset prices.

The first reduced-form regime-switching model that we describe is that of Kent and Lowe (1997). The elements of the model are: an asymmetric effect of asset price

[4] *Usually, the models test the relation between monetary policy and asset prices. Only recent studies, like Baxa* et al*. (2011), take into account the nexus between monetary policy and financial stability, assessed by a financial stress index proposed by the IMF.*

[5] *DSGEs gained popularity as tools for policy discussions and analysis among academics and central banks because of their usefulness in identifying sources of economic fluctuations, and for forecasting and predicting the effects of policy interventions (Goodhart* et al*., 2009).*

[6] *The first equation describes the output gap, the second one describes the inflation and the third one the asset prices.*

increases and decreases on goods and services price inflation; a central bank with an inflation target, which cares about the variability of inflation as well as about its expected level; the probability of an asset-price bubble bursting is influenced by the level of interest rates; and an assumption that once an asset-price bubble has burst, it does not return (at least within any reasonable policy horizon). The economy runs for only three periods and they assume that a bubble emerges in the first period. Their results show that a large and rapid fall in the nominal price of these assets can have adverse effects on the financial system stability.

Bordo and Jeanne (2002) propose a similar regime-switching model, but covering two periods. As in the case of Kent and Lowe (1997), the authorities' dilemma is related to the type of monetary policy strategy. The central bank can adopt a reactive rule and, in this case, reduce the loss in t0, but it accepts the risk of a loss in t1 in case of a credit crunch. If, on the contrary, the monetary policy is preventive and the interest rate increases in t0, the central bank avoids the credit crunch, but it can thus sacrifice the inflation target and the economic growth in t0. In this case the central banks have two possibilities: to save the economy if the credit crunch appears, or to diminish the risk of a credit crunch. In the first case, it is necessary to respond to the actual or forecasted level of inflation and output gap. In the second situation, the monetary policy can influence, in a preventive way, the indebtedness capacity in t0. Comparing the encountered losses in the two cases indicates the conditions in which a central bank can adopt one of these strategies. A preventive policy must be implemented only if the level of the interest rate necessary to counterattack a credit crunch risk is not too high.

These kinds of models do not explain the circumstances which determine the central bank to switch from one regime to another. Additionally, the indicators which can provide information about a credit crunch are not specified. Furthermore, the joint increase in credit and asset price does not explain by itself the financial instability.

We can see the limits of the reduced-form models. As Trecroci and Vassalli (2010) state, this category of models does not allow for shifts and asymmetries in behavioural relationships and could produce misleading results. Consequently, the dynamic stochastic general equilibrium models represented one potentially promising way of overcoming these problems.

3.2. The DSGE Models

The dynamic stochastic general equilibrium models (DSGE) have dominated the macroeconomic literature before the crisis and they were used to describe *inter alia* the monetary policy-financial stability relationship. In this line, Gray *et al*. (2007) propose a four-modules simple monetary policy model consisting of an equation for the GDP output gap, an equation for inflation, an equation for exchange rate and real interest rates, and a Taylor rule for setting the domestic policy rate. The inclusion of financial system risk indicators and of other financial risk parameters into the simple monetary policy models is explored. The authors employ a contingent claim framework. This kind of models represents the border between reduced-form models and DSGE models.

Another study in this category is that of Ceccheti and Li (2008), which estimates a Taylor rule, augmented by a measure of banking stress. They found out that a potential conflict between monetary policy and financial supervision can be avoided if the interest rate rule takes (procyclical) capital adequacy requirements into account, in particular if the policy interest rates are lowered when financial stress is high. In a related study, Christiano *et al*. (2008) suggest augmenting the Taylor rule with an aggregate private credit and find that such a policy would raise welfare by reducing the magnitude of the output fluctuations.

Bauducco *et al*. (2008) contribute in their turn to the analysis of monetary policy confronted with financial instability. In particular, they expand the new standard Keynesian dynamic stochastic general equilibrium model with sticky prices to include a financial system. Their simulations suggest that, if financial instability affects the output and inflation with a lag and if the central bank has privileged information about credit risk, the monetary policy that responds instantly to increased credit risk can trade off more output and inflation instability today for a faster return to the trend than the policy that follows the simple Taylor rule with only the contemporaneous output gap and inflation. In the model, the central bank responds to the financial sector instability, not because the financial sector developments would have a direct place in its utility function, but simply because responding this way improves developments in future inflation and output.

More recently, Sedghi-Khorasgani (2010) has investigated the effect of financial instability on the design of monetary policy rule for a small open economy, using a DSGE model. In the same spirit, Cúrdia and Woodford (2010) show the desirability of modifying a standard Taylor rule for a central bank's interest-rate policy to incorporate either an adjustment for changes in interest-rate spreads or a response to variations in the aggregate volume of their credit. They conduct their analysis using the simple DSGE model with credit frictions. Like Teranishi (2009), they find little support for augmenting a Taylor rule by the credit volume given.

