Norwegian School of Economics

Bergen, Fall 2016

Taylor Rules and Monetary Policy in the Eurozone

Sverre Wiseth Haug, Martin Bergsholm Nesse

Supervisor: Øystein Thøgersen

Master Thesis in Economics

NORWEGIAN SCHOOL OF ECONOMICS

Abstract

In this thesis, we analyse the monetary policy in the Eurozone since the origin of the euro. The aim of the thesis is to assess whether, and to what extent, the common monetary policy of the Eurozone has contributed to stabilization of business cycles within the various economies.

By utilizing alternative versions of the Taylor rule, we have calculated several Taylor-rates for each of the member states in the Eurozone, which in turn are compared to the actual interest rate path from the European Central Bank (ECB). Deviation between the Taylor-rates and the actual policy rate is used to analyse the suitability of the common monetary policy for each member country.

The thesis also discusses the notion of the Eurozone constituting a good approximation to an optimum currency area by comparing the deviations between the Taylor-rates and the policy rate with developments in other macro-variables.

A key variable that has implications for our results was the neutral real rate of interest. When assuming a constant neutral rate, we find that in the first decade of the euro the policy rate set by the ECB was much closer to the suggested rates of the core-countries than for the peripheral-countries. The Taylor rule suggests that the monetary policy was too accommodative for the peripheral-countries during this period. In the period after the financial crisis it seems that the monetary policy was too strict for the peripheral-countries, whilst being too accommodative for the core-countries.

Estimations of the neutral real rate using the Laubach-Williams - model show that an assumed value of the neutral real rate equal to 2% was a fairly good assumption for the core-countries, such as Germany, France, Belgium, Netherland and Austria. However, in the peripheral-countries the fluctuations of the neutral real rate have been far greater over the entire period. This adds to the notion that the perceived stability of the Eurozone during some time intervals has mainly been a feature of the core countries.

We also calculate Taylor-rates using country-specific estimates of the neutral real rate. The main features of the country-specific Taylor-rates remain unchanged when compared to the Taylor-rates which assumed a common constant neutral real rate.

We find no evidence of any member states being implicitly prioritized by the ECB when the policy rate is decided. Although it did seem as the monetary policy of the ECB was better suited for the core-countries during the first decade of the euro, it appears as stability for the Eurozone as a whole has been prioritized.

Looking at the end of the time-series it appears as some of the countries that have experienced the most severe struggles in the aftermath of the financial crisis now starting to see an upswing, which is evident in both the Taylor rules and the neutral real rate of interest. Our results suggest that the Eurozone does not currently seem to be a good approximation of an Optimum Currency Area, but this does not mean it cannot evolve into one in the future.

Acknowledgements

We would like to express our deepest appreciation to all of those who have contributed to make this thesis possible. In particular, we would like to give a special thanks to our supervisor,. Prof. Dr. Øystein Thøgersen. We much appreciate your efforts in helping us find a feasible topic and for highly valuable feedback and motivation throughout the semester. We feel privileged to have been able to work on a topic of such social importance.

We also wish to thank Dr. Ansgar Belke and Prof. Dr. Jens Klose for sharing their dataset. Without their help, the last part of the analysis in this thesis would not have become a reality.

We would also like to thank our friends and families for support and motivation throughout these past few months.

Bergen, December 2016

Martin Bergsholm Nesse Sverre Wiseth Haug

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1. Introduction

1.1 Motivation

Regarding the stabilization of the country-specific business cycles; to what extent has the monetary policy of the European Central Bank (ECB) been beneficial or problematic for the different countries of the Eurozone? This is a crucial question given that we observe very different level of capacity utilization and macroeconomic performance among the different member-countries. Have the member countries in fact converged towards more synchronized business cycle fluctuations, or has the euro instead led to new, bigger challenges when it comes to stabilization policy?

As a background for our study, we will highlight the initial ambitions for the process that led to the introduction of the euro. Establishing a common currency for member countries of the European Union had been a goal since the 1960s. A major breakthrough in this process came in 1986 with the signing of the Single European Act (SEA). The Act was the first major revision of the Treaty of Rome, signed in 1957. The Treaty of Rome proposed to establish a single market for goods, labour, services and capital across the member states of the European Economic Community (EEC) and was a significant step towards strengthened economic integration amongst the European states. The revision brought forward by the SEA came as a result of a desire to increase trade between European countries by harmonizing laws amongst countries. The SEA established an objective for the European Community to establish a single market by December 31st 1992. The key element in the SEA was to reform the legislative process by extending qualified majority voting to new areas (as opposed requiring unanimity) (Moravcsik (1991)).

The Maastricht Treaty of 1992 led to the formal establishment of the European Union and the creation of the euro, a single common European currency. In this treaty a set of convergence criteria were set, which all member states of the European Union are required to meet in order to adopt the euro as their currency. This included government deficits not surpassing 3% of annual GDP, government debt not exceeding 60% of GDP, the inflation rate not being higher than 1,5 percentage points above the average of the three best performing (lowest inflation) countries in the EU, as well as criteria regarding the exchange rate and long-term interest rates. The euro became an official currency on January 1st 1999 and through this a common monetary policy was established, under the authority of the ECB.

The introduction of the euro meant that countries fulfilling the criteria were now part of a fully-fledged economic and monetary union, removing frictions previously caused by having separate currencies, such as fluctuation risk and exchange cost. In other words, doing business in the Eurozone would now be more cost-effective and less risky. This resulted in capital and labour now being able to move more freely than what had previously been possible. The intention was that the internal market could now develop in a manner that had not been achieved by the Treaty of Rome or the SEA. The new common currency would give all member countries improved economic stability and growth; this would encourage increased investment and increased employment.

The benefits of the euro were not just restricted to the European single market, the euro would also bring worldwide benefits. A common currency meant a stronger presence for the EU in the global economy, akin to what one could see with the US dollar. A common currency would make the Eurozone a more attractive region for third countries to do business with, thus promoting even more investment and trade. Prudent economic management also meant that the euro would be an attractive reserve currency for third countries.

However, in spite of all its positive sides, the introduction of the euro also brought a very visible disadvantage – the lack of domestic monetary policy flexibility. A common currency now meant that members of the Eurozone could no longer use domestic monetary policy to either improve their own competitiveness at the expense of other Eurozone members, nor to adjust the country-specific level of capacity utilization when needed. Their monetary policy would now be centrally decided by the ECB.

The main question now was whether or not the initial member states of the Eurozone constituted an optimum currency area (OCA). The theory of OCA was first pioneered by Robert Mundell, who published an article on the subject in 1961. For an area to constitute an OCA, economic homogeneity between the countries making up the currency area is essential. This is to ensure that member countries are equally affected by external shocks, and that none will be destabilized by the imposition of centrally decided currency policies regarding the exchange rate, currency rate and so on. The focus on economic homogeneity was apparent when the euro was introduced, which can be seen in the convergence criteria in the Maastricht Treaty. The strict requirements every country had to meet to become a part of the Eurozone were to ensure stability. Ron Martin (2001) discusses the regional convergence and divergence in the Eurozone, and presents four main homogeneity criteria that has to be met for an area to be an OCA. These criteria will be fully presented in Section 2.

Eichengreen (1991) wrote a paper comparing the economy of Europe to that of the US to see whether Europe was close to constituting an OCA or not. One must take into consideration that this paper was written before the introduction of the euro, and before the effects of the Maastricht Treaty, but it still gives a useful assessment for the situation in Europe at that time. His conclusion was that Europe remained further from being an OCA than USA. It was shown that real exchange rates were more variable in Europe than in the US, indicating greater prevalence for region-specific shocks. Also, labour mobility was far lower in Europe. Although the paper concludes that this was likely to be improved by the removal of legal restrictions in accordance with the 1992 program, it was also pointed out that the absence of legal restrictions in itself would not sufficient to ensure high levels of labour mobility. Cultural differences will also affect the mobility of labour.

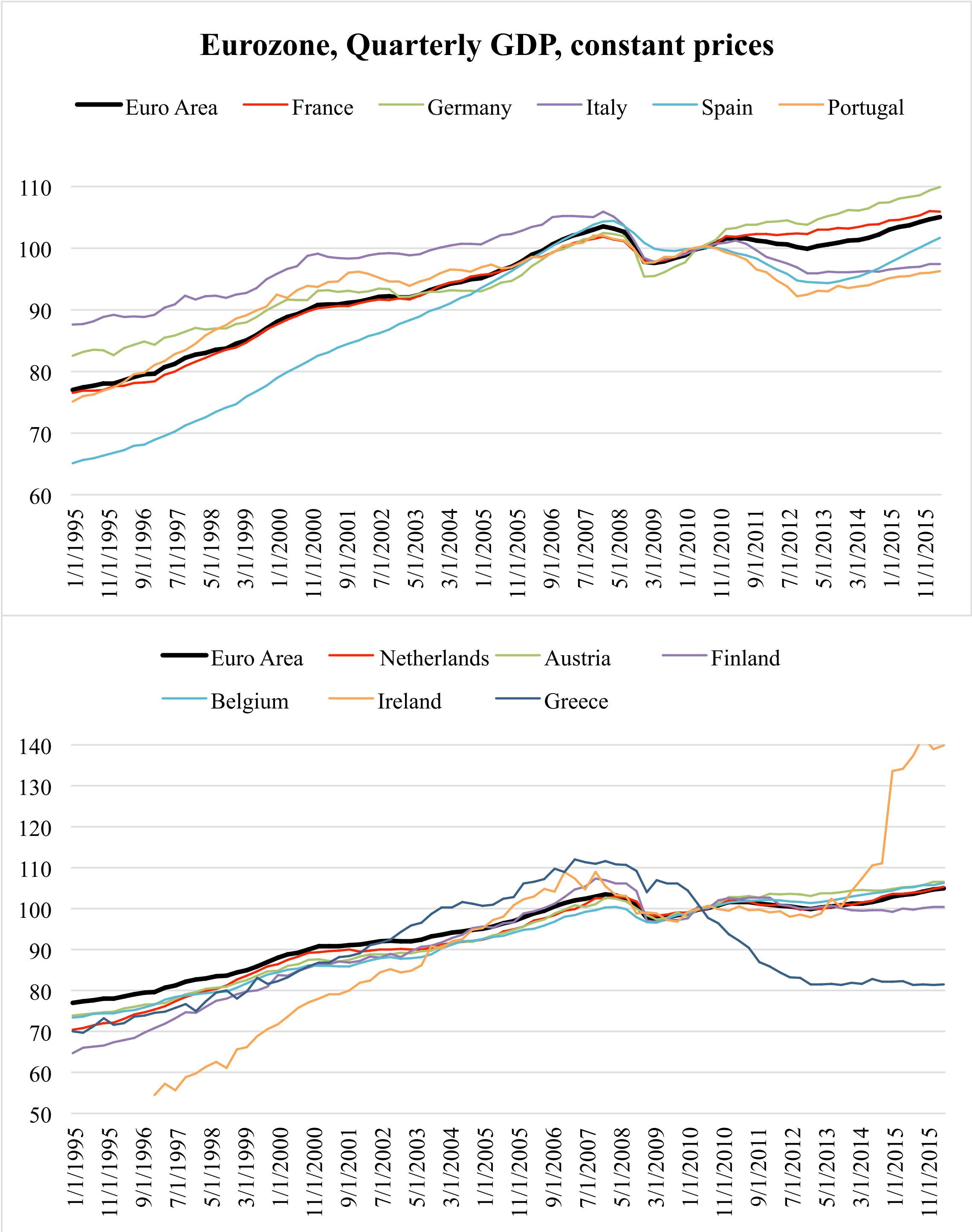

Figure 1 - Quarterly GDP for the Eurozone and its member states, index, 2010=100

Figure 1 shows an index value of quarterly GDP for the Eurozone and its founding member states (with the exclusion of Luxembourg and inclusion of Greece). As the common currency was first introduced, the hope was that the member countries would converge towards each other as time passed by. Meaning GDP growth would become more stabilized between the member states. Judging by figure 1 it does not appear as though GDP growth has become more synchronized since the introduction of the common currency. Some may argue that the initial deviations in GDP growth was simply down to a convergence in GDP per capita, some countries “catching up” with the rest with respect to this measure, and thus being a desirable feature for the initial phase of the Eurozone. However, synchronization does not appear to have improved all that much since the infant stages of the euro, this may be an indication that the euro has not had the unifying effect that many had hoped for.

The national authorities in the member countries still have the possibility to stimulate the economy through fiscal policy, such as tax-levels and government spending, which affects GDP both directly and through private consumption. But there is an on-going discussion whether the use of fiscal policy should be centralized as well, in order to harvest the benefits and synergies of centralizing all economic policy in the union.

Some argue that the public debt-crisis that has been building up in the Eurozone-countries is due to decentralized fiscal policy, and that the union is vulnerable to asymmetric shocks as long as the fiscal policy is decided on a national level. Others argue that a fiscal union is the end of the member countries sovereignty, and that it gives incentive for each member to take more risk, since the other countries if needed will, in the end, bail them out.

1.2 Research Question

Little to none pointed to Europe constituting an OCA before the common currency. But the belief was that with the introduction of the euro, the economies would converge towards each other, and over time approach an optimum currency area. Again one can look at the strict criteria from the Maastricht Treaty. In this thesis we will investigate whether this has been the case by estimating a suggested nominal rate for the different members of the European Economic and Monetary union to see how well this coincides with the actual policy rate set by the ECB.

This thesis will investigate the “success” of the Eurozone and the ECB. By using the Taylor rule to estimate optimal interest rate paths for each Member State we will contribute to the discussion of whether the Eurozone has become any closer today to constituting an OCA than it was when the euro was first introduced. In this discussion lies an investigation of whether or not it is possible to see a convergence of optimal monetary policy amongst the member states of the Eurozone. Additional to this, this thesis will also look into whether or not it is possible to claim that certain countries have a bigger influence on the ECB when the policy rate is set.

We start off by presenting relevant theory in Section 2, then the empirical analysis follows in Section 3. In Section 4 we discuss the findings in Section 3, before Section 5 concludes.

2. Theory

In the following chapter theoretical concepts needed to explain how monetary policy affects the real economy will be presented. First, we provide a more in-depth presentation of the theory on Optimum Currency Area, which was outlined in the introduction. This will be used to evaluate whether the Eurozone is close to fulfilling the criteria for successfully having a single currency. Furthermore, we will present the objectives of monetary policy. This is relevant to understand what monetary policy ideally should do, and what limitations exist within this framework. In the final part, we present the Taylor rule, which is the main concept used for completing the actual empirical analysis of the different Eurozone member states.

2.1 Optimum Currency Area

A natural starting point when beginning to study Optimum Currency Area (OCA) theory is the work of Lerner (see Scitovsky (1984)). Lerner discusses the benefits of variable exchange rates, and he argues that variable exchange rates will make it easier to maintain a steady level of employment and growth. Which leads to the question, why restrict variable exchange rates to countries; what is an optimum currency area?

Robert A. Mundell laid the first brick in the foundation of optimum currency area theory with his work, "A theory of Optimum Currency Areas" from 1961, and is therefore considered as one of the pioneers of OCA-theory. Mundell argues that a key element is the mobility of production factors, such as labour and capital, as well as that the argument for a national flexible exchange rate is only as valid as the Ricardian assumption[1] regarding production factor mobility. It is necessary with a close to perfect factor mobility of production factors in order for asymmetrical shocks not to create imbalance between the regions.

