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THE TAYLOR RULE AS A BENCHMARK FOR ECB INTEREST RATE SETTING

Master's thesis

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Tallinn 2014

I hereby declare that I have written the master's thesis independently.
All works and opinions of other authors, as well as any data from other sources used in writing this paper have been referenced.

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ABSTRACT

The European Central Bank (ECB) is conducting monetary policy based on area wide aggregate indicators and sets interest rates that are common for all currency area countries. Despite the harmonized monetary policy and convergence criteria the countries have met while joining the euro zone, there has been increased heterogeneity in the financial and economic conditions of the countries in the recent years.

The thesis seeks to identify by means of applying the Taylor rule if the rate set by ECB is appropriate for the euro area as a whole and for the individual countries as well. The overview of empirical research on different compositions and periods of the Euro area countries establishes that the Taylor principle holds and generally the ECB interest rate tends to be in line with the area wide indicators while favouring core countries.

The author's empirical research extends the period up to year 2013 to grasp the entire span of the Euro, including also the period following the financial crisis of 2008. The main finding is that the ECB rate is consistently too low for both the euro area and the individual countries. The rate setting is driven by inflation and output gap is rejected as a not relevant variable. The large inflation deviation from the area wide indicator makes the ECB rate extremely low for the late joiners of the euro zone, while the rate is more appropriate for the core countries which give more than 70% of the nominal GDP of the currency area.

Keywords: Taylor rule, ECB, policy rule, inflation targeting, monetary policy, interest rate setting, central bank

JEL codes: E42, E43, E52, E58

INTRODUCTION

The single most important objective of the European Central Bank is to conduct the monetary policy in a manner that would maintain price stability, adding onto that are the objectives of full employment and balanced economic growth as stated in the Maastricht Treaty. Hence, the price stability which is translated into an annual inflation rate of close to but not above 2% is the key objective.

By entering a monetary union, the member states have relinquished their authority to conduct a monetary policy of their own, where they would be able to respond directly to country-specific indicators. The nations have had a solid history of economic convergence evidenced by adhering to the convergence criteria at the time of adopting the Euro, but the changing composition of the single currency area and external shocks have not smoothed out the differences. Despite the unilateral objective, the 18 countries that currently use Euro as their legal tender out of the 28 member states hold vastly different positions in terms of unemployment, inflation and GDP.

To illustrate the scale of differences, already the key tables in the Eurostat database suffice. The unemployment rate of 2013 for the Euro area is 12%, with the lowest in Austria 4.9%)and highest in Greece 27%. The inflation level for 2013 is an average of 1.5% for the Euro area, with the lowest deflationary rate of -0.9% in Greece and highest in Estonia 3.2%. Lastly, of the total nominal GDP of euro zone Germany makes up 28%, followed by France with 21%. The tiniest country is intuitively Malta with its contribution of 0.07% to the GDP, followed by Estonia with 0.20%.

The Euro and consequently common monetary policy is highlighted by the European Union as “the most tangible proof of European integration” (European Union, 2014). However, the large differences in key economic indicators of the countries would make the application of a common monetary policy at least difficult if not risky. Conducting of open market operations, offering of standing facilities and setting minimum reserve requirements for credit institutions are the monetary policy tools that lay the foundation for all the single currency area countries.

Within the described framework, the thesis seeks to analyze the ECB short term interest rate, by way of applying the Taylor rule, a simple policy rule, used as a benchmark by both academics and bankers. The aim is to identify the differences between the actual rate and a Taylor rule rate first for the entire Euro area and then compare the area wide rate to hypothetical individual country rates. Bearing in mind the differences in key economic indicators, a justified expectation exists that the ECB rate may not be suitable to all countries and may differ greatly from the rates of some countries, that in turn deviate significantly from area wide aggregate indicators.

The first chapter of the thesis aims to set theoretical foundations of the role of a central bank, focusing on the targets it sets and the instruments it has to pursue these targets. Some insight is provided into the analytical tools the bank uses to determine variables or parameters for the instruments. Also, the link between bank actions and targets, otherwise known as the monetary transmission mechanism is briefly described. Building on the theory of monetary policy, the Taylor rule is then introduced.

While turning to the empirical pieces on the Taylor rule, it can be seen that the rule can be found useful in answering very different questions. The thesis is however restricted to the area of interest - on the largest scale, the aim is to find sufficient evidence that the Taylor rule can be used analyze the ECB actions, e.g. to answer the question if the Taylor Rule is applicable to the euro area at all. Secondly and more importantly the thesis seeks to identify evidence from the empirical pieces that pose a question if the ECB interest rate serves all countries equally if the ECB has achieved the aforementioned goal. The countries are of very different economic health, but the monetary policy is applied unilaterally. This has been of interest for many researchers in the field and different combinations of time periods and compositions of the euro area have been tested by way of applying the Taylor rule.

Based on the theoretical foundations and empirical works, an analysis is carried out with the aim of validating the ECB interest rate applicability to the Euro area composition as it is today. Country specific rates and deviations are then explored with the aim of answering the question – if and to what is extent is the ECB interest rate appropriate to individual countries?

1. THEORY OF INTEREST RATE SETTING

The first chapter of the thesis focuses firstly on the key theoretical aspects of the role of a central bank and then turns to inflation targeting by way of setting short term nominal interest rate. Then a famous policy rule named Taylor rule is discussed. The chapter concludes with modifications of the Taylor rule and connections of the rule and how interest rate setting is viewed by a central bank.

1.1. Role of the Central Bank

1.1.1. Monetary Policy

Central Banks of today have come a long way in terms of their role and functions they are expected to perform. Goodhart (1995) describes that the first central banks were established by the government of the day in a position as the main commercial bank in the country, with special privileges provided to them – for example the privilege of the note issue in certain areas.

During the different currency regimes and political events of the 20th century, the remit of the banks as they carry out today has slowly evolved. The central banks are institutions conducting monetary policy and on aggregate level two schools of monetary thought can be identified. Firstly, the central bank can have as its main tool the growth of money supply, more specifically the level or growth of money supply. Secondly, the tool can be short term interest rate, which is used to keep a target price level and instilling a sense of stability in the economy. To identify between these two paradigms, the following features apply (Carlin, Soskice, 2006, p. 27):

1. The money supply can be characterized by the following:
    a. the ultimate determinant of the price level and rate of inflation is the money supply;
    b. the instrument of monetary policy is money supply;

c. the mechanism through which the economy adjusts to a new equilibrium with constant inflation flowing a shock is that embodied in the IS/LM model plus the inertia-augmented (or expectations augmented) Phillips curve

2. The interest rate reaction function or MR paradigm can be characterized by the following:
   a. the ultimate determinant of the price level and rate of inflation is policy;
   b. the instrument of monetary policy is the short term interest rate;
   c. the mechanism through which the economy adjusts to a new equilibrium with constant inflation following a shock is encapsulated in an interest rate rule.

In the 1970s and 1980s, the dominant school of monetarists argued that domestic monetary policy should be more directly aimed at the achievement of internal price stability, through the adoption of rules and pre-commitment to the achievement of a certain, declining monetary growth path. Thus, the new policy programme was based on the view that there existed a limited number of key stable medium or long-term relationships within the economy (Goodhart, 1995, p.214):

- There was a natural rate of unemployment, to which the economy would revert;
- The nominal exchange rates would adjust quite sensitively to relate domestic purchasing power (PPP); and
- That the relationship between growth of some (preferred) monetary aggregate and nominal incomes (ultimately prices), would remain stable.

Given such long-term stable relationships, and the ability of rational agents, operating in efficient markets, to predict the way that the economy would revert to such long-term equilibrium states, the role of the Central Bank was clearly to establish the rule for monetary growth which would allow for the medium-run attainment of price stability. Controversially, the long-term equilibrium conditions, to which the system was supposed to revert, have tended to fall apart. Velocity has proven unstable, even in the medium-term; exchange rates have been misaligned, remaining far from their PPP equilibrium by considerable margins, and over long periods, in a way that has caused great industrial disruption. In particular, the breakdown of the stability of the velocity of money, of the relationship between money and nominal incomes, has undermined the rationale for the continuing adoption of publicly-announced monetary targets. In this context, currently the prime objective for which the

Central Banks adjust their discretionary instrument, notably their command over short-term interest rates, remains the control and limitation of inflation. (Goodhart, 1995, p. 214)

Central banks have in their disposal several instruments, which can be used to conduct the monetary policy. From the two schools of thought came the short term interest rate and money supply, additionally a central bank is setting reserve requirements. Furthermore, a significant characteristic of the central bank is its independence. According to Mishkin (2007, p. 393) two types of independence of central banks can be identified:

- Instrument independence, the ability of the central bank to set the goals of monetary policy instruments;
- Goal independence, the ability of the central bank to set goals of monetary policy.

The strongest argument for an independent bank is the political business cycle, in which just before an election, expansionary policies are pursued to lower unemployment and interest rates. After the election, the bad effects of these policies – high inflation and high interest rates – come home to roost, requiring contractionary policies that politicians hope the public will forget before the next election. Controversially, it is undemocratic to have monetary policy (which affects almost everyone in the economy) controlled by an elite group that is responsible to no one. The public holds [politicians] responsible for the economic well-being of the country, yet they lack control over that specific government agency that may well be the most important factor in determining the health of the economy. In addition, to achieve a cohesive program that will promote economic stability, monetary policy must be coordinated with fiscal policy (management of government spending and taxation). Only by placing monetary policy under the control of the politicians who also control fiscal policy can these two policies be prevented from working at cross-purposes. (Mishkin, 2007, p. 401)

1.1.2. Economic Implications

Central Bank is an institution whose sets base interest rate, is responsible for the amount of credit available and regulates money supply. These tools have a direct impact on financial markets and hence the economy in its entirety, which conveys also to output and inflation. As seen from Figure 1, the inflation targeting central bank causes a chain-reaction in the economy by means of setting an interest rate in response to inflation. The impact is in the short and medium term carried forward to aggregate supply and also employment.

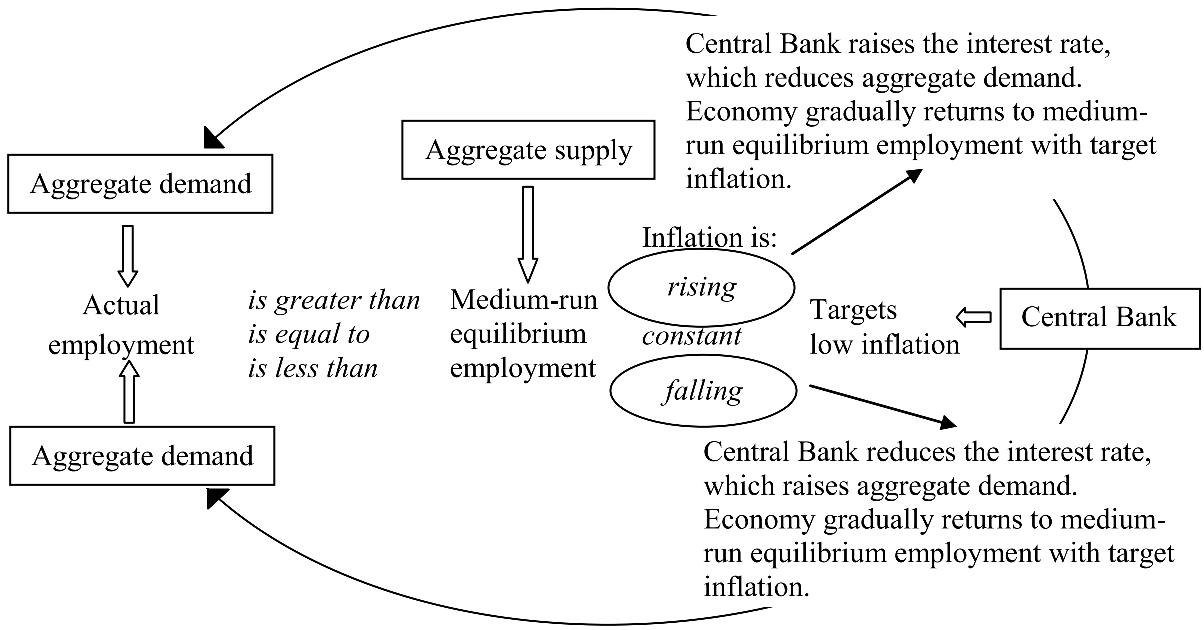

Figure 1. Schematic view of the short- and medium-run model. Reference: (Carlin, Soskice 2006, 12).

Regarding the instrument rate itself, the repurchase rate or open market operations rate, then according to Smith (2006b) the short term rates such as bank rates on loans or deposits move in the same way as the central bank rate. Additionally Smith (2006b) points out that the long term rates can move either way, being influenced by expectations, as well as central bank credibility and transparency.

Boivin (et al 2010) correspondingly discusses that with the monetary policy instrument being a short-term interest rate, then the monetary transmission mechanism involves the link between short and long-term interest rates through some version of the expectations hypothesis of the term structure. They are of the opinion that when monetary policy raises short-term interest rates, long-term interest rates also tend to rise because they are linked to future short-term rates; consequently the user cost of capital rises and the demand for capital asset falls. Boivin (et al 2010) conclude that the decline in the demand for the capital asset leads to lower spending on investment in these assets, and so causes aggregate spending and demand to decline.

The question on how and when the central bank instruments have an impact on the economy can be explained by the concept of monetary transmission mechanism. The way a policy instrument is transmitted to actual economic activity may be different for different agents in the economy and vary in timing. Furthermore the transmission is impacted by various conditions, such as business cycles or unexpected events such as shocks.

The direct targeting of inflation involves a number of problems - the presence of long and variable lags, slow response/adjustment processes within the economic system. In a world without lags, where nominal incomes and expenditures reacted instantaneously to movements in interest rates and where inflation reacted instantaneously to the pressure of demand, monetary policy would be vastly easier. Even in the face of stochastic drifts in economic relationships, the instantaneous nature of relationships would enable the authorities to adjust their policy response quite closely to immediate needs. The main problems are caused by the interaction of uncertainty about, and stochastic shifts in, the underlying relationships and the long and variable lags. (Goodhart, 1995, p.224).

The transmission mechanism is a large area of research and according to Svensson (1999) monetary policy affects the exchange rate and the CPI (inflation) in the current period, aggregate demand in one period and domestic inflation in two periods. Complementing the lag with the concept that high inflation is costly will make the central bankers want to forecast accurately and hence avoid high inflation.

Pre-emption refers to the idea that policymakers achieve better results when they act in advance to forestall developing problems. Early action works best both because monetary policy works with a lag and because developing problems (such as rising inflation) may often be defused at lower cost in their early stages. In principle, simple feedback policies are not inconsistent with a pre-emptive approach; however, to the extent that each episode has unique features, more information than can be captured in a simple feedback policy may be needed to deal effectively with emerging issues. (Bernanke 2004)

Taylor and Williams (2010) summarize central bank decision making impact on the economy as the central bank loss function:

$$L = E\{(\pi - \pi^*)^2 + \lambda y^2 v (i - i^*)^2\} \tag{1}$$

where

E – the mathematical unconditional expectation

$\lambda, \upsilon \geq 0$ – parameters, describing the central bank's preferences

The first term represents the welfare costs associated from nominal and real fluctuations from desired levels. The second term stands for the welfare costs associated with large swings in interest rates (and presumably other asset prices). The quadratic terms, especially those involving inflation and output represent the common sense view that business cycle fluctuations and high or variable inflation and interest rates are undesirable, but these can also be derived as approximations of welfare functions of representative agents. The central bank's problem is to choose the parameters of a policy rule to minimize the expected central bank loss subject to the constraints imposed by the model. (Taylor, Williams 2010)

Svensson (1999) argues that inflation targeting can be described as creating mechanisms for commitment to a stable loss function, with transparency about the loss function and the decision framework as crucial ingredients. His view is supported by the facts that the loss function is relatively explicit, because the decision framework under inflation targeting, inflation-forecast targeting, can be interpreted as a way of ensuring that first-order conditions for a minimum of the loss function are (approximately) fulfilled, and because the high degree of transparency and accountability associated with inflation targeting allows outsiders to monitor that those first-order conditions are fulfilled. He concludes that this creates stronger incentives for the central bank not to deviate from minimizing the relatively explicit loss function than in other monetary policy regimes.

Despite the stability that inflation targeting may create this may not translate unilaterally other economic indicators. Mishkin (2007, p. 402) points out that when central banks are ranked form least independent to most independent, inflation performance is found to be the best for countries, with the most independent central banks. However, he notes that although a more independent central bank appears to lead to a lower inflation rate, this is not achieved at the expense of poorer real economic performance. Conclusively, countries with independent central banks are no more likely to have high unemployment or greater output fluctuations than countries with less independent central banks.

The greater emphasis on inflation stabilization is likely to lead to greater stability in inflation but not necessarily in output, as a focus on price stability will accommodate increases in output reflecting productivity advances and resist such movements due to fluctuations in risk premium or some other demand factors. The subtle difference between overall output stability and stability in output around an efficient level – i.e. the notion that policy makers should design policy so as to accommodate productivity movements while resisting inefficient movements due to risk premium – has also represented an important evolution in understanding regarding how the monetary transmission mechanism should be used to promote price stability. (Boivin et al 2010)

1.2. The Taylor Rule

1.2.1. Context and Original Specification of Taylor rule

According to Taylor and Williams (2010) monetary policy rules have been around since Adam Smith touched upon the concept that "a well-regulated-paper-money" could have significant advantages in improving economic growth and stability. Events such as the Great Depression and the Great Inflation have lead economists to search for a monetary policy tool that would instil a greater sense of stability and prevent such economically dramatic periods from occurring.