The last studies that we mention in this category are different, considering the employed methodologies. For example, Angelini *et al*. (2011) use a dynamic general equilibrium model featuring a banking sector to assess the interaction between macroprudential policy and monetary policy. They find that, in “normal” times, macroprudential policy generates only modest benefits for macroeconomic stability over a “monetary-policy-only” world. All in all, their results suggest that the benefits of macroprudential policy depend crucially on the source and magnitude of the shocks and on the degree of coordination with the monetary policy.

There are also studies in this category which are interested in the Euro Area case. For example, Casares (2007) scrutinizes the stabilizing properties of alternative monetary policy rules in the ECB case, based on a new Keynesian Euro Area model. His finding was that a simple rule that provides the reaction of the nominal interest rate to price inflation, wage inflation, and its previous observation can fairly well approximate the optimal monetary policy.

Granville and Mallick (2009) test if low and stable inflation has been associated with financial stability, characterized in terms of changes in share prices, interest rates and the nominal effective exchange rate. First, they established whether there was a direct link between inflation and asset prices, by estimating the response of the term structure of interest rates, share prices, nominal effective exchange rate, house price inflation and bank deposit–loan ratio (proxies for financial stability) to changes in the price level (proxy for monetary stability). Secondly, they investigated, using a sign-restriction based VAR approach, whether and to what extent changes in asset prices were caused by inflation shocks and – extending this analysis – policy responses through the ECB policy rate.

In their comparative study, Belke and Klose (2010) assess the differences that emerge in Taylor rule estimations for the FED and the ECB before and after the start of the subprime crisis. For this purpose, they apply an explicit estimate of the equilibrium real interest rate and of potential output in order to account for variations within these variables over time. They argue that measures of money and credit growth, interest rate spreads and asset price inflation should be added to the classical Taylor rule because these variables are proxies of a change in the equilibrium interest rate and are, thus, also likely to have played a major role in setting policy rates during the crisis. Hence, they estimate Taylor reaction functions for central banks, both separately for the period before the start of the financial turmoil and the period thereafter, in order to test whether there are significant differences in the response coefficients in both periods.

However, the DSGE approach imposes a large number of restrictions on the data. In the specific context of interest rate rules, its ability to generate qualitative and robust assessments on monetary policy conduct appears problematic. That is why a new category of studies has emerged. These studies estimate policy rules, as summarized by simple reaction functions. They employ a time-varying parameter (TVP) methodology based on the Kalman filter algorithm to estimate the instrument rules.

3.3. The Time-Varying Models

Trecroci and Vassalli (2010) estimate forward-looking monetary policy rules for five large OECD economies, allowing for time variation in the responses to macroeconomic conditions and in the variance of the policy rate. In contrast with most existing analyses, they employ a TVP methodology based on the Kalman filter algorithm to estimate the instrument rules. In practice, the policy rules' coefficients vary over time. Using this procedure, the authors obtain estimates of the state vector for each observation in the sample. These estimates can then describe the evolution of monetary policy over time. However, this study is not interested in the relation between monetary policy and financial stability, but only in the optimal monetary policy.

A recent study of Baxa *et al*. (2011) introduces the financial stress issues and presents a forward looking approach. They investigated whether and how the main central banks responded to episodes of financial stress over the last three decades. They employed the same methodology for monetary policy rules estimation, which allows for time-varying response coefficients as well as corrections for endogeneity, like in the above study, namely the state-space models. Their findings suggest that central banks often change the policy rate: mainly decreasing it to cope with high financial stress. The financial stress was proxied by means of the financial stress index provided recently by the IMF.

The state-space models have in their turn their limitations, as Baxa *et al*. (2011) underline. They are commonly estimated by means of a maximum likelihood estimator via the Kalman filter or smoother. Consequently, the results are somewhat sensitive to the initial values of the parameters, which are usually unknown, especially in the case of variables whose impact on the dependent variable is not permanent and whose size is unknown. This is also the case of the financial stress and of its effect on the interest rates. In addition, the log likelihood function is highly nonlinear and, in some cases, optimization algorithms fail to minimize the negative of the log likelihood.

IV. A Reduced-Form Model for the Euro Area

Our model is a simple model, developed on the basis of Filardo's (2000) approach (for a detailed description see Appendix 1). The model comprises, as in Filardo's case, three key components: a system of equations describing the macroeconomic key aspects, a monetary policy interest rate equation and the preferences of the central bank. The Filardo model was simulated in three steps to solve for optimal monetary policy. First, the monetary policy rule was introduced into the system of equations. Second, the system was simulated with random numbers that represent shocks to output, consumer price inflation and asset price inflation. Third, the coefficients of the optimal policy rule were numerically chosen to minimize the central bank's loss function.