Mundell also pointed out that another key element is that the homogeneity levels of the regions must be roughly the same in order for the effects of monetary policy to be

[1] An important assumption in the Ricardian model is that labour is mobile across industries within a country without additional cost or friction, but is immobile across countries.

symmetrical in the different regions. This worked as a theoretical starting point for the on-going discussion at that time regarding a Western European union, which captivated famous economists as J. E. Meade (1957) and Tibor Scitovsky (1984). Both arguing for and against a union with arguments quite similar to those used fifty years later in the origin of euro currency.

The third great contributor on the field is Roland I. McKinnon, who in 1963 published his work "Optimum Currency Area" where he constructed a model consisting of tradable and non-tradable goods. The model is meant to show that the ratio of a country´s tradable and non-tradable goods must be roughly similar for the regions constituting a possible Optimum Currency Area (OCA). In the model, non-tradable goods are goods that cannot be shipped abroad and are therefore domestically consumed, while tradable goods are import and export. Two countries sharing the same ratio should then be of similar degree of homogeneity, according to the model. Sharing the same degree of homogeneity will then qualify the region as a possible OCA since they both would respond well to a common interest rate. If the ratios of the two countries were dissimilar, the country with higher level of non-tradable goods would respond less to a change in the exchange rate, making a possible union vulnerable for asymmetric shocks.

Kenen (1969) argues that diversity in industrial production within nations is another claim that must be fulfilled in order for a region to be considered an OCA. The argument is that in a diversified region asymmetric shocks will even out over time, relative to a specified region and given high mobility of production factors within the region.

Magnifico (1973) makes another important and still highly relevant argument within OCA-theory, due to the history of the member countries. Magnifico argues that the different countries must share the same propensity to inflation. If the countries utilize the same level of productivity factors, but have different levels of inflation, it may indicate that the countries do not have the same propensity to inflation. Different socio-institutional structural differences, strong unions, social expectations etc. may cause such differences.

Martin (2001) identified four homogeneity criteria for a region in order to classify as an OCA. Three of them mentioned above, and the last one being automatic fiscal mechanisms through a centrally-organized tax-benefit system. These mechanisms are meant to compensate for temporary differences in growth and impact of asymmetric shocks in the different regions. It is assumed that the sum of the compensations between the regions will add up to zero, in the long run. These inter-region mechanisms are intended to function in the same way as social security benefits, taxation, etc. do within a country. Since there are no region-specific currencies or exchange rates in an OCA, these mechanisms are to compensate for such absence.

The four homogeneity criteria may be summed up as followed:

- Economies should be roughly similar and synchronized. This is to ensure that shocks are also symmetrical, so that when a shock occurs, all member states are affected in roughly the same way and, hence, they will also be affected in roughly the same way by a centralized currency policy.
- Full capital and labour mobility. Such factors must be able to move freely between the regions if asymmetric demand and technology shocks are not to result in regional imbalances in economic development and growth.
- Regions should have similar propensities to inflation. Large differences in propensity to inflation could cause instability to the system. For instance, if a central decision is carried out aimed at stemming price increases originating from regions with high propensity to inflation, this is likely to be harming to industry and jobs in regions with low inflation propensity.
- A centralized tax-benefit system to compensate for differential national and regional shocks and growth. By entering a currency union, a country concedes its monetary policy upwards to a centralized body, thus depending on being integrated into a corresponding centralized system of automatic fiscal stabilizers.

The importance and emphasis on each of these homogeneity criteria are difficult, if not impossible, to determine and will most likely vary from each potential OCA. In the pre-euro currency years, neoclassical growth models and models of regional growth predicted different outcomes of a common currency in the EU. Neoclassical models predicted that a common currency would lead to inter-country convergence, while regional growth models predicted divergence. The theoretical framework of OCA provides us with a method for analysing the underlying reasons for an OCA´s success or failure.

2.2 The Objective of Monetary Policy

The main objective for monetary policy is to ensure stability and to maintain a proper equilibrium in the economic system. Within this objective lie factors such as securing high employment, stable inflation and high economic growth. One question that can be asked in this regard is whether these objectives are all mutually compatible, or if one has to compromise between them. How a central bank conducts its monetary policy to achieve the aforementioned goals can be expressed (at least in many cases) through a simple loss function:

$$L_t = (\pi_t - \pi^*)^2 + \lambda(y_t - y^*)^2$$

The first term in this equation represents the inflation gap, while the second one is the output gap. This total loss is given as a weighted sum of these two gaps. As neither positive nor negative gaps are desirable, both terms are squared. The central bank should in this instance set their policy rate so that the total loss is minimized. The λ-value expresses the degree of flexibility with which a central bank conducts its monetary policy, how quickly the central bank demands the inflation gap to be closed. As λ approaches 0, the flexibility of the central bank can be said to be reducing. Operating after this principle implies paying no mind to the output-gap, with the only aim being to close the inflation-gap as quickly as possible – the central bank is strictly inflation targeting. The other extreme is when λ approaches infinity, in this instance, the loss function is minimized by closing the output-gap as quickly as possible, a central bank operating after this principle pays no mind to the inflation in the economy. Most (if not all) central banks find themselves with a λ-value somewhere between these two extremes. A gradually increasing λ-value indicates that the central bank is willing to persist with inflation deviating from target for a longer period of time.

Regions who share a common currency will also share common monetary policy. In the EU, the ECB regulates the monetary policy. The ECB defines the objective of monetary policy as:

"To maintain price stability is the primary objective of the Eurosystem and of the single monetary policy for which it is responsible."

Treaty on the Functioning of the European Union, Article 127 (1).

The main objective of the monetary policy in the Eurozone is then to have stable inflation. But what is price stability? The ECB defines price stability as:

"Price stability is defined as a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) for the Eurozone of below – but close to – 2%."

The ECB does not operate with an explicit goal of ensuring both inflation stability and maximum employment akin to the Dual Mandate of the Federal Reserve (FED) in the US (See footnote 3). Instead only the goal of price stability is explicitly stated by the ECB. However, Issing (2004) states that the ECB will "need to respond gradually to economic shocks, taking output fluctuations into account". Thus policy of the ECB could also be understood from simple loss function.

2.3 The Taylor Rule

Since the early 1990s research on monetary policy rules have experienced somewhat of a renaissance. One important contribution from an applied point of view is the Taylor Rule, introduced by John B. Taylor in the article "Discretion versus policy rules in practice" published in 1993. The Taylor Rule is an instrument rule[2], meaning it expresses the monetary policy instrument as an explicit function of a few variables. The simplicity of such rules is one of the main reasons why they have become so popular both amongst researchers and central banks. Rules such as the one introduced by Taylor can be used to evaluate the performance of monetary policy in hindsight by "cross-checking" the Taylor rate with policy decisions based on a forward looking framework. It can also be used as an instrument when making interest rate decisions, as well as form guidelines for future monetary policy.

When introduced, the Taylor Rule was based on the U.S. economy. Taylor (1993) demonstrated how well this rule coincided with the actual federal funds rate in the period 1987-1992, the beginning of a period known as the Great Moderation in which volatility of business cycle fluctuations was remarkably low. The results from Taylor's research showed that placing positive weight both on the price level and real output produced rules that

[2] The alternative to instrument rules are called targeting rules. When using a targeting rule, the central bank utilizes a target function, often expressed as a loss function, to reach their monetary policy goal. An example of such a function is described in section 2.2. From this loss function follows an implicit rule for how the central bank should conduct its monetary policy.

performed better than rules focusing solely on price stability[3]. The Taylor rule can be expressed as[4]:

$$[2.1]\; i_t = r^* + \pi_t + \mu(\pi_t - \pi^*) + \gamma(y - y^*)$$

Where:

i_t- The key policy rate as suggested by the Taylor Rule (also referred to as the Taylor rate).

r^*- The neutral real interest rate.

$(\pi_t - \pi^*)$ - The inflation gap – the difference between actual inflation (π_t) and the long-run inflation target (π^*).

$(y_t - y^*)$ - The output gap – the difference between actual output (y_t) and potential output (y^*).

μ and γ are parameters expressing the weight put on stabilizing the inflation gap and the output gap respectively.

It is important to note that the Taylor rule by definition is backwards-looking, in this respect Taylors' rule is a strong contrast to the forward-looking approach used by central banks. When central banks make policy decisions, they are based on estimates for future macro-variables, often shrouded in significant uncertainty. In this respect, modifications to the Taylor rule would be necessary if one wanted to use it for real-time policy decision-making.

2.3.1 The Taylor Principle

A central condition to the Taylor Rule has become known as the Taylor Principle. This principle illustrates a condition necessary for a central bank to run a monetary policy with the desired effects. The principle implies that given an increase in the inflation rate of one percentage point, the central bank should increase the nominal interest rate by more than one percentage point. From equation [2.1] we see that the total response coefficient to an

[3] These results are in line with the Federal Reserve´s "dual mandate", under which it has operated since 1977. This mandate states that the FED should conduct its policy in such a way that it "promotes effectively to the goals of maximum employment, stable prices, and moderate long term interest rates". Thus it is clearly stated that the FED should consider additional factors when deciding its policy besides securing stable inflation.

[4] Equation as expressed in Taylor (1999b)

increase in inflation, π_t, is equal to (1+ μ). For the Taylor principle to hold we see that the condition μ>0 must hold. If $\mu \leq 0$ we see that an increase in inflation of one percentage point will give an increase in the nominal interest rate of one percentage point or less. This will result in the real rate of interest either maintaining its current rate or declining. In the former case you get a situation where monetary policy is treading water, raising the nominal interest rate at a one for one rate with increasing inflation will only maintain inflation at its current level. In the latter case, increasing the nominal interest rate by less than the increase in inflation, the result will be a further increase in inflation, as the lower real interest rate will result in further upwards pressure to the real economy.

The coefficient for the output gap, γ, should also be positive. If this coefficient is negative, the nominal interest rate will fall if the output gap is positive. This will create further pressure on the real economy and contribute to larger business cycle fluctuations, rather than dampening these effects. Defining $\gamma = 0$ would imply a policy rule which only focuses on the inflation gap, which, as argued by Taylor, does not perform as well as a rule which considers both inflation and production (Taylor 1993). So, in order to maintain stability in both price levels and economic growth, the production gap should also be attributed with a positive coefficient (Taylor 1999a).

2.3.2 The Neutral Real Rate of Interest

The relationship between the real rate and nominal rate of interest is formally expressed through the Fisher equation, which is derived from the following equation:

$$[2.2]\ (1 + r_t) = \frac{(1 + i_t)}{(1 + \pi_t)}$$

Solving for i_t gives us $i_t = r_t + \pi_t$, which tells us that the nominal interest rate is equal to the real rate of interest plus the inflation rate. This implies that the real rate of interest can be expressed as $r_t = i_t - \pi_t$.

The neutral real rate of interest is defined as the level of the real rate of interest consistent with stable inflation and production equal to potential production. Thus, the neutral real interest rate can be used as a benchmark for monetary policy. So, in principle, knowing the level of the neutral real interest rate is essential in order to assess the monetary policy carried out by the central bank.

In Taylor's paper from 1993, he estimated the neutral rate of interest to be constant at 2%[5]. However, the neutral rate of interest is not expected to be constant over time, as it depends on the structure of the economy. Estimating the neutral real interest rate is surrounded by a lot of uncertainty, one reason being that it is not actually observable. Also, macroeconomic figures are often subject to substantial revisions, thus estimating the rate in real-time is an exercise with obvious sources of error. Due to the uncertainty in estimating the neutral real rate of interest, economists often decide to use a constant rate instead of a floating one. The chosen method for estimating the neutral rate of interest will undoubtedly have a major impact on the results one get from estimating the Taylor-rate of interest.

Belke & Klose (2011) estimated a floating neutral real interest rate basing their estimations on the Fisher equation to find the real rate of interest. Thereafter, they applied the Hodrick-Prescott (HP)[6] - filtering technique to derive a trend level for the real rate of interest. This trend level is assumed to be equal to the neutral real rate of interest, assuming that actual real interest fluctuates around its long-run neutral level. They do point to the fact that this is a simplistic and relatively uncertain method of finding the neutral real rate of interest, but that it would still provide better results than simply assuming a constant rate.

2.3.3 The Output-gap

Due to natural and institutional constraints in an economy, there is a limit of how much output an economy can sustain in the long run. The highest level of output that can be sustained in the long run is referred to as potential output and was first proposed by Okun (1962). This is then the level of output that "can be achieved without giving any upside or downside pressures on inflation"[7]. The output gap is the difference between actual and potential output in percent of potential output.

$$[2.2]\ \frac{GDP_{Actual} - GDP_{Potential}}{GDP_{Potential}}$$

[5] This 2% "equilibrium" real interest rate was close to the assumed steady-state growth rate of 2.2% in GDP.

[6] See Section 2.3.4

[7] Based on Okun (1962)

Potential GDP is not an observable variable, thus estimating it is a challenging task, and there is no widely acknowledged method for doing so[8]. Most commonly used methodologies seek to distinguish potential GDP from the cyclical variations in the actual data. Taylor (1993) estimated potential output as a linear trend. This method has not been widely replicated in later papers as it assumes a constant trend growth rate in GDP over the entire sample period. A popular method is to make use of the HP-filter on the actual output data. The HP-filtering technique separates actual output from the underlying trend without assuming a constant growth-rate over the entire period. As potential output is affected by underlying factors in the economy, which change over time, this method is a way of estimating a more realistic trend growth rate for GDP. An important assumption regarding this method is that actual output in the long run fluctuates around potential output.

There are some problems using such a simple method, and an often-criticized problem is the simplicity itself. Since it is sufficient with one data series, the actual output, the method does not take into account other possibly important factors, such as unemployment and inflation. Other weaknesses of the HP-filter will be discussed in the next segment.

2.3.4 The Hodrick-Prescott Filter

The Hodrick-Prescott filter is a mathematical equation used to distinguish the cyclical component of a data series from the estimated smoothed trend. The filter estimates the trend by calculating a weighted moving average, where the moving average is symmetric and centred. If we assume Y_t is real GDP in period t, we can define Y_t as the product of a growth component, Y_t^g, which is the trend value Y_t would assume if the economy was on its long-term growth path, and a cyclical component, Y_t^c, which fluctuates around a long-run mean value of 1 (Sørensen & Whitta-Jacobsen (2010)).

$$[2.4]\ Y_t = Y_t^g Y_t^c$$

The assumption on the mean value of Y_t^c implies that $Y_t = Y_t^g$ on average. As we wish to look at percentage change in the variables, it is useful to work with the natural logarithms of

[8] Bjørnland, Hilde C., Brubakk, Leif and Jore, Anne Sofie (2008). This paper looks at several ways for estimating potential output and compares the difference in output gap that they produce.

said variables, as change in the log of a variable X approximates percentage change in X. Log-transforming [2.4] gives us:

$$[2.5]\ y_t = g_t + c_t$$

Where $y_t = lnY_t, g_t = lnY_t^g and\ c_t = lnY_t^c$ for t=1,…,T

In order to determine the growth component, we must separate g_t from c_t. This is done by solving the following equation with respect to all the g_t:

$$[2.6]\ \underset{\{g_t\}_{t=-1}^{T}}{\text{Min}} \left\{ \sum_{t=1}^{T} (y_t - g_t)^2 + \lambda \sum_{t=1}^{T} [(g_{t+1} - g_t) - (g_t - g_{t-1})]^2 \right\}$$

The first term of this equation: $(y_t - g_t)^2$, measures the cyclical component, c_t. As neither positive nor negative deviations are desirable, the expression is squared so both types of deviations are weighted the same.

The second term is the moving average multiplied with λ, which penalizes the variability in the growth component, g_t. As y_t is measured in logarithms, the terms $g_{t+1} - g_t$ and $g_t - g_{t-1}$ are approximately the percentage growth rates of the trend value of real GDP in periods t+1 and t respectively.

