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# Monetary Policy Rules and Directions of Causality: A test for the Euro Area

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**Abstract**

Use is made of a VAR model in first differences with quarterly data for the Eurozone to ascertain whether decisions on monetary policy can be interpreted in terms of a "monetary policy rule", with specific reference to the so-called "nominal GDP targeting rule" (McCallum 1988; Hall and Mankiw 1994; Woodford 2012). The results obtained indicate a causal relation proceeding from deviation between the growth rates of nominal GDP and target GDP to variation in the three-month market interest rate. The same analyses do not, however, appear to confirm the existence of a significant inverse causal relation from variation in the market interest rate to deviation between the nominal and target GDP growth rates. Similar results were obtained on replacing the market interest rate with the ECB refinancing interest rate. This confirmation of only one of the two directions of causality does not support an interpretation of monetary policy based on the nominal GDP targeting rule and gives rise to doubt in more general terms as to the applicability of the Taylor rule and all the conventional rules of monetary policy to the case in question. The results appear instead to be more in line with other possible approaches, such as those based on

Post-Keynesian analyses of monetary theory and policy and more specifically the so-called “solvency rule” (Brancaccio and Fontana 2013, 2015). These lines of research challenge the simplistic argument that the scope of monetary policy consists in the stabilization of inflation, real GDP or nominal income around a “natural equilibrium” level. Rather, they suggest that central banks actually follow a more complex purpose, which is the political regulation of financial system with particular reference to the relations between creditors and debtors and the related solvency of economic units.

Keywords: VAR models, Granger causality test, monetary policy rules, nominal GDP targeting rule, solvency rule.
JEL classification: E12, E52, E58

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## 1. Introduction

Conventional analyses of monetary policy over the last twenty years have described the behaviour of central banks in terms of monetary policy rules. The types of rule to be found in the literature are numerous. While the best-known is perhaps the “Taylor rule”, formulated by John B. Taylor in 1993, there are others, including the nominal GDP targeting rule put forward in 1977 by James Meade, which has recently found new admirers. For all their diversity, these rules of monetary policy follow the same logical framework. First, a rule of conduct is formulated for the central bank in the pursuit of particular objectives of economic policy, such as certain levels of inflation and real or nominal GDP. The rule is then taken as a point of reference to ascertain whether the monetary authority, by acting on interest rates or other instrumental variables, has effectively affected aggregate demand in such a way as to reduce deviation of the effective levels of inflation and real or nominal GDP from their respective targets. Within this logical framework, the adoption of such rules by central banks would therefore need to be confirmed by verification of the existence of a dual causal relationship: first from the gap between target variables and their actual values to the values assumed by the instrumental variables of monetary policy and then in the other direction from the instrumental variables to the gap. In this connection, the conventional empirical literature on the rules of monetary policy tends to focus above all on the relation that proceeds from the gap between effective variables and target variables to the instrumental variables. The inverse causal relation is instead often taken for granted or only implicitly analysed, e.g. through calculation of the variance of the gap between effective variables and target variables in the periods of application of the rule in question. Confirmation of both directions of causality is, however, required by the logic of the rules of monetary policy. The non-existence of one of them would necessarily call into question the conceptual basis of such rules and pave the way to alternative interpretations of monetary policy.

The purpose of this study is to ascertain whether both these causal relations are supported by significant empirical evidence. The empirical criterion adopted rests on the use of a VAR model in first differences. While the VAR model is nothing new in the literature on the rules of monetary policy, this paper will take advantage of this model for the specific purpose of investigating both the directions of causality implicit in the functioning of the rules of monetary policy. It is worth pointing out that the technique that we suggest can be applied to all the conventional rules of monetary policy. However, the rule selected for examination in this paper is that of nominal GDP targeting, which has been the object of renewed attention on the part of researchers and policy makers in recent times. The geographical area examined is the Eurozone. In this analysis, the rule indicates a link between deviations of the growth rate of nominal GDP with respect to a given target, and a variation in the three-month market interest rate. This rule rests on the idea that the monetary authority registers the gap between the effective growth of nominal GDP and its desired trend at set intervals and adjusts the interest rates in order to reduce it. Use is made of a VAR model in first differences with quarterly data for the Eurozone in order to ascertain the existence of a causal relation from deviation of the nominal GDP growth rate from the target GDP growth rate to variation of the three-month market interest rate, and vice versa from the variation of the three-month interest rate to the deviation of monetary GDP growth rate. The period considered starts from 1999Q1, when the European single currency was born, and ends in 2013Q3. In order to test the robustness of the results obtained, the analysis is then repeated for the same period of time, but using the ECB quarterly refinancing interest rate rather than the market interest rate. In accordance with Woodford (2012), it is assumed that the target levels of nominal GDP correspond to its trend from 1999Q1 to 2013Q3. This trend is calculated on the effective data of the single interval stretching from 1999Q1 to 2008Q3, i.e. to the beginning of the “Great Recession” (IMF 2012).