Unlike Filardo, we have chosen to solve the model in two steps. First, we introduced the interest rate equation into the initial system of equation, with the restriction related to the loss function, and we solved the system using the ordinary least square method. Second, we transformed the system into a model and we performed a stochastic static simulation in order to see if the proposed model fits the real data. Consequently, this technique allowed us to compare the ECB key interest rate to the interest rate obtained from the optimal monetary policy model. We worked with Eurostat quarterly data for the period 1999-2011 (the period covering the time horizon ellapsed since the ECB setup up to the present).

The three equation of the first component are:

$$y_t = c_{(1)} r_{t-1} + c_{(2)} y_{t-1} + \varepsilon_t \quad (1)$$

$$\pi_t = c_{(3)} \pi_{t-1} + c_{(4)} y_{t-1} + c_{(5)} i_{t-1} + \eta_t \quad (2)$$

$$i_t = c_{(6)} \pi_{t-1} + c_{(7)} y_{t-1} + \nu_t \quad (3)$$

where: y is the output gap for the Eurozone, constructed as a difference between the GDP growth rate and the potential GDP growth rate calculated on the basis of the HP filter, π is the inflation rate, i is the aggregate financial stability index, ε, η and ν are the term errors for each equation and $c_{(1..7)}$ are the coefficients.

In the first equation, the output gap is modelled like an IS equation (investments-savings) and is determined by the past interest rate and a lag of output gap. We expect a negative sign for the first lag of the interest rate in the case of an "overheated" economy and a positive sign in the case of recession. For the first lag of the output gap we expect a positive sign, as the effects of the output gap are channelled from one period to another.

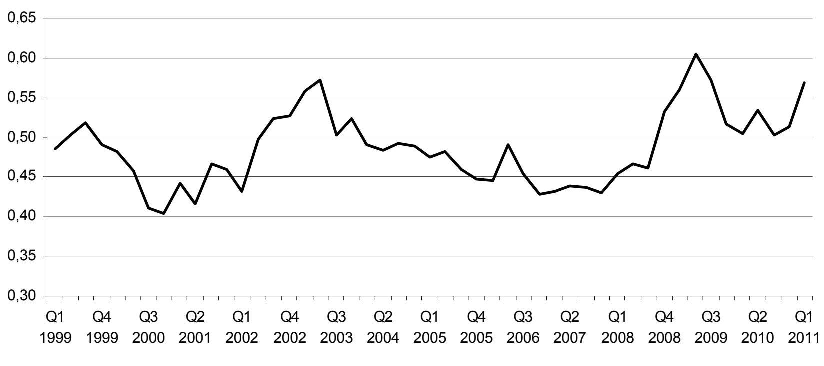
The second equation looks like a PC (personal consumption) equation and describes inflation as a function of lagged consumer price inflation, of economy strength as measured by lagged output gap and of lagged financial instability index. For this equation we expect positive signs for all the coefficients. An economic boom period favours the increase in consumption prices. At the same time, the increasing financial instability can determine increase in pricese due to the investors' lack of confidence (this phenomenon occurred in many EU member countries during the recent crisis).

The third equation of the system is the financial instability equation (FI). The aggregate financial instability index is specified as a function of past consumer price inflation and output gap. High inflation positively influences the financial instability. At the same time, an important output gap means that the economy performs considerably under or above its potential. Consequently, a negative sign is expected in this case.

The process of building up the aggregate financial instability index is presented in Appendix 2[7]. The basic steps in the construction phase consist in the selection of the individual instability indicators, the normalization procedure and the aggregation of the values. This index presents an important feature in the ECB monetary policy rule, namely it covers the financial risks which threaten the efficiency of the monetary policy decisions. According to the ECB status, the monetary policy decisions are based on a large set of economic and financial variables – the "second" pillar. Thus, the ECB is interested not only in the monetary indicators but also in the economic and financial indicators. The advantages of the aggregate index are related to the overall vision on the instability level in the Euro area and to the fact that, by including supplementary indicators or excluding existing ones, the general evolution of the index does not change significantly. The trend of the index for the Euro area is presented in Figure 1.