Equation [2.5] provides us with a trade-off between the two components. On the one side we want choose the g_t so that the changes in estimated trend is minimized over time. On the other hand, we want to bring g_t as close as possible to the log of real output to minimize the first term. The value of the λ will determine the penalizing effect of the second term, and thus the relative weight put on the conflicting objects. Setting λ=0 means that the last term becomes insignificant, this would be equal to implying that all fluctuations in y_t is due to changes in the underlying trend growth[9]. The other extreme is found by assuming $\lambda = \infty$, this would imply that the trend growth is perfectly linear[10], meaning trend growth is constant. Thus we see that the smoothness of the trend growth is determined by the λ-value.

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[9] In this case the minimizing problem is solved by setting $y_t = g_t$ for all t´s.

[10] Here the minimizing problem is solved by setting $g_{t+1} - g_t = g_t - g_{t-1}$ for all t=2,3,4….,T-1

Clearly this value should be positive, but finite. The international standard when working with quarterly data is to set $\lambda = 1.600$.

2.3.4.1 Weaknesses of the Hodrick-Prescott Filter

The HP-filter has received its fair share of criticism. One major problem is the preciseness of the estimates at the end-points of a time series. Since the filter uses a weighted moving average, the data from the latest periods are included in the average of an earlier period, and since we do not know the future values of the data series, the scope of the smoothing average determines how close to the present it is possible to estimate the trend[11]. An implication of this problem is that the estimates of the trend at either end of the time series to a greater degree is affected by the actual output in that period rather than the average for several periods. This problem may be even more prominent when using real-time data, as some real-time series are the subjects of substantial revisions. This is unfortunate as one is often particularly interested in estimating the output gap for the most recent periods in order to evaluate the need for active macroeconomic policy to smooth the business cycle[12].

Another problem is that there is no established "correct" way of determining λ. Although there is a common practice of setting λ=1600 for quarterly data, this is not unconditionally the best value. This arbitrariness makes using the HP-filter more problematic, as the estimated trend is largely affected by the chosen λ-value.

One can also experience problem during particularly long business cycles. If, for instance, the economy is experiencing a prolonged period with a negative output gap, the HP-filter will gradually estimate a lower level of trend growth to close this gap. This may produce a misleading image of the negative output gap closing, which may not truly be the case.

The HP-filter will also not be able to capture structural breaks in the trends of an economic time series. For instance, if the economy experiences a major technological shock, which drastically raises potential production, this will only slowly and gradually be picked up by the HP-filter as the trend level of potential output rises.

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[11] Observations from periods t-1, t and t+1 are used to estimate the trend for period t.

[12] Actual monetary policy is also conducted with a forward-looking perspective, thus in order to estimate the optimal policy in real-time, the central bank will rely on estimates of most likely future values for the variables in question. This provides further problems in identifying the optimal policy, as your decisions largely depends on the quality of your estimates.

In order for the filter to work optimally, two conditions must be fulfilled. The first condition being that the original data series must be known to have an I(2) trend. This is essential, or else the filter will create shifts in the trend growth that do not correspond with the original data series. The second condition is that the noise in the original data series is normally distributed. King & Rebelo (1993) argue that none of these conditions are likely to hold true in practice.

2.3.5 Real-time Versus Revised Data

Several studies using the Taylor rule have highlighted that the decision to use either real-time or revised data can have a major effect on the estimates provided. Real-time data is the original observations, the values that were observed before any revisions were made. The real-time data gives us the information available to policymakers at the time they decided upon a monetary policy. Several macroeconomic variables are subject to substantial revision at several points in time; especially GDP-figures are subject to such revisions.

The difference between real-time and revised data stems from three sources according to Belke & Klose (2011). First, and possibly the most obvious one, we have uncertainty due to data revisions. Second, statistical uncertainty because the central bank can only observe the data up to a certain point in real-time and not the whole sample period. Third, the time lag with which data becomes available.

Deciding which type of data one should use depends on the problem being discussed. If the goal is to decide whether or not the central bank has followed a specific monetary policy rule, real-time data should be used. The reason for this is simply that this was the information available to the decision makers at the time. As policymakers not only base their decision on currently available data, but forecasts as well, a challenge when using the Taylor rule with real-time data is to replicate forecast values as close to those that the central bank used as possible. This causes further uncertainty to the Taylor rule estimations. Using revised data to evaluate monetary policy decisions made in real-time would leave the evaluators with an unfair advantage as their data is far superior to what was available when the decision was made.

Using revised data is common when making ex-post analysis. Meaning we look at the past using our understanding of the data today. A major benefit with using this type of data is that you do not have to rely on forecasts of future values. Though not suitable to evaluate past policy decisions, this data can be used to compare different desired paths for different economies. As part of the purpose of this thesis is to highlight the difficulty in not being able to carry out a local monetary policy for the different Eurozone member states, revised data will be the preferred type. One should nevertheless be aware of the potential differences in the estimated Taylor rule that stems from the type of data chosen when analysing the results. An option if one wishes to mitigate some of the difference caused by deviation in the data is to use data that is less frequently revised.

2.3.6 Taylor´s Estimates of the US Economy

When first estimating the Taylor rule, Taylor chose to set $r^* = 2\%$ and $\pi^* = 2\%$. The Federal Reserve did not state an explicit inflation target until 2012, so Taylors' inflation target was chosen based on average inflation for the period 1985-1992. The neutral real interest rate is the rate consistent with "neutral" monetary policy. Taylor assumed that the neutral real rate was constant at 2%. This number was chosen because it approximately equalled the average real interest rate over a long-time horizon.

There is no single "correct" answer as to how much weight should be put on the inflation gap and output gap, also the weighting of the gaps relative to each other is a matter that can be debated. The weights will reflect the central banks' preferences with regard to stabilizing the respective gaps. In his original estimation, Taylor chose to set $\mu = \gamma = 0{,}5$, meaning equal weight on both gaps. Regardless of the weights chosen, Taylor argued that rules putting weight on both gaps would perform better than rules only considering the inflation gap. Choosing these parameters led to the following Taylor rule being published in Taylor (1993):

$$[2.7]\ i_t = 2\% + \pi_t + 0{,}5(\pi_t - 2\%) + 0{,}5(y - y^*)$$

Intuitively, this policy rule stated that the Federal Funds rate should increase if inflation rises above 2% or if real GDP rises above potential GDP (all else being equal). If both gaps were zero, the suggested Taylor rate would equal the neutral real rate (2%) plus the inflation (2%), which would result in a nominal rate of 4%.

As concluded by Taylor, this rule followed that actual policy of the FED remarkably well. Which could imply that the FED had followed a policy much like the one suggested by Taylor during this period, meaning they put equal weight on the inflation gap and the output gap. The result of Taylor's estimations is illustrated in figure 2. As monetary policy was considered to have been very successful during this period, Taylor's rule received acclaim for having been able to suggest an optimal interest rate path so close to what had actually been carried out.

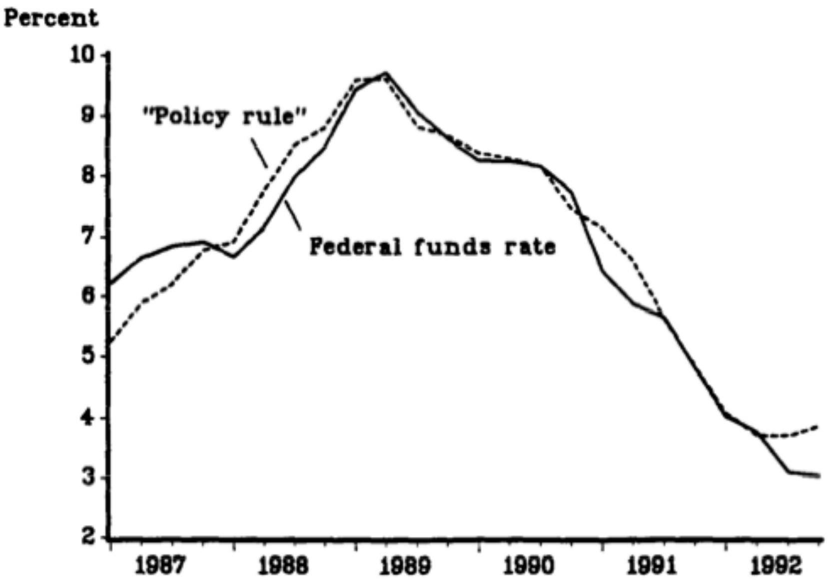


Figure 1. Federal funds rate and example policy rule.

Figure 2 Comparison of the Taylor rate and the actual Federal Funds rate. As illustrated in Taylor (1993)

3. Empirical Analysis

3.1 Overview of the Analysis

Our analysis will be split up into two parts: in part one we will use the Taylor rules from 1993 and 1999 to estimate the Taylor-interest rate for each of the Eurozone countries as well as for the Eurozone as a whole. The Taylor rules from 1993 and 1999 can respectively be expressed as:

$$[3.1]\ i_t = 2 + \pi_t + 0{,}5(\pi_t - 2) + 0{,}5(y_t - y_t^*)$$

$$[3.2]\ i_t = 2 + \pi_t + 0{,}5(\pi_t - 2) + 1(y_t - y_t^*)$$

As a measure for production we use GDP series which are all in constant prices and which have been seasonally adjusted. Using series of constant prices corrects the growth in GDP for inflation such that we find the real growth in GDP. The seasonal adjustment ensures that fluctuations that normally occur at about the same time and with the same significance each year are removed.

We choose to estimate potential output (y_t^*) as varying instead of assuming a linear trend, in this respect, our estimations deviate from Taylor´s original work. As a measure for inflation we use CPI indices for each country where changes to energy and food are excluded. Changes to energy and food are excluded because they are highly volatile. This volatility may have a big impact on the estimated Taylor-interest rate, causing more volatility, without necessarily reflecting changes in the economy in a correct manner. As Taylor recommended in his original work the rate of inflation is estimated with a four-quarter moving average[13]. This is done to smooth out sudden, short-lived fluctuations in inflation that may occur. Smoothing out these fluctuations provides more stability to the interest rate paths. The interest rate paths will be estimated on a quarterly basis from as far back as the data allows us (there are some differences in the availability of the data material for the respective countries) until 2016Q2. This estimation will provide two interest rate paths for each

[13] Taylor did, however, use a GDP deflator as the measure of inflation, thus our approach also differs in that we utilize CPI indices. He also did not use a moving average when making his estimations, as he wanted to keep his rule as simple as possible. In taking his advice and including a moving average, our assumptions also slightly differ from his original rule.

country. The purpose of this is to see how well the monetary policy of the ECB fits each country according to the Taylor rules. In addition, our analysis of the Eurozone as a whole will allow us to see how well the original Taylor rules explain the interest rate setting of the ECB. These initial estimations will provide us with a good reference point for the next parts of our analysis where some of the assumptions from Taylors original rule are changed.

As a robustness-test of the reaction-coefficients an estimated Taylor rule for the Eurozone was obtained using regression. The main point behind doing this regression was to estimate the reaction-coefficients to both gaps that best described the actual policy decisions from the ECB. Imposing these reaction-coefficients on the Taylor rules for each separate county, one could possibly have gotten a different perspective as to how well the actual policy response of the ECB suits each respective country. However, these estimations did not provide coefficients that were substantially different from the original Taylor rules, thus we did not go further in imposing them on each separate country. For more details on how the estimation was done, and the results we refer to **Appendix 6.1.**

As we are focusing on the Eurozone as an OCA, the main focus of our analysis will be on the fit of the Taylor rule from 1999Q1 until 2016Q2, as this is the period for which the members of the Eurozone have been subject to a common monetary policy.

Part two of the analysis looks further into the issue regarding the neutral real interest rate. Estimation of the neutral real interest rate is an issue that has received much attention in recent time (see for instance Taylor & Wieland 2016 for references to several studies on the issue). As mentioned in section 2.3.1.2, the neutral real rate of interest is expected to change over time depending on changes in the structure of the economy.

As the neutral rate of interest is the rate that ensures stable inflation and an output gap of 0 percent, having a grasp of the level at which this lies on is essential for policymakers. Setting the interest rate level above or below the neutral rate of interest will tend to depress or stimulate economic activity. Thus, not knowing or having a good estimate of where this rate currently lies may hamper a central bank’s ability to influence the economy in the desired manner. Without knowing this rate, judging whether or not the current monetary policy stance is restrictive or accommodative becomes all the more difficult.

In today’s economic climate, we see nominal interest rates constricted at the zero lower bound (although it has been shown that it is possible to reduce the rates into slightly negative territory). Thus there has arisen a debate of whether these low interest rates are a passing phenomenon, or if this is the start of a new economic reality where the neutral real interest rate is lower than before. When analysing this issue, we first turn to estimating the Taylor rules for each country using an approach where we change the neutral real interest rate in "steps". Especially interesting are the changes that may have occurred following the financial crisis. With a particular focus on this period, we use estimates for the neutral real interest rate published by the ECB specifically for this period, along with estimations for earlier periods provided by other papers. As the neutral real rate of interest is not observable, estimation is still victim to substantial uncertainty; this is exemplified through the estimates from ECB where three different approaches for estimation have been used, which again have provided results that somewhat differ.

As these estimates for the neutral real interest rate are all based on the correct level for the Eurozone as a whole, a floating neutral real rate of interest estimated for each individual country will also be utilized. The estimations of the neutral real rate of interest come from Belke & Klose (2016). The addition of a unique neutral rate for each country will make it possible to distinguish even more nuances between the separate countries. How the neutral rate for each country develops over time will provide useful insight into how stable growth has been for the separate Eurozone member states.

3.2 Results

In the following section our results from the analysis will be presented.

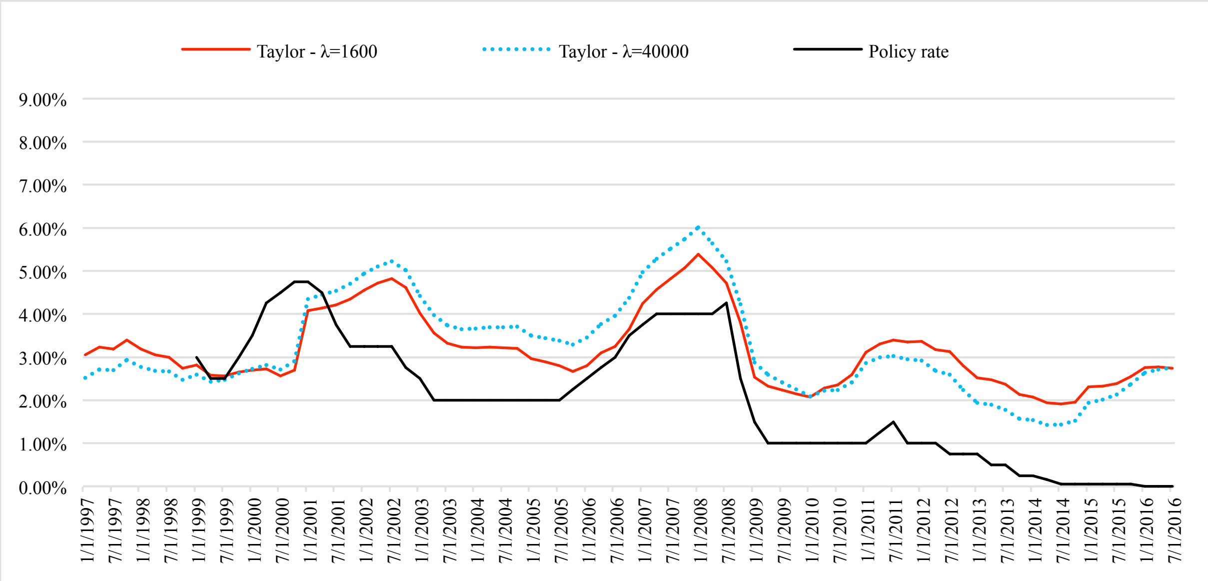
As discussed in section 2.3.2.3 on the weaknesses of the HP filter, deciding on the λ-value is, despite of certain common standards, somewhat arbitrary. Deciding on a value gives an indication of how large fluctuations in the underlying growth potential of the real economy you believe to be realistic. A lower λ-value gives a more fluctuating trend, especially if the data material is very volatile. As a result, the international standard of $\lambda = 1.600$ for quarterly data is in some cases considered to be too low. The Central Bank of Norway utilize $\lambda = 40.000$ to get a less volatile trend. As a result, cycles will appear larger than by the international standard, as volatility in the data has less impact on the estimated trend.