The paper is organized as follows. Section 2 discusses the characteristics of the nominal GDP targeting rule, and the reasons for the renewed attention it has recently received. Section 3 describes the data and tests stationarity and cointegration. Section 4 implements an unrestricted VAR model in first differences. Section 5 presents the Granger causality test and the results obtained. Section 6 analyses the robustness of the results by replacing the market interest rate with the refinancing interest rate. Section 7 shows that our results do not support the nominal GDP targeting rule or other conventional monetary policy rules and suggests an alternative interpretation of the empirical analysis based on a Post-Keynesian interpretation of monetary policy and, more specifically, on the so-called "solvency rule" proposed by Brancaccio and Fontana (2013; see also Brancaccio and Fontana 2015).

## 2. Characteristics of the nominal GDP targeting rule

The nominal GDP targeting rule has played a non-negligible role in the debate on monetary policy over the last thirty years. The earliest advocates of the adoption of a given level or rate of variation of nominal GDP as an objective of monetary policy include Meade (1978), von Weizsacker (1978) and Tobin (1980). This proposal was then translated into a precise formal rule according to which deviation of nominal GDP with respect to a set trend should guide the decisions of the monetary authority as regards determination of a monetary aggregate or the short-term interest rate (McCallum 1988; Hall and Mankiw 1994). While the rule generally takes the past trend of nominal GDP as its point of reference, forward-looking formulations also exist in the literature (Judd and Motley 1992; Dueker 1993; Clark 1994, McCallum 1999). Attention is focused here on the most common version, whereby monetary policy decisions regarding the current level of the short-term interest rate are to be guided by past percentage deviations of the nominal GDP from a given target. With $i_t$ as the level of the short-term nominal interest rate at time $t$, $Y_{t-1}$ as the level of nominal GDP and $Y^*_{t-1}$ as the target level of the nominal GDP at time t-1, the rule can be expressed as $i_t = \alpha + \beta(Y_{t-1} - Y^*_{t-1})/Y^*_{t-1}$, which corresponds to:

$$i_t = \gamma + \delta[ln(Y_{t-1}) - \ln(Y^*_{t-1})] \qquad \textbf{(1)}$$

The same rule can obviously be represented also in terms of variations: $\Delta i_t = \beta(y_{t-1} - y^*_{t-1})$, where $y$ and $y*$ indicate the growth rates of nominal GDP and target GDP.

Criticisms of this rule have been put forward in the literature and some studies have suggested that it could increase rather than decrease the variance of nominal GDP and the other macroeconomic variables around their respective targets (Taylor 1985; Ball 1997). For this reason, some maintain that it is preferable to adopt other measures, such as the Taylor rule (Taylor 1993, 1999; Taylor and Williams 2009). These observations do not appear, however, to have prevented a recent revival of interest in the nominal GDP targeting rule, and new agreement as to the possibility of its employment has emerged since the outbreak of the international economic crisis in 2008. A thesis fashionable among its supporters is that the nominal GDP targeting rule would not be a source of instability: on the contrary, it could have mitigated the effects of the Great Recession and could today help countries that adopt it to regain the rate of growth prior to the crisis more quickly. One of the reasons put forward is that the nominal GDP targeting rule would prompt the central bank to react to variations in real GDP and the rate of inflation with the same intensity, whereas other and more celebrated rules, including the Taylor rule, make the monetary authority more sensitive to changes in inflation than in real GDP. In this sense, the nominal GDP targeting rule is described as more "general" than the Taylor rule (Koenig 2012). On the basis of these and other arguments, the nominal GDP targeting rule has been revived in the academic sphere by various scholars, including Sumner (2011) and Woodford (2012), and in the political debate by the *Economist* (2011) and the

*New York Times* with Christina Romer (2011). Indeed, the adoption of this rule would not be something wholly unprecedented as a number of central banks seem to have implicitly adopted it (see the case of the Bank of England in King 2011, among others; moreover, the rule has been explicitly taken into consideration by the FOMC of the Federal Reserve 2010).

It is interesting to note that the adoption of a nominal GDP targeting rule has also been suggested as a point of compromise between economic models that belong to the mainstream approach: that is, to the so-called "new consensus macroeconomics" or "core" of current macroeconomic theory (Taylor 2000; Blanchard 2000). The potential theoretical ecumenicity of the nominal GDP targeting rule stems from its logical compatibility with various interpretations of the macroeconomic nexus between monetary and real variables and the possibility of variations in the former proving neutral or otherwise with respect to the dynamics of the latter. This is a well-known question and one upon which there has been disagreement even within the mainstream debate. The advantage of the nominal GDP targeting rule is that it does not need to make the terms of the nexus between real and monetary variables explicit. That is why this rule has been regarded as a possible candidate to identify an area of common ground for the various scholars, at least in the sphere of monetary policy. Those who adopt models in which money is neutral also in the short period should agree that this rule would in any case ensure satisfactory stability of prices, whereas those who regard monetary variables as having at least a short-term influence on real variables could consider the rule a valid compromise between the stability of prices and the stability of real GDP and employment. In the light of this reasoning, the nominal GDP targeting rule has been described as the most "efficient" of the rules that seek to establish the optimal behaviour of the monetary authority on the basis of a single, specific macroeconomic model (Hall and Mankiw 1994; McCallum 2011).