A significant change in economists' search for simple monetary policy rules occurred in the 1970s as a new type of macroeconomic model appeared on the scene. The new models were dynamic, stochastic, and empirically estimated. But more important, these empirical models incorporated both rational expectations and sticky prices, and they therefore were sophisticated enough to serve as a laboratory to examine how monetary policy rules would work in practice. These were the models that were used to find new policy rules, such as the Taylor Rule, to compare the new rules with earlier constant growth rate rules or with actual policy, and to check the rules for robustness. (Taylor, Williams 2010)

The Taylor rule is a famous policy guideline. It is useful to compare inflation forecast targeting and the Taylor rule as two different policy descriptions/prescriptions. The Taylor rule was designed to provide 'recommendations' for how a central bank should set short-term interest rates to achieve both it short-run goal for stabilizing the economy and its long-run goal for inflation. (Smith, 2006) In its essence the Taylor rule is an instrument rule, which means that it is a formula for setting a value for an instrument in response to variables used in the equation. It is important to distinguish an instrument rule and a policy reaction function, the former a narrower and latter a broader element of monetary policy. Throughout academic literature these two concepts may have slightly different interpretations, but it is useful to bear in mind that (Gerlach-Kristen 2003):

- For central bank purposes, empirical reaction functions illustrate how, given economic conditions, interest rates were set in the past, which may provide background information for future policy decisions.
- From an academic perspective, reaction functions are attractive because they capture the main considerations underlying a central bank's interest rate setting.

The original Taylor rule as proposed by Taylor (1993) is based on the assumption of both the equilibrium real interest rate and the inflation target having a value of 2 per cent. He defined the trend of GDP at 2.2 percent per annum based on data from 1984.1 through 1992.3. In his calculations Taylor used quarterly data, specifically a moving average over four quarters to eliminate the impact of temporary price fluctuations. The equation to determine the short term interest rate is as follows (Taylor, 1993):

$$r = p + 0.5y + 0.5(p - 2) + 2 \quad (2)$$

where

r – the federal funds rate,

p – the inflation over the previous four quarters,

y – the percent deviation of real GDP from a target.

By rearranging terms in the equation above, the Taylor Rule stipulates that the short term interest rate should have a response coefficient of 1.5 times for inflation, 0.5 response coefficient to output deviation and plus one. If the inflation is equal to the target and there is no output gap, then the short term interest rate is a sum of the equilibrium interest rate and the inflation target.

The Taylor rule was able to describe the Federal Reserve behaviour in setting the nominal interest rate for the years of 1987-1992. The period under review also contained one exception, the year 1987, when Fed lowered interest rates in response to a crash in the stock market. However, for the remainder of the research period Taylor (1993) displays that the Fed's rate could be determined by the abovementioned equation as if the Fed was reacting to changes in the current output gap and inflation.

Taylor (1998b) clarifies that the equation was not fitted to the data in the sense of a regression, but it described actual Fed behaviour fairly well and further suggests that one could get a better fit of the equation using regression techniques, especially if one used lagged variables and added more terms, but the equation was meant to be a normative recommendation of what the interest rate should be, a recommendation that Federal Reserve officials could use to help formulate policy. Taylor (1998b) summarizes that the discrepancies between the equation and reality could be a measure of discretion, either for good or bad.

With the aim of further exploring the applicability of the Taylor (1993) rule, Taylor (1998b) examines a longer history of monetary policy, a period from 1879 to 1914 and a later period from 1955 to 1997. Due to different exchange rate eras, the Federal Reserve's actions have been vastly different. He bases the discussion on deriving the monetary policy rule from the quantity equation of money, drawing attention to the facts that he has not neglected the concept of money growth and that one of the assumptions to Taylor (1993) rule is constant or fixed money growth. Hence Taylor (1998b) starts with the quantity equation of money:

$$M \times V = P \times Y \tag{3}$$

where

M – the stock of money,

V – the velocity,

P – the price level,

Y – the real output.

Building on the assumption that money supply is either fixed or growing at a constant rate and in parallel considering that velocity is dependent on interest rate (r) and on real output (Y) Taylor (1998b) then substitutes V in the quantity equation and gets a relationship between interest rate (r), the price level (P) and real output (Y). After having established the connection between money supply, he arrives at an equation by rearranging the variables:

$$r = \pi + gy + h(\pi - \pi^*) + r^f \tag{4}$$

where

r – the short term interest rate (linear),

π – the inflation rate or percent change in P (logarithm),

y – the percentage deviation of real output (Y) from a target (logarithm).

This large revision of the applicability of the rule lead Taylor (1998b) to note that regarding the coefficients g and h, as opposed to the original specification of the rule by Taylor (1993), it would be useful to increase the coefficient g to closer to a value of 1.0 and keeping coefficient h at the value of 0.5 to arrive at a more procyclical interest rate.

With a policy that keeps the growth rate of the money stock constant, the response of the interest rate to an increase in real output will depend on both the income elasticity of money demand and the interest rate elasticity of money demand. The higher the interest rate elasticity of money demand (or velocity) the smaller would be the response of interest rates to an increase in output or inflation. The size of these coefficients make a big difference for the effects of the policy. Simulations of economic models indicate for example, that the coefficient (h) should not be negative; otherwise 1+h will be less than one and the real interest rate would fall rather than rise when inflation rises. As a result inflation could be highly volatile. (Taylor 1998b).

However, after further research Taylor (2013) cautions to have the coefficient on output gap smaller, as the deviation of real GDP from potential GDP is difficult to measure and a good policy would suggest smaller weight on the gap because of measurement error. Additionally he refers to further studies on the coefficient, proposing the size of the coefficient should decline by a specific amount with the amount of uncertainty.

The Taylor rule embodies two important characteristics of monetary policy rules that are effective at stabilizing inflation and the output gap in model simulations. First, it dictates that the nominal interest rate react by more than one-for-one to movements in the inflation rate. In most existing macroeconomic models, this condition must be met for a unique stable rational expectations to exist. The basic logic behind this principle is clear: when inflation rises, monetary policy needs to raise the real interest rate in order to slow the economy and reduce inflationary pressures. The second important characteristic is that monetary policy "leans against the wind", that is it reacts by increasing the interest rate by a particular amount when real GDP rises above potential GDP and by decreasing the interest rate by the same amount when real GDP falls below potential GDP. In this way, monetary policy speeds the economy's progress back to the target rate of inflation and the potential level of output. (Taylor, Williams 2010).

The response coefficient is considered significant also by further research into the Taylor rule, for instance Fourçans and Vranceanu (2007) stress that the coefficient on inflation especially is crucial within the framework of simple macroeconomic dynamic models. They reiterate that when a shock pushes inflation above the target, the central bank increases its interest rate according to the policy rule. They imply the foundations of a Taylor principle, stating that if $\beta < 1$, the increase is not strong enough to bring about a higher real interest rate, investment and demand are kept strong, and via some Phillips curve mechanism, inflation is further enhanced. Fourçans and Vranceanu (2007) conclude that on the other hand, if $\beta > 1$, the strong response of the central bank tempers demand and inflation.

In addition to the relevance of the size of the response coefficients, it must be noted that better policy rules have three general characteristics (Taylor, Williams 2010):

1. An interest rate instrument performed better than a money supply instrument
2. Interest rate rules that reacted to both inflation and real output were better than rules which focused on either one
3. Interest rate rules, which reacted to the exchange rate were inferior to those that did not

Taylor (1993) takes great care to emphasize that a policy rule is not something mechanical that can be done purely by a computer and would therefore exclude all elements of judgement. Rather he favours the definitions where a policy rule is referred to as the "optimal", the "rules" or the "pre-committed" solution, respectively, to a dynamic optimization problem. Discretionary policy is referred to as the "inconsistent", the "cheating", or the "short-sighted" solution, respectively. Taylor (1993) is confident that literature demonstrates the advantage of rules over discretion being very similar to the advantage of a cooperative solution over a non-cooperative solution in the game theory.

As a true advocate of policy rules Taylor (1998b) states that monetary policy mistakes are in their essence deviations of actual short-term rates from a benchmark rule and can be measured quantitatively, conclusively the deviations can be associated with either high and prolonged inflation or drawn out periods of low capacity utilization, much as simple monetary theory would predict. A slightly softer interpretation is given by Smith (2006), reiterating that defenders of the Taylor rule say, that Taylor never meant it as a mechanical rule, but only as a guideline. Further she assures that according to Taylor policymakers are allowed to deviate from the rule, but would need to justify such deviations – policy could respond to other variables too, although inflation and output gap are the only ones policy should consistently respond too.

1.2.2. Modifications of Taylor Rule and Related Issues

As explained in the previous section the original specification of the Taylor Rule uses as input current inflation and current output deviation to set interest rate that will be valid from now and henceforth today's parameters will define the economic outcome of the future. Taylor's (1993) original research is an ex-post analysis of the Fed's behaviour. Some empirical works have tried to incorporate a forward-looking inflation rate and output gap into a Taylor rule with the aim responding to lags in transmission mechanism.

Taylor and Williams (2010) also agree that a key issue regarding the specification of simple rules is to what extent they should respond to expectations of future inflation and output gaps. They conclude, however, after investigating the optimal choice of lead structure in the policy rule in various models that no significant benefit is found from responding to expectations out further than one year for inflation or beyond the current quarter for the output gap.

Furthermore, Hayo (2006) points out that a significant issue with forward-looking and contemporaneous variables is the possible correlation with the error term, hence leading to inaccurate estimates of the coefficients of interest. Also, the error term may display non-normality, autocorrelation and heteroscedasticity, leading to problems with statistical estimation and inference.

Despite the challenges, researchers try to align their work with the thinking of a central bank, incorporating forward-looking terms. According to Fourçans and Vranceanu (2007) the basic interest rate rule incorporating future information on inflation would have the following format:

$$i_t^* = \bar{\imath} + \beta(E[\pi_{t+k}|I_t] - \bar{\pi}) + \gamma y_t \quad (5)$$

where

i_t^*	is the target interest rate,
E[]	is the expectations operator,
I_t	the information set at the time the interest rate is chosen (i.e. at time *t*),
π_{t+k}	the inflation rate *k* periods ahead,
$\bar{\pi}$	the target inflation rate,
y_t	the output gap,
$\bar{\imath}, \beta, \gamma$	given parameters.

In so called "contemporaneous" rules, k is set to zero; it is positive in "forward looking rules" and negative in "backward looking rules". Variables other than the inflation and the output gap, that may have a bearing on interest rate determination, could also be included in these types of rules. (Fourçans, Vranceanu 2007)

Another key issue for simple policy rules is the appropriate measure of inflation to include in the rule. Simple rules that respond to smoothed inflation rates such as the one-year rate typically perform better than those that respond to the one-quarter inflation rate, even though the objective is to stabilize the one-quarter rate. Evidently, rules that respond to a smoothed measure of inflation avoid sharp swings in interest rates in response to transitory swings in the inflation rate. (Taylor, Williams 2010)

Hence if the central banker is concerned by the fact that overly abrupt changes in interest rates may disrupt bond and equity markets, he would smooth changes in interest rates such as to reach the desired i_t^* after a more or less lengthy period. For instance, the effective interest rate chosen by the central bank, i_t , might follow the dynamics: $i_t = \rho i_{t-1} + (1-\rho)i_t^*$, with $\rho \in [0,1]$. In this case, the (effective) interest rate rule can be written

$$i_t = \rho i_{t-1} + (1-\rho)\{\bar{\iota} + \beta(E[\pi_{t+k}|I_t] - \bar{\pi}) + \gamma y_t\} \quad (6)$$

The coefficient $(1-\rho)$ may then be interpreted as a measure of the effective change in interest rate as compared to the desired change. (Fourçans, Vranceanu 2007)

Taylor and Williams (2010) also support the concept of the existence of policy inertia or "interest rate smoothing", saying that a high degree of inertia can significantly help improve performance in forward looking-models. Further they assure that inertial rules take advantage of the expectations of future policy and economic developments in influencing outcomes and contrast this to purely backward-looking models, where the channel is entirely absent and highly inertial policies perform poorly.

To conclude the list of issues to consider about Taylor rule, Taylor (1998b) brings out two further difficult problems with monetary policy rules, namely the fact that potential GDP and the real rate of interest are uncertain. He assures that uncertainty about the level of potential GDP (and the natural rate of unemployment) is a problem faced by monetary policy makers today regardless of whether they use a policy rule for guidance.

The "output gap" that one should seek to stabilize is the gap between actual output and the natural rate of output. This contrasts with the assumption made in Taylor's (1993) comparison between the proposed rule and actual U.S. policy, where the output gap is assumed to be measured by output relative to a deterministic trend. In theory, a wide variety of real shocks should affect the growth rate of potential output in the relevant sense; these include technology shocks, changes in attitudes toward labour supply, variations in government purchases, variation in households' impatience to consume, and variation in the productivity of currently available investment opportunities, and there is no reason to assume that all of these factors follow smooth trends. As a result, the output-gap measure that is relevant for welfare may be quite different from simple detrended output. (Woodford, 2001).

Further elaborating the problem with output, Peersman and Smets (1999) summarize that the impact of estimation error in the output gap is bound to have an impact on the efficient feedback parameters and overall performance of the Taylor rule. They build on research proving that indicators of capacity utilization such as the output gap are estimated with a considerable margin of uncertainty, especially for a currency area-wide value of such an indicator.

A final question about the Taylor rule is whether commitment to an interest-rate rule of this kind, incorporating no target path for any monetary aggregate, can serve to determine an equilibrium price level at all. It is sometimes argued that interest-rate rules as such are undesirable, as they lead to indeterminacy of the rational-expectations equilibrium price level. In fact, many simple optimizing models imply that Taylor rule incorporates feedback of a sort that suffices to ensure determinacy, owing to the dependence of the funds-rate operating target upon recent inflation and output-gap measures. Another argument against interest-rate rules with a venerable history asserts that targeting a nominal interest rate allows for unstable inflation dynamics when inflation expectations extrapolate recent inflation experience. The basic idea is that an increase in expected inflation, for whatever reason, leads to a lower perceived real interest rate, which stimulates demand. This generates higher inflation, increasing expected inflation still further and driving inflation higher in a self-fulfilling spiral. Even granting that the Taylor rule involves feedback of a kind that should tend to exclude instability due to purely self-fulfilling expectations, one must consider whether the equilibrium determined by such a policy is a desirable one. (Woodford, 2001)

1.2.3. Central Bank and the Taylor Rule

Taylor and Williams (2010) summarize that as the history of economic thought makes clear, a common purpose was a simple, stable monetary policy that would both avoid creating monetary shocks and, cushion the economy from other disturbances, and thereby reduce the chances of recession, depression, crisis, deflation, inflation, and hyperinflation. They further argue that some simple rule could improve policy by avoiding monetary excesses, whether related to money finance of deficits, commodity discoveries, gold outflows or mistakes of central bankers with too many objectives.

Among both academics and bankers there are advocates and adversaries of policy rules. To set aside the debate which variables best convey the dynamics of the present state and desirable future state of the economy, the discussion on rules can be roughly divided into two sub-sections. Firstly, the question of deviating from a policy rule is seen by advocates as central bank using discretion rather than honouring their commitment to pursue a rule. The adversaries interpret such a situation as the rule being unable to provide sound guidance during times of either turbulence or economic distress as these are generally the moments when the rule fails.

Secondly, the simplicity of the rule is the second cause of debate. Pro-policy rule thinkers value the simplicity, as according to their view it captures the essence of what a central bank should respond to. The number of variables and complexity of methods used has an inverse relationship to the output, while the probability of error is increasing, extreme fine tuning of the models may not work in favour of changing circumstances as well as the model being very difficult to communicate or explain to the general public. The adversaries of course are of the opposite opinion.

Peersman and Smets (1999) convey their criticism by saying that as a guide for monetary authorities the Taylor rule has two big disadvantages - first, it is too restrictive, as the number of variables in the feedback list is very limited and in general, there is no reason why central banks in the pursuit of price stability would not want to respond to other information, such as the exchange rate, other asset prices, money and credit aggregates, and so on. Secondly, Peersman and Smets (1999) stress that the instrument rules may not be robust to changes in the structure of the economy. Generally speaking, the efficient feedback coefficients will be complicated functions on the structural parameters of the model economy and the central bank's preferences. They conclude that for the abovementioned reasons, central banks would never want to commit to such simple instrument rules.

Furthermore Svensson and Rudebush (1999) agree that no central bank, whether inflation targeting or not, follows an explicit instrument rule (unrestricted or simple). They bring out that every central bank uses more information than the simple rules are based on, and no central bank would voluntarily restrict itself to react mechanically in a predescribed way to new information. According to them, the role of unrestricted or simple explicit instrument rules is at best to provide a baseline and comparison to the policy actually followed.

Many monetary policy-makers routinely use policy rules as inputs to their own policy decisions. It is not unusual now for monetary policy officials to discuss openly the use of scientific policy rules in framing their policy decisions and to examine the academic research that has been done on rules. Moreover, the staffs of central banks are actively doing research on the application of policy rules. And financial market economists are now using policy rules to help analyze and predict monetary policy decisions. (Taylor, 1998a) Hence the policy rules are not a unique and final tool in framing central banker's decisions, but a complementary piece that analysis can be benchmarked against.

Modifications of the rule as discussed in chapter 1.2.2. are also an integral part of why central banks would not resort to Taylor rule as their main tool of analysis. As a reminder Taylor (1993) presented a normative ex-post description of the Fed's behaviour, which in comparison with central bank interest rate setting is quite the opposite as the bankers are aware of a time-lag in the transmission mechanism.

A considerable literature emphasizes that the environment in which the central banks operate is a forward looking one, in which agents' actions today are influenced by their expectations of policy actions tomorrow. For example price-setting behaviour may be forward looking, that is, agents set prices partly based on the expected behaviour of future inflation. If agents are convinced that monetary policy will systematically stabilize inflation in the future, they will be less inclined to raise prices today which further facilitate the task of monetary policy in controlling inflation. (Stracca, 2007)

In addition to the Taylor rules' shortcomings when it comes to listing the preferences and principles of a central bank, one should also bear in mind that the environment is constantly changing. The zero bound on the nominal interest rate is the reality for the sluggish and slow economic growth as the EU and US are facing today.