Economic growth has come to a halt following the financial crisis. This economic shock also has an impact on the estimated Taylor rules. As we are now experiencing a prolonged period of low growth, the choice of λ-value will be decisive for indicating whether we believe this is a result of permanently lower potential growth, or part of a longer business cycle. A lower λ-value will to a larger extent indicate that potential growth has been reduced. This will reduce the size of the negative output-gap, as the trend moves faster towards actual output. Since we have experienced a period of such dramatic economical changes, we have chosen to estimate the output-gap with both λ-values indicated above to highlight the differences this causes.

3.2.1 The Original Taylor Rules

The Eurozone as a Whole

As a result of the specification above, four different interest rate paths will be estimated for each country. As a starting-point, we first show the Taylor-rules for the Eurozone as a whole to see how well the Taylor-rule is able to explain the policy decisions for the aggregate of the Eurozone.



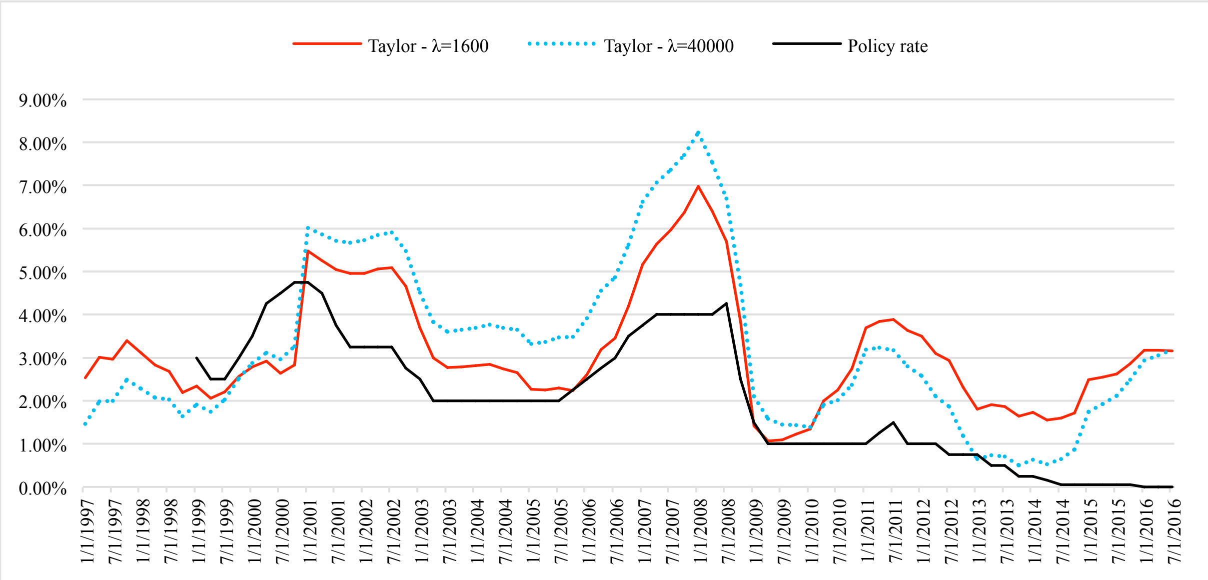


Figure 3 - Suggested interest rate paths for the Eurozone. Top panel shows the 1993-rule, while the bottom panel illustrates the 1999-rule

We see that both the 1993- and the 1999-rule follows the policy rate set by the ECB relatively well. Although, with the exception for the period prior to 2000, both Taylor rules consistently suggest a higher nominal rate as opposed to what was set by the ECB. The consequence of changing the λ-value is also clearly visible from these two graphs. We see that in the period 2000-2010 the $\lambda = 1600$ follows the actual ECB rate more closely. This is a result of the trend growth component (y^*) being more flexible with this specification. The opposite of what was discussed earlier then holds true, in a period of strong economic growth, this specification will ascribe more value to the underlying potential growth an less to cyclical factors. After 2010 the Taylor rule where $\lambda = 40.000$ is the better fit. This comes as a consequence of this specification indicating a more severe negative output-gap, making a lower nominal interest rate desirable. Although the choice of λ does not alter the conclusion with respect to the Taylor rule in this case, it is apparent from this initial estimation that it can have a significant impact under other circumstances. Thus, the potential problems related to the arbitrariness of the λ-value are illustrated through this initial estimation for the Eurozone.

Looking at which rule fits the actual monetary policy carried out by the ECB the best, we see that prior to the financial crisis, the 1993-rule, putting equal weight on both the inflation- and output-gap seem to follow the ECB rate more closely. After the financial crisis, however, we see that the 1999-rule, putting more weight on the output-gap seems to better describe the policy carried out by the ECB. As output is given increased importance in this rule, the dramatic drop in output in 2009 following the financial crisis is given more weight, this seem to coincide better with the drastic reduction in the policy rate from the ECB. This may be indicative of a shift in policy from the ECB. After the financial crisis hit the economy, it may now very well seem like the ECB has been more focused on stabilizing production and thus to a larger extent neglect the inflation target. This impression is also confirmed by estimating the deviation between the actual ECB rate and the suggested Taylor-rate. When looking at the whole sample, se see that the 1993-Taylor rule produces smaller deviations than the 1999 rule. However, for the last period, 2009Q1-2016Q3, the 1999-rule is the better fit[14]. However, one can also note that the 1999-rule provides a more volatile interest rate path. Since 2014 this rule has suggested a steady increase in the nominal rate as ideal, over the same time-period we see that the ECB has continued to cut its policy rate until reaching the zero lower bound. This may be indicative of different policies being needed in different parts of the Eurozone, and that the ECB has to try to accommodate the struggling economies, resulting in an expansionary monetary policy stance for the countries that have navigated out of the crisis. This result gives and early indication of the strain currently on the ECB.

The period 2000-2006 coincides with the period dubbed “The Great Deviation” by Taylor (2007 & 2009). Following “The Great Moderation”, a period of stable inflation and output,

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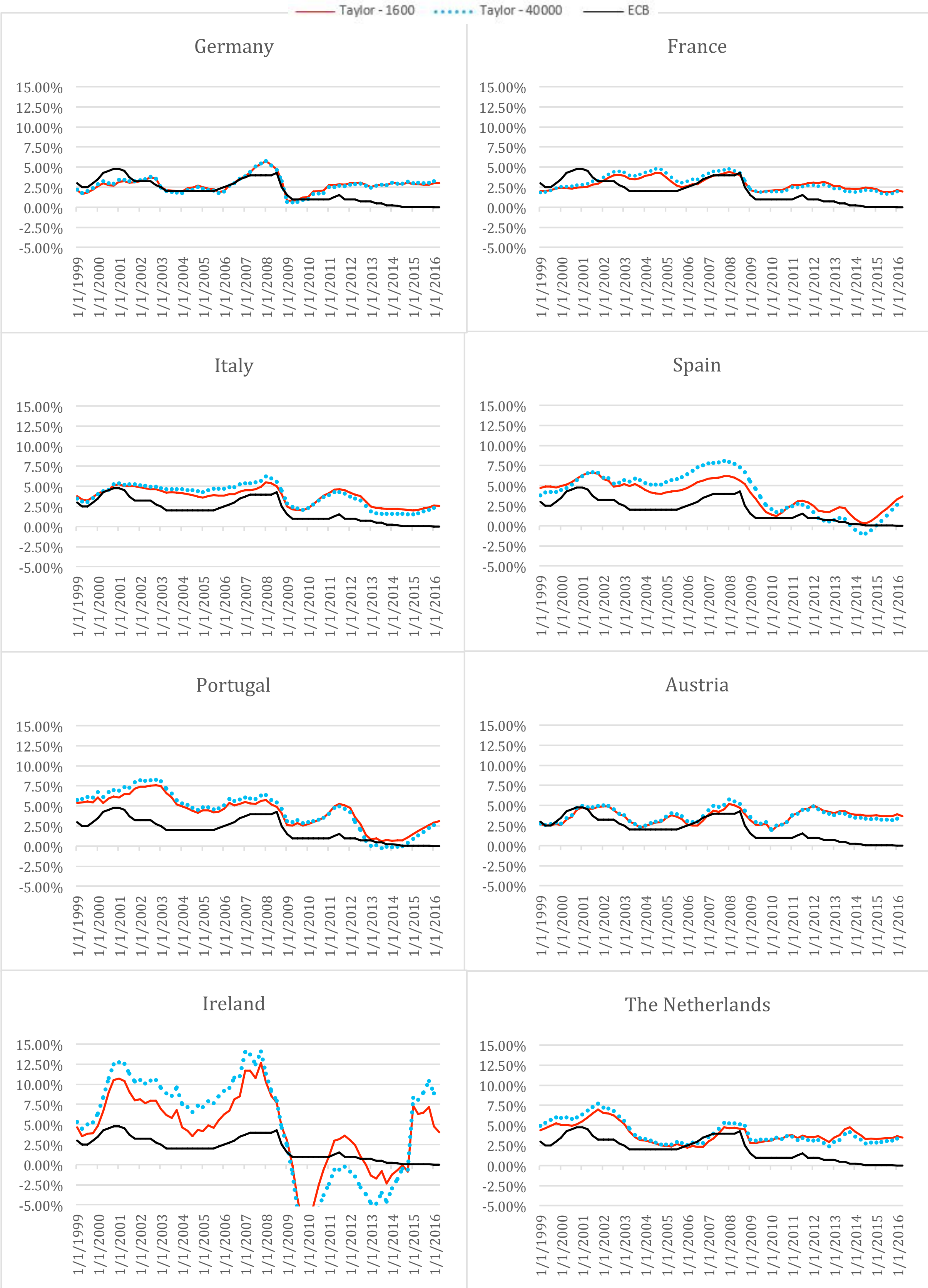
[14] See appendix 6.4 for estimated values. Only values from the Taylor-rules using $\lambda = 1.600$ were included, as the differences between the two options were relatively small and did not provide any contradicting conclusions.

"The Great Deviation" is characterized by, according to the views of Taylor, monetary policy being too accommodative. This monetary policy stance is illustrated by the suggested Taylor-rate being consistently higher than the actual policy rate. The initial research of Taylor was focused on the US economy, but in Taylor (2009) he also shows that the same pattern emerges for the Eurozone, which our results concur with.

The Separate Countries of the Eurozone

In this section the analysis is shifted over to the separate countries of the Eurozone. To limit our analysis we have chosen to look at ten of the eleven original members of the Eurozone with the addition of Greece, making the total number eleven. Of the original members, the country excluded is Luxembourg, as they are rather unique, in both geographical and economical terms, compared to the other members. Other members that have joined the Eurozone at a later stage have also been excluded, as data availability is rather limited in their case. The true effect of joining the Eurozone may yet have to unfold for these countries as well.



Taylor - 1600
Taylor - 40000
ECB
Germany
France
Italy
Spain
Portugal
Austria
Ireland
The Netherlands
15.00%
12.50%
10.00%
7.50%
5.00%
2.50%
0.00%
-2.50%
-5.00%
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
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1/1/2015
1/1/2016

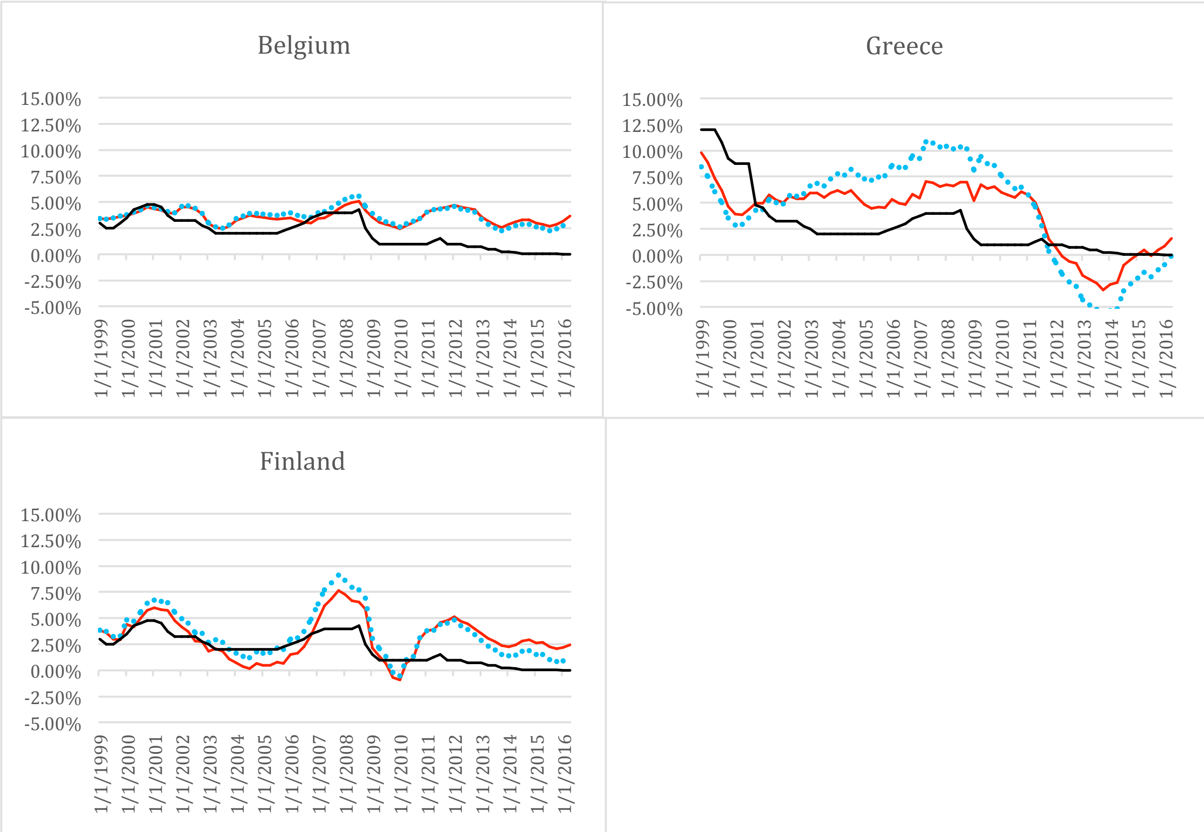


Figure 4 - Interest rate paths according to the 1993 Taylor rule

Above, Taylor rules according to Taylor (1993) have been estimated for our selected economies[15]. Starting off by analysing the period prior to the interest rate peak in 2008Q3 an interesting pattern emerges. There are clear differences in the deviation between the suggested Taylor-rate and the actual ECB policy rate when comparing the countries. And we see the largest deviations in the countries that have struggled the most since the financial crisis hit. Most markedly we see huge differences between the estimated and actual rate for Ireland and Greece. But also Spain, Portugal and Italy have long periods of policy deviation. Also, the deviations seem to begin at approximately the same period in all countries, 2000Q1. This image bears much resemblance to what we found for the Eurozone as a whole, and coincides with Taylor (2007 & 2009) in suggesting that monetary policy was to accommodative in these economies during this timespan. On the opposite side you find Germany, France, Austria, Netherlands and Belgium, where the deviations are generally much smaller. Finland stands out from all other nations, as we see that in the same period as

[15] Estimates according to the 1999-rule; see Appendix 6.2.

the other countries had a too accommodative monetary policy, the Taylor-rate for Finland actually suggests that the policy rate should have been lower than what was set by the ECB.