The nominal GDP targeting rule can, however, constitute a point of compromise only between economic models that belong to the mainstream approach, which is based on the idea that the GDP target corresponds to the "natural equilibrium" determined by the so-called Neo-Classical "fundamentals" of preferences, technology and endowments. This theoretical view assumes that the management of the short-term interest rate by the monetary policy authority makes it possible to bring aggregate expenditure, output and employment toward their "natural" equilibrium levels, and hence the inflation rate toward a given target level. This assumption, which is shared by the nominal GDP targeting rule and the Taylor rule, is often taken for granted in the predominant literature or subjected only to implicit analysis. The empirical analyses most in vogue at present confine themselves in actual fact to verifying whether a decrease in the variance of the gaps between the effective variables and the target variables of monetary policy takes place in the periods when the rules examined are applied (McCallum 1997; Taylor 1999; Taylor and Williams 2009). This view, however, has been called into question on various occasions. In the predominant literature, difficulties have emerged especially in the sphere of the empirical studies with respect to the non-linearity, the asymmetry and even the non-existence of some of the connections that are supposed to justify this view, such as the link between the interest rate and investment (Blanchard 1984; Caballero 1999; Taylor 1999). The most recent debate on monetary policy does not appear, however, to concentrate on these objections. There is discussion about the choice between various rules to be adopted by the monetary authority in setting the interest rate, but not about the fact that the sole use of the interest rate or other conventional monetary policy tools could prove inadequate for the management of aggregate expenditure and the attainment of the target variables incorporated into the same rules. These difficulties were instead well known to pioneers of nominal GDP targeting like Meade (1978) and Tobin (1980), who rightly held that responsibility for pursuing a given target of nominal GDP should be assigned to both monetary and fiscal authorities.

The problem is therefore of recognition that the nominal GDP targeting rule, just like the Taylor rule and the other conventional rules of monetary policy, is based on a dual causal relation: from deviations between effective and target variables to instrumental variables and conversely from instrumental variables to the same deviations. The lack of adequate empirical evidence for even just one of the two relations would raise doubts about the very meaning usually attributed to these rules and open the way to alternative interpretations of monetary policy. It may therefore prove useful to identify a criterion making it possible to ascertain the existence or otherwise of both causal relations. This is the precise purpose of the paper.

A VAR model in first differences is used here to assess whether the monetary policy of the Eurozone can be adequately interpreted in the light of a nominal GDP targeting rule in the sense not only of nominal GDP contributing to determination of the short-term interest rate, but also of the interest rate contributing to the stabilisation of nominal GDP around a given target trend. To this end, analysis is carried out on quarterly data for the period 1999Q1–2013Q3 with reference to the three-month market interest rate. In order to verify the robustness of the results, the analysis is then repeated for the same period with reference to the ECB three-month refinancing interest rate.

## 3. Data, unit roots test and cointegration analysis

This work analyses the monetary GDP targeting rule on the basis of the equation (1) presented in the previous section. The sample examined regards the Eurozone and covers the period from 1999Q1 to 2013Q3. The back-to-top data are quarterly and drawn from the Eurostat database.[1] The analysis focuses on the following time series: the three-month market interest rate (*imr*) and the deviation of the log-level of the nominal GDP of the Eurozone with respect to the log-level of the target nominal GDP *gdp_dev*). In accordance with Woodford (2012), the target nominal objective GDP series corresponds to the log-linear trend obtained from 1999Q1 to 2013Q3 by applying the ordinary-least-squares (OLS) method to the data of nominal GDP from 1999Q1 to 2008Q3, e.g. from the birth of the European single currency to the start of the Great Recession (IMF 2012).

Both series show outliers at the end of 2008 and the beginning of 2009 in connection with the start of the Great Recession. From graphical inspection of the series in levels of the deviation of nominal GDP and the market interest rate, both appear to be I(1), i.e. non-stationary (Figure 1):

**Please Insert Figure 1:**

**Series of the levels and first differences of *gdp_dev* and *imr***

The non-stationarity of the series is confirmed by the Augmented Dickey-Fuller (ADF) test, the Phillips Perron (PP) test and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, as shown in Table1.

**Please Insert Table 1:**

**Unit roots test of the series in levels**

The ADF, PP and KPSS tests never reject the null hypothesis of unit root's presence at the 1% significance level. It is therefore possible to attempt to make the series stationary by transforming them into first differences (Figure 1). The ADF, PP and KPSS tests confirm the stationarity of the series in first differences of the *imr* at the 1% significance level and of the *gdp_dev* at the 5% significance level (Table 2).

**Please Insert Table 2:**

**Unit roots test of the series in first differences**

In order to confirm the presence of a unit root and to take into account the events connected with the Great Recession (IMF 2012), which could be seen as a structural break, separate ADF tests were carried out on the pre-crisis period (1999Q1–2008Q3) and the post-crisis period (2008Q4–2013Q3) for both the series considered. The hypothesis of the presence of a unit root is never rejected at the 5% significance level. The obtained results do not support the presence of a structural break.