Once the zero bound on nominal interest rates is taken into account, active interest rate feedback rules can easily lead to unexpected consequences. Taylor rules are destabilizing because the multiplicity of steady-state equilibria that they induce opens the door to a much larger class of equlibria. In general there exist an infinite number of equilibrium trajectories originating in the vicinity of the active steady state that converge either to the steady state at which the monetary policy is passive (a saddle connection) or to a stable limit cycle around the active-steady state. The inflation rate fluctuates for long periods of time around the steady-state at which monetary policy is active. Thus, an econometrician using data generated from a saddle connection equilibrium to estimate the slope of the interest rate feedback rule may very well conclude that the economy is displaying stationary fluctuations around the active-steady state, even though the economy is in fact spiralling down to a liquidity trap. (Benhabib et al 2001)

Lastly, Taylor (1998b) summarizes that the model-based approach cannot be the sole grounds for making policy decisions as no monetary theory is a completely reliable guide to the future, and certain aspects of the current models are novel, especially the incorporation of rational expectations with wage and price rigidities. Hence, Taylor's (1998b) view is that the historical approach to monetary policy evaluation is a necessary complement to the model-based approach, saying that big historical changes in policy rules – even if the evolve slowly – allow one to separate policy effects from another influences on economy.

2. REVIEW OF EMPIRICAL RESEARCH ON TAYLOR RULE IN EMU

The Taylor rule has become a method for analyzing central bank behaviour, initially for the U.S. as initiated by Taylor (1993), who provided the guidance for more than one-on-one response of interest rate to change in inflation. Regardless of the short history of European Central Bank, there have been numerous researches applying a Taylor rule in the European single currency area. The empirical pieces encompass both the pre-euro period as well as the first decade of the 2000.

The overview of significant articles on the application of the Taylor rule in the euro area is divided into two subsections to distinguish between pre-euro area and the period post euro adoption. Majority of the articles reviewed will either pose a single question if the Taylor rule is applicable in a certain composition of the euro area within a chosen timeframe. Additionally many of the articles will pose another question aimed at the remit of the ECB to conduct area wide inflation targeted monetary policy. The said problem can have very different angles as will be seen from the overview. The chapter will conclude with a summary of the key items to note from the research.

2.1. Taylor Rule Applications in the Euro Area

2.1.1. Pre-Adoption Era Models of Taylor Rule

Peersman and Smets (1999) evaluate Taylor rule in the context of the closed economy model of the euro area, using it to determine inflation and output stabilization properties. It is a challenging task since at the time the single currency had recently come into existence. They build the model on the one presented by Rudebush and Svensson (1999) consisting of four equations, which bring together the Phillips curve, aggregate demand, potential output and output gap. The parameters they use are weighted average of output and inflation during a period of 1975 to 1997 in Germany, France, Austria, Belgium and the Netherlands as a measure of aggregate output and inflation and the real German policy rate as a measure of the common monetary policy.

The model serves as a laboratory for testing out the Taylor rules, pure interest rate rules and optimal feedback rule by introducing a loss function for the ECB. Important elements of the loss function are the deviations of annual inflation from a constant inflation target, variations in the output gap and changes in the short-term interest rate while the bank's main purpose is to set the policy instrument, interest rate, in a way that minimizes the loss function, in the environment specified by the model. Evaluating seven different rules, four of which are Taylor rules (simple, forward looking, allowing for interest rate lagging) and two are pure inflation rate forecast rules, Peersman and Smets (1999) achieve the minimal loss with the simple Taylor rule. They consider unrestricted optimal feedback rule as a benchmark.

Peersman and Smets (1999) conclude that a simple Taylor rule with a relatively strong feedback on output would perform quite well in stabilizing the economy in the event of macroeconomic shocks. With the given objective function the response coefficient on output in the used Taylor rule is higher than Taylor initially proposed, that is about 1.5 response on output, making the output gap much more significant than in the original rule and hence making the role of the output in inflation stabilization much more important. Furthermore, they find that including other information such as lagged variables, foreign variables or the exchange rate does not improve the model sufficiently to consider adding such variables.

Gerlach and Schnabel (2000) show that during 1990-1998 the average interest rates in the EMU can be described by a Taylor rule, except for the period of 1992-1993. They suggest that for the analysis period, excluding the years of market turbulence, adopting such a rule as a rough guideline for policy would lead to interest rates with the same correlations with average output gaps and inflation as in the past and would in this sense offer some continuity in the setting of monetary policy in the EMU area.

They use as inflation the annual change in quarterly averages of national consumer price indices and aggregated that for the EMU are by using weights provided by the OECD, inflation objective is aligned with Taylor (1993). To arrive at a target interest rate, they calculate the average realised real interest rate over the period of 1982-1997 consequently adjusting it by inflation, and the average depreciation of the Deutsche mark over the same period for 13 EU countries. The average real rate and the rate of depreciation are then regressed. After applying the initial Taylor rule with GDP as output measure, consequently also applying dummies for the market turmoil period, and introducing additional variables such as lagged inflation, money growth, Federal Reserve funds rate and a real euro/U.S. dollar exchange rate they conclude that the original benchmark rule performs the best and could be therefore used. Gerlach and Schnabel (2007) state that the interest rate obtained by the original benchmark rule would in fact not deviate much from past (weighted) interest rate setting behaviour in the countries forming the EMU area.

Gerlach-Kristen (2003) however finds poor econometric quality in Taylor rule, while analyzing the interest rate setting based on quarterly data during 1988.1 to 2002.2. Weighted average of national three-month money market rates are proxy for the short term interest rate, inflation is calculated as the HICP change over four quarters and output gap is measured by the residuals of a regression of the logarithm of GDP on a third-order polynomial in time and inflation. After applying the traditionally specified Taylor rule on the period indicated, it turns out that the rule fails to capture appropriately the dynamics of the data and non-stationarity of the exogenous factors appears. The model layout passes econometric tests but presents signs of instability and mis-specification, which suggests the Taylor rule may provide a poor forecast.

Castelnuovo (2007) turns to Taylor Rule to study monetary policy conduct in the Euro area, using quarterly data during 1980 – 2003, HCIP as proxy for inflation, GDP as a measure of output and restricting the number of countries to 12. The aim was to identify firstly if the Taylor rule is applicable for the Euro area and if the gradual implementation of monetary policy is a result of endogenous factors e.g. is resulting from the systematic nature of the monetary policy or exogenous factors. The latter can be attainable to the unpredictability of the standard term structure regressions which consequently implies that the quarterly smoothing of the interest rate has an insignificant impact if any. Hence Castelnuovo (2007) suggests that persistency of the observed policy rate is due to serially correlated deviations from the Taylor rate, such as commodity price scares, credit crunches or financial crises.

Starting off with the null hypothesis of absence of any interest rate smoothing mechanism e.g. the serial correlation assumption holds in the Euro area, Castelnuovo (2007), builds models in first differences – one capturing the partial adjustment of interest rate and the other representing the serial correlation. In order to determine the presumable ECB rate, Castelnuovo (2007) uses the Taylor rule by adding to the original formula specification a third regressor, which helps to control for quadratic transformation of the output gap level. The simple feedback rule is tested in various specifications: standard, forward looking, forward looking/consensus forecast, asymmetric preferences and also in terms of exchange rate and money supply. All simple feedback rules confirm the applicability of the Taylor (1993) rule to the Euro area for the period under review.

Conclusively Castelnuovo (2007) finds that both the exogenous and endogenous factors are present due to empirical relevance based on application of simple Taylor rules. Hence he concludes that both the tight reaction to changes in inflation as well as business cycle fluctuations play an important role in determining the policy rate.

Sauer and Sturm (2007) alongside with other researchers wish to analyze actions and activities of the ECB by posing the question if the bank is conducting a stabilizing or destabilizing monetary policy. They derive from the ECB decision making mechanism which includes a broad range of economic and financial variables that it would be possible to apply a Taylor rule. They start with the initial rule proposed by Taylor (1993) as the ECB expectations for inflation and nominal interest rate are aligned with the values of the original research, viewing the period of 1991-2003. They consider as nominal interest rate the Euro Overnight Index Average (EONIA) lending rate on the money market, inflation as the HICP and as a proxy for the output gap, they apply the industrial production index of the Euro area.

They test by means of a regression analysis several categories of Taylor-rules, including real-time and forward looking rules. The former would suggest a destabilizing policy on behalf of ECB, enhancing inflation. The forward looking specification provides the best result and also conveys a stabilizing impact. Sauer and Sturm (2007) also add some words of caution, as the period under review where the EMU already existed saw inflation very close to target hence the reaction magnitude of the bank might be more reserved than a situation where the bank was faced with above target inflation. Additionally they note that ECB seems to engage in interest rate smoothing, applying the policy in a gradual manner.

2.1.2. Post-Adoption Era Models of Taylor Rule

Fourçans and Vranceanu (2007) analyze the ECB monetary policy during 01.1999-03.2006, with the recent years being of more interest, describing first the declared goals and then weigh against estimates of ECB interest rate rules. They combine both qualitative and quantitative analysis, as the central bank decisions are never solely based on linear feedback rules, and incorporates an element of discrepancy, which may not seem evident from the quantitative analysis. As the interest rate, they use the monthly average of EONIA (overnight interest rate), the proxy for inflation is the yearly percentage change of the representative price index and as output, similarly to other empirical works, the monthly percent deviation of the industrial production index from the Hodrick-Prescott trend or the deviation of the industrial production growth rate from the over-the-period average of 1.7%. In the equation they also use a variable for future inflation, which represents the policymaker's inflationary expectations *k* months ahead and also they incorporate smoothing.

Out of the four Taylor-type rules Fourçans and Vranceanu (2007) construct, only the forward looking ones meet OLS test criteria, as in the contemporaneous equations inflation is not a significant variable. To gain further confidence of the models' viability, they construct a model of the Euro area economy, with the first equation being the interest rate rule, second the IS relationship and the third being the Phillips curve. By applying the FIML (Full Information Maximum Likelihood) method and testing for both output gap definitions, they find that the models are econometrically of good quality. Furthermore, the models imply a positive wealth effect (the coefficient on the stock index in the output equation is positive and significant), and emphasize the relationship between real interest rates and real activity. The OLS and FIML method produce similar coefficients as well. Fourçans and Vranceanu (2007) conclude that the response of the central banker to the real activity indicator is economically significant, to a similar extent the future inflation is, and boldly infer that the ECB therefore pursues a direct real activity objective. The result of incorporating smoothing mechanism to the interest rate setting is that the effective adjustment per quarter for is between 8%-20%.

As a final critique towards the ECB monetary policy Fourçans and Vranceanu (2007) assert the fact that the bank shares the mainstream view that inflation is a monetary phenomenon and that monetary growth is the main driving force behind inflation in the medium and long terms. Furthermore, since the ECB recognizes that the interest rate it sets is the dominant factor explaining the changes in M3 growth, then instead of having an independent inflation target, the bank should position the money growth as an intermediate target variable while inflation remains the main target.

Van Poeck (2010) encompasses in his research both the era before the euro and the single currency era. He assumes that the ECB is conducting monetary policy that can be benchmarked to a Taylor rule and analyzes in that context if the ECB policy has become more balanced towards the member states. He incorporates twelve countries, the initial joiners and Greece, setting the analysis period to 1990-2009. The Taylor rule used is in its original form, where inflation has three times as much weight as the output gap. He divides the years into two subperiods, helping to distinguish between pre-euro and post euro eras.

As it may be anticipated Van Poeck (2010) finds that the deviations during the pre-euro area are a lot more significant that in the post euro area, coming to the conclusion that the ECB, if in existence in the 1990s would have had an impossible task as the countries have significantly converged in terms of inflation and output gap when compared to the pre-euro era. Still, it is possible to identify countries that have benefitted or lost from the ECB rates. As Van Poeck (2010) outlines the ECB rates were on average too low for Ireland and Greece, somewhat too low for Spain and Portugal. Controversially the rate was too high for Germany and corresponded to the individual rates calculated for Italy and France. As the inflation rates for the individual countries have become more similar to the EU average rate, so has also the difference decreased.

Heinemann and Huefner (2004) debate over the role of national information in the decision making process of the ECB claiming that the Governing Council members are pressurized by their home audience. This goes for both a personal viewpoint as they get media coverage in home country as well as them being the targets of lobbying activities of local politicians. Also, taking into consideration the voting mechanics in the Council, each country gets one vote which is not proportional to their GDP contribution to the overall area total.

To test the decision making of the governors, Heinemann and Huefner (2004) devise an individual reaction function for a council member, extending the standard Taylor equation by adding terms which represent the impact of inflation rates and output gaps in council member's country. They restrict the equation to two opposing hypotheses "euro area advocates hypothesis", where national data is eliminated, and "pure national advocates hypothesis", where intuitively euro area data is left aside, while taking an intermediate rule into account as well. The period for analysis is January 1999 until April 2002, output gap is indicated by the difference between the actual industrial production and a measure of potential production, inflation is the one-year-ahead consensus forecast for CPI and of the member states initial joiners and Greece are included. The empirical methods used are restricted to Taylor rule estimations as described and additionally a probit model, where the interest rate decisions are the discrete variable.

However, based on the Taylor type regressions, Heinemann and Huefner (2004) are not able to make a distinction which of the opposing views prevails in the decision making of the Council. They note that the conventional Taylor rules built on euro zone aggregate variables alone might be biased, especially regarding the inflation coefficient. The ordered probit approach used further confirms the relevance of divergence between national data and euro zone averages. They conclude that despite the ECB aim to conduct an area-wide monetary policy, there are still traces of bias within the policy execution.

Maza and Sanchez-Robles (2013) have analyzed the ECB monetary policy with the aim of finding a simple model that can provide some insight into the bank's activities. They turn to the Taylor rule and apply a modified version of the rule during a period from 1999 to 2009 by means of a regression analysis performed on the Euro zone of 15 members. As the interest rate they have used the interest rate for main refinancing operations of ECB, as the inflation they have used the HCPI and correspondingly output has been captured by the Industry Production Index. Furthermore they have also introduced a lag of four months for output and inflation. Conclusively, the Taylor rule supported the ECB activities during two sub periods, 1999-2002 and 2007-2009.

As a second step Maza and Sanchez-Robles (2013), compute the appropriate interest rates for individual Euro area countries and found that the optimal individual rates deviate from the rate set by the ECB. The latter rate seems to be favouring the traditional core countries like Germany, France, Italy or Belgium. Large differences can be spotted for Spain, Ireland, Greece and Netherlands. However, the differences are smaller for the sub period 2007–2009 with also the response coefficient of the Taylor rule being higher for the output for the period in question.

Nechio (2011) also establishes a stance that ECB rate is not unilaterally useful for all Euro zone countries, by applying a Taylor rule containing unemployment gap instead of the output gap. The response coefficients are 1.5 on inflation and -1 on the unemployment gap, and a constant of 1 is also added. To account for the existing differences in inflation and unemployment within the euro area, Nechio divides the countries into core (Germany, France, Austria, Belgium, Finland and the Netherlands) and peripheral (Spain, Greece, Ireland, Portugal and Italy).

According to Nechio (2011) computations, the paths of rates recommended by Taylor rule are in line with the euro area as a whole. However, if the countries are divided into the groups of core and periphery countries, it is evident that the ECB's behaviour when setting rates tends to favour the core countries. Nechio (2011) notes that the policy target rate for the peripheral countries based on the Taylor rule should be negative. During the period from 2001 to 2008 the rates suggested by the Taylor rule are much higher for the peripheral countries and after the 2008 crisis the rates plunge to below zero levels. Nechio notes that the core countries have been more successful at recovering from the crisis, while the peripheral countries are still struggling with large unemployment and other remnants of the sovereign debt crisis.

2.2. Significant Items to Note from the Empirical Research

The Taylor rule can be used to answer a variety of questions. The empirical works start off intuitively with the question if the Taylor principle holds in the euro area within the given time and composition. This usually encompasses various forms of the rule, ranging from the original specification to forward looking to interest rate smoothing and various combinations of the aforementioned types. If an econometrically sound rule is found, the authors often set further questions to which the rule can provide some insight into.

The problems that researchers try to solve is usually centered around specific aspects of the monetary policy of the ECB, which by definition is carried out based on area-wide indicators and aims to target inflation. The research can be divided into different streams. One of the streams tries to substantiate if the ECB is actually pursuing area-wide indicators or taking into account the individual country information, either by having biased voting in the governing council or just incorporating the country data into models it bases its decision making on. Additional stream tries to understand if the bank is targeting only inflation, or is it trying to respond to changes in output as well. Other large areas of interest are around the stabilizationary properties of the interest rate and appropriateness of the rates to individual countries. Conclusively the problem of the euro area composition, which joins very different countries, is viewed from various angles.

The methodology used varies from constructing a model of the euro area economy defined by several equations, one of them usually the Phillips curve, complemented by a combination of aggregate demand, aggregate output, output gap, IS or MR curves. The model is considered sophisticated enough to serve as a laboratory to simulate reactions to interest rate setting and testing responsiveness to macroeconomic shocks. In addition a central bank loss function is devised, where the Taylor rule generated rate is then put to the test.

In contrast also more simplistic approaches are used without constructing model economies and just computing the interest rate using an appropriate specification of the Taylor rule for the individual countries and the euro area as a whole. Regression analysis and basic econometric tests are run to validate the rules. Rates obtained by applying rules of solid econometric quality are then compared against each other to determine how far the individual countries stand from the European general rate applicable for all.