By estimating average absolute deviation and the root mean square error the initial impression is confirmed. These two measures are used to estimate the difference between the actual policy rate and the suggested Taylor-rate. Firstly, comparing the estimates for the whole sample[16] with the period 1999Q1-2016Q2, we see that the deviations have become smaller for most countries. Due to short time-series for the policy rate for some countries, the 3-month interbank-rate has been used as a proxy for the actual policy rate. This may have influenced the estimations somewhat as the interbank-rate includes a risk premium. However, the interbank-rate has only been used as a proxy in the estimation of the earlier parts of the time-series, so for the period in which the Eurozone has been under a common monetary policy the policy rate has been available. The reduction in deviation between the policy rate and the Taylor-rate may also reflect the success different countries have experiences in curbing inflation and stabilizing output.

Pre 1999: Before the ECB and the Common Monetary Policy

In the later stages of the 1960s and during the 1970s economies experienced rates of inflation substantially higher than what has been seen over the last couple of decades. The period of high inflation in the 70s has since famously been named "The Great Inflation" and was a period in which inflation reached two-digit rates in several countries as well as being very volatile. This will naturally also affect our estimates in a major way. We have assumed a constant inflation target of 2%, in line with the goal the ECB has for securing price and growth stability in the Eurozone, for our entire estimation period. In periods of great inflation this will bias the Taylor-rates upwards. If one looks at monetary policy from that period, little support can be found that stabilizing inflation around 2% was a goal for the central banks around the world. For instance, in the US the goal was to secure full employment, which one thought, at the time, would be possible to do with only a small increase in inflation. As this proved wrong, we saw a period of high inflation and rising unemployment. This eventually led to the collapse of the Bretton Woods system. The fixed exchange rate system requires all countries to pursue a common monetary policy. When the

[16] As the starting-point for different countries differ somewhat, see the appendix 6.3 for estimated interest rate paths for the entire time-period.

US leaned towards a policy of higher inflation, this deviated from the desired policy of European policy makers. This resulted in increasing pressure on the system in the late 1960s and early 1970s and eventually to its demise in 1973. Following the collapse of the Bretton Woods, inflation remained high throughout the 70s, and only in Germany, among future Eurozone member states, did inflation peak at single-digit levels[17].

This illustrates one of the critiques of the Taylor-rule, although it did reflect the US economy very well in the period 1987-1992, it proves less successful in other periods, especially going back in time. In Taylor (1999a) he dubs this period prior to "the Great Moderation" a period in which "policy mistakes" were made. There were huge deviations between monetary policy models and actual monetary policy. Following this argument, the larger deviations found in the earlier parts of our estimations becomes more intuitive. This was a period when, according to Taylor, monetary policy was not being conducted the ideal way. Specifically, Taylor separates this period into three episodes, (1) excessive monetary tightness in the early 1960s, (2) excessive monetary ease during the late 1960s and 1970s, and (3) excessive monetary tightness in the early 1980s.

The "policy mistakes" in Taylor (1999a) were defined as large deviations from two baseline monetary policy rules, which are the same rules has is used in this analysis (Taylor (1993) and Taylor (1999b)). As mentioned, the popularity of the Taylor rule is largely based on how well it described the monetary policy of the FED in the period 1987-1992, a period when monetary policy is thought to have been very successful. Thus, this period constitutes a period where the FED responded to inflation- and output-gaps in a desirable manner. Periods where the policy rate deviated from the settings given by this preferred policy rule could thus be dubbed as "mistakes". Although the discussion in Taylor (1999a) was solely focused on the US economy, the same traits are visible in our estimations as well. Especially visible is the excessive monetary ease during the late 1960s and 1970s[18].

As a part of the process of establishing a common currency in Europe, the European Exchange Rate Mechanism (ERM) was introduced in 1979. The aim of the ERM was to reduce exchange rate variability within Europe and achieve monetary stability. In this system

[17] This is illustrated in appendix 6.3 where one can see that the Taylor rate for Germany in the 70s remains more stable than for the other countries that we had time-series going back to the 70s for.

[18] See appendix 6.3 for estimated interest rate paths for the full time-series.

fixed currency exchange rate margins was introduced, i.e. exchange rates should fluctuate within predetermined margins. Large differences in inflation rates between the member countries of the ERM meant it was difficult to maintain stability within the system. However, by the mid 1980s inflation rate differentials narrowed, and thus we saw a convergence in monetary policy between the member countries. This stabilization of inflation is also evident in our estimations, as we see that during the 1980s deviations between the policy rate and the Taylor-rate became smaller than they were during the 1970s, as well as a downward-sloping trend to the suggested Taylor-rates for all member states during this decade. This is the result of successful policies aimed at lowering the inflation rate and keeping it consistently at this lower level. The lower inflation also makes our assumption of a constant inflation target of 2% more realistic than for the earliest periods, as there would now be less upwards bias in the Taylor-rule estimations.

1999 to 2008

After the introduction of the ECB and the euro, the premises for evaluating the Taylor-rule changes. Now the possibility of evaluating how well suited each member of the Eurozone has been to the common monetary policy carried out by the ECB is present. Since the establishment of the Eurozone the ECB has had an explicit target of having inflation stable at around 2%. The presence of this target means that for this period there will not be an upwards bias in the estimation of our Taylor-rates when we have assumed a constant inflation-target of 2%. This would imply that the Taylor-rules we have estimated is perhaps better suited to evaluate this period of monetary policy in Europe than the pre-1999 period, where inflation was somewhat more volatile and the aim of monetary policy clearly different. This is also shown through the calculated deviations between the Taylor rate and the policy rate, the deviations generally go down when only considering the period 1999-2008 (or 1999-2016) as compared to the whole period for each country.

However, despite smaller deviations in the ECB era, there still are substantial deviations between the suggested rate and the policy rate. As mentioned, these deviations are especially large in the countries that have struggled the most in the aftermath of the financial crisis. Overall, these deviations are in line with the period dubbed “the Great Deviation”, and could, as Taylor suggested, indicate that monetary policy was largely too loose in this period. However, it is important to note that the size of deviation differs substantially between the different countries. From our estimates of the deviations between the policy rate and the Taylor rate, it seems as though the core countries Germany, Belgium and Austria have a particularly close fit in the period 1999Q1-2008Q4[19]. All of these countries had a smaller deviation than the Eurozone as a whole. France had a deviation almost identical to the Eurozone, while the last of the core countries, the Netherlands, actually had a worse fit for this period than countries such as Italy and Finland. This is caused by a particularly large deviation between 2000Q1 and 2005Q4. Results show that the by far largest deviations were recorded in Ireland and Greece, but quite substantial deviations were witnessed in Portugal and Spain as well. As for Italy, although the deviation here was not as large as what was seen in the other peripheral countries, we do see that the Taylor rate was consistently higher than the policy rate throughout the entirety of this period. So although estimates indicate a better fit for Italy than for instance the Netherlands, were Italy consistently finds itself with a Taylor rate above the policy rate, the Netherlands eventually managed to realign with the policy rate by 2005.

For all countries, with the exception of France, it is the 1993-Taylor rule that provides the closest fit, the same as what was found for our estimations for the Eurozone. For the Eurozone it was implied that this might have reflected that the ECB did in fact but equal weight on the output gap and the inflation gap in this period. If a larger weight on the output-gap was assumed to be in keeping with actual policy decisions from the ECB for this period, the Taylor rates suggest that monetary policy was even further from being ideal over the first decade of the euro. As we find the same result with regards to how well the rule fits for the separate countries, this may indicate that given these two options, an equal weight on both the inflation gap and the output gap was the better choice for the individual member states for the period in question.

From the first decade of the euro, what is most noticeable is the apparent difference between the core- and the peripheral-countries. The core countries have overall had a closer fit between their Taylor rates and the policy rate. This could provide some argument towards the notion that certain countries were implicitly prioritized when the policy rate was decided. At the very least, it provides evidence towards the notion that the monetary policy of the ECB seemed better suited for the core-countries in this period.

[19] See appendix 6.6 for measures of deviaiton for each Member State for entire time period, 1999-2008 and 2009-2016.

2009-2016

When looking at the period after the policy rate peaked in 2008 the impression one could get from looking at the preceding period changes somewhat. For this period we register that the deviations for Germany, France, Belgium, the Netherlands, Austria, Finland and Italy have increased. There is a particularly large increase for Germany, Belgium, and Austria, the three countries that had the closest fit between their estimated Taylor rule and the policy rate in the period 1999-2008. We find that both Spain and Portugal now have a closer fit between their Taylor-rate and the policy rate than all three of these countries. We also see that Finland, despite experiencing an increase in deviation, now has a better fit than both Belgium and Austria for this period.

Comparing the results of this period with what we found for 1999-2008 does provide evidence against the notion that the ECB might have implicitly prioritized certain countries when setting the policy rate. At least one could say that, if this was the case in the earlier stages of the existence of the Eurozone, this has changed following the financial crisis. These results give indications that the ECB is focused on stabilizing the real economy for the Eurozone as a whole.

The deviations for Ireland and Greece are still very large compared to the other countries, but these were also two of the countries hit the hardest by the crisis. As can be seen from the interest rate paths for these two countries, they were the only two with a suggested Taylor-rate below zero for a long period of time (other countries briefly hit negative rates, but quickly bounced back). Looking at Greece we see that their estimated Taylor-rate passes back into the positive range just at the end of the time-series. The validity of those estimations could be questioned by remembering that using the HP-filter gives less reliable results at the end of the time-series. Revision of time-series may also become a factor; especially GDP can be subject to substantial revisions[20].

[20] As a robustness exercise for the problems related to the end-points of the time-series, the period 1999-2016 has been estimated again using estimates for future values of GDP. Looking at these results for Greece, the estimated Taylor rate does not reach positive values at the end of the time-series. This illustrates the weakness of the HP-filter. Still, the positive trend to the suggested Taylor rate persists. It should also be mentioned that when using estimated values of future GDP, the analysis is only as good as those estimates, thus this is a potential weakness in the robustness-test. See appendix 6.5 for the revised interest rate path for Greece and the other member states.

Special attention should also be given to the development in Ireland. As can be seen from the interest rate path, the interest rate for Ireland plummeted following the Financial Crisis. Interestingly, the Taylor-rate rose extremely quickly back up to between 7-8% in 2015, giving Ireland the by far highest Taylor-rate of any of the Eurozone countries. This rather dramatic change is explained by the growth in GDP for Ireland in 2015. Due to a low corporate tax rate, Ireland has become a popular destination for foreign corporations. Foreign corporations exploit such favourable rates by obtaining a legal address abroad, typically by acquiring a company in the country that offers a lower rate on corporate tax. By doing so, the balance sheet of this foreign company suddenly appears on the Irish capital stocks. Such "tax inversions" results in the Irish economy becoming artificially inflated. But even if one were to omit this artificial number from the estimations, the Taylor-rate for Ireland would be positive, showing that the country has bounced back much quicker than Greece. Estimating the Taylor rate using the unemployment rate as a proxy for GDP, as done in Kahn (2012), could give a more realistic image of actual development in Irish real economy. Estimating the natural rate of unemployment is done by the same HP-filtering technique as for potential output. Doing this provides us with the following results for Ireland:

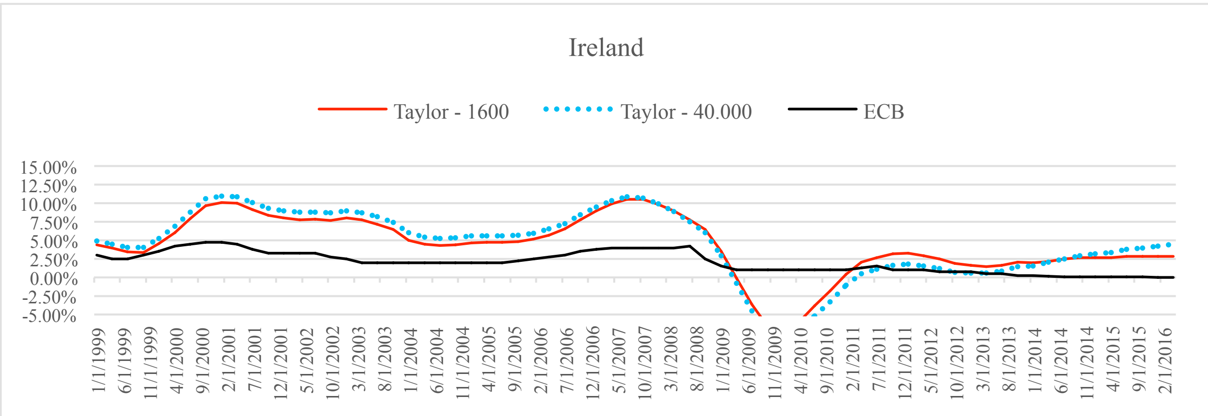


Figure 5 - Estimated interest rate path using unemployment as a proxy for the output-gap.

By replacing GDP with unemployment in the equation we see that the path of the Taylor-rate becomes smoother than it previously was. Also, the interest rate path reaches a positive value already at the beginning of 2011. The suggested Taylor rate has been reduced quite substantially following this specification, but it is still the highest suggested Taylor-rate for any of the Eurozone members in 2016. This reflects the case that the Irish economy has been growing at a higher pace than its peers in the Eurozone, but still moderates the results as opposed to the inflated GDP figures.

Comparing this period with the first decade of the Eurozone exemplifies one of the problems with the common monetary policy over this period. Where the core-countries had the closer fit during the first decade, both Spain and Portugal have smaller deviations than for instance Germany, Belgium and Austria in the last period. Thus it may seem as though accommodating the periphery comes at a cost of a less suited monetary policy for the core, the reversed image of what was registered in 1999-2008.

By looking at the Taylor-rates for the Eurozone economies you notice that, apart from Greece, all countries have a positive suggested Taylor-rate as of 2016. And apart from Greece and Ireland, the Taylor rates have mostly suggested a higher rate for all countries for most of the period following the financial crisis. One might then ask why the policy rate is still being kept at the zero lower bound. One possible explanatory factor to this is the neutral real rate of interest. In estimations thus far, a constant rate of 2% for all countries has been assumed. In what follows next, the effect of a change to this assumption will be analysed.

3.2.2 Assuming a Varying Neutral Real Interest Rate

A key variable in the conduct of monetary policy is the neutral real interest rate. As mentioned in section 2.3.1, this variable can serve as a benchmark to which monetary policy can be evaluated. Swedish economist Knut Wicksell (1898) defined the neutral rate of interest as the following: “there is a rate on interest on loans which is neutral with respect to commodity prices, and tends neither to raise nor lower them”. This definition implies the rate of interest that ensures that the economy operates at its full potential with neither upwards nor downwards pressure on the rate of inflation relative to its trend (or target value as set by the central bank).