As the variables are I(1) in levels and they become I(0) in their first order differences, it is possible to apply the Johansen cointegration test (1991). This more general test is preferred to the Engle-Granger test (1987). In this case it is assumed that all the variables of the system are endogenous and it is not necessary to establish a direction of causality amongst them *a priori*. The test is carried out by including the option "unrestricted constant" and two lags, which minimise the information criteria of Akaike (AIC), Schwartz Bayesian (BIC) and Hannan-Quinn (HQC). According to the trace test and eigenvalue test, the null hypothesis of the absence of a relation of cointegration between *gdp_dev* and *imr* is not rejected. In this case, the presence of a stationary linear combination between the two variables is ruled out. The results are shown in Table 3.

**Please Insert Table 3:**

**Johansen cointegration test (series in levels)**

## 4. The VAR model

As the VAR model specified on the series in levels proves non-stationary, it was decided to proceed with estimation of the model specified in first differences (for further applications of this model, see Heather et al. 1997; Lamdin et al. 2008; Coad et al. 2011, 2013). In the VAR model estimated in the reduced form, all the variables are endogenous except the dummy (dum1) inserted as an exogenous variable. In order to test for the presence of outliers, the temporal dummy variable (dum1) assumes the value of one in the quarters 2008Q4 and 2009Q1, and zero in all the other quarters. The variable is proved significant by applying the Wald test. On the basis of the information criteria of Akaike (AIC), Schwartz Bayesian (BIC) and Hannan-Quinn (HQC), it was decided to insert two lags for the series in levels, and one lag for the variables in first differences. The VAR model estimated is therefore as follows:

$$\begin{bmatrix} \Delta imr_t \\ \Delta gdp\_dev_t \end{bmatrix} = \begin{bmatrix} a_{imr\,imr} & a_{imr\,gdp\_dev} \\ a_{gdp\_devimr} & a_{gdp\_devgdp\_dev} \end{bmatrix} \begin{bmatrix} \Delta imr_{t-1} \\ \Delta gdp\_dev_{t-1} \end{bmatrix} + \begin{bmatrix} dum_{imr} \\ dum_{gdp\_dev} \end{bmatrix} dum1 + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} \qquad (\mathbf{2})$$

Table 4 presents the results of the estimation of the VAR model. The exogenous dummy variable (dum1) is significant. The results reported in Table 4 show that in the short term the variation in the three-month market rate is positively influenced by the deviation of the growth rate of nominal GDP, whereas the coefficient for variation of *imr* does not prove statistically significant in the equation of the deviation of the nominal GDP growth rate. The unidirectional relation is confirmed by application of the Granger causality test (Table 5). The results obtained are robust with respect to conditional heteroscedasticity and autocorrelation. The Ljung-Box Q test shows the absence of serial autocorrelation at the 1% significance level for both the equations of the VAR model.[2] The test for the presence of ARCH effects in the residuals confirms homoscedastic residuals. The absence of serial autocorrelation and ARCH effects is also confirmed when the number of lags is varied from one to four. Moreover, the residuals plot shows that the residuals of the VAR model are stationary. The normality tests confirm normal distribution at the level both of the system and of the single equation.[3] Finally, the tests of structural stability (CUSUM test and CUSUMQ test) of the parameters of the VAR model provide no evidence of instability and the series moves within the confidence intervals.

**Please Insert Table 4:**

**Results of the estimation of the VAR model**

## 5. Granger causality test

This section is dedicated to the Granger causality test (Granger 1969), which proposes a definition of causality centered on the lag structure of the variables of the model. Within the VAR models the null hypothesis of Granger Causality of a variable with respect to another variable is ascertained through the use of F-test of joint significance of the lags. The null hypothesis is accepted if the lags of the variable whose causality is verified are not significant. In this case, the lags of this variable do not help to predict the variable of interest. Considering the VAR estimated by the equation (2) it has been carried out the Granger causality test to verify if the deviation of GDP *causes* the money market interest rate and vice versa (Table 5).

Unidirectional Granger causality is detected from deviation of the nominal GDP growth rate to variation in the three-month market interest rate at 1% significance level. It therefore appears that deviation of the growth of nominal GDP with respect to the target precedes movement of the variation in three-month market interest rate but not the other way round. On the whole, the analysis of Granger causality shows that the deviation of the nominal GDP growth rate with respect to the target rate is a driving force capable of explaining a large proportion of variation in the three-month market interest rate. These results confirm the causality analysis of the VAR estimated. In order to confirm the robustness of the results obtained, the Granger causality test was also repeated varying the number of lags from one to four quarters (Kholdy et al. 1990; Casillas 1993; Moosa 1997; Vera 2001).

Even in this case, the null hypothesis is rejected and the variation of the market interest rate depends on the deviation of the growth of nominal GDP delayed up to a period of four quarters. Therefore, the deviation of the nominal GDP growth can be considered influential in the prediction of the changes in the market interest rate. On the contrary, the causal relation does not apply in the other way round.