Data used in the works is generally a measure of inflation, either a country-based consumer price index or the HCIP. As a measure of economic slack or the lack of it is measured either by GDP and its trend or industrial production index, also unemployment in one of the researches. Comparative rate is either the German policy rate in the pre-euro era or a rate set by the ECB, that is either Euro Overnight Index Average (EONIA) lending rate on the money market or main refinancing operations fixed rate.

In most of the works the researchers have found a Taylor rule which is econometrically sound and describes the euro area as a whole well. Discrepancies appear when the concept of individual Taylor rules or rates for different countries or groups are taken into account. Due to different inflation and output positions of the countries, the rates seem to favor core countries. Also, some traces of bias are found within the policy execution, leading the researchers to conclude that country specific information is taken into account while deciding rates for the area as a whole. Finally, the ECB seems to be implementing the policy in a gradual fashion, there is some doubt of the bank responding to changes in output. Hence, it can be concluded that the Taylor rule is a useful tool in the analysis multiple facets of a central bank monetary policy.

3. EMPIRICAL ANALYSIS

3.1. European Central Bank and the Monetary Policy in the EMU

The ECB is a relatively young central bank as it was established on June 1, 1998 and seven months later on January 1, 2009 when the Euro was adopted as an electronic currency the Governing Council began conducting the monetary policy for all countries in the currency union.

The ECB has been given a lot of independence by the Maastricht Treaty to conduct the monetary policy. This is to rigorously pursue the primary objective of price stability, measured by a year-on-year increase of the harmonized index of consumer prices (HICP) which is expected to be below but very close to 2% over the medium term. One interpretation of the independence is that the individuals deciding on the key outcomes of the monetary policy must not be influenced by politics. Hence the price stability objective cannot be tampered with in terms any subjective measures in a single country to grant re-election.

A common currency should bring about multiple advantages. The technicalities of engaging in financial transactions should simplify and risks associated with exchange rate brought to a minimum. This in turn should increase investments in and out of a country within the area. Additionally the trade flows should be enhanced, as the product market should have a greater degree of intra-currency area transactions. The countries might take slightly different positions here, as the amount of trade a country is conducting with non-members of that same area might be vastly different from its neighbours, hence the exposure to currency risk or benefits will be different. Finally, the financial markets should also be further integrated and in addition to minimizing the currency risk, the transaction costs should plummet. Simultaneously to gaining access to the aforementioned benefits a country renounces its ability to conduct monetary policy responding to the country-specific macroeconomic situation.

The larger the extent of similarity between a single member country and the union, the more tailored and tuned the monetary policy will be for the single country as well. Also, the increased similarities between countries should make the execution of the monetary policy considerably easier for the central bank of a monetary union. Additionally the advantages or disadvantages depend heavily on whether the deviations of currency area average indicators such as inflation or output gap from individual country values are driven by common problems for the euro area or country specific situations.

To start with, there was a general consensus among academics that the euro area was ex ante not an optimum currency area. And this was not the only complicating factor: there were national differences in the transmission of monetary policy; there was risk that countries could be hit by asymmetric shocks; there was the issue of whether autonomous national fiscal policies could be considered compatible with a supranational monetary policy; and moreover, there was the question of whether, on account the decentralised nature of the Eurosystem, national interests would dominate the implementation of monetary policy. (Issing, 2005)

The European Commission has established measures to minimize the risks such as the ones listed above. Since countries of the European Union are required to adopt the euro (with the exception of United Kingdom and Denmark) then such a step must only be taken when it is economically appropriate for both the individual country and the union as well.

Table 1. The Five Convergence Criteria

What is measured	Price stability	Sound public finances	Sustainable public finances	Durability of convergence	Exchange rate stability
How is it measured	Consumer price inflation rate	Government deficit as % of GDP	Government debt as % of GDP	Long-term interest rate	Deviation from a central rate
Convergence criteria	Not more than 1.5 percentage points above the best rate of the three best performing Member States	Reference value: not more than 3%	Reference value: not more than 60%	Not more than 2 percentage points above the rate of the three best performing Member States in terms of price stability	Participation in the ERM II for at least 2 years without severe tensions

Source: (European Commission, 2014)

The economic entry conditions are designed to ensure that a Member State's economy is sufficiently prepared for adoption of the single currency and can integrate smoothly into the monetary regime of the euro area without risk of disruption for the Member State or the euro area as a whole. In short, the economic entry criteria are intended to ensure economic convergence – they are known as the 'convergence criteria' (or 'Maastricht criteria') and were agreed by the EU Member States in 1991 as part of the preparations for introduction of the euro. (European Commission, 2014).

Despite the fact that five convergence criteria apply when joining, it is evident from today's outlook on the euro area members that their standing is vastly different. To take inflation as an example, one can say there have been different developments that have taken place since 1990s. Based on Eurostat data, inflation in the EU was for year 2013 at 1.4 per cent and has hence landed below its target of 2%. The countries that are most similar to the central level are Italy and Belgium with their slightly lower rates and Germany, Slovakia and Spain with slightly higher rates. The extremes are respectively the lowest in Greece that is actually a deflationary rate of 0.9 per cent while Estonia has the highest at 3.2 per cent.

Van Poeck (2010) has analyzed inflation in the Euro area, focusing on dispersion of the inflation rate during the period of 1990-2009. In the context of his paper, the range, the un-weighted standard deviation and the un-weighted mean absolute deviation are used as measures of dispersion. He concludes that the period preceding the monetary union is characterized by a fall in inflation dispersion, an increase up to 2003 and from the latter onwards the trend reversed e.g. dispersion started to decrease again reaching the absolute minimum in 2007. He points out the main contributing factors that are behind this and stressing that some are permanent in their nature while others are just a part of convergence process:

- The processes driven by the creation of the monetary union itself as the drastic fall of 1990 could be attributable to countries aiming to fill the convergence criteria and the consecutive rise in dispersion due to price level convergence
- Triggering of the Balassa-Samuelson mechanism as countries with low productivity will suffer from a higher inflation driven by productivity growth which in turn is the result of wage formation mechanism, as the wage adjustments in the non-tradable goods sector will eventually push for an

increase in the tradable goods sector, transferring the increase of wage and also inflation across borders

- Different cyclical positions
- Significance of the trade with non-euro countries, whereby larger import from outside the euro area in the light of euro weakness would lead to greater financial suffering compared to the countries in which the import is not that significant.

According to Issing (2005) the ECB in its pursuit of price stability and controlling inflation conducts two complementing pieces of analysis for the assessment of risks to price stability – an economic and monetary analysis.

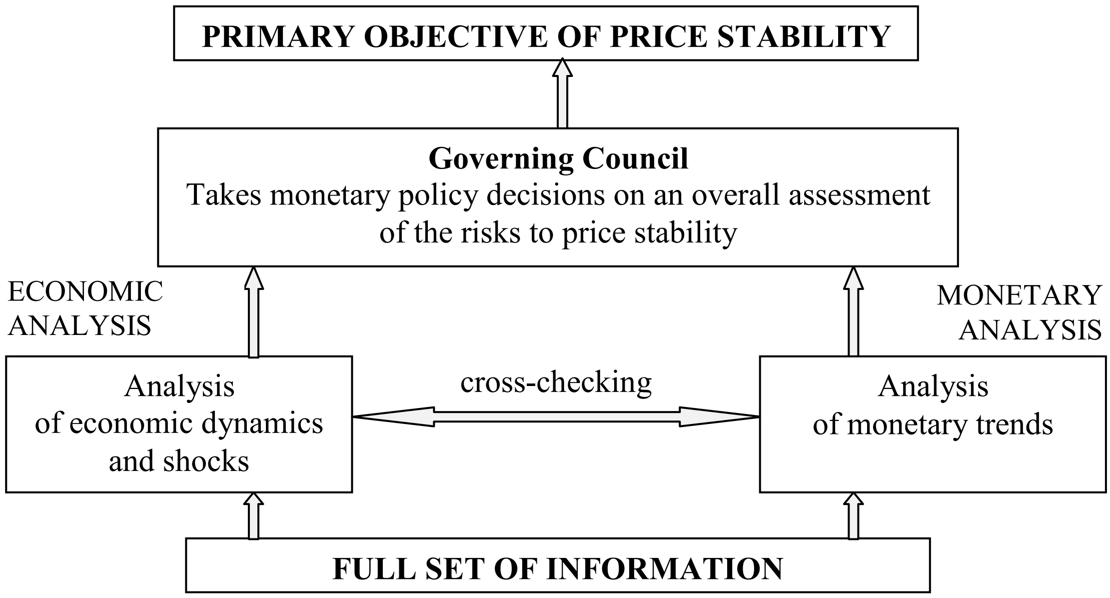

Figure 2. The stability-oriented monetary policy strategy of the ECB. Reference: (Monetary Policy. Strategy. 2014).

The economic analysis focuses on the assessment of current economic and financial developments, analyzing the connections and trends between supply and demand in the goods, services and factor markets. The financial analysis serves as a checking tool for the medium to long-term perspective by validating the implications rising from short to medium-term economic analysis. Issing (2005) furthermore assures that ECB has taken the view that in the medium to long run inflation and monetary growth are closely related. So despite the duration of instruments at ECBs disposal, the aim is to target medium-term monetary policy.

With the two pillars and medium-term orientation of its strategy, the ECB pays due attention to the need to take into account the entire horizon over which monetary policy impacts on the state of the economy (Issing 2005)

In addition to European Central bank, inflation targeting is also pursued by the central banks of New Zealand, Canada, the United Kingdom, Sweden, Australia and the Czech Republic. Inflation targeting in these countries is characterized by (Svensson, Rudebush 1999):

1) a publicly announced numerical inflation target (either in the form of a target range, point range, or a point target with a tolerance interval);
2) a framework for policy decisions that involves comparing an inflation forecast to the announced target, thus providing an "inflation-forecast targeting" regime for policy, where the forecast serves as an intermediate target;
3) a higher than average degree of transparency and accountability.

Very high or low (deflationary) inflation rates in individual countries will certainly diverge from the EU inflation target hence putting the countries in a position where the ECB policy may not be directly addressing them as they deviate from the norm. Another mechanism that may trigger is the high growth countries which owe a lesser or greater extent of the growth impetus to convergence. This means the countries are trying to catch-up in an economic sense with other more successful members, but consecutively might experience higher interest rates. Usually economic growth tends to accelerate also inflation, which in turn is the price tag that's added to real interest rate. If the inflation divergence from the norm is large then the countries positioned further from the euro zone average could have an accelerating growth or deepening recession as a result of the nominal interest rate and their specific inflation measure.

From a bank's point of view the execution and logic of monetary policy translates into monetary transmission mechanism, which is a high level view of the transmission channels. On a highly simplified level the monetary policy is transmitted as ECB intervenes in the money markets, sets bank lending and deposit rates and in turn this has an impact on investment and consumption, finally transferring into changes in prices. For the ECB, the mechanism is as seen from Figure 3.

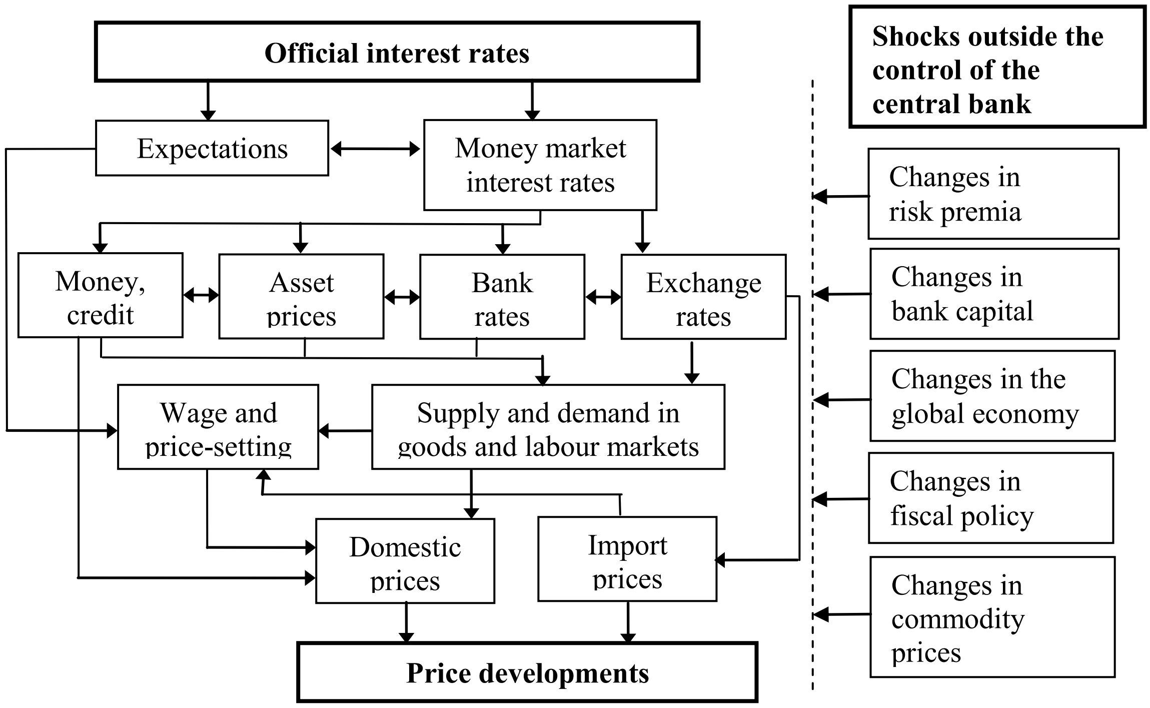

Figure 3. Monetary transmission mechanism ECB. (European Central Bank, 2010).

In 1999 the Eurosystem launched a research network to study the transmission of monetary policy. Monetary policy affects the economy mainly through the interest rate channel: a tightening of monetary policy was found to lead to a transitory decrease in output, which was estimated to reach its maximum between one and two years after the change in monetary policy. Prices were estimated to decline gradually, responding much more slowly to the change in monetary policy than output. Beyond these aggregate effects, and in line with the credit channel of monetary policy, it was found that interest rate changes could also affect economic activity via its impact on firms' cash flows and the supply of bank loans. The supply of bank loans was found to be related mainly to the impact of these changes on the availability of liquid funds, while other channels, such as the potential role of bank capital in the transmission of monetary policy, were not found to be significant. (European Central Bank, 2010)

The empirical evidence is that on average it takes up to about one year in this and other industrial economies for the response to a monetary policy change to have its peak effect on demand and production, and that it takes up to a further year for these activity changes to have their fullest impact on the inflation rate. However, there is a great deal of variation and uncertainty around these average time-lags. In particular, the precise effect will depend on many other factors such as the state of business and consumer confidence and how this responds to the policy change, the stage of the business cycle, events in the world economy, and expectations about future inflation. These other influences are beyond the direct control of the monetary authorities, but combine with slow adjustments to ensure that the impact of monetary policy is subject to long, variable and uncertain lags. (Bank of England, 1999) As a general guidance however, the ECB states that the monetary policy is characterized by long, variable and uncertain time lags. (European Central Bank, 2014)

While the ECB may conduct monetary policy based on union-wide aggregates, the impact of the policy can be different across the member countries. Specifically, under EMU, member countries are subject to common monetary policy shocks. Given the diversity in economic and financial structures across the economies, common monetary policy shocks can be expected to have a different impact in terms of timing, magnitude and distributional effects. In the context of EMU, there is an important difference between a monetary policy shock at the individual country level and a common monetary policy shock because of large trade linkages between the member countries. The simulation of a common monetary policy shock could be much more similar across countries than a shock at the country level because of spillover effects between countries. Another problem is that the size of the estimated monetary policy shock differs across countries, making a comparison among countries very difficult. Moreover, even with the same shock, the monetary policy responses would not be harmonized because a different monetary policy reaction function is estimated across countries (endogenous component of monetary policy), which can significantly alter the results. (Peersman 2004)

The financial system is the primary channel through which monetary policy affects the economy. Stable efficient and integrated financial markets are the basis for the smooth transition of monetary policy across countries. Thus, the current heterogeneity in financial conditions poses a major challenge for the single monetary policy. Although some degree of national differentiation in financial developments is a normal feature of a monetary union, heterogeneity in financial conditions across the euro area has increased significantly, as some countries have been affected more substantially by the financial crisis. Money markets have become increasingly impaired, especially across national borders, and yields in sovereign bond markets have diverged significantly. (ECB, 2012)

The financial crisis that erupted in September 2008 with the default of Lehman Brothers, following a period of financial turmoil from August 2007, marked a halt in the trend towards more homogenous financial conditions. Sovereign bond yields also started to diverge at that time, but this became more pronounced following the onset of the sovereign debt crisis in May 2010. Prior to the crisis, the convergence of financial conditions masked divergences in national policies and the accumulation of fiscal, macroeconomic and financial imbalances in several euro area countries. They created vulnerabilities in these countries and paved the way for the sudden return of differentiated financial conditions when risks were repriced. (ECB, 2012)

3.2. Scope, Data and Methodology

Firstly the aim is to validate if a standard specification of the Taylor rule is fitted to the euro area, identifying the specific periods if applicable. If the rule is not appropriate, the next step would be to determine what the specification adhering to econometric evaluation could be. The analysis is carried out on the changing Euro area composition and then expanded by way of indentifying the possible Taylor rates for individual countries in the euro area. Based on the results of the computations, analysis for differences will follow.

All data used in calculations is obtained from the Eurostat database. The data used for inflation is monthly data displaying the annual rate of change in HICP with year 2005 set in the calculation of indices to a value of 100. The output gap is measured by the difference of log of real GDP and the log of trend GDP. To determine the trend, the Hodrick-Prescott filter is applied with a smoothing parameter of $\lambda = 1600$, to enable the separation of cyclical element from the time series on a quarterly basis. ECB interest rate is considered to be the refinancing operations rate. Econometric tests and modelling will be performed by freeware named Gretl.