Not unlike research on monetary policy rules, research on the neutral real rate of interest has also received more attention in recent years than in years past. In both the years preceding and following the financial crisis we are witnessing persistently low rates of interest across all developed economies. Rates are at an unprecedented low level. The major difference from previous periods of low interest rates is the activity level in the economy that follows. Based on previous episodes, such a long period of low interest rates should have been accompanied by rising inflation and activity levels. This effect has thus far been absent, or at least the increase in the activity level has been much lower than what one would have expected based on history. This rather unique trend by historical comparison has prompted a debate regarding both the current level of and the continuing change to the neutral real rate of interest.

Estimating the neutral real rate of interest is, however, a difficult task. The reason for this being that, although the theoretical definition of the neutral real rate of interest is intuitive enough, it cannot be observed. Thus, there is always some uncertainty as to what is the true value of this variable. The model developed by Laubach & Williams (2003) has in this respect received widespread attention. They utilize a statistical filtering technique in order to jointly estimate potential output, growth in potential output and the neutral real rate of interest. In an updated paper (Laubach & Williams 2015) they estimate the neutral real rate of interest for the US economy for the period 1980-2015, showing a clear downward sloping trend, with the rate hovering around 0% since 2010. This approach has since been used in several other studies, including Mésonnier & Renne (2004), Bjørnland et al. (2009) and Belke & Klose (2012) for the Eurozone. Holston et al. (2016) applies this approach to find the neutral real rate for the Eurozone, the US, Canada and the UK, while Belke & Klose (2016) estimates the neutral real rate of interest for each member state of the Eurozone. The one common denominator in all of these studies is a downward trend in the neutral real rate of interest. These studies, among others, give support to the argument that the low interest rates we are currently witnessing is not a cyclical effect, but in reality the result of a trend seen over the last couple of decades.

The relevance for looking closer at the neutral real rate of interest in this thesis is clearly illustrated by looking directly at the Taylor rule (as illustrated in Laubach & Williams (2015)). Variation in the neutral real rate of interest represents policymakers with challenges, as it affects the appropriate stance of monetary policy. To illustrate this we can assume that a policymaker is setting the policy rate according to the standard Taylor rule, furthermore we assume a lasting decline in the neutral rate from r^* to r^{**}. With the Taylor rule defined as $i_t = \widehat{r^*} + \pi_t + \mu(\pi_t - \pi^*) + \gamma(y_t - y^*)$ where $\widehat{r^*}$ is the policymakers current estimate of the neutral real rate of interest. Without any disturbances in the economy, the output gap should converge to zero, and the real interest rate, given as $i - \pi$ converges to r^{**}. From the Taylor rule we then get the following implication:

$$r^{**} - \widehat{r^*} = \mu(\pi - \pi^*)$$

Thus, only when the policymaker's estimate of the neutral real rate of interest is equal to the true value r^{**}, will the policymaker achieve the inflation target over time. If the policymaker continues to assume the old, higher level of r^{*}, the rate of inflation will run below target inflation by the amount $(r^{*} - r^{**})/\mu$. The nominal interest rates will be pulled towards too high a level if the intercept $\widehat{r^{*}}$ is kept at its old level.

In keeping with recent research on the topic, our previous assumption of a constant neutral real rate of 2%, in keeping with the original work of Taylor, does not seem likely to hold. Resulting from this, new interest rate paths for the Eurozone and the member states have been estimated where the neutral real rate of interest is allowed to change over time.

3.2.2.1 Changing the Neutral Real Rate of Interest in Steps

In the first part, the neutral real rate of interest has been assumed to change in steps. This may seem as a crude approach, as certain points in time is set where the neutral rate is assumed to have suddenly changed. This is instead of allowing it to float throughout the entire time-series. Although this approach has its faults, it will allow for a closer look at how a changing neutral real rate can affect the conclusions drawn from the Taylor rates – which is the main point of the analysis. Constâncio (2016) provides estimates for the neutral rate for the period 2009-2016 for the Eurozone. We have chosen to utilize these for this period, as they highlight the effects of the recent financial crisis. For estimates going further back in time Belke & Klose (2012) estimates the neutral rate going back to 1998 showing that it was rather stable around the 2% mark until 2009 when the crisis hit. This constitutes our main period of focus, however, for the period before 1998 we have chosen to look at Mésonnier & Renne (2004), which indicates a neutral real rate higher than 2% before 1998 (they also estimate a rate that fluctuates to a much greater extent than what is for instance found in Belke & Klose (2012) for the more recent time-period). We thus choose to assume, as a rough assumption, a neutral real rate of 4% for the period preceding 1998. Illustrating the uncertainty surrounding estimates of the neutral real interest rate, the estimations from Constâncio (2016) use three different approaches to estimate this variable. These three techniques provide somewhat deviating results. As a result, we choose to estimate the interest rate path using all three suggested rates for the period 2009-2016.

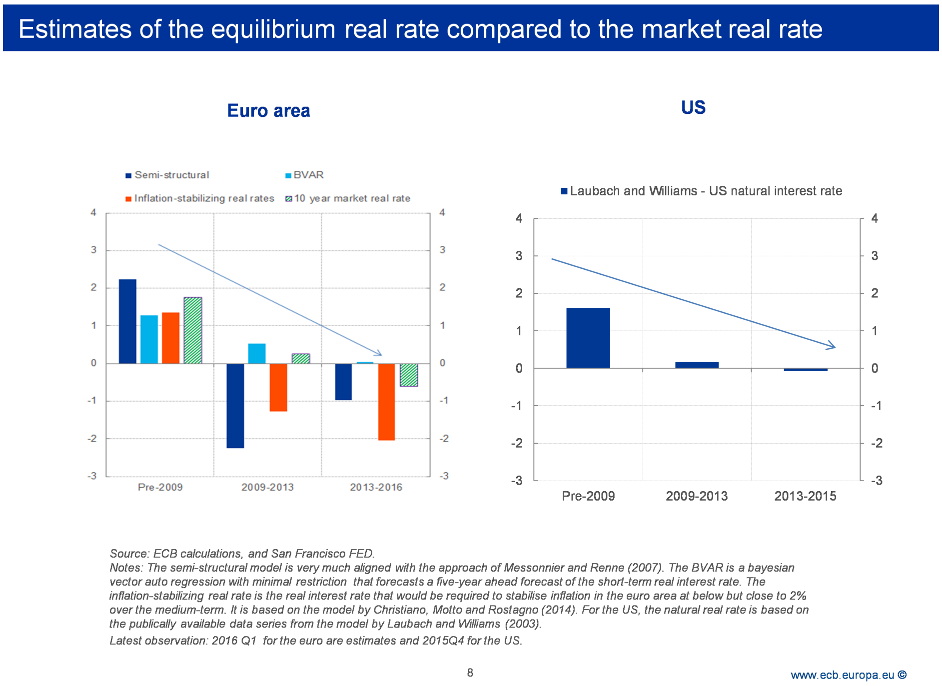


Figure 6 - Estimations from Constâncio (2016)

The Eurozone as a Whole

As in the previous section, the interest rate path for the Eurozone as a whole is shown first. This is done for the same reason as before, to provide us with an image as to how well the Taylor rule can explain the policy decision of the ECB for the Eurozone as a whole, but now with a change to the initial assumptions. For clarity, only the estimates where $\lambda = 1.600$ have been used in this part of the presentation.

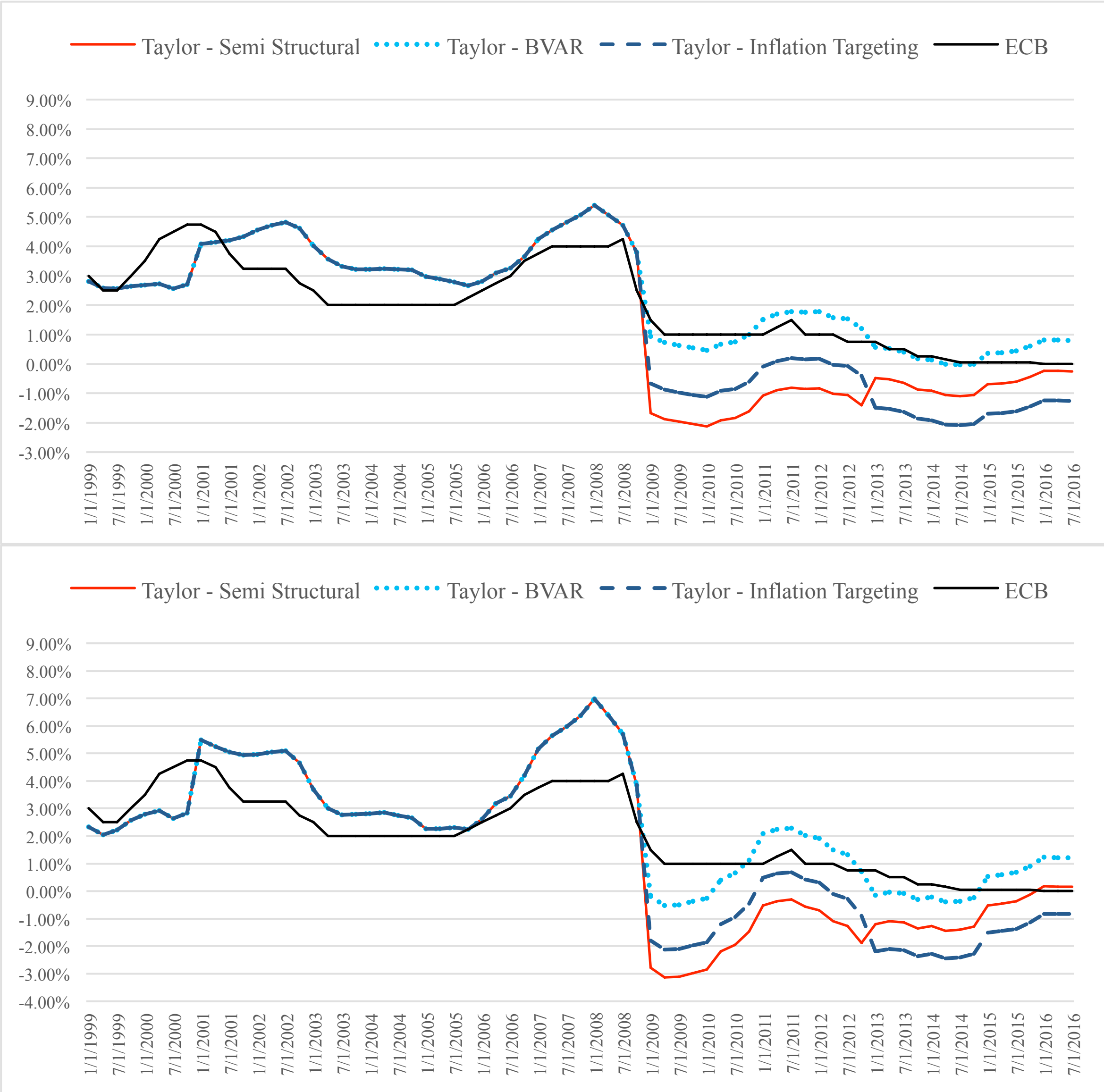


Figure 7 - Top panel shows estimates of the 1993 Taylor rule. Bottom panel shows the 1999-rule

Comparing these interest rate paths with the ones where a constant neutral real rate of interest is chosen clearly shows the impact changing the neutral real rate of interest has on the results. When a constant neutral real rate was assumed, the resulting interest rate path suggested that the monetary policy stance from the ECB had been largely too accommodative in the years following the financial crisis. The dramatic drop in the policy rate did not reflect ideal monetary policy according to the Taylor rule. Changing this assumption, however, provides a Taylor rule that follows the actual policy carried out by the ECB much more closely.

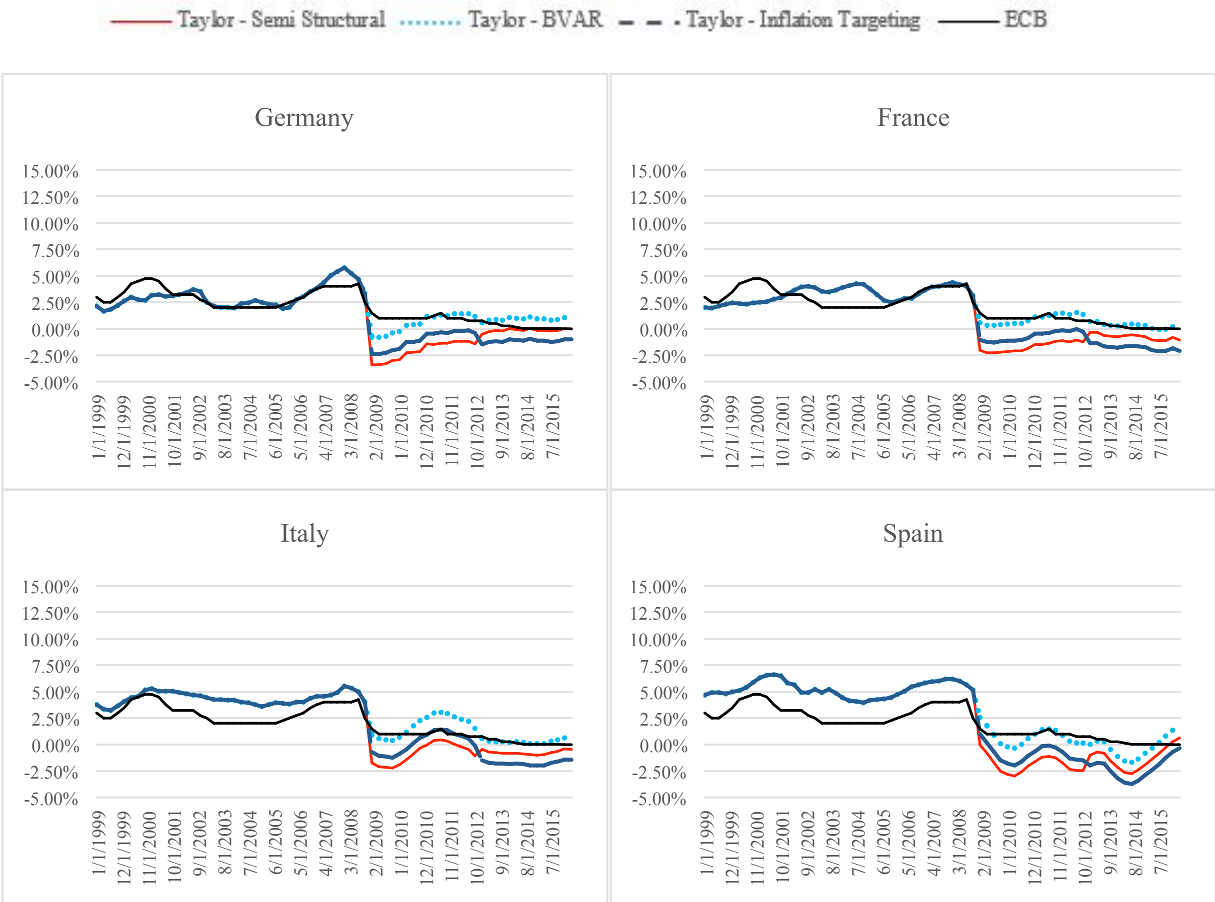
As previously mentioned, the assumption of a constant neutral real rate is not a realistic one. Research also shows, that although estimates differ somewhat, there seems to be consensus that the neutral rate has had a negative trend and is close to zero in the current environment. This is a trend shared for both the Eurozone and for the US economy (Holston et al. (2016)). All three approaches presented estimate the neutral rate to be at a lower level now than prior to the financial crisis, but their differences also highlight the uncertainty involved in estimating this rate. For instance, in the period 2009-2013 the semi structural-approach suggests a neutral rate below -2%, whilst the BVAR-approach[21] suggests a rate close to 0,5%. Previously, the importance of assuming the correct neutral rate in order to reach the inflation target over time was discussed. The discrepancy in the estimations of this rate illustrates how difficult a goal this is to reach for the policymakers. This uncertainty is the reason why policymakers would not mechanically use simple rules that depend too much on the neutral rate when making policy decisions.