Figure 1

The Aggregate Financial Instability Index for the Euro Area



[7] *There are many techniques to construct such an index. For a review of the literature, see Illing and Liu (2003), Nelson and Perli (2005), Gersl and Hermanek (2006), Rouabah (2007), Albulescu (2010) and Albulescu (2011). Since 2008 the IMF has also constructed a financial stress index.*

Besides the three equation described above (IS, PC, FI), we have introduced a fourth equation in the original macroeconomic system of equations, namely an interest rate equation describing the optimal monetary policy in the Euro Area. The central bank is assumed to respond to changing economic conditions, but also to financial risks. Many studies demonstrated that the simple Taylor rule cannot explain by itself the ECB behaviour. Consequently, the interest rate equation, which resembles a standard Taylor-type interest rate rule, is augmented by an additional financial instability term.

$$r_t = c_{(8)}\, \pi_t + c_{(9)}\, y_t + c_{(10)}\, i_t \tag{4}$$

The increase in inflation should normally determine an increase in the interest rate. A positive sign for $c_{(8)}$ is thus expected. The impact of the output gap is influenced by the state of the economy and the financial instability should determine in the first phase an augmentation of the interest rate, due to the risks perception and to the increased uncertainty (positive sign for the $c_{(10)}$).

In these conditions, the central bank chooses coefficients to achieve its goals for reduced inflation, output gap and financial instability variability. These preferences are represented in the loss function:

$$l = \text{var}\,(\pi) + \text{var}\,(y) + \text{var}\,(i) \tag{5}$$

where: var (π) is the variance of inflation, var (y) is the variance of output gap and var (i) is the variance of the aggregate financial instability index.

Unlike Filardo (2000), we have chosen not to introduce in the loss function the interest rate variability. On the contrary, we consider the interest rate must fluctuate in order to reach a smaller variability of the final objectives: inflation, output gap, instability. Consequently, instead of the interest rate, we introduced in the central bank loss function the variability of the aggregate financial instability index. After solving the system of equations, we obtained the following results for the coefficients, as presented in Table 1.

Table 1

Econometric Results

Coefficients	Eq. 1	Eq. 2	Eq. 3	Eq. 4
$c_{(1)}$	-0.027			
$c_{(2)}$	0.846***			
$c_{(3)}$		0.601***		
$c_{(4)}$		0.186***		
$c_{(5)}$		1.735***		
$c_{(6)}$			0.216***	
$c_{(7)}$			-0.069***	
$c_{(8)}$				1.006***
$c_{(9)}$				-0.046
$c_{(10)}$				1.303*

*Note: *,**,***, mean statistic relationship significant at 10%, 5%, respectively 1%.*

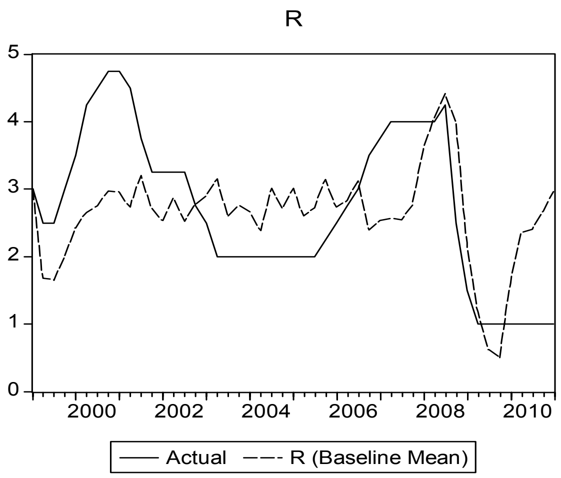
We may see in Table 1 that the majority of the coefficients are significant and the sign is as expected. Apparently, the increase in financial instability determines a consumer price augmentation. Reversely, the instability is influenced by a high level of inflation and output gap. In the interest rate equation, the output gap does not influence the monetary policy decision, which is surprising due to the fact that central banks must look for the economic performance. However, regardless of this statistical evidence, it does not mean that the ECB pays no attention to the output gap. In the same equation, a high level of inflation causes the ECB to increase the key interest rate.

The next step is to transform the equation system into a model and to perform the in-sample econometric simulations. The purpose is to compare the fitted model predictions to the observed interest rate. We have chosen the stochastic simulation and a static approach. A stochastic simulation relies on repeated random sampling to compute the results and the uncertainty is incorporated into the model by adding a random element to the coefficients. A temporary series is created for every endogenous variable in the model, which is solved repeatedly for different draws of the stochastic components of the model. Taking into account that our model contains lagged endogenous variables, we bind these variables on the actual historical data and we perform the simulation.

In Figure 2, we compare the interest rate, calculated on the basis of the described optimal policy rule, with the observed key rate of the ECB. We may see that the model performs quite well for the period 2002-2009 (Appendix 3 confirms our affirmation, especially in te case of inflation and the output gap).

Figure 2

Actual Interest Rate and Its Values Calculated on the Basis of the Optimal Policy Rule



In the first part of the considered period (1999q1-2001q1), the ECB can be blamed for applying a more restrictive monetary policy than it was necessary, therefore affecting the real output growth. This confirms that, in the Duisenberg period, the ECB established the key rate at a higher level than necessary in order to increase its credibility. A discrepancy can be also underlined in 2009, when our model indicated the need for reducing the key rate bellow the level of 1% decided by the ECB, to overcome the liquidity problems in the market. At the same time, for the interval 2010q1-2011q1 our model indicates the need to increase the level of the interest key rate due to inflationary pressures.