3.2.1. Standard Specification of the Taylor Rule

The first method to apply is computing the Taylor rates using the standard specification of the rule $i_{Taylor} = \pi + 0.5y + 0.5(\pi - 2) + 2$. This follows the path that Taylor (1993) took, as he did not validate the relationship by means of regression. Also the inflation target value of 2 fits the ECB scenario well, as the target is to keep inflation close to but below 2. The assumption of an equilibrium real interest rate is also considered to be 2.

Regarding the output gap, Taylor considered the output target to follow the GDP growth trend of 2.2 percent. The period under review did contain a glitch of the US stock markets, but he did not face such a significant event as the 2007-2008 Financial Crisis, paving way for the global recession and for EU sending the sovereign debt crisis into full swing in 2010. Hence the output gap is not calculated based on constant indexed growth, making the deviation very large due to impact of the crises. Opposed to Taylor, a Hodrick-Prescott filter is applied to determine the trend. The natural logarithm of the GDP is subtracted from the natural logarithm trend GDP to arrive at the output gap.

As seen from Figure 4, the Taylor rate closely follows the ECB refinancing operations rate until the rates drift apart in 2001.2. The Taylor rate is considerably higher than the actual rate until 2006.3, which could be interpreted as the ECB rate being too low or too stimulating for the economy. The output gap is fairly small considering the HP filter, hence the rate fluctuations are driven to a great extent by the inflation. From 2007.3 the inflation makes a leap upward and the Taylor rate responds, suggesting a higher rate to cool down the economy. As a result of the crises that then swiftly followed, the Taylor rate plunged to similar levels with the ECB. During the last years, however, the rates have been vastly different. The troubled times during and after the crisis could have impacted the mechanism of the interest rate tool and fears of the recession worsening or returning has kept the interest rates lower than the Taylor rule would suggest. The rate plummets in 2009.3 but from 2009.4 the Taylor principle would suggest a significantly higher rate for the four preceding years.

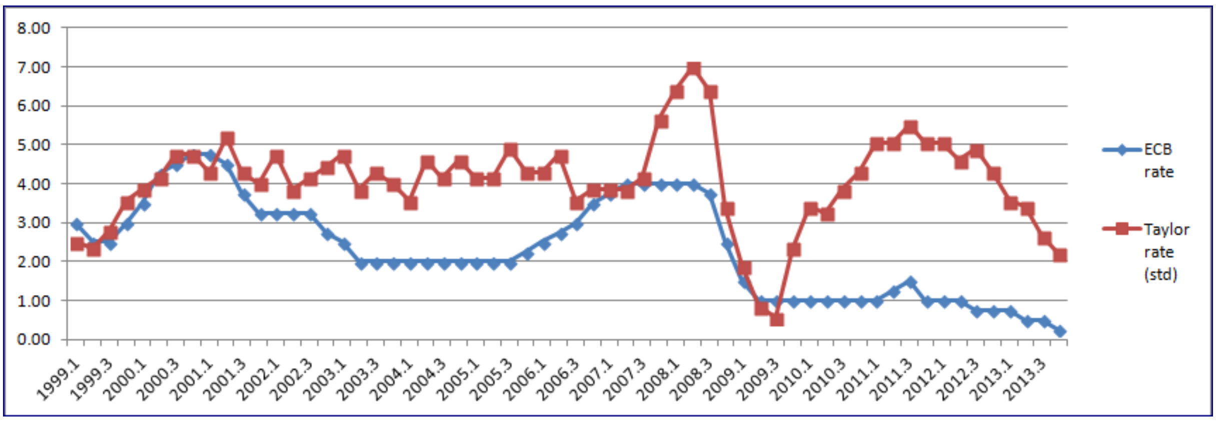

Figure 4. Refinancing Operations Rate in Comparison to Taylor Standard Specification Rate for the Euro Area During 1991.1 – 2013.4. (Author’s calculations, Appendix 2).

3.2.2. Regression Analysis

The base assumption while attempting to model time-series data is that the underlying series is stationary. Gujarati (2004, p 798) explains that if a time series is stationary, its mean, variance and autocovariance (at various lags) remain the same no matter at what point they are measured, that is they are time invariant. He further elaborates that such a time series will tend to return to its mean (called mean reversion) and fluctuations around this mean (measured by its variance) will have a broadly constant amplitude.

Firstly it is possible to identify from a time series plot just by visual examination if a trend exists. To understand if we are dealing with a random or a stochastic process, it is useful to bear in mind that each of the variables (currently output gap and HCIP) are random variables and the time series in its totality is a collection of random variables. They can also be considered discreet, as economic data is collected at specific moments in time and not measured continuously. The processes under review can be considered by their nature stochastic as either the GDP or inflation could take any value for any of the given observations, caused by on the economic and political factors shaping the economy at the time of observation. The particular value it has for a quarter is just a realization of that process.

For the changing euro composition area, the plot for the dependent variable suggests a trend, while the plots for independent variables would suggest no trend. (Appendix 3)

The next step is to perform an Augmented Dickey Fuller (ADF) test to determine if the trend indeed exists. The null hypothesis for the ADF is that a unit root exists, which means the generating process is a random walk, making the time-series a non-stationary process.

Table 1, ADF test details for the variables

Variable	Test type	|τ| empirical	τ critical	*p-value* ADF	*p-value* constant
Inflation	With constant	4.92	4.04	$3.02*10^{-5}$	$2.05*10^{-5}$
Output gap	Without constant	3.79	2.60	0.001	-
Interest rate	With constant and trend	3.27	4.04	0.071	0.002

Source: (Author's computations)

The ADF test for inflation is performed with a constant as the mean of the data range is larger than zero. The ADF gives sufficiently low asymptotic p-value, confirming that the series is stationary. The τ statistic absolute empirical value exceeds critical value (1%) and also the constant is relevant on a confidence interval of 99%.

The ADF for output gap y is performed without a constant as the mean of the sample is almost at zero and without a trend. The p-value for the test is also sufficiently low and the τ statistic absolute empirical value exceeds critical value (1%), suggesting that the time-series is stationary.

Finally the refinancing operations rate a trend presence is assumed and the ADF is performed therefore with both a constant and trend. The constant is relevant on a confidence interval of 99%, and an asymptotic p-value of 0.07 suggests a present trend. The τ statistic computed absolute value does not exceed the DF critical tau values, hence the null hypothesis holds and a trend is present. This suggests that a model obtained by OLS is not stable and may provide a poor dynamic forecast.

The result for the refinancing operations rate restricts the usability of a regression model to the time period that the data covers. According to Gujarati (2004, p 789), the consequence of non-stationarity is that it is not possible to generalize the relationship between the variables to other time periods and for the purpose of forecasting, such series may be of little practical value. While keeping this limitation in mind, the thesis seeks to identify a relationship for the current time period only, hence the forecast quality of the regression is not of utmost importance.

Using annual data for the changing euro area composition during 1999-2013, the refinancing operations rate is regressed on a constant, the inflation as represented by HCIP and output gap, which is the log difference of nominal GDP against a HP filtered trend. All details on model tests are given in Appendix 4.

Applying the OLS gives the following equation and quality for the full period with the standard deviations for variables in brackets:

$$i = 0.62\pi - 20.8y + 1.13 + u_t \quad (7)$$

$$(0.196) \quad (26.2) \quad (0.428)$$

$$T=60 \qquad R^2 = 0.16$$

where

i– refinancing operations rate

π– inflation for current year

y – log difference of output gap from HP quarterly trend

The model itself and π have a p value well below 0.01 and the constant has a p-value nearly at 0.01. The output gap is not relevant and the response coefficient has a nonsense value. The R-squared is a meagre 0.155, implying that the terms have low descriptive power for the refinancing operations rate.

Removing the output gap from the model significantly enhances the p value for the variable, constant and model – all within a confidence interval of 99%. The R-squared has still a very low value, although there is a marginal improvement. The equation takes the following form with the standard deviations for variables in brackets:

$$i = 0.61\pi + 1.14 + u_t \qquad (8)$$

(0.195) (0.43)

T=60 $R^2 = 0.15$

where

i– refinancing operations rate

π– inflation for current year

A significant improvement in model quality occurs when also the constant is removed, consequently making the refinancing operations rate respond to changes in inflation and to random shocks (error term). Displayed with the standard deviations for variables in brackets:

$$i = 1.10\pi + u_t \qquad (9)$$

(0.07)

T=60 $R^2 = 0.80$

where

i– refinancing operations rate

π– inflation for current year

Gujarati (2004, p 807) outlines that according to Granger and Newbold, an $R^2 > d$, is a good rule of thumb to suspect that the estimated regression is spurious. To clarify if this really is the case, Gujarati advises to regress first differences of the dependent and independent variable, where the R^2 should be practically zero and Durbin-Watson d about 2. This test currently does not validate a spurious regression, as the R^2 is 0.23 and d has increased to 1.14.

To further understand the quality of the regressions (8) and (9), some key tests for the base assumptions of a good regression model will be performed and discussed. Testing for normality of residuals by means of Dornik-Hansen test yields the validity of null-hypothesis for both equations that is the error term is normally distributed for both. To further understand if the error term has a constant dispersion, White's test for heteroskedasticity is performed. Residuals have a constant dispersion for equation (8), but not equation (9). Ramsay's Reset test confirms that the model specification is correct for both. Testing for autocorrelation by means of comparing the computed Durbin-Watson statistic with critical values, it is evident that positive correlation exists for both of the equations. As seen from Table 2, the models have similar quality in all items, except heteroscedasticity or White's test.

Table 2, Regression quality testing for Equations 8 and 9

Equation	White's test p-value	Ramsey's RESET p-value	Dornik-Hansen test p-value	Durbin-Watson p-value
Inflation and constant (Equation 8)	0.073	0.760	0.104	$7.689*10^{-14}$
Inflation (Equation 9)	$2.423*10^{-8}$	0.142	0.080	$1.043*10^{-13}$

Source: (Author's computations)

In econometric terms the models are not of excellent quality in terms of forecasting and may both provide results that are biased, inefficient and not consistent. However, when distancing from the technical results, the regression may provide some insight into the decision making of the ECB. By regressing the HICP against the ECB refinancing operations rate, the R^2 of 0.796 suggests that a great extent of the rate setting could be explained by the movements in the inflation rate and the output gap is not something the ECB addresses.

The regression results plotted along with ECB refinancing operations rate as seen from Figure 5 run both in a fairly similar manner. Equation 8 (Taylor rate, OLS, c on the graph) is closer to ECB rate (refinancing) in the beginning of the observation period an also during the peak and bottom of the financial crisis rates, however now it would suggest even a higher rate than the pure inflation reaction function Equation 9 (Taylor rate, OLS, nc on the graph).

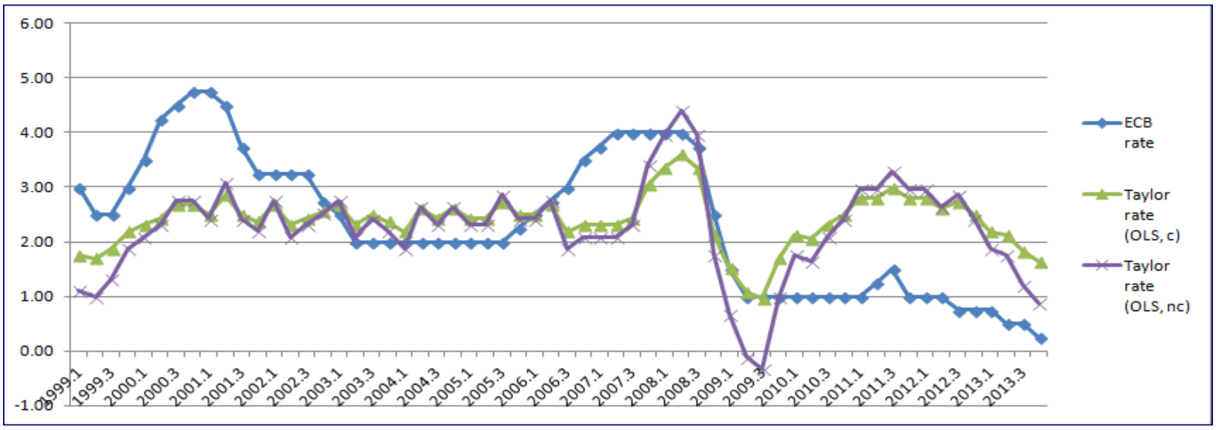

Figure 5. Refinancing Operations Rate Compared to Models (Equation 8, Equation 9) during 1991.1 – 2013.4. (Author's calculations, Appendix 2).

Concluding the analysis for the changing Euro area composition, it is worth to stress that the regression results show the output gap does not matter for the ECB. This is in line with the underlying assumption, as in theory stimulating the output is secondary on the ECB agenda – more suited to the context of fiscal, not monetary policy. The part of interest rate setting that is not related to inflation can either be explained by some other variables the ECB would like to respond to while setting the rate or it could be also due to interest rate smoothing.

The restriction of applying the OLS in the described manner is that it is not possible to determine the impact of the inflation target or more exactly separate the inflation target and the equilibrium real rate. The attempt to add a variable to OLS where the inflation target is subtracted from the actual inflation yields no results as this variable is omitted due to exact collinearity with inflation itself.

3.2.3. Applying the Taylor Rule for Individual Countries

The significance of the area-wide HICP provides valuable insight in terms of the interest rate's suitability for other countries in the euro area. Significant deviations of the individual country HICP from the area wide aggregate can lead to an interest rate which is too low, providing excess funds and creating the possibility of even further increased inflation, or a rate that is too high, hindering investment and consequently growth.

To provide further insight into the inflation dynamics of the countries, then before the calculation of interest rate the HICP changes for individual countries are reviewed. It must be granted, that the countries have joined the currency area at different times, or more specifically have met the convergence criteria at different times, but this does not mean that the HICP standing of the initial joiners is fully aligned. The inflation which is both the key target for ECB and a significant component in interest rate setting differs greatly from country to country.

As seen from Table 3, the Euro composition today consisting of 18 countries can be divided into three categories in terms of standard deviation from the changing Euro area composition HICP. The standard deviation of the individual country is computed by way of establishing the difference from the Euro area HICP for each of the quarterly observations during 1999-2013 and consequently the standard deviation for these differences is then computed for every country.

Table 3, Inflation and Real GDP Analysis for the Euro composition in 2014

Abbreviation	Country	σ^2 of HICP from EUR area	Category	Real GDP (millions Eur)	% of real GDP	Year of joining
FR	France	0.23	Low	2 059 852	21.5%	1999
IT	Italy	0.30	Low	1 560 024	16.2%	1999
DE	Germany	0.34	Low	2 737 600	28.5%	1999
AT	Austria	0.45	Low	313 197	3.3%	1999
BE	Belgium	0.51	Low	381 401	4.0%	1999
ES	Spain	0.58	Medium	1 022 988	10.7%	1999
LU	Luxembourg	0.61	Medium	45 478	0.5%	1999
MT	Malta	0.75	Medium	7 186	0.1%	2008
PT	Portugal	0.92	Medium	165 666	1.7%	1999
FI	Finland	0.93	Medium	193 443	2.0%	1999
CY	Cyprus	0.96	Medium	16 504	0.2%	2008
NL	Netherlands	1.07	Medium	602 658	6.3%	1999
GR	Greece	1.26	Medium	182 054	1.9%	2001
IE	Ireland	1.74	High	164 050	1.7%	1999
EE	Estonia	1.91	High	18 435	0.2%	2011
SI	Slovenia	2.46	High	35 275	0.4%	2007
SK	Slovakia	3.49	High	72 134	0.8%	2009
LV	Latvia	3.83	High	23 372	0.2%	2014

Source: (Eurostat Statistics Database, author's computations)

In parallel, the comparison of GDP contribution for each country is computed, based on the 2014 real GDP figures. It is evident from Table 3 that the countries in the category of low deviation (capped at 0.51) yield a significant amount of the total GDP, based on 2014 numbers a staggering 73.4%. The medium category has high GDP providers of Spain and Netherlands, where the inflation already deviates more than 0.51 from the Euro area current composition HICP. Intuitively, the countries with the highest standard deviations are the late joiners, however the HICP for Ireland has deviated on an average 1.74% (in absolute terms) from the area wide indicator.

To make a comparison of the suitability of the area wide rate against individual country rates in the current Euro area composition (18 countries), individual rates will be computed using Equation 9, which is a pure inflation rate reaction function. The R-squared has a sufficiently high value of 0.796 to make the assumption that the changes in interest rate are largely described by changes in HICP. The response coefficient of inflation is larger than one, which is aligned with the Taylor principle - in order to set a meaningful interest rate the response coefficient can't be equal to or lower than one. The individual rates will be then compared to the Euro area wide rate, which will also be computed using Equation 9. Secondly the individual rates will be compared to the actual refinancing operations rate of ECB.

The countries which have had appropriate interest rate, defined as either 1% higher or lower rate, small deviations are up to 2% lower or higher from the area wide rate. Larger differences start from 3% and have different categories where necessary to bring out some outlying observations. Individual country rates are listed for each of the quarters in the analysis period of 1999-2013 in Appendix 4. To illustrate the differences, the rates of individual countries in the category of low deviation from area wide HICP are plotted on Figure 6 and the high deviation ones on Figure 7.

While the rates move mostly in a similar manner if the graphs are observed separately, it must be noted that the rates do carry the individual HICP e.g. the group is not entirely aligned. While the individual country rate is displayed on y-axis in percentages and the quarters along the x axis, it is important to note that the values or rather the amplitude of fluctuation for the rates is very different.