**Please Insert Table 5:**
**Granger causality test**

## 6. Robustness check

An analysis of the robustness of the results was carried out over the same span of time (1999Q1–2013Q3) by replacing the three-month market interest rate with the ECB three-month refinancing interest rate (*refi*) and testing the relation between the three-month refinancing interest rate and the deviation between the log-level of nominal GDP and the log-level of the target GDP (*gdp_dev*). Once again, both of the I(1) series can be described as difference-stationary processes I(0) and are not cointegrated. A VAR model in first differences was therefore estimated with the same exogenous dummy as previously adopted. It emerges from estimation of the bivariate VAR model that variation in the refinancing interest rate is positively influenced (0.37) in the short term by deviation of the growth rate of nominal GDP but not vice versa. Moreover, the exogenous dummy proves statistically significant in both the equations of the VAR. The unidirectional relation from the deviation of nominal GDP to the three-month refinancing interest rate is confirmed by the Granger causality test. Here too, the analysis of Granger causality test shows that the deviation of the growth of nominal GDP with respect to the growth of the target is capable of explaining a large proportion of the variation in the refinancing interest rate but not vice versa. The result is also confirmed when the number of lags is varied from one to four quarters. The diagnostics of the model respects the requirements of the absence both of serial autocorrelation and of conditional heteroscedasticity, the normality of residuals and the structural stability of the parameters estimated. The results obtained therefore confirm the analysis of causality of the VAR model estimated for the relation *imr-gdp_dev*. The results of the estimation of the VAR model and the tests regarding the analysis of robustness are available on request.

**7. An alternative interpretation**

The estimation of the VAR model has shown that in the short term the deviation of the nominal GDP growth rate from the growth rate of the target GDP is not influenced by variation of the market interest rate. The same estimation has also shown, however, that the variation in the market interest rate is positively influenced by deviations of the nominal GDP growth rate from the target. This unidirectional relation is confirmed in the period considered by the Granger causality test. The robustness of the result is also confirmed when the number of lags is varied from one to four quarters and when we take the three-month refinancing interest rate rather than the three-month market interest rate as its point of reference.

It is therefore possible to draw the conclusion that the decisions of monetary policy on interest rates in the Eurozone appear to be effectively influenced by the dynamics of monetary GDP with respect to the target GDP. There appears, however, to be no confirmation of an inverse causal relation from the interest rate to the deviation of monetary GDP. This second result does not support interpretations of the behaviour of the monetary authorities in the light of the nominal GDP targeting rule. In more general terms, it also casts some doubt on the possibility of interpreting the case examined here in the light of the Taylor rule and all the other conventional monetary policy rules that presuppose a two-way causal relation: not only from the divergence between effective and target variables to instrumental variables but also in the other direction.

For the mainstream approach these results seem to be a difficult puzzle to solve. On the contrary, the conclusions of our empirical analysis could find adequate support within alternative lines of research. The Post-Keynesians and members of the other schools of critical thought have repeatedly challenged the theoretical bases of a supposed rigid, mechanical link from monetary policy to GDP, and more specifically of one of its main pillars: the inverse relation from the interest rate to demand for investment. Some scholars have focused on the radical uncertainty that characterizes investment and more generally any decision in a monetary economy (Davidson

1996), while others have focused attention on the weakness and instability of the relation between monetary policy, interest rates and GDP (Wray 2007) and more specifically have stressed that investments depend not only on the cost of capital but also on financial factors, including internal cash flows (Arestis and Sawyer 2004; Krisler and Lavoie 2007; Fazzari, Hubbard and Petersen 1987; see also Realfonzo 1998, among others). Moreover, the followers of the Classical tradition have stressed that the inverse relationship between interest rates and investment is based on the Neo-Classical theory of capital, and therefore falls with it when the criticisms to that theory are accepted (see, among others, Garegnani 1978; Pasinetti 2000; Petri 2004).

The objections to the Neo-Classical notions of capital are also important because they call into question the very existence of that "natural equilibrium" on which the mainstream macroeconomic analysis and the related monetary policy rules are based. This theoretical implication is also useful for interpreting our empirical analysis. Previously we noticed that the empirical applications of the conventional rules of monetary policy usually set the trend of GDP target in ways that can seem somewhat arbitrary: Woodford (2012), for example, determines the nominal GDP target on the basis of the log-linear trend obtained from 1999Q1 to 2013Q3 by applying the ordinary-least-squares method to the data of nominal GDP from 1999Q1 to 2008Q3, e.g. from the birth of the European single currency to the start of the Great Recession. For the mainstream approach this method of determining the GDP target can result quite embarrassing, given that the reference to the theoretical concept of "natural equilibrium" seems rather evanescent, to say the least. This problem, however, does not apply to the members of the schools of critical thought, which reject the concept of "natural equilibrium" and therefore do not need to refer to it to interpret monetary policy rules and their empirical applications. These schools conceive the "equilibrium" as the political-institutional result of a contest between opposing social forces (Brancaccio 2009). This alternative view also allows to interpret the way in which the GDP target can be determined for what it is: a mere convention, perhaps the result of a political balance.