However, it is hard to consider that the important increase in the key rate for the last period, as indicated by the model, is triggered only by the increase in the consumer prices. We can see here the limitations of our linear model, which suggest that a time variant model probably performs better when normal and crisis periods alternate. Moreover, the important inertness of the key rate could have affected our results. Nevertheless, we support the idea of a more interventionist monetary policy in order to achieve price and financial stabilisation, even if the ECB's only stated purpose is, at present, the price stability.

V. Conclusions

The purpose of our paper was to identify an optimal monetary rule for the ECB, underlying the importance of financial instability signals. At the same time, we compared the predicted fitted values of our model with the real values of the key rate in order to estimate the efficiency of the ECB monetary policy, since its setup until nowadays (1999-2011). The main contribution of our work is the construction of a financial instability index for the Euro Area, which is then included into an augmented Taylor rule, helping us to design an optimal monetary policy. Another contribution is related to the analysis of the efficiency of the ECB monetary policy, comparing fitted data with real data.

The ECB particular case was not intensively addressed in the literature. The few attempts regarding the identification of an optimal monetary policy rule rely on a Taylor type rule modified by including financial instability signals, associated with the asset price volatility or with the credit boom. Based on Filardo's (2000) reduced-form model, we describe a different optimal monetary policy rule for the ECB. A three equation system, IS-PC-FI, is proposed, and an augmented Taylor rule with the financial instability index closes the model. A restriction associated with the reduction of a central bank loss function is introduced.

Our results show that the model performs well in the sample, even if some discrepancies can be observed for the first and the last part of the analysed period. Thus, for the interval 1999q1-2001q1, the model indicates that the interest rate was set by ECB to a level much higher than necessary, in an attempt to consolidate its credibility. During the peak of the financial crisis (2009), the ECB should have fixed the key rate below 1% to promptly and effectively solve the problem related to the lack of liquidity in the market. For the last period (2010-2011), our model suggests that the ECB should have considerably increased the key rate in order to cope with inflation threats, even if the economic recession gained the field.

However, the performance of the model decreases during turbulent periods. Consequently, the future development of our work should be oriented towards the construction of a time varying model, in order to overcome these limitations. .

References

Albulescu, C.T., 2010. Forecasting the Romanian Financial System Stability Using a Stochastic Simulation Model. *Romanian Journal of Economic Forecasting*, 13(1), pp. 81-98.

Albulescu, C.T., 2011. Economic and Financial Integration of CEECs: The Impact of Financial Instability. *AUCO Czech Economic Review*, 5, pp. 27-45.

Angelini, P., Neri, S. and Panetta, F., 2011. Monetary and Macroprudential Policies. *Temi di Discussione*, Banca d'Italia, No. 801.

Bauducco, S., Bulír, A. and Cihák, M., 2008. Taylor Rule Under Financial Instability. *IMF Working Paper*, No. 18.

Baxa, J., Horváth, R. and Vašícek, B., 2011. Monetary Policy Rules and Financial Stress: Does Financial Instability Matter for Monetary Policy?. Applied Economics Department, Universitat Autonoma de Barcelona, WP 1.

Belke, A. and Klose, J., 2010. (How) Do the ECB and the FED React to Financial Market Uncertainty? – The Taylor Rule in Times of Crisis. DIW Berlin, DP 972.

Bernanke, B.S. and Gertler, M., 2001. Should Central Banks Respond to Movements in Assets Prices?. *American Economic Review*, 91(2), pp. 253-257.

BIS, 2011. Central bank governance and financial stability. BIS, Central Bank Governance Group. Available at: www.bis.org/publ/othp14.pdf.

Bordo, M.D. and Jeanne, O., 2002. Boom-Busts in Asset Prices, Economic Instability, and Monetary Policy. *NBER Working Paper*, No. 8966.

Brousseau, V. and Detken, C., 2001. Monetary policy and fears of financial instability. *ECB Working Paper*. No. 89.

Casares, M., 2007. Monetary Policy Rules in a New Keynesian Euro Area Model. *Journal of Money, Credit and Banking*, 39(4), pp. 876-900.

Cecchetti, S.G., Genberg, H. and Wadhwani, S, 2002. Asset Prices in a Flexible Inflation Targeting Framework. Federal Reserve Bank of Chicago and the World Bank Conference on Asset Price Bubbles: Implications for Monetary, Regulatory, and International Policies, Chicago, 22-24 April.

Cecchetti, S. and Li, L., 2008. Do Capital Adequacy Requirements Matter for Monetary Policy?, *Economic Inquiry*, 46(4), pp. 643-659.