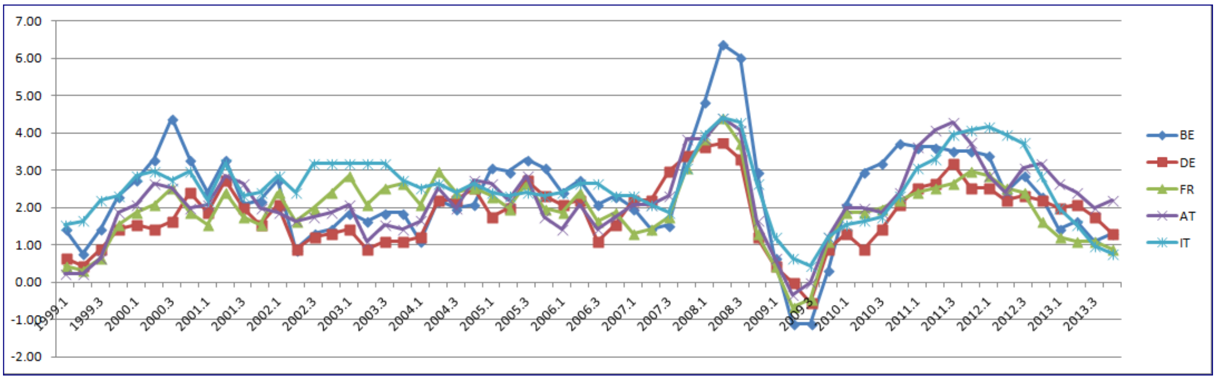

Figure 6. Taylor rates for individual countries of low HICP deviation from area wide indicator by applying Equation 9 during 1999.1 – 2013.4. (Author's calculations, Appendix 4).

While the rates remain below 7% for the low deviation countries, then in the high deviation category the rates nearly touch the 20% line. Also, the scaling is different, while on the low deviation it suffices to move with a step of one percentage point, then in the high deviation countries have a step of five percent, making the movements much larger.

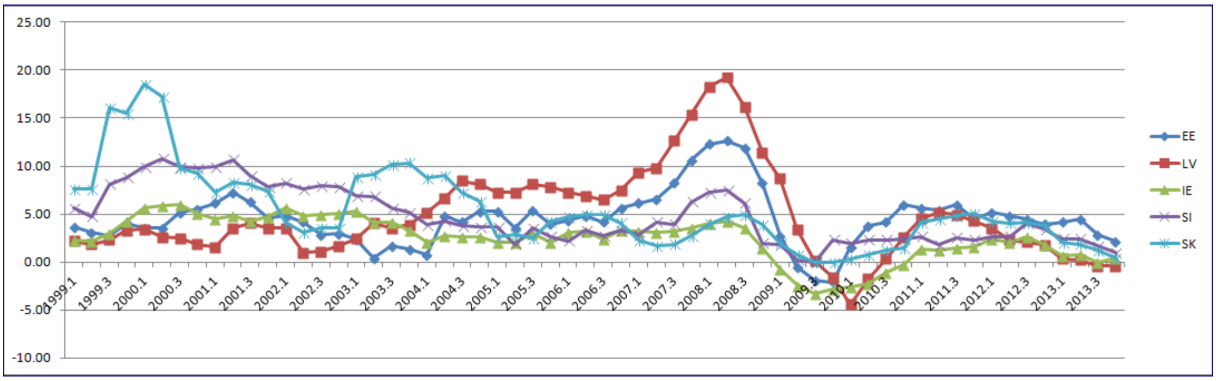

Figure 7. Taylor rates for individual countries of high HICP deviation from area wide indicator by applying Equation 9 during 1999.1 – 2013.4. (Author's calculations, Appendix 4).

Firstly the computed individual country rates are compared against the area wide rate, which is computed by using also Equation 9 (comparison details against area wide rate in Appendix 5). As it may be expected, the low deviation countries of Belgium, Germany, France, Austria and Italy have an appropriate rate for most of the quarters in the analysis period – a range from 85% to 100% of quarters with a deviation that does not exceed 1% in absolute terms.

A similar observation can be made for the countries where the inflation deviation is high. Estonia is standing out with 63% of the quarters with a rate that deviates more than 2% in absolute terms from the area wide rate. Mostly the rate has been too low by 2%-3%, but there have been 13 quarters where the rate has been significantly lower. Also, for Estonia the rate has been least appropriate as the number of quarters where the rate does not deviate more than 1% is only 7, a lot less than for any other country, regardless how much the HICP deviates from the area wide indicator. Latvia, Slovenia and Slovakia follow Estonia with the high number of quarters of too low rates.

An interesting observation can be made for Spain, Greece, Ireland and Portugal as their individual country rates are roughly equally divided between appropriate deviation of 1% in absolute terms and higher deviation. Spain and Portugal have had appropriate rates for about 60% of the time and for 40% of the time, the rate has been two low by at least 2%. Greece and Ireland have had an appropriate rate for about 40% of the time, and too low rates for about 60%. The rates being low for these countries does not necessarily mean extremes of rates being lower by 5% or 10% like they have been for the late joiners of the currency area, but a persistent deviation for 1%-3% lower rates exists.

Secondly the individual country rates are compared against the actual ECB refinancing rate and as it may be expected, the deviations are larger than for the rates computed using the same equation for individual countries and the area wide. The OLS method as applied in chapter 3.2.2. found the best possible solution for minimizing the differences for exogenous variable estimated values from the actual values, however it does not mimic the actual rate with a 100% precision.

The real ECB rate as compared to the computed individual rates appears to be within the 1% absolute term fluctuation for 50% or more of the time period for Ireland, Italy, Malta and Netherlands. Based on inflation analysis, only Italy is the country where the variance of inflation is very small from the Euro area composition. This can also be seen from Figure 6, where the low deviation inflation country rates are plotted. Belgium has notable ups and downs in its rate, while the rest seem to move in an aligned way, but still fluctuate amongst themselves.

Germany, Luxembourg, Spain and Austria are the countries with greatest number of quarters with a deviation of up to 2% from the ECB rate. It is interesting to note, that for Germany the ECB rate has been too high for 18 quarters and extremely high for 8 quarters.

For Luxembourg and Spain the deviations have been mainly due to the rate being too low. Also, Germany Austria and France are the countries which have had the least number of quarters where the rate has been more than 1% lower than the individual rate would suggest.

Intuitively the late joiners of the EU, like Estonia, Latvia, Slovenia and Slovakia are again the countries for which the rate has been too low for more than 50% of the period under review. Figure 7 displays the movement of the individual country rates, which are of much different scale than on Figure 6. During the year 2008 the rates have nearly touched the 20% line. However, the actual rate is more suited to these countries than the computed one as the previous comparison described.

Latvia, Slovenia and Slovakia have had around 10 quarters where the rate has been lower by at least 5% and up to 10%. Estonia has again experienced 16 quarters of a rate that has been lower at least by 3% and up to 5%. These countries have been accelerated by a total of 36-44 quarters of rates, which have been much lower than appropriate. It must be granted that they joined in the common currency area later, but nevertheless the currencies being pegged to Euro before yielding has had a strong impact also in terms of interest rate applicability.

3.2.4. Key Items To Note from Empirical Analysis

A common finding in the methods applied is that the Euro area wide rate has been for most of the observed period of 1999-2013 too low. This was firstly evident while comparing the Taylor standard specification rate to the actual ECB refinancing operations rate, where overall the computed Taylor rate was higher for only seven of the total sixty quarters under review. After having identified the most suitable reaction function by means of OLS, the rates computed for individual countries were also too low whether compared to the area wide rate also computed by means of using the same function or to the actual ECB refinancing operations rate. The OLS additionally implies that ECB sets the interest rate based on HICP and does not deem output gap as a relevant variable.

HICP for the individual countries is the key component of the interest rate and the countries are not homogenous what comes to individual HICP deviation from the area wide HICP indicator. The late joiners, namely Estonia, Slovakia, Slovenia and Latvia deviate significantly from the area wide indicator. Notably, so does Ireland – even though it joined the single currency area already in 1999. Also, it is useful to consider the GDP contribution of the countries, which is very much in line with the HICP deviation. The smaller the deviation category (Table 3, pp. 46), the larger the GDP contribution. This means that setting the interest rate in line with expectations for these core countries that have quite similar HICP indicator with the area wide one, is a large risk mitigating factor for the ECB - more than 70% of the real GDP is contributed by countries for whom the rate is appropriate.

Possibly the large number of quarters or observations with lower rates than appropriate can be related to the Financial Crisis of 2008 and the European sovereign default crisis of 2010. Also, it can be questioned if the short term interest rate as a tool has lost its purpose, but this is something the thesis is not attempting to answer. Perhaps it is suitable to conclude the analysis with the statement European Union has on its webpage, that the low rates since the crisis of 2008 have been the result of all EU institutions (including the ECB) working closely together to support growth and employment, protect savings, maintain a flow of affordable credit for businesses and households and to ensure financial stability.

CONCLUSION

The Central Bank is an independent institution conducting monetary policy, which in a current context is inflation targeting by means of setting a short term interest rate. The bank must be independent in its decisions to pursue price stability as the tools at the bank's disposal impact the entire economy. The timing and impact of the central bank instruments is described by monetary transmission mechanism. This is a large area of research on its own, but most importantly it is a process characterized by long and uncertain lags. High inflation is costly for the economy and so are abrupt changes. Hence, the policymakers would want to forecast the future with a high degree of precision, in order to be able to set an appropriate short term rate, generally by smoothing it and also well in advance to sustain good economic performance. The transparency and consistency of policy actions undertaken by a central bank are also a key in promoting stable growth.

A method to analyze the actions of a central bank is a famous policy rule by the name of Taylor rule. The rule was designed to provide 'recommendations' for how a central bank should set short term interest rates to achieve both the short-term goal of stabilizing the economy and a the long run goal of a desired inflation. In order to determine the short term interest rate, the Taylor rule proposes with an inflation target of 2% and an equilibrium real interest rate of 2%, a response coefficient of 1.5 to inflation and 0.5 to output gap. The Taylor rule follows the basic rule-of-thumb - when inflation is rising, then a strong response must be made by means of setting a higher interest rate to cool down economy and when inflation is falling, the interest rate must also fall. Despite the simplicity of the rule, a central bank would never resort to setting the short term rate based on such a simple equation. However, the rule serves as a good benchmark to both academics and bankers alike.

The Taylor rule was initially used in the U.S. to analyze Fed behaviour, both by Taylor and other researchers. Despite the different level of currency area integration of the Euro area as opposed to the United States, the same exercises have been conducted for the E.U. as well. The researches have incorporated different time periods, including years well before the adoption of the Euro, and various compositions of countries. Firstly, it can be concluded that empirical works have found the Taylor rule a useful tool to analyze the euro area on an aggregate level. Secondly, the suitability of the rate for an individual country can be looked at from different perspectives, either by questioning the bias of decision making of the Governing Council, or after having established a solid rule for the Euro area as a whole, try to identify if the rates are more favourable to specific countries. The empirical pieces find that traces of bias are found within the decision making, the rate tends to be prefer to core countries and interest rate changes are applied gradually or smoothed.

The relevant take away from the ECB monetary policy as communicated to the public is that the monetary policy is conducted by area wide aggregate indicators. Decisions are preceded by a two-pillar analysis, comprising of both the economic analysis and monetary analysis, which constitutes a so-called full set of information and consequently enables cross-checking. This would imply that the monetary policy would favour more those countries, whose economic indicators do not deviate much from the area-wide aggregate indicators. The monetary transmission mechanism might also not have a flawless pass-on of the rates, as countries may still be exposed to different events or shocks that may not impact all members equally or with equal force.

Bearing these preconditions in mind the thesis seeks to independently validate firstly if the standard specification of the Taylor rule is fitted to the euro area. Secondly a Euro composition area suitable reaction function is identified by means of regression analysis. Thirdly the analysis is expanded to individual countries. All data used in calculations is obtained from the Eurostat database. The data used for inflation is the monthly data displaying the annual rate of change in HICP. The output gap is measured by the difference of logarithm of real GDP and the logarithm of trend GDP. The trend is determined by applying the HP filter with a smoothing parameter of $\lambda=1600$ to iron out the cyclical element. ECB rate is the main refinancing operations rate. Econometric analysis is carried out in freeware *Gretl*.

Econometric evaluation of the data yields non-stationarity in the interest rate time-series, output gap is not a relevant parameter and the best model is a pure inflation rate reaction function, with a sufficiently high *R-squared* value. The key finding of the regression analysis might be the economic interpretation that the output gap is not a relevant variable for the ECB and in fact it shouldn't be, as the primary objective is to address inflation.

The best regression result is then considered an area-wide Taylor rule, based on which the rates of individual countries are computed. The different HICP indicators for individual countries suggest that the rates will be of different value and for some cases the deviation may be significant. An appropriate rate is a deviation of less than a percentage in absolute terms.

Based on the calculations, it can be said that the ECB rate has not been appropriate for the countries for most of the observations and also following the financial crisis of 2008, the rate for the Euro area itself has been significantly off the course that a Taylor rate would suggest. Secondly, the countries belonging into the single currency area are of very different economic health and a common monetary policy would then make the financial conditions much more aligned than the fiscal conditions.

The financial conditions remain heterogeneous and make the execution of a single monetary policy very challenging and following the crisis, the countries have diverged as opposed to converging. Conclusively, the years after the financial crisis of 2008 and the European sovereign debt crisis of 2010 have seen nothing but record low interest rates. In the European context, the European Central Bank brought down the main refinancing operations rate to 0.25% on November 13, 2013 and the most recent Governing Council meeting on May 8, 2014 left the interest rate unchanged. Modifications to the Taylor rule that would help to study the interest rate setting in a zero-lower bound environment are yet a topic of further research. Additionally the financial impact of having a significantly lower or higher rate would fuel further research as well as incorporating the exchange rate into the Taylor rule.

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Resümee

Euroopa Keskpanga tähtsaim eesmärk on viia ellu rahapoliitikat hinnastabiilsust säilitaval viisil, mille tulemusena peaks aastane inflatsioon jääma lähedale, kuid siiski allpoole 2%. Liikmesriigid, kelle koduvaluutaks on euro, on loobunud iseseisva rahapoliitika elluviimisest ning ei saa kohandada seega oma tegevust riigipõhiste majandusnäitajate alusel. Ühisele eesmärgile vaatamata, on rahaliitu kuuluvad riigid väga erinevad. Antud kontekstist lähtuvalt on käesoleva magistritöö eesmärgiks selgitada välja EKP intressimäära sobivus nii euroala jaoks tervikuna kui ka individuaalsete riikide jaoks ning tuua välja leitud on erinevused kui ka erinevuste põhjustajad.

Keskpanga näol on tegemist iseseisva rahapoliitikat elluviiva institutsiooniga, mis tänapäeva mõistes tähendab inflatsioonisihi kehtestamist ning majanduse tüürimist antud sihi poole läbi lühiajalise intressimäära seadmise. Keskpanga instrumentide mõjuulatust ning ajastust aitab selgitada rahapoliitika ülekandemehhanism, kusjuures oluline on võtta arvesse, et rahapoliitika instrumentide mõju majandusele avaldub viitajaga, mille kestust ei ole võimalik täpselt kindlaks määrata. Inflatsiooni sihi poole püüdlemise olulisust rõhutab nii kõrge inflatsioon kui ka äkiliste muudatuste kulukus. Seega püüavad keskpangad koostada võimalikult täpseid prognoose, millele tuginedes seatakse lühiajaline intressimäär, vajadusel silumist kasutades.

Keskpanga tegevuse analüüsimiseks kasutatakse kuulsat rahapoliitika reeglit nimega Taylori reegel. Tegemist on seaduspäraga, mille esialgseks eesmärgiks oli anda keskpangale n.ö. soovituslik intressimäär, mis peaks lühiajalises perspektiivis stabiliseerima majandust ning pikas perspektiivis tagama inflatsioonisihi saavutamise. Lühiajaline intressimäär sõltub inflatsioonist võimendusega 1.5 ning SKP hälbest võimendusega 0.5 ning seda eeldusel, et nii tasakaalu reaalintressimäär kui ka inflatsioonisiht on väärtusega 2%. Taylor uuris Föderaalreservi rahapoliitikat perioodil 1987-2002 ning jõudis järeldusele, et kehtivad intressimäärad oleks justkui arvutatud antud reeglit kasutades.

Taylori reegel vastab põhimõttele, et kasvava inflatsiooni ohjamiseks on vaja seada piisavalt suur lühiajaline intressimäär majanduse jahutamiseks. Reegel on leidnud kasutust nii

akadeemikute kui pankurite poolt, ning leidnud nii pooldajaid kui ka vastaseid. Taylor ei kasutanud oma esialgses uurimuses ökonomeetria võtteid nagu regressioonanalüüs. Edasised uurimused nii Taylori kui teiste teadlaste poolt pakkusid välja mitmeid täiendusi nagu viitaegade kasutamine, intressimäära järkjärguline kehtestamine ehk silumine, prognoositud inflatsiooni ja SKP hälbe kasutamine või alternatiivsete indikaatorite kasutamine SKP hälbe asemel (näiteks tööpuuduse määr). Lisaks on tasakaalu intressimäär ja prognoositav SKP tase subjektiivsed suurused, mis tekitavad hulganisti diskussiooni. Lisaks mainitud täiendustele ja piirangutele on oluline täheldada, et keskpank ei piiraks oma analüüsiprotsessi kunagi selliselt, et langetaks otsuse intressimäära suuruse üle Taylori reeglit kasutades. Seega on väike tegurite arv Taylori reegli jaoks nii eeliseks kui ka puuduseks.

Taylori reegel leidis esialgu kasutust Ameerika ühendriikide rahapoliitika analüüsimiseks, kuid peagi hakati katsetama reegli paikapidavust Euroopa ühisraha piirkonnas. Uurimused on käsitlenud erinevaid vaatlusperioode, nii enne kui ka pärast Euro kasutuselevõttu, ning kaasatud riikide kompositsioon on samuti olnud erinev. Metoodika keerukusaste on kõikunud lihtsast Taylori reegli arvutusest kuni dünaamilis-stohhastiliste ökonomeetriliste tasakaalumudeliteni, milles majanduskeskkonda jäljendades on testitud Taylori reegli sobilikkust.