On the basis of these theoretical arguments, the critical schools of thought also challenge the simplistic argument that the central bank has the role of stabilizing inflation, real GDP or nominal income around a certain equilibrium level. These studies rule out that the central bank has direct control over these variables. They rather suggest that the monetary authorities follow a more complex scope, which is to manage liquidity and interest rates in order to regulate the financial system, with specific reference to the relations between creditors and debtors and the related solvency of economic units. Although some of its aspects are also present in mainstream analyses (Agénor and Pereira da Silva 2012; Stein 2012; Buiter 2012), this interpretation of monetary policy has been developed mainly in the field of critical schools of thought, with particular reference to the studies inspired by the Radcliffe Report (Kaldor 1960, 1982) and some leading contributions in the Post-Keynesian literature (Davidson 1982; Minsky 1986, 1992; see also Argitis 2013; Girón and Chapoy 2013; Palacio Vera 2001, among others). It should be clarified that this alternative view of monetary policy does not exclude the possibility that the central bank, acting on liquidity and interest rates, will affect the performance of the GDP. However, the link between these variables is much more complex than envisioned by mainstream analysis: for example, movements in interest rates, impacting on the relationship between creditors and debtors and more generally on income distribution, can affect the dynamics of aggregate demand and GDP (Docherty 2012). But this is a very indirect and tortuous link, which can easily escape the empirical analyses, as has just happened in the case of our tests. At the same time, the alternative view admits that the central bank can set the interest rates in the light of the dynamics of GDP in order to prevent financial instability: for example, a recession may have a dramatic impact on the relationships between creditors and debtors, which can make necessary a reduction in interest rates in order to avoid a proliferation of bankruptcies; and it is interesting to note that in this different theoretical context, there is no need to assume that in order to pursue its objective the central bank has to define a GDP target in terms of "natural equilibrium". All these features make the alternative interpretation once again in line with our empirical results.

If this general alternative conception of the role of the central bank is accepted, then it is also possible to summarize it in a specific monetary policy rule: that is, a specific, formalized assumption on the actual behaviour of central bankers. In this perspective, it appears possible to interpret the results obtained in this paper in the light of the so-called “solvency rule” puts forward by Brancaccio and Fontana (2013), whereby the monetary authority decides on the levels of the interest rate in relation to the deviation of inflation, production or nominal GDP from their respective target rates. The solvency rule is drawn from a model that rules out the possibility of manoeuvres of the central bank on the interest rate directly controlling fluctuations of inflation, production or nominal GDP. This rule insists rather on the fact that by acting on interest rates, the monetary authority can influence the amount of the sums that debtors must repay to creditors in every single period, and thereby affect the average solvency conditions of the economic system. In phases of economic expansion, characterized by rising aggregate expenditure, nominal GDP, production and inflation, the solvency of debtors improves and the central bank can set comparatively higher interest rates. Conversely, in phases of depression, when aggregate demand and nominal GDP decrease, the probability of defaults increases and the maintenance of average solvency may need a reduction of interest rates. If this reduction does not occur, it is reasonable to expect an increase in bankruptcies of weaker and insolvent capitals and acquisitions by stronger and solvent capitals. This means, among other things, that the central bank, adjusting interest rates on the basis of the performance of GDP, is also able to regulate the pace of defaults and thus the related processes of merger, acquisition and “centralization” of capital in Marxian terms, both within a nation and between different nations (Brancaccio and Fontana 2015; on the concept of centralization, and more generally of “concentration of economic power”, see also Wray 2009). In support of this interpretation of monetary policy it can also be noted that there is a significant relation between nominal GDP and non-performing loans (NPL), which can be seen as a confirmation of the thesis that changes in nominal GDP affect the solvency of economic units.[4]

At this point it should be clear why an alternative interpretation of the monetary policy summarized in the solvency rule appears to be more in line with the empirical results of this work. Unlike the conventional rules of monetary policy, the view on the effective role of central bank based on the solvency rule does not require that the movements in interest rates will in turn affect the dynamics of nominal GDP. The validity of the solvency rule requires only the confirmation of the causal relationship running from nominal GDP to interest rate, which is exactly the only one that has been confirmed by our empirical analyses. Then, the solvency rule appears to be consistent with the empirical results of this paper while the nominal GDP targeting rule and other rules of conventional monetary policy are not.