Christiano, L., Ilut, C., Motto, R. and Rostagno, M., 2008. Monetary Policy and Stock Market Boom-Bust Cycles. *ECB Working Paper*, No. 955.

Corbo, V., 2010. Financial stability in a crisis: What is the role of the central bank?. In: *Perspectives on inflation targeting, financial stability and the global crisis*, BIS Papers, No 51.

Cúrdia, V. and M. Woodford, 2010. Credit Spreads and Monetary Policy. *Journal of Money Credit and Banking*, 42(1), pp. 3-35.

De Gregorio, J., 2010. Recent challenges of inflation targeting. In: *Perspectives on inflation targeting, financial stability and the global crisis*, BIS Papers, No 51.

Driffill, J., Rotondi, Z., Savona, P. and Zazzara, C., 2006. Monetary policy and financial stability: What role for the futures market?. *Journal of Financial Stability*, 2, pp. 95–112.

Filardo, A., 2000. Monetary policy and asset prices. *Federal Reserve Bank of Kansas City Economic Review*, 85(3), pp. 11-37.

Filardo A., 2001. Should Monetary Policy Respond to Asset Price Bubbles? Some Experimental Results. *Federal Reserve Bank of Kansas City Working Paper*, No. 4.

García Herrero, A. and del Río, P., 2003. Financial Stability and the design of monetary policy. *Bank of Spain Working Paper*, No. 15.

Gersl, A. and Hermanek, J., 2006. Financial Stability Indicators: advantages and disadvantages of their use in the Assessment of the Financial System Stability. In: *Czech National Bank Financial Stability Report*.

Goodhart, C., Osorio, C., and Tsomocos, D., 2009. Analysis of Monetary Policy and Financial Stability: A New Paradigm. *CESifo Working Paper*, No. 2885.

Granville, B. and Mallick, S., 2009. Monetary and financial stability in the euro area: Pro-cyclicality versus trade-off. International Financial Markets, Institutions and Money, 19, pp. 662-674.

Gray, D.F., Merton, R.C. and Bodie, Z., 2007. New Framework for Measuring and Managing Macrofinancial Risk and Financial Stability. *NBER Working Paper*, No. 13607.

Illing, M. and Liu, Y., 2003. An index of Financial Stress for Canada, *National Bank of Canada Working Paper* , No. 14.

Kent, C. and Lowe, P., 1997. Asset Price Bubbles and Monetary Policy. *Reserve Bank of Australia Discussion Paper*, No. 9709.

Kent, C. and Debelle, G., 1998. Trends in the Australian banking system: Implications for financial system stability and monetary policy. Presented at BIS Autumn Central Bank Economists' Meeting, Basel, 28-29 October.

Rouabah, A., 2007. Mesure de la vulnérabilité du secteur bancaire luxembourgeois. *Luxembourg Central Bank Working Paper*, No. 24.

Schoenmaker, D. and Wierts, P., 2011. Macroprudential Policy: The Need for a Coherent Policy Framework. *DSF Policy Paper*, No. 13.

Schwartz, A., 1995. Why financial stability depends on price stability. *Economic Affairs*, 15(4), pp. 21-25.

Sedghi-Khorasgani, H., 2010. Financial Instability and Optimal Monetary Policy Rule. *FIW Working Paper*, No. 42.

Teranishi, Y., 2009. Credit Spread and Monetary Policy. *IMES Discussion Paper*, Bank of Japan, No. 14.

Trecroci, C. and Vassalli, M., 2010. Monetary policy regime shifts: new evidence from time-varying interest rate rules. *Economic Inquiry*, 48(4), pp. 933-950.

Appendix 1

Reduced-Form Models for Testing the Relation between Monetary Policy and Asset Prices

One simple model in this category, composed of three equations, is proposed by Filardo (2000):

$$y_t = -0.34r_{t-1} + 0.62y_{t-1} + \varepsilon_t \quad (6)$$

$$\pi_t = \pi_{t-1} + 0.17y_{t-1} + 0.17\pi_{AP,t-1} + u_t \quad (7)$$

$$\pi_t^{AP} = \pi_{t-1} + 0.12y_{t-1} + v_t \quad (8)$$

where: y_t is the output gap, π is the consumer price inflation, π_{AP} is the asset price inflation.