Changing the neutral real rate of interest according to those three estimates gives two interest paths that indicate that the policy stance of the ECB in the period following the financial crisis has in fact failed to be accommodative. This result is according to the semi structural- and inflation targeting-approach. To suggest that the monetary policy is not accommodative when the policy rate is at 0% may seem like a strange conclusion to make, as this is as loose a monetary policy a central bank can utilize using traditional policy measures, but this highlights the difficulty the ECB and other policymakers today are facing. Having reached the zero lower bound, they are unable to convincingly reduce the policy rate much more to increase activity in the economy. This has resulted in other, more unconventional, monetary policy measures being made, such as quantitative easing, in an effort to boost economic activity and restore growth. Looking at the semi structural-approach, such measures may have started to have a positive effect on growth in the Eurozone; this approach suggests that the neutral real rate of interest has increased between the two periods 2009-2013 and 2013-2016. However, the remaining two approaches still indicate a declining trend over the entire time-period.

[21] BVAR stands for a bayesian vector auto regression approach. See Constâncio (2016) for details on the model and reference to the paper the model is based on.

The most conservative of the three estimates is produced by the BVAR-approach. This is the only of the three where the suggested neutral rate does not reach negative territory. Given this assumption of the neutral rate, the suggested interest rate path derived from the Taylor rule indeed seem to follow the actual policy of the ECB very well. Indicating that monetary policy over this period, according to the rule, have been rather neutral. The improved fit is also evident when, for instance, comparing the average absolute deviation of the BVAR-interest rate path with the one where a constant neutral rate was assumed. In the original estimations, this deviation was 1,935% for the period 2009-2016, whilst with the new estimates of the neutral real rate this has been reduced to 0,467% (according to the Taylor 1993 rule)[22].

The Separate Countries



[22] See appendix 6.7 for measures of deviation for the Eurozone.

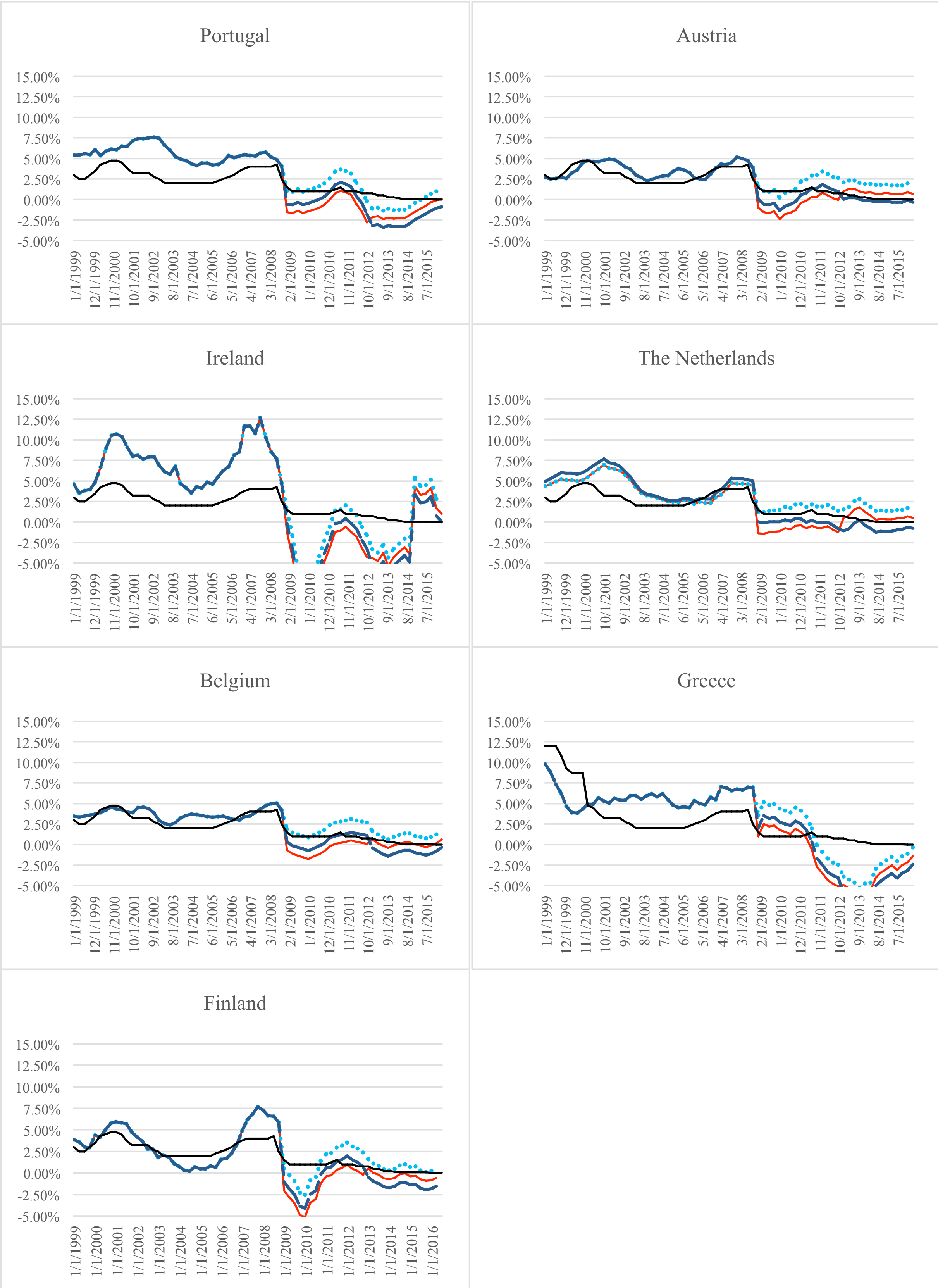


Figure 8 - Interest rate paths according to the 1993-rule with changing neutral real rate of interest.

As in the previous section, the suggested interest rate paths according to the 1993 Taylor rule have been presented here[23]. For the period 1998-2008 the same neutral real rate of interest as in the original Taylor rules has been assumed, thus there are no differences here from the previous analysis. Thus, the focus in this part of the analysis is on how changing the assumption of the neutral rate affects the Taylor rule prior to 1998 and the most recent period 2009-2016.

For the whole time-period, deviations between the policy rate and the Taylor rate have generally increased. This can to a large extent be attributed to the earlier periods of the time-series. As previously discussed, inflation was high in most countries in the late 1960s and 70s (for some countries this also persisted well into the 80s). During this period of high inflation, the policy rate was generally lower than the suggested Taylor rate. As the neutral real rate has been increased to 4% prior to 1998, this only adds to the suggested Taylor rate, making it even higher, and, thus, the deviation between the rule and actual policy even greater.

The main period of interest is 2009-2016 as this is this is part of the period when all Eurozone member states have been under a common monetary policy. Naturally, as with the estimations for the Eurozone, reducing the neutral real rate of interest has impact on the conclusions drawn for the separate countries. The general conclusion is very much the same as for the Eurozone as a whole; the monetary policy stance of the ECB is less accommodative than what first appeared, but there are still some nuances in these new estimations that were previously not visible.

First, the core-countries – Germany, France, Austria, the Netherlands and Belgium – can be examined more closely. For the sake of being conservative, the BVAR-estimate of the neutral real rate is assumed to be the correct one. Among the core-countries it is the smaller economies (Belgium, Austria and the Netherlands) that have the biggest deviations, and where the BVAR-approach has consistently suggested a positive nominal rate throughout the period. The suggested interest rate paths for Germany and France seem to be hovering very closely around the actual policy rate throughout the period. This impression is also confirmed when looking at the measures of deviation. Average absolute deviation is 0,780%

[23] For results according to the 1999-rule see appendix 6.8.

and 0,336% for Germany and France respectively in the period 2009-2016. This is down from 1,887% and 1,737% when assuming a constant neutral rate. Reducing the neutral rate has also reduced the deviation of the three smaller economies as well, and their average absolute deviation for 2009-2016 now all lie within 1,5%[24].

Judging from these interest rate paths, the monetary policy stance of the ECB has still been slightly more accommodative in the three smaller countries, albeit with a much narrower margin. Overall, assuming a reduced neutral real rate of interest has changed the impression that monetary policy has been too accommodative in all core countries in the years following the financial crisis.

Looking at the peripheral countries, Ireland, Spain, Portugal, Italy and Greece (also including Finland) the same trend of reduced deviations as was seen in for the core countries can also be found here. The exceptions are Ireland and Greece, where the deviations have increased ever so slightly compared to when a constant neutral real rate was assumed. As the focus is on the BVAR-approach it is in particular Italy and Spain that now have a close fit between the policy rate and the Taylor rate. As a consequence of this change in assumption Spain, Portugal and Finland now join Ireland and Greece, as countries were a nominal rate substantially below zero has been suggested as the appropriate response. The change appears particularly persistent in Portugal. Spain and Portugal only just reaches positive Taylor rates at the end of the time-series (although it has fluctuated into positive values for periods of time between 2010 and 2016 as well). Greece is the only country that has a suggested interest rate path that lies consistently below zero from 2011 until 2016Q2, this is illustrative of Greece being the country that is experiencing the biggest struggles in regaining traction in the economy following the financial crisis.

As before, the estimated interest rate path for Ireland appears somewhat erratic, which was previously explained by the inflated GDP figures. Using unemployment as a proxy again provides the following result:

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[24] See appendix 6.10 for measures of deviation for all countries.

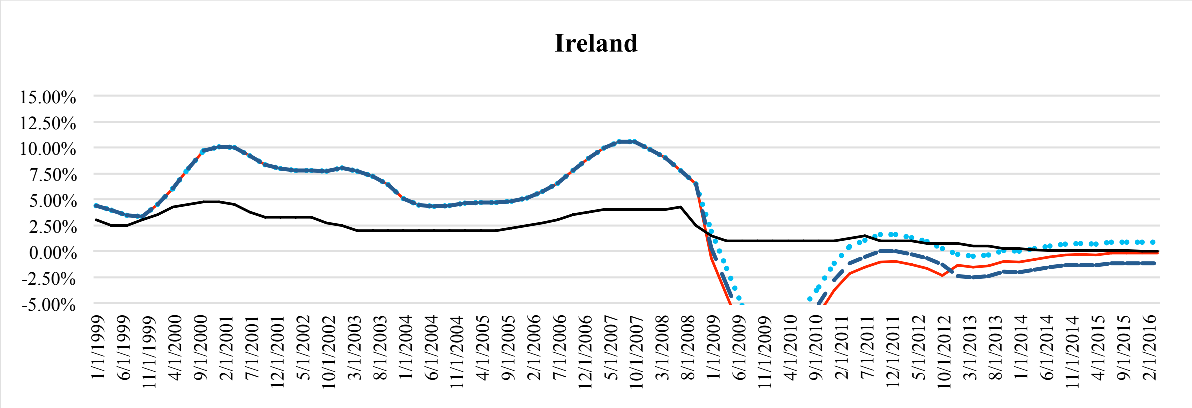


Figure 9 - Interest rate path for Ireland with unemployment as a proxy and changing neutral real rate of interest.

This result indicates a much more stable suggested interest rate path, as with the original Taylor rules. But whereas the estimation using a constant neutral rate suggested that the policy rate for Ireland should be positive, the rule now suggests a policy rate much closer to the one set by the ECB. In fact, since recovering from the financial crisis, Ireland has one of the closest fits between the Taylor rate and the actual policy rate for the period 2011Q4-2016Q2.

Changing the assumption that the neutral real rate has been constant throughout the entire period does not change the argument from the previous section with respect to certain countries being implicitly prioritized by the ECB when the policy rate is being set. For the period 1999-2008 there was no change in the assumption of the neutral rate, as it was set to 2%, thus there are no changes as to the ranking of how well the policy rate firth with the Taylor rule interest rate paths. However, when looking at the period 2009-2016, Spain, France, Germany and Italy were the four countries with the smallest deviations when a changing neutral real rate was applied, thus making the four largest economies also the four economies with the closest fit. So although it may be exaggerating to state that the two largest economies are being prioritized, they have consistently been among the countries with the smallest deviations since the launch of the Euro according to these specifications.

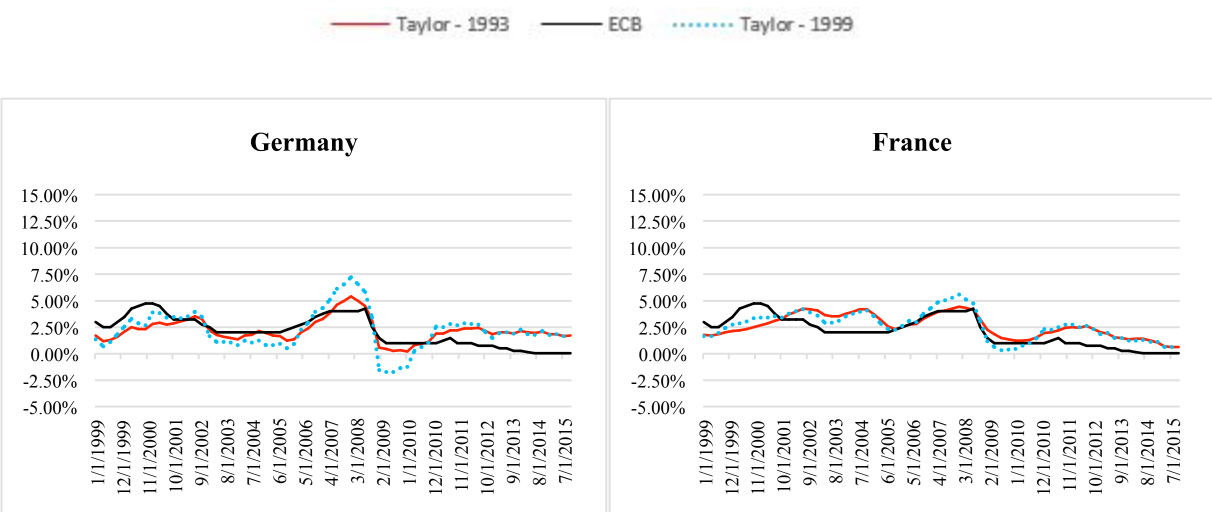
Changing the neutral real rate does, however, change the impression one could generally get by looking at the original Taylor rules regarding how accommodative the monetary policy of the ECB has been over this last period. Originally, the Taylor rules suggested a positive policy rate for all countries but Greece (and Ireland for certain periods). Now, when changing this assumption, the current monetary policy appears far less accommodative. For countries such as Spain, Portugal, Ireland and Greece, the Taylor rule now suggests that the monetary policy in the period 2009-2016 has been too restrictive for long periods of time (this illustrates the limitations of traditional monetary policy. With a policy rate of 0%, the ECB is reaching the limits of how this measure effectively can be used. Traditionally, the zero lower bound would have indicated the limit to the easing capacity of traditional monetary policy. However, in recent years it has been shown that the policy rate can effectively reach slightly negative values. In spite nearing the limits of traditional monetary policy, according to the Taylor rule, monetary policy is still not accommodative enough. For the other members of the Eurozone, the interest rate paths now suggest a rather neutral monetary policy stance for this period, although the paths for the Netherlands, Belgium and Austria may still suggest a tighter monetary policy as preferred to the current stance. Overall it may appear as though one could separate the periphery from the core with respect to ideal monetary policy, where the periphery generally needs a lower interest rate than the core countries. This is a result that makes intuitive sense, as the peripheral countries were also the countries hit hardest by the financial crisis.