Sisenditena on kasutusel harmoniseeritud tarbijahinnaindeks, SKP reaalväärtused ja – kasv, tööstustoodangu indeks. Keskpanga intressimäärana on kasutatud nii Euro üleööhoiuse indeksi keskmist (EONIA), refinantseerimisoperatsioonide intressimäära või enne Euro kasutusele võttu Saksamaa keskpanga intressimäära. Empiirilised uurimused Euroopa ühisraha piirkonnast on jõudnud erinevatele tulemustele, kuid pea kõikidel juhtudel on leitud reegli kuju, mis jäljendab Euroopa keskpanga tegevust intressimäära seadmisel, olgu selleks siis Taylori esialgne väljapakutud reegel, prognoositud näitajaid kasutav reegel või viitaegu rakendav reegel. Analüüsides euroala riike eraldivõetuna, on läbivaks jooneks tõsiasi, et Euroopa keskpanga intressimäär ei ole sobilik kõigile - peamiselt on intressimäär sobiv n.ö. tuumikriikide jaoks nagu Saksamaa, Prantsusmaa, Itaalia.

Analüüsimaks Euroopa Keskpanga tegevust intressimäära seadmisel on oluline täheldada, et rahaliitu kuuluvad riigid on oma majandusnäitajatelt väga erinevad, kuid rahapoliitilised otsused langetatakse liidu agregaatnäitajate põhjal, analüüsides eelnevalt nii majanduse dünaamikat ja šokke kui ka monetaartrende. Otsuste tegemine on keerukas, kui mitte öelda, et riskantne. Riigid, kelle näitajad eristuvad oluliselt euroala agregaatnäitajatest, võivad langeda kas liiga soodsa või liiga kalli intressimäära osaliseks, mis omakorda avaldab soovitust vastupidist mõju. Rahapoliitika ülekandemehhanismi uuring toob jällegi välja, et intressimäära kanali kaudu majanduse mõjutamine saavutab maksimaalse efekti umbes aasta või kahe jooksul. Ülekandemehhanism võib aga toimida erineval moel, seda nii rahaliidu ühiste šokkide mõju erineva avaldumise tõttu või hoopiski riigipõhiste šokkide tõttu. Alahinnata ei saa ka 2008. aastal Lehman Brothers pankrotistumisega vallandunud finantskriisi, mis peatas euroala riikide finantstingimuste ühtlustumise ning euroala riigi võlakirjade kriisi järgselt 2010. aastal ilmnesid lahknemised riikide makroökonoomilistes- ning finantsnäitajates.

Töö empiirilise osa läbiv idee on testida perioodil 1999-2013 Taylori reegli paikapidavust nii euroalal tervikuna kui ka individuaalsete riikide lõikes. Sisenditeks on kvartaalsed näitajad Eurostati andmebaasist. Inflatsiooni kirjeldab harmoniseeritud tarbijahinnaindeks (edaspidi HICP), SKP hälve trendist on leitud SKP reaalkasvu ning Hodric-Prescott filtri abil leitud trendi vahena, kus on kasutatud silumiskoefitsienti väärtusega $\lambda=1600$. Euroopa Keskpanga intressimääraks on kasutatud refinantseerimisoperatsioonide intressimäära. Taylori reeglile vastav intressimäär on esmalt leitud reegli standardset kuju jälgides ning kasutades programmi Excel. Seejärel on regressioonanalüüsi võtteid kasutades leitud sobilik Taylori reegli vaste euroala agregaatnäitajaid kasutades, arvutused on läbi viidud vabavaras Gretl. Saadud intressimäärasid on võrreldud nii erinevate piirkondade lõikes kui ka tegelike intressimääradega.

Taylori reegli klassikalist kuju kasutades leitud intressimäär euroala jaoks tervikuna jälgib EKP tegelikku intressimäära vaid perioodini 2001.2 ning seejärel on Taylori määr oluliselt kõrgem tegelikust. Järgmiseks leitakse analüüsiperioodi andmetele sobilik Taylori reegli kuju ökonomeetria võtteid kasutades. Andmete testimisel esineb intressimäära aegreal ootuspäraselt trend ning parimast lineaarsest regressioonvõrrandist selgub, et intressimäära seades reageeriks EKP justkui ainult muutustele inflatsioonis. Mudeli kvaliteet on keskpärane - esineb heteroskedastiivsus, mudel on oluline usaldusnivool 0.01, kirjeldusvõime on 0.8, kuju on korrektne ning jäägid on normaalselt jaotunud. Saadud mudelit kasutades on leitud individuaalsete riikide jaoks sobilikud intressimäärad.

Sarnaselt käsitletud uurimustega Taylori reegli rakendamisest euroalal on tulemuseks intressimäära sobimatus. Euroala jaoks tervikuna on intressimäär olnud liialt madal, standardse reegli rakendamisel on vaid seitsmel juhul olnud EKP intressimäär kõrgem.

Tingituna regressioonvõrrandi kujust, mis taandus inflatsiooni reaktsioonifunktsiooniks, võib riigipõhise inflatsiooni hälbe alusel eeldada, et sarnase mõjuulatusega hälve on ka euroala intressimäära ning individuaalsele riigile sobiliku intressimäära vahel. Nõnda selgubki, et euroalaga hiljem liitunud riigid nagu Eesti, Läti, Slovakkia ja Sloveenia on märkimisväärselt soodsama intressimäära osaliseks langenud. Iirimaa on erandiks, kes on küll liitunud euroalaga juba aastal 1999, kuid kõrge inflatsiooni tõttu on intressimäär taaskord liiga kõrgeks osutunud. Sobivaimaks kujunes intressimäär n.ö. tuumikriikide jaoks nagu Saksamaa, Prantsusmaa. EKP käitumist võib pidada ka riski maandavaks - seades tuumikriikide jaoks sobiva intressimäära, kaetakse euroala kogutoodangust veidi üle 70%.

EKP intressimäära vastavust Taylori printsiibile nii euroala jaoks tervikuna kui ka individuaalsete riikide jaoks on mõjutanud oluliselt 2008. aasta finantskriis, millest tulenevalt on intressimäärad jäänud rekordmadalateks, et tagada finantsvõimenduse kättesaadavus ka kriisist aeglaselt taastuvate riikide jaoks. Sellest tulenevalt oleksid edasised olulised uurimissuunad Taylori reegli rakendamine nullilähedase intressimäära oludes või vahetuskursi lisamine Taylori võrrandisse.

Appendices

Appendix 1. Quarterly Data and Computations for Taylor rates

Period	GDP per capita	GDP trend per capita	GDP growth	Output gap (ln)	HCIP	ECB rate	Taylor rate (std)	Taylor rate (OLS, c)	Taylor rate (OLS, nc)
1999.1	5 770.80	5 758.44	0	0.0021	1.00	3.00	2.50	1.75	1.10
1999.2	5 759.35	5 757.46	-0.20%	0.0003	0.90	2.50	2.35	1.69	0.99
1999.3	5 776.53	5 756.39	0.30%	0.0035	1.20	2.50	2.80	1.88	1.32
1999.4	5 787.98	5 755.21	0.20%	0.0057	1.70	3.00	3.55	2.18	1.87
2000.1	5 793.70	5 753.90	0.10%	0.0069	1.90	3.50	3.85	2.31	2.09
2000.2	5 770.80	5 752.48	-0.40%	0.0032	2.10	4.25	4.15	2.43	2.31
2000.3	5 742.18	5 750.99	-0.50%	-0.0015	2.50	4.50	4.75	2.68	2.75
2000.4	5 753.63	5 749.46	0.20%	0.0007	2.50	4.75	4.75	2.68	2.75
2001.1	5 770.80	5 747.94	0.30%	0.0040	2.20	4.75	4.30	2.49	2.42
2001.2	5 719.28	5 746.48	-0.89%	-0.0047	2.80	4.50	5.20	2.86	3.08
2001.3	5 719.28	5 745.13	0.00%	-0.0045	2.20	3.75	4.30	2.49	2.42
2001.4	5 725.00	5 743.92	0.10%	-0.0033	2.00	3.25	4.00	2.37	2.20
2002.1	5 725.00	5 742.90	0.00%	-0.0031	2.50	3.25	4.75	2.68	2.75
2002.2	5 747.90	5 742.06	0.40%	0.0010	1.90	3.25	3.85	2.31	2.09
2002.3	5 730.73	5 741.41	-0.30%	-0.0019	2.10	3.25	4.15	2.43	2.31
2002.4	5 719.28	5 740.96	-0.20%	-0.0038	2.30	2.75	4.45	2.55	2.53
2003.1	5 713.55	5 740.71	-0.10%	-0.0047	2.50	2.50	4.75	2.68	2.75
2003.2	5 719.28	5 740.63	0.10%	-0.0037	1.90	2.00	3.85	2.31	2.09
2003.3	5 742.18	5 740.70	0.40%	0.0003	2.20	2.00	4.30	2.49	2.42
2003.4	5 753.63	5 740.87	0.20%	0.0022	2.00	2.00	4.00	2.37	2.20
2004.1	5 742.18	5 741.10	-0.20%	0.0002	1.70	2.00	3.55	2.18	1.87
2004.2	5 747.90	5 741.34	0.10%	0.0011	2.40	2.00	4.60	2.61	2.64
2004.3	5 736.45	5 741.58	-0.20%	-0.0009	2.10	2.00	4.15	2.43	2.31
2004.4	5 730.73	5 741.76	-0.10%	-0.0019	2.40	2.00	4.60	2.61	2.64
2005.1	5 730.73	5 741.87	0.00%	-0.0019	2.10	2.00	4.15	2.43	2.31
2005.2	5 753.63	5 741.85	0.40%	0.0020	2.10	2.00	4.15	2.43	2.31
2005.3	5 753.63	5 741.66	0.00%	0.0021	2.60	2.00	4.90	2.74	2.86
2005.4	5 753.63	5 741.26	0.00%	0.0022	2.20	2.25	4.30	2.49	2.42
2006.1	5 770.80	5 740.61	0.30%	0.0052	2.20	2.50	4.30	2.49	2.42
2006.2	5 782.25	5 739.68	0.20%	0.0074	2.50	2.75	4.75	2.68	2.75
2006.3	5 753.63	5 738.48	-0.50%	0.0026	1.70	3.00	3.55	2.18	1.87
2006.4	5 776.53	5 737.01	0.40%	0.0069	1.90	3.50	3.85	2.31	2.09
2007.1	5 765.08	5 735.31	-0.20%	0.0052	1.90	3.75	3.85	2.31	2.09
2007.2	5 742.18	5 733.43	-0.40%	0.0015	1.90	4.00	3.85	2.31	2.09
2007.3	5 747.90	5 731.45	0.10%	0.0029	2.10	4.00	4.15	2.43	2.31
2007.4	5 736.45	5 729.43	-0.20%	0.0012	3.10	4.00	5.65	3.04	3.41

Appendix 1. Quarterly Data and Computations for Taylor rates (continued)

Period	GDP per capita	GDP trend per capita	GDP growth	Output gap (ln)	HCIP	ECB rate	Taylor rate (std)	Taylor rate (OLS, c)	Taylor rate (OLS, nc)
2008.1	5 753.63	5 727.47	0.30%	0.0046	3.60	4.00	6.40	3.35	3.96
2008.2	5 696.38	5 725.66	-1.00%	-0.0051	4.00	4.00	7.00	3.60	4.40
2008.3	5 684.93	5 724.11	-0.20%	-0.0069	3.60	3.75	6.40	3.35	3.96
2008.4	5 621.95	5 722.91	-1.11%	-0.0178	1.60	2.50	3.39	2.12	1.76
2009.1	5 558.98	5 722.12	-1.12%	-0.0289	0.60	1.50	1.89	1.51	0.66
2009.2	5 707.83	5 721.75	2.68%	-0.0024	-0.10	1.00	0.85	1.08	-0.11
2009.3	5 742.18	5 721.70	0.60%	0.0036	-0.30	1.00	0.55	0.96	-0.33
2009.4	5 747.90	5 721.86	0.10%	0.0045	0.90	1.00	2.35	1.69	0.99
2010.1	5 747.90	5 722.13	0.00%	0.0045	1.60	1.00	3.40	2.12	1.76
2010.2	5 770.80	5 722.44	0.40%	0.0084	1.50	1.00	3.25	2.06	1.65
2010.3	5 742.18	5 722.72	-0.50%	0.0034	1.90	1.00	3.85	2.31	2.09
2010.4	5 753.63	5 722.94	0.20%	0.0053	2.20	1.00	4.30	2.49	2.42
2011.1	5 770.80	5 723.08	0.30%	0.0083	2.70	1.00	5.05	2.80	2.97
2011.2	5 725.00	5 723.14	-0.79%	0.0003	2.70	1.25	5.05	2.80	2.97
2011.3	5 725.00	5 723.15	0.00%	0.0003	3.00	1.50	5.50	2.98	3.30
2011.4	5 707.83	5 723.13	-0.30%	-0.0027	2.70	1.00	5.05	2.80	2.97
2012.1	5 719.28	5 723.12	0.20%	-0.0007	2.70	1.00	5.05	2.80	2.97
2012.2	5 707.83	5 723.14	-0.20%	-0.0027	2.40	1.00	4.60	2.61	2.64
2012.3	5 713.55	5 723.20	0.10%	-0.0017	2.60	0.75	4.90	2.74	2.86
2012.4	5 690.65	5 723.33	-0.40%	-0.0057	2.20	0.75	4.30	2.49	2.42
2013.1	5 713.55	5 723.51	0.40%	-0.0017	1.70	0.75	3.55	2.18	1.87
2013.2	5 742.18	5 723.73	0.50%	0.0032	1.60	0.50	3.40	2.12	1.76
2013.3	5 730.73	5 723.98	-0.20%	0.0012	1.10	0.50	2.65	1.82	1.21
2013.4	5 736.45	5 724.23	0.10%	0.0021	0.80	0.25	2.20	1.63	0.88

Appendix 2. Time Series Plots for Euro Area Variables

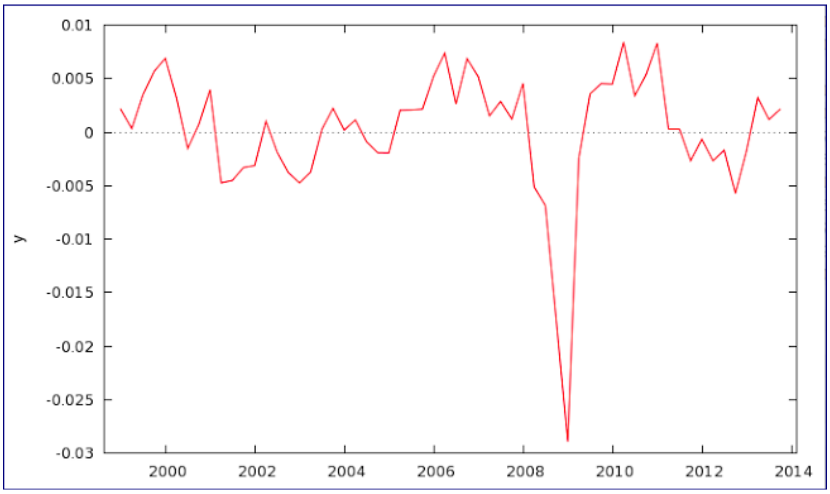

Figure X, Time Series Plot for the Output Gap

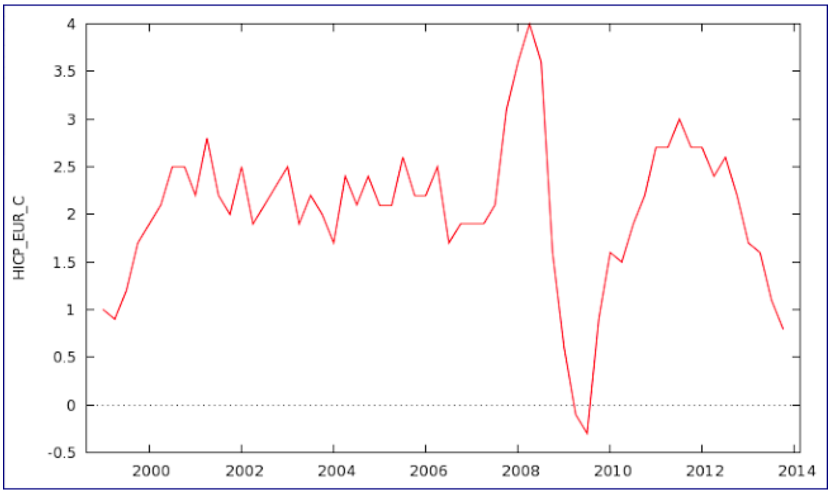

Figure Y, Time Series Plot for the HCIP (inflation)

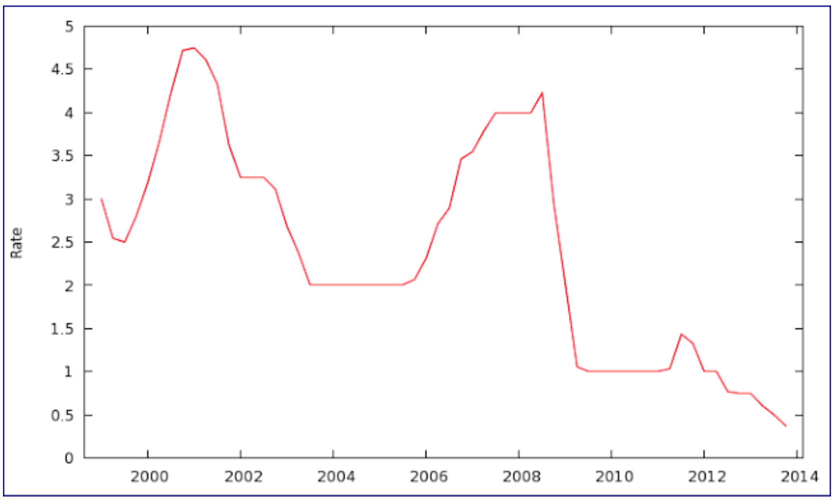

Figure Z, Time Series Plot for the ECB Refinancing Operations Rate (inflation)