It is assumed that the monetary authority chooses the real interest, r, in order to minimize its quadratic loss preference function:

$$L = var\ (y) + \mu_\pi\ var\ (\pi) + \mu_r\ var\ (r-r_{t-1}) \quad (9)$$

The monetary rule which closes the model is:

$$r_t = a_1\pi_t + a_2y_t + a_3\pi_{AP,t} \quad (10)$$

In 2001, Filardo revised its model (see Filardo, 2001). He assessed the advantages of an assets price augmented monetary rule, whether the central bank is or not capable to distinguish if the assets price trend is due to its fundamentals or to speculative actions. As in 2000, the model is completely autoregressive, but in this case, the asset prices have a fundamental (F) and a speculative component (B). The model is composed of three blocks of equations: the output and inflation block (eq. 11 and 12), the asset price inflation block (eq. 13, 14, 15) and the monetary policy block (eq. 16).

$$y_t = -0.2r_{t-1} + 0.6y_{t-1} + 0.2(\pi_{AP,t-1} - \pi_{t-1}) + \varepsilon_t \quad (11)$$

$$\pi_t = \pi_{t-1} + 0.15y_{t-1} - 0.1\pi_{B,t-1} + \eta_t \quad (12)$$

$$\pi_{AP,t} = \pi_{F,t} + \pi_{B,t} \quad (13)$$

$$\pi_{F,t} = \pi_{t-1} + 0.5y_{t-1} + \nu_t \quad (14)$$

$$\pi_{F,t} = \zeta_t \quad (15)$$

$$L = var\ (y) + \mu_\pi\ var\ (\pi) + \mu_r\ var\ (r-r_{t-1}) \quad (16)$$

where: ζ_t is a semi-Markov process which depends on the duration of the bubble.

The monetary policy rule is:

$$r_t = a_y y_t + a_\pi\pi_t + a_F\pi_{F,t} + a_B\pi_{B,t} \quad (17)$$

In this model, optimal monetary policy is a choice of (a_y ,a_π ,a_F ,a_B) that minimizes the loss function, L.

Two alternative monetary policy rules are evaluated. The first alternative (eq. 18) corresponds to a monetary authority that does not respond to asset price inflation. This rule is consistent with conventional Taylor-type rules.

$$r_t = a_y y_t + a_\pi\pi_t \quad (18)$$

The second alternative corresponds to a monetary authority that responds to overall asset price inflation (eq. 19), $\pi_{AP,t}$:

$$r_t = a_y y_t + a_\pi \pi_t + a_{AP} \pi_{AP,t} \quad (19)$$

The results show that the desirability of using asset price information depends critically on the monetary authority's preference for interest rate smoothing and the variability of asset prices.

One reduced-form regime-switching model is that of Kent and Lowe (1997). The elements of the model are: an asymmetric effect of asset price increases and decreases on goods and services price inflation; a central bank with an inflation target, which cares about the variability of inflation as well as about its expected level; the probability of an asset-price bubble bursting is influenced by the level of interest rates; and an assumption that once an asset-price bubble has burst, it does not return (at least within any reasonable policy horizon). The economy runs for only three periods and they assume that a bubble emerges in the first period.

The first equation of the model (eq. 20) regards the inflation[8]:

$$\pi_t = \alpha A_t + \beta D_t \Delta A_t - R_{t-1} \qquad \alpha>0,\ \beta>0 \quad (20)$$

where: π_t is the deviation of inflation from the central bank's target, A_t is the deviation of the asset price from its fundamental value, R_t is the deviation of the policy interest rate from its neutral level and D_t is a dummy variable which takes on a value of 1 if the asset price has fallen, and 0 otherwise.

One should note that in this model the monetary policy operates with a lag. If current inflation is above target, the central bank cannot immediately return it to the target. This means that the central bank must forecast future events when setting the current interest rate.

Afterwards, the authors model the relationship between today's interest rate and the probability of the bubble collapsing in the next period, as follows:

$$p_{t+1} = \Phi + \varphi R_t \quad \varphi>0 \quad (21)$$

If the bubble does not burst, it is assumed to grow at rate g* so that:

$$A_{t+1}=gA_t \quad (22)$$

where: $g = 1 + g^*$.

Having observed that a bubble has emerged in period 1, the task for the central bank is to minimize the sum of the expected squared deviations of inflation from the target. Since the central bank cannot affect the current rate of inflation, this amounts to minimising:

$$E_1(\pi_2^2) + E_1(\pi_3^2) \quad (23)$$

where: E denotes the expected value and subscripts refer to time periods.

This objective function assumes that the central bank is not only concerned about the expected value of inflation but also the variability of inflation. The above problem is solved recursively. The results show that a large and rapid fall in the nominal price of these assets can have adverse effects on financial system stability.

Bordo and Jeanne (2002) propose a similar regime-switching model but with two periods. Like in the case of Kent and Lowe (1997), the dilemma for the authorities is

[8] The equation relates the inflation rate of goods and services to the level of asset prices, rather than the inflation rate of asset prices (which would be more natural).

related to the type of monetary policy strategy. The central bank can adopt a reactive rule and, in this case, reduce the loss in t_0, but it accepts the risk of a loss in t_1 in the case of a credit crunch. If, on the contrary, the monetary policy is preventive and the interest rate increases in t_0, the central bank avoids the credit crunch, but it can thus sacrifice the inflation target and the economic growth in t_0.