Obviously, any attempt to reduce a general alternative interpretation of the functions of the central bank to a mere formalized monetary policy rule determines an inevitable trivialization of reality. It may be noted, for example, that in fact an “easy money” policy which reduces interest rates is not in itself a sufficient condition for solvency (Davidson 2008). More generally, it seems to us that if not taken critically, any attempt to reduce the behaviour of central bankers to mere monetary policy rules is likely to give a hand to a broad conception of the functioning of the economic system based on a banal idea of “equilibrium”, which *a priori* tends to exclude a study of the real processes of cumulative causation and “evolution” (for a distinction between equilibrium and evolution, see Kregel 2011). Therefore, the fact that the solvency rule appears to be consistent with the empirical results of this paper while the nominal GDP targeting rule or other rules of conventional monetary policy are not, does not necessarily mean that our analysis has been able to identify the actual, specific rule of conduct of the ECB or other central bankers. Rather, the empirical results of this study should be interpreted more broadly, in the sense that they seem to be in line with a general alternative interpretation of monetary policy which suggests that central bankers actually follow a different scope than the one that emerges from mainstream analyses: that is to say, not so much the neutral management of the business cycle around a hypothetical "natural equilibrium" but rather the political regulation of financial system with particular reference to the relations between creditors and debtors, the related solvency of economic units and consequent processes of merger, acquisition and centralization of capital (Brancaccio and Fontana 2013, 2015); where "political regulation" is to be understood in the sense that the monetary authority is always in front of a choice: it could manage liquidity and interest rates in order to ensure the solvency of weaker economic units and even to pursue the "euthanasia of the rentier" (Wray 2007), or conversely it can move towards a monetary policy that favors the bankruptcies of weaker capitals and centralization in favor of the strongest, and in more general terms to pursue the interests of rentiers. After all, it is exactly in this general sense that the solvency rule has been conceived by its designers, and is in the same sense that the empirical support to the solvency rule that seem to emerge from this work should in our view be interpreted.

**…..**

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Figure 1: Series of the levels and first differences of *gdp_dev* and *imr*

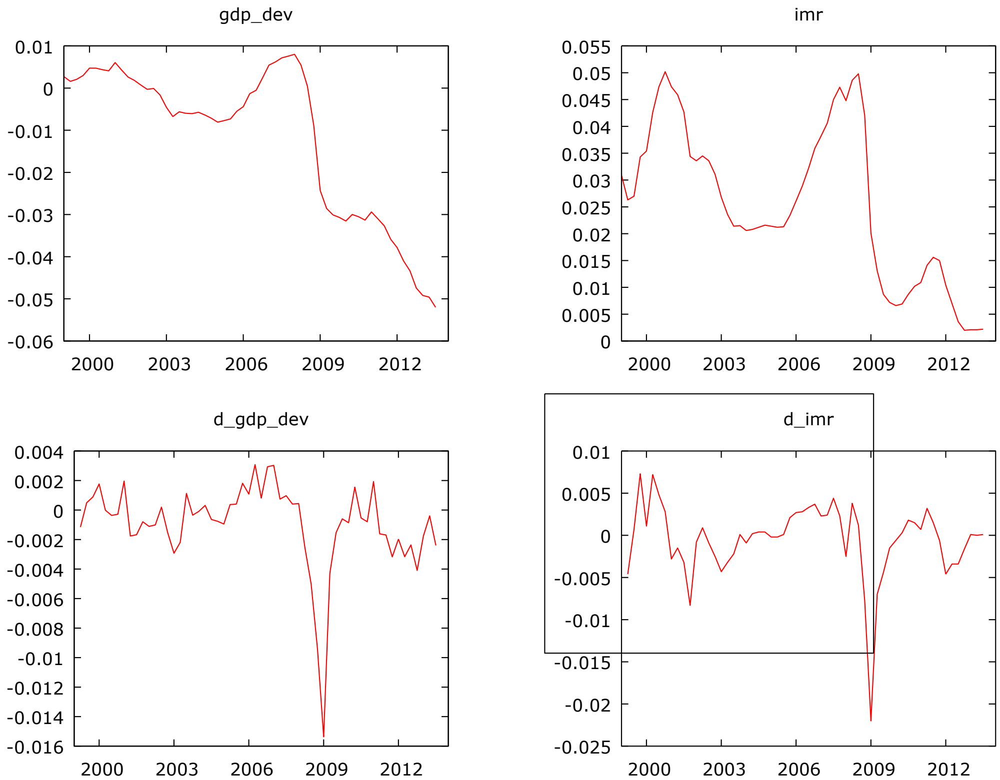

Table 1: Unit roots test of the series in levels

| Variables | Lags | ADF Test (test statistic)[a] | KPSS Test (test statistic)[b] | PP Test (test statistic)[c] | Results |
|---|---|---|---|---|---|
| **gdp_dev** | 2 | -2.12 | 0.26 | -1.24 | **I(1)** |
| **imr** | 2 | -3.13 | 0.23 | -2.02 | **I(1)** |

*Note:* It was chosen for both series a model with trend and constant that both resulted significant on performing an OLS regression on the *imr* and *gdp_dev*.[a] The critical value for both series at the 5% level of significance is equal to -3.49 and at the 1% level of significance is equal to -4.13. [b] The critical value for both series is equal to 0.14 at the 5% level of significance and it is equal to 0.21 at the 1%level of significance.[c] The critical value for both series is equal to-3.49 at the 5% level of significance and it is equal to
-4.13 at the 1% level of significance.