Appendix 3. Changing Euro Area Composition Regression Results

Table 4, Equation 7 (pp. 43) regression results

Variable	Coefficient	Std. error	t-ratio	p-value
const	1.132	0.428	2.648	0.010
y	-20.756	26.193	-0.792	0.431
π	0.617	0.196	3.151	0.003

R^2	0.155	Adjusted R^2	0.125
Schwarz criterion	198.520	Akaike criterion	192.243
Durbin-Watson	0.089	P-value (F)	0.008

Table 5, Equation 8 (pp. 44) regression results

Variable	Coefficient	Std. error	t-ratio	p-value
const	1.136	0.426	2.665	0.010
π	0.614	0.195	3.146	0.003

R^2	0.145	Adjusted R^2	0.131
Schwarz criterion	195.089	Akaike criterion	190.900
Durbin-Watson	0.083	P-value (F)	0.002

Table 6, Equation 9 (pg 44) regression results

Variable	Coefficient	Std. error	t-ratio	p-value
π	1.100	0.076	15.180	$4.92*10^{-22}$

R^2	0.796	Adjusted R^2	0.796
Schwarz criterion	197.926	Akaike criterion	195.832
Durbin-Watson	0.164	P-value (F)	$4.92*10^{-22}$

Table 7, Equation 9 (pg 44) spurious regression validation results

Variable	Coefficient	Std. error	t-ratio	p-value
d_inflation	0.324	0.077	4.180	$9.97*10^{-5}$

R^2	0.231	Adjusted R^2	0.2314
Durbin-Watson	1.137	P-value (F)	0.0001

Appendix 4. Taylor Rate Results for Individual Countries

Period	BE	DE	EE	IE	GR	ES	FR	IT	CY	LV	LU	MT	NL	AT	PT	SI	SK	FI
1999.1	1.4	0.7	3.6	2.3	3.3	2.3	0.4	1.5	1.5	2.2	0.7	2.6	2.2	0.2	3.1	5.6	7.6	1.0
1999.2	0.8	0.4	3.1	2.2	1.7	2.3	0.3	1.7	0.4	1.9	1.3	1.7	2.3	0.2	2.3	4.7	7.6	1.3
1999.3	1.4	0.9	2.8	3.0	1.4	2.8	0.7	2.2	0.3	2.3	1.8	2.1	2.2	0.7	2.1	8.1	16.1	1.5
1999.4	2.3	1.4	4.1	4.3	2.5	3.1	1.5	2.3	4.0	3.3	2.5	4.8	2.1	1.9	1.9	8.8	15.5	2.4
2000.1	2.8	1.5	3.5	5.6	3.1	3.3	1.9	2.9	5.6	3.4	3.3	3.7	1.8	2.1	1.5	9.9	18.5	3.5
2000.2	3.3	1.4	3.5	5.8	2.4	3.9	2.1	3.0	5.7	2.6	5.0	3.6	2.8	2.6	3.1	10.8	17.3	3.4
2000.3	4.4	1.7	5.2	5.9	3.3	4.1	2.5	2.8	5.0	2.5	4.6	3.5	3.2	2.5	4.0	9.9	9.8	3.7
2000.4	3.3	2.4	5.5	5.1	4.1	4.4	1.9	3.0	4.1	1.9	4.7	1.1	3.2	2.0	4.2	9.8	9.2	3.2
2001.1	2.4	1.9	6.2	4.5	3.5	3.3	1.5	2.2	1.7	1.5	3.3	1.8	5.5	2.1	5.6	9.9	7.3	2.8
2001.2	3.3	2.8	7.3	4.8	5.0	4.1	2.4	3.2	3.4	3.5	3.0	3.0	5.6	2.9	5.1	10.7	8.4	3.3
2001.3	2.1	2.0	6.3	4.3	4.4	2.5	1.8	2.3	2.4	4.1	2.1	3.5	5.8	2.6	4.5	9.0	8.0	2.9
2001.4	2.2	1.5	4.6	4.7	3.9	2.8	1.5	2.4	2.3	3.5	1.0	4.0	5.6	2.0	4.3	7.8	7.4	2.5
2002.1	2.8	2.1	4.8	5.6	4.8	3.5	2.4	2.9	2.2	3.5	1.9	3.4	4.7	1.9	3.6	8.3	4.2	2.9
2002.2	0.9	0.9	4.2	4.8	4.0	3.7	1.7	2.4	2.3	1.0	1.4	2.3	4.2	1.7	3.9	7.6	3.1	1.7
2002.3	1.3	1.2	2.9	5.0	4.2	3.9	2.0	3.2	3.9	1.1	2.4	2.4	4.0	1.8	4.2	7.9	3.5	1.5
2002.4	1.4	1.3	3.0	5.1	3.9	4.4	2.4	3.2	3.4	1.7	3.1	2.3	3.5	1.9	4.4	7.8	3.5	1.9
2003.1	1.9	1.4	2.4	5.3	4.3	4.1	2.9	3.2	6.9	2.4	4.1	2.6	3.1	2.1	4.2	6.9	8.9	2.1
2003.2	1.7	0.9	0.4	4.2	4.0	3.1	2.1	3.2	4.1	4.1	2.2	2.4	2.3	1.1	3.7	6.8	9.1	1.3
2003.3	1.9	1.1	1.7	4.2	3.6	3.3	2.5	3.2	3.6	3.5	2.9	1.9	2.2	1.5	3.5	5.6	10.1	1.3
2003.4	1.9	1.1	1.3	3.3	3.4	3.0	2.6	2.8	2.4	3.9	2.6	2.6	1.8	1.4	2.5	5.2	10.3	1.3
2004.1	1.1	1.2	0.8	2.1	3.2	2.4	2.1	2.5	0.1	5.2	2.2	2.3	1.3	1.7	2.4	3.9	8.8	-0.4
2004.2	2.2	2.2	4.8	2.8	3.3	3.9	3.0	2.6	2.6	6.7	4.2	3.5	1.7	2.5	4.1	4.3	9.0	-0.1
2004.3	2.0	2.2	4.2	2.6	3.2	3.5	2.4	2.4	2.0	8.5	3.4	3.5	1.3	2.0	2.3	3.7	7.3	0.2
2004.4	2.1	2.5	5.3	2.6	3.4	3.6	2.5	2.6	4.3	8.1	3.9	2.1	1.3	2.8	2.9	3.6	6.4	0.1

Appendix 4. Taylor Rate Results for Individual Countries (continued)

Period	BE	DE	EE	IE	GR	ES	FR	IT	CY	LV	LU	MT	NL	AT	PT	SI	SK	FI
2005.1	3.1	1.8	5.3	2.1	3.2	3.7	2.3	2.4	2.6	7.3	3.9	2.9	1.7	2.6	2.5	3.6	2.6	1.0
2005.2	3.0	2.0	3.5	2.1	3.5	3.5	2.0	2.3	1.7	7.3	3.5	2.3	1.7	2.2	0.7	1.9	2.9	1.1
2005.3	3.3	2.8	5.4	3.0	4.2	4.2	2.6	2.4	2.3	8.1	5.2	2.2	1.9	2.9	3.0	3.5	2.5	1.2
2005.4	3.1	2.3	4.0	2.1	3.9	4.1	2.0	2.3	1.5	7.8	3.7	3.7	2.2	1.8	2.8	2.6	4.3	1.2
2006.1	2.4	2.1	4.4	3.1	3.6	4.3	1.9	2.4	2.9	7.3	4.1	3.2	1.5	1.4	4.2	2.2	4.7	1.3
2006.2	2.8	2.2	4.8	3.2	3.7	4.4	2.4	2.6	2.9	6.9	4.3	3.6	2.0	2.1	3.9	3.3	5.0	1.7
2006.3	2.1	1.1	4.2	2.4	3.4	3.2	1.7	2.6	2.4	6.5	2.2	3.4	1.7	1.4	3.3	2.8	5.0	0.9
2006.4	2.3	1.5	5.6	3.3	3.5	3.0	1.9	2.3	1.7	7.5	2.5	0.9	1.9	1.8	2.8	3.3	4.1	1.3
2007.1	2.0	2.2	6.2	3.2	3.1	2.8	1.3	2.3	1.5	9.4	2.6	0.6	2.1	2.1	2.6	2.9	2.3	1.8
2007.2	1.4	2.2	6.6	3.1	2.9	2.8	1.4	2.1	1.9	9.8	2.5	-0.7	2.0	2.1	2.6	4.2	1.7	1.5
2007.3	1.5	3.0	8.3	3.2	3.2	3.0	1.8	1.9	2.5	12.7	2.8	1.0	1.4	2.3	2.2	4.0	1.9	1.9
2007.4	3.4	3.4	10.7	3.5	4.3	4.7	3.1	3.1	4.1	15.4	4.7	3.4	1.8	3.9	3.0	6.3	2.8	2.1
2008.1	4.8	3.6	12.3	4.1	4.8	5.1	3.9	4.0	4.8	18.3	4.8	4.7	2.1	3.9	3.4	7.3	4.0	4.0
2008.2	6.4	3.7	12.7	4.3	5.4	5.6	4.4	4.4	5.7	19.3	5.8	4.8	2.5	4.4	3.7	7.5	4.7	4.7
2008.3	6.1	3.3	11.9	3.5	5.2	5.1	3.7	4.3	5.5	16.2	5.3	5.4	3.1	4.1	3.5	6.2	5.0	5.2
2008.4	3.0	1.2	8.3	1.4	2.4	1.7	1.3	2.6	2.0	11.4	0.8	5.5	1.9	1.7	0.9	2.0	3.9	3.7
2009.1	0.7	0.4	2.8	-0.8	1.7	-0.1	0.4	1.2	1.0	8.7	-0.3	4.3	2.0	0.7	-0.7	1.8	2.0	2.2
2009.2	-1.1	0.0	-0.6	-2.4	0.8	-1.1	-0.7	0.7	0.1	3.4	-1.1	3.1	1.5	-0.3	-1.8	0.2	0.8	1.8
2009.3	-1.1	-0.6	-1.9	-3.3	0.8	-1.0	-0.4	0.4	-1.3	0.1	-0.4	0.9	0.0	0.0	-2.0	0.0	0.0	1.2
2009.4	0.3	0.9	-2.1	-2.9	2.9	1.0	1.1	1.2	1.8	-1.5	2.8	-0.4	0.8	1.2	-0.1	2.3	0.0	2.0
2010.1	2.1	1.3	1.5	-2.6	4.3	3.0	1.9	1.5	2.5	-4.4	3.5	0.7	0.8	2.0	0.7	2.0	0.3	1.7
2010.2	3.0	0.9	3.7	-2.2	5.7	2.3	1.9	1.7	2.3	-1.8	2.5	2.0	0.2	2.0	1.2	2.3	0.8	1.4
2010.3	3.2	1.4	4.2	-1.1	6.3	3.1	2.0	1.8	4.0	0.3	2.9	2.6	1.5	1.9	2.2	2.3	1.2	1.5
2010.4	3.7	2.1	5.9	-0.2	5.7	3.2	2.2	2.3	2.1	2.6	3.4	4.4	2.0	2.4	2.6	2.4	1.4	3.1

Appendix 4. Taylor Rate Results for Individual Countries (continued)

Period	BE	DE	EE	IE	GR	ES	FR	IT	CY	LV	LU	MT	NL	AT	PT	SI	SK	FI
2011.1	3.6	2.5	5.6	1.3	4.7	3.6	2.4	3.1	3.5	4.5	4.4	3.1	2.1	3.6	4.3	2.6	4.2	3.9
2011.2	3.6	2.6	5.4	1.2	3.4	3.3	2.5	3.3	5.0	5.2	4.2	3.4	2.5	4.1	3.6	1.8	4.5	3.7
2011.3	3.5	3.2	5.9	1.4	3.2	3.3	2.6	4.0	2.8	5.0	4.2	3.1	3.3	4.3	3.9	2.5	4.8	3.9
2011.4	3.5	2.5	4.5	1.5	2.4	2.6	3.0	4.1	4.6	4.3	3.7	1.7	2.8	3.7	3.9	2.3	5.1	2.9
2012.1	3.4	2.5	5.2	2.4	1.5	2.0	2.9	4.2	3.9	3.5	3.2	2.9	3.2	2.9	3.4	2.6	4.3	3.2
2012.2	2.4	2.2	4.8	2.1	1.1	2.0	2.5	4.0	3.2	2.3	2.9	4.8	2.8	2.4	3.0	2.6	4.1	3.2
2012.3	2.9	2.3	4.5	2.6	0.3	3.9	2.4	3.7	4.0	2.1	3.5	3.2	2.8	3.1	3.2	4.1	4.2	3.7
2012.4	2.3	2.2	4.0	1.9	0.3	3.3	1.7	2.9	1.7	1.8	2.8	3.1	3.7	3.2	2.3	3.4	3.7	3.9
2013.1	1.4	2.0	4.2	0.7	-0.2	2.9	1.2	2.0	1.4	0.3	2.2	1.5	3.5	2.6	0.8	2.4	2.1	2.8
2013.2	1.7	2.1	4.5	0.8	-0.3	2.4	1.1	1.5	0.9	0.2	2.2	0.7	3.5	2.4	1.3	2.4	1.9	2.5
2013.3	1.1	1.8	2.9	0.0	-1.1	0.6	1.1	1.0	0.3	-0.4	1.7	0.7	2.6	2.0	0.3	1.7	1.2	2.0
2013.4	1.3	1.3	2.2	0.4	-2.0	0.3	0.9	0.8	-1.4	-0.4	1.7	1.1	1.5	2.2	0.2	1.0	0.4	2.1

Appendix 5. Individual Country Taylor Rates in Comparison to Area Wide Rate

	No of periods when area wide rate has been larger by:			No of periods when area wide rate has been lower by:					Within a range of:					
	1%...2%	2%...3%	3%...	1%...2%	2%...3%	3%...5%	5%...10%	10%...	-1%...1%	% of Q	-2%...2%	% of Q	< -2%, or > 2%	% of Q
Austria	0	0	0	2	0	0	0	0	58	97%	2	3%	0	0%
Belgium	2	0	0	6	1	0	0	0	51	85%	8	13%	1	2%
Cyprus	1	1	0	11	2	3	0	0	42	70%	12	20%	6	10%
Germany	8	0	0	0	0	0	0	0	52	87%	8	13%	0	0%
Estonia	3	0	1	12	24	7	6	0	7	12%	15	25%	38	63%
Spain	0	0	0	26	0	0	0	0	34	57%	26	43%	0	0%
Finland	8	4	0	9	0	0	0	0	39	65%	17	28%	4	7%
France	0	0	0	0	0	0	0	0	60	100%	0	0%	0	0%
Greece	2	6	0	23	3	3	0	0	23	38%	25	42%	12	20%
Ireland	7	3	4	9	10	3	0	0	24	40%	16	27%	20	33%
Italy	0	0	0	4	0	0	0	0	56	93%	4	7%	0	0%
Luxembourg	1	0	0	19	2	0	0	0	38	63%	20	33%	2	3%
Latvia	7	1	2	11	1	8	9	5	16	27%	18	30%	26	43%
Malta	8	1	0	11	2	3	0	0	35	58%	19	32%	6	10%
Netherlands	5	0	0	10	2	3	0	0	40	67%	15	25%	5	8%
Portugal	7	0	0	16	2	1	0	0	34	57%	23	38%	3	5%
Slovenia	1	0	0	9	4	7	14	0	25	42%	10	17%	25	42%
Slovakia	1	0	0	12	4	4	13	4	22	37%	13	22%	25	42%

Appendix 6. Individual Country Taylor Rates in Comparison to Actual ECB Rate

	No of periods when ECB rate has been larger by:			No of periods when ECB rate has been lower by:					Within a range of:					
	1%...2%	2%...3%	3%...	1%...2%	2%...3%	3%...5%	5%...10%	10%...	-1%...1%	% of Q	-2%...2%	% of Q	< -2%, or > 2%	% of Q
Austria	18	4	0	7	6	0	0	0	25	42%	25	42%	10	17%
Belgium	11	6	0	8	10	0	0	0	25	42%	19	32%	16	27%
Cyprus	8	5	1	8	7	4	0	0	27	45%	16	27%	17	28%
Germany	18	8	0	13	0	0	0	0	21	35%	31	52%	8	13%
Estonia	3	1	1	10	10	16	5	0	14	23%	13	22%	33	55%
Spain	6	1	0	20	7	1	0	0	25	42%	26	43%	9	15%
Finland	14	7	0	6	8	1	0	0	24	40%	20	33%	16	27%
France	14	8	1	8	0	0	0	0	29	48%	22	37%	9	15%
Greece	6	1	0	19	2	4	1	0	27	45%	25	42%	8	13%
Ireland	2	2	5	11	6	0	0	0	34	57%	13	22%	13	22%
Italy	9	2	0	5	6	2	0	0	36	60%	14	23%	10	17%
Luxembourg	12	3	0	19	8	2	0	0	16	27%	31	52%	13	22%
Latvia	3	5	2	6	3	10	11	4	16	27%	9	15%	35	58%
Malta	2	2	4	8	7	2	0	0	35	58%	10	17%	15	25%
Netherlands	9	3	0	9	6	1	0	0	32	53%	18	30%	10	17%
Portugal	10	3	0	11	6	1	0	0	29	48%	21	35%	10	17%
Slovenia	0	0	0	17	6	11	10	0	16	27%	17	28%	27	45%
Slovakia	2	2	0	5	5	13	9	4	20	33%	7	12%	33	55%