The equations of the reduced-form model are as follows:

$$y_t = m_t - p_t \tag{24}$$

$$y_t = \alpha p_t + \varepsilon_t \tag{25}$$

$$y_0 = -\sigma r \tag{26}$$

where: y_t is the output at time t, m_t is the money supply, p_t is the price level and r is the interest rate between t_0 and t_1, ε is not a classic "supply shock" which affects the productivity of firms but instead a "financial" shock[9]. All variables, except the real interest rate, are in logs.

The first two equations characterize aggregate demand and aggregate supply. Aggregate supply is increasing with the nominal price level because the nominal wage is sticky. The third equation says that the first-period output is decreasing with the real interest rate[10]. For simplicity, the authors assume that the credit crunch can occur only in period t_1 and determine a supply shock - ε.

In period t_1, the firms' access to new credit depends on the value of their collateral. Because of a debt renegotiation problem, firms' total debt cannot exceed the value of their collateral. Denoting by Q1 the real value of collateral in period t_1, and by γ the required level of intra-period credit, the firms that require intra-period credit can operate if and only if: $(1+r)D + \gamma < Q_1$. There is a credit crunch if and only if this condition is not satisfied.

$$Q_1 < (1+r)D + \gamma \tag{27}$$

The collateral price can take on two values: a high value corresponding to "new economy" or to a good state of the economy and a small value corresponding to the "old economy" situation. The probability of good state occurrence, when economic agents are optimistic, is PH. In this case, a credit crunch can appear ex-post with a high probability in case PH is important.

In this situation, the central banks have two possibilities: to save the economy if the credit crunch appears, or to diminish the risk of credit crunch. In the first case, it is necessary to respond to the actual or forecasted level of inflation and output gap. In the second case, the monetary policy can influence in a preventive way the indebtedness capacity in t_0.

Comparing the encountered losses in the two cases indicates the conditions in which a central bank can adopt a strategy or another. A preventive policy must be implemented only if the level of the interest rate necessary to counterattack a credit crunch risk is not too high.

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[9] *The "financial" shock is not entirely exogenous, since its distribution depends on firms' debt and the price of assets, two variables that monetary policy may influence.*

[10] *It is based, in the micro-founded model, on the Euler equation for consumption (see Bordo and Jeanne, 2002 for further explanations).*

Appendix 2

The Aggregate Financial Instability Index for the Euro Area

Step 1 – The Choice of Individual Indicators

Individual indicators	Expected contribution to the financial instability	Database
Volatility of the stock index return	+	Yahoo finance
Stock market capitalization (% GDP)	-	Eurostat
Interest rate spread	+	Eurostat, ECB
Bank nonperforming loans to total loans	+	OECD, IMF
Bank capital to assets ratio	-	OECD, IMF
Bank regulatory capital to RWA	-	OECD, IMF
ROA	-	OECD, IMF
ROE	-	OECD, IMF
Liquid assets to total assets	-	OECD, IMF
Regulatory Tier 1/risk-weighted assets	-	OECD, IMF
REER excessive depreciation or appreciation	+	Eurostat
International reserves to imports ratio	-	Eurostat
Current account deficit to GDP	+	OECD, Eurostat
Economic sentiment indicator	-	EC
General government deficit to GDP	+	Eurostat
Public debt to GDP	+	Eurostat
Interest rate volatility	+	OECD, Eurostat
Loans (% change)	+	OECD
Credits to deposits ratio	+	OECD

Step 2 – The Normalization Procedure

For the second step in the index construction, a re-scaling approach was employed to normalise the individual indicators' values, for each Euro area country.

$$\mathrm{I}_{\mathrm{ijc}}\,\mathrm{n} = \frac{\mathrm{I}_{\mathrm{ijc}} - Min\ (I_i)}{Max\ (I_i) - Min\ (I_i)} \tag{28}$$

where: I_{ijc} represents the indicator i during the j period corresponding to the country c, $Min(I_i)$ and $Max(I_i)$ represent the best value and, respectively, the worst value registered by the indicator i during the analysed period in the respective country and $I_{ijc}n$ is the normalised value of the indicator.

Step 3 – The Aggregation

In the third phase, the AFII for each country is calculated as an arithmetic mean of the data available for the 19 normalised individual indicators (the standard procedure):

$$AFII = \frac{\sum_{i=1}^{19} I_{ij}}{19} \tag{29}$$

Finally, the aggregate financial instability index for the Euro area is constructed by weighting the individual countries index with their percentage into the Euro area GDP.

Appendix 3 – The Performance of the Empirical Model