Table 2: Unit roots test of the series in first differences

| Variables | Lags | ADF Test (test statistic)[a] | KPSS Test (test statistic)[b] | PP Test (test statistic)[c] | Results |
|---|---|---|---|---|---|
| **d. gdp_dev** | 1 | -3.22 | 0.35 | -3.42 | **I(0)** |
| **d.imr** | 1 | -3.87 | 0.12 | -4.15 | **I(0)** |

*Note:* [a] The critical value for both series is equal to -2.91 at the 5% level of significance and it is equal to-3.55 at the 1% level of significance.[b] The critical value for both series is equal to 0.47 at the 5% level of significance and it is equal to 0.72 at the 1% level of siginificance. [c] The critical value for both series is equal to -2.91 at the 5% level of significance and it is equal to -3.55 at the 1% level of significance.

Table 3: Johansen cointegration test (series in levels)

| **Variables** | **Lags** | $\mathbf{H_0}$ | $\boldsymbol{\lambda_{trace}}$ **Stat.** | $\boldsymbol{\lambda_{max}}$ **Stat.** | **Results** |
|---|---|---|---|---|---|
| **imr, gdp_dev** | **2** | **r=0** | 13.16 (0.108)[a] | 12.75 (0.1) | **NOT COINTEGRATED** |

*Note:* **[a]** The *p-values* are shown in brackets.

Table 4: Results of the estimation of the VAR model

| | $\Delta_{\mathbf{imr}_\mathbf{t}}$ | $\Delta_{\mathbf{gdp\_dev}_\mathbf{t}}$ |
|---|---|---|
| $\Delta_{\mathbf{imr}_{\mathbf{t-1}}}$ | 0.29** | 0.062 |
| | (0.1217) | (0.0743) |
| $\Delta_{\mathbf{gdp\_dev}_{\mathbf{t-1}}}$ | 0.36* | 0.35*** |
| | (0.1956) | (0.1194) |
| **dum1** | -0.01*** | -0.009*** |
| | (0.002) | (0.0013) |
| **$R^2$adjusted** | 0.64 | 0.73 |
| **AIC** | -19.08 | |
| **BIC** | -18.86 | |
| **HQC** | -18.99 | |
| **ARCH Test** | First eq. | Second eq. |
| **Ljung-Box Q' Test** | 0.44 | 0.82 |
| | First eq. | Second eq. |
| | 0.32 | 0.40 |

*Notes*: The standard errors are shown in brackets. (*), (**), (***) respectively indicate significance at 10%, 5% and 1%. The dummy (dum1) inserted regards the trimesters 2008Q4–2009Q1.

Table 5: Granger causality test

| **Variables** | **Optimal Lags[a]** **(p.value)** | **2 Lags** **(p.value)** | **3 Lags** **(p.value)** | **4 Lags** **(p.value)** |
|---|---|---|---|---|
| $\Delta_{gdp\_dev_t}$- >$\Delta_{imr_t}$ | 0*** | 0*** | 0.005*** | 0.0012*** |
| $\Delta_{imr_t}$->$\Delta_{gdp\_dev_t}$ | 0.36 | 0.10 | 0.204 | 0.32 |

*Note:* Ho: No Granger-causality. **[a]** The information criteria of Akaike (AIC), Schwartz Bayesian (BIC) and Hannan-Quinn (HQC) were used to select the optimal number lag that is equal to one. (*), (**), (***) respectively indicate significance at the 10%, 5% and 1% level.

[1] The series of nominal GDP expressed in millions of euros is taken from the Eurostat database at current prices and seasonally adjusted by means of the X-12 ARIMA procedure.

[2] The absence of autocorrelation is also confirmed by the Pormanteau test.

[3] The normality of the residuals is confirmed by the Jarque-Bera test.

[4] By adopting an approach in line with the analysis conducted within our paper, we can test the following equation: 〖dNPL〗t=a+〖dlGDPN〗t, where NPL (bank non-performing loans) are the value of non-performing loans divided by the total value of the loans drawn from World Bank database and the GDPN is the nominal GDP drawn from Eurostat database. In the equation the nominal GDP growth rate, dlGDPN, is regressed on the variation in the bank non-performing loans, dNPL. The sample used regards the Euro Area and it relates to the period from 1999 to 2013, i.e. from the birth of the single currency to the beginning of the Great Recession. The finding of this analysis is that bank non-performing loans significantly change over time in relation with business cycle conditions and more specifically they increase during the so-called great recession. Changes in economic activity are then related to the quality of loans: worse economic conditions correspond to a higher percentage of bank non-performing loans. A 10% decrease in the growth rate of nominal GDP is related, in average, to a bank non-performing loans increase of around 0.21 points at 1% level of significance. These results seem also to be supported by the correlation analysis: variations in bank non-performing loans are negatively related to nominal GDP growth rate - (corr dNPL dlGDPN)=-0.68. Both analyses suggest that nominal GDP may be considered as a proxy of bank non-performing loans in the Euro Area for the period between 1999-2013. Therefore, albeit in first approximation, the causal relationship going from nominal GDP to interest rate on which the solvency rule is based can also be interpreted as an indirect relationship between non-performing loans and interest rate: a decrease in nominal GDP corresponds to an increase in NPL and then pushes the central bank to reduce interest rates in order to limit bankruptcies, and vice versa.