This result does seem more appropriate given what has been observed in these countries following the financial crisis. When looking at the graphs in figure 1 (page 10) in the introduction, one can see that for the Eurozone as a whole, growth in GDP has been close to zero ever since the crisis hit. It was not until 2015Q3 that GDP had surpassed its previous peak in 2008Q1, meaning it took over seven years to return to the old GDP level and surpassing it. It would then appear wrong to indicate that monetary policy should have been tighter in this period.

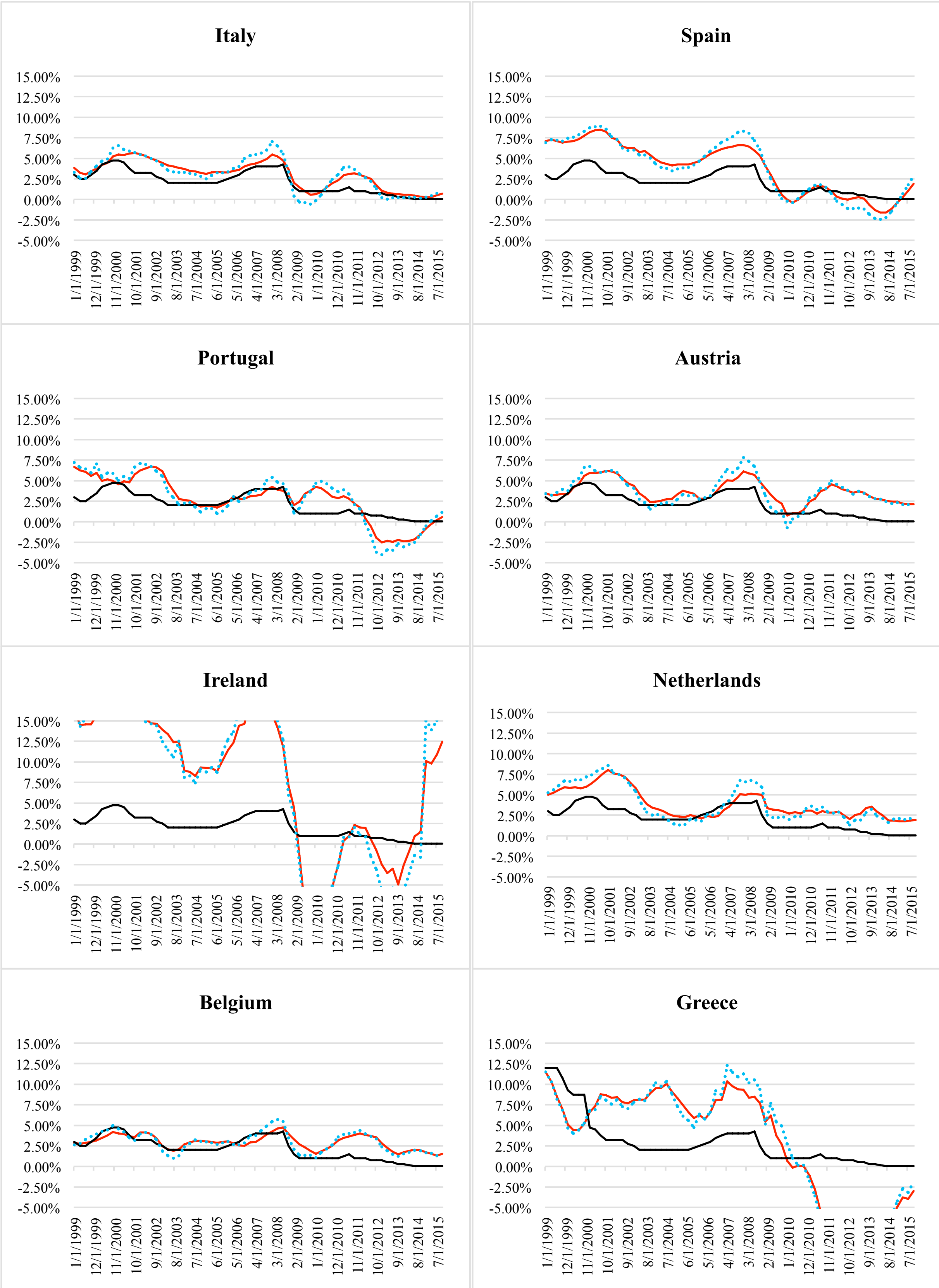
In this section the effect of changing the neutral real rate of interest on the estimated interest rate paths has been analysed. In doing so, it has thus far been assumed that the neutral real rate has remained the same for all member-countries of the Eurozone. As indicated earlier, this may be somewhat of a crude assumption. For instance, looking at figure 1, it seems clear that there are some countries contributing positively to GDP growth in the Eurozone, while others are struggling. The countries contributing to GDP growth in the Eurozone are primarily Germany, France, Austria, the Netherlands, Belgium and Ireland (with its inflated GDP figures). Countries such as Portugal, Italy, Spain, Finland and Greece all lie below the Eurozone aggregate. These countries have all yet to reach the level of their pre-crisis peak. This could indicate that the neutral real rate of interest differs between the individual countries, as they seem to be operating at difference pace (the Laubach & Williams model, as mentioned earlier, assumes a close relationship between the growth rate of potential output and the neutral real rate. Given that these countries have yet to experience a major lift in GDP growth, this eventually leads to the neutral rate being reduced as potential output is assumed to be shrinking). So, although the assumptions made in this section have been useful to alter the initial impression one could get from the Taylor rule, they still consists of some major simplifications, which has its limitations and is likely to still leave some nuances unable to be discovered.

3.2.2.2 Assuming a Floating Neutral Real Rate of Interest

The previous section assumed a neutral real rate changed in steps. The two main simplifications, which one could argue has major impact on the results, are the assumption that all countries have the same neutral real rate at all times (and that this is equal to that of the Eurozone), and that this rate is constant until changed suddenly at a given point in time. To correct for these simplifications, this part of the analysis utilizes a floating neutral real rate of interest, unique for each country. The data for the neutral real rates for each country are those estimated in Belke & Klose (2016), which have utilized the Laubach-Williams model for each country[25].



[25] For more details on the Laubach-Williams model see appendix 6.9.


Italy
Spain
Portugal
Austria
Ireland
Netherlands
Belgium
Greece
15.00%
12.50%
10.00%
7.50%
5.00%
2.50%
0.00%
-2.50%
-5.00%
1/1/1999
12/1/1999
11/1/2000
10/1/2001
9/1/2002
8/1/2003
7/1/2004
6/1/2005
5/1/2006
4/1/2007
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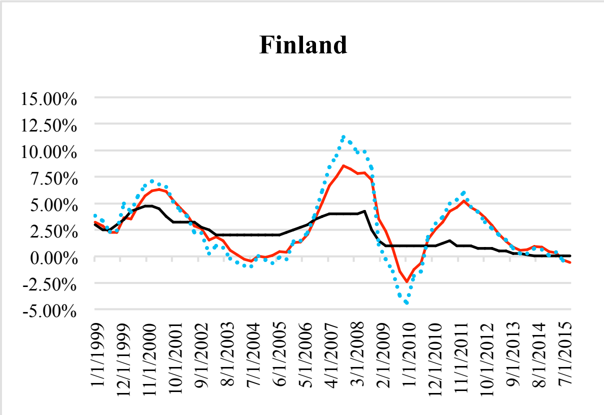

Figure 10 - Interest rate paths when assuming a floating neutral real interest rate.

1999-2008

Judging the first decade of the Eurozone under this new assumption, the first impression one could get may be somewhat surprising. There appears to be relatively small changes to the suggested interest rate paths for the majority of the countries when assuming a floating neutral real rate as compared to the previous analysis where a constant rate of 2% was assumed for the same period. This is in particular the case for the core-countries, but also the peripheral-countries Italy, Spain and Finland only register minor changes. This impression is further confirmed when looking at the measures for average absolute deviation and root mean square error for these countries[26]. Both measures indicate relatively small changes from the results obtained when assuming a constant neutral real rate.

Judging from these results, the assumption of a constant neutral real rate of 2% for these countries over this period does indeed seem to be a good approximation. Looking solely at the estimations of the neutral real rate from Belke & Klose (2016) also confirms this. Their estimations indicate that the neutral real rate was close to 2% for all of these countries for the majority of this decade, with relatively small fluctuations. The one exception is perhaps Spain, where the neutral rate was between 4% and 5% at the beginning of the period for then to steadily decline towards 2% over the first five years of this decade. This is also visible when looking at the estimated interest rate path for Spain, where the path has a higher

[26] See appendix 6.11 for measures of deviation for all member states under this assumption.

starting point in this estimation than it did when a constant real rate was assumed. Spain did have an increase to its measures of deviation for this period, albeit only a slight increase, this alteration to the beginning of the time period explains this change as well. So despite Spain experiencing a boom-period during the first decade of the Eurozone, the neutral real rate was steadily declining over the first half of this period. Once the neutral rate of Spain had declined to around the same level as the core-countries, it seemed to stabilize, and held this level for the remainder of this decade with only small fluctuations.

The countries with the most drastically changed interest rate paths for this decade are Portugal, Ireland and Greece. Of these countries Portugal is perhaps the most peculiar case, as the change caused by the floating neutral rate for this country also changes the conclusions previously made with respect to the need for a tighter monetary policy. The first four years looks much the same as when looking at previous analysis. The change caused by the floating neutral rate becomes visible after 2003 and up until the interest rate peak in 2008Q4, over this period the interest rate path of Portugal now follows the actual policy rate very closely. This is due to the negative trend in the neutral real rate for Portugal. The neutral rate of Portugal peaked in 1994Q1 at just above 7,5%, five years prior to the euro being introduced. Since that peak it had been steadily declining, and at the introduction of the euro in 1999Q1 it had declined to just over 3%. Although the rate had more than halved over this period, it was still substantially higher than what was seen in the core-countries. But where, for instance, the neutral rate of Spain seemed to stop declining once it reached the level of the core countries, the rate of Portugal kept on declining. From the end of 2000 until the crisis struck, Portugal had an estimated neutral real rate fluctuating between slightly negative values and 1%, by far the lowest rate among all the Eurozone members, no other country came even close to reaching negative values during this period.

To find a possible rationale for this development in Portugal, which is very distinct when compared to the other Eurozone members over the same period, one has to look to the period prior to the introduction of the euro. Blanchard (2006) argues that the prospects of joining the euro led to a boom-period in Portugal, in particular during the last five years of the 1990s. During the 90s, nominal and real interest rates in Portugal declined drastically, this happened due to expectations of what would happen once Portugal joined the euro. The reduced interest rates combined with expectations that joining the euro would provide Portugal with faster convergence and faster growth, resulted in an increase in both consumption and investment. The initial result of this was higher output-growth and reduced unemployment. This is also clearly visible in figure 1, where the growth in GDP for Portugal is particularly strong in the period 1995-2001. With decreasing unemployment, nominal wage growth in this period was much higher than labour productivity growth, leading to growth in labour unit costs higher than what witnessed in the rest of the Eurozone. At the time, the Eurozone also accounted for roughly 70% of all Portuguese trade. Reduced competitiveness and high output growth lead to increases in the current account deficit over the same period[27].

As further explained by Blanchard (2006) the future did not turn out as positive as expected for Portugal. An expected increase in labour productivity was never confirmed by data, and the investment boom ended. Also, a continuing increase in relative labour costs offset what should have been a reduction of the current account deficit following lower import demand. The decrease in nominal wage growth was more than offset by the decline in productivity growth, resulting in relative labour costs increasing by more than 10% between 2001-2006. As Portugal is a price taker with respect to its export goods the price of its exported goods have not increased significantly over the same period. This also led to a major decrease in the profitability in non-tradables. Further worsening the situation for Portugal was the fact that a larger share of their exports, as compared to the Eurozone average, was based around “low tech” goods. These were the type of goods from which the competition with emerging economies was strongest.

Thus, Portugal witnessed a slump already during the first decade of the Eurozone – a period that in general was associated with growth and prosperity for the member states. Some of the structural developments witnessed in Portugal will be further discussed in the next chapter, and this will show similar development for other peripheral countries, however, Portugal seem to have felt the force of such effects at a much earlier stage than its peers in similar situations.

The other two countries with significant changes in their interest rate paths were Ireland and Greece. Compared to Portugal, the opposite effect is observed here; both countries have a suggested interest rate path lying higher than what was previously estimated. In particular Ireland has a very high estimated neutral real rate for this decade. Although trending

[27] See appendix 6.13. One can see that for the period 1995-2000, Portugal has a more drastic increase to its current account deficit than its Eurozone peers.

downwards, this rate peaks at just over 14% at the beginning of 2000, and for the period 2002Q3-2008Q2 its lowest estimated value is 6,23%, thus exceeding the rates of the core countries for the entire decade by a clear margin. In Greece the same trend is detected, albeit with less extreme deviations. Greece did not join the Eurozone until 2001, but since joining, only Ireland has had a higher neutral real rate during the period prior to the interest rate peak in 2008Q4. Apart from Ireland, Greece had a substantially higher neutral rate than the remaining member states. This indicates that Ireland and Greece, as opposed to Portugal, did experience the period of sustained economic growth that the euro had envisaged. Although, these results do indicate that growth for these two countries may have been coming at a too extreme pace. The neutral rates suggest that monetary policy for both countries should have been far stricter than already previously estimated, in particular for Ireland.

So summarizing this first decade, there were only major differences for three of the eleven countries over the whole decade, as well as some changes for Spain at the beginning of the decade. Only for Portugal does the conclusion change from previous estimates. For Ireland and Greece the only change is that the suggested interest rate paths deviate even more from the actual policy rate, suggesting the nominal rate in these countries should have been even higher than what was suggested in previous estimations.

2009-2015

Looking firstly at the core-countries for the period after the crisis hit, the estimated suggested interest rate paths for these countries are more similar to those provided by the original Taylor rules with a constant neutral rate of 2% than the estimations where the rate was changed in steps. This indicates that assuming a smaller decrease in the neutral real rate of interest following the financial crisis for the core-countries than what was estimated for the Eurozone as a whole seem like a correct assumption. It also signals that the neutral real rate of interest has remained very much stable for these member states. This is also confirmed when comparing the neutral rates obtained in Belke & Klose (2016) with the estimations for the Eurozone as a whole from Constâncio (2016)[28]. In Constâncio (2016) two of the three approaches suggested a negative neutral real interest rate for the period 2009-2016 for the Eurozone as a whole. Estimations for the separate countries indicate that none

[28] See appendix 6.14 for the neutral real interest rate paths for each country and figure 4 for estimates from Constaâncio (2016).

of the core-countries have experienced negative neutral rates at any point during this time-period. And although trending downwards, the neutral rate estimated lies, at all times, above the BVAR-approach in Constâncio (2016), which did not suggest negative neutral rates.

The results from this estimation provides insight that somewhat contradicts the conclusions one could have made based on the estimated interest rate paths when the neutral rate was changed in steps for the core-countries. In particular, this holds true for Germany and France. In the previous estimation it appeared as though the monetary policy of this period should have been seen as neutral with respect to these countries. Here, though, it appears as though the conclusion revert back to what was concluded when using the original Taylor rules. Monetary policy seems to have been too accommodative for Germany and France for the majority of the period following the financial crisis. This also indicates that these countries, along with the other core-countries managed to bounce back relatively quickly following the worst period of the crisis. This impression is reinforced when looking at how the neutral real rate develops over this period. Although the rate does trend downwards for all core-countries during the crisis and in the years since, fluctuations are much smaller than for the peripheral-countries. For the remaining core-countries, the change in assumption from the 2% neutral rate to changing it in steps in the previous section did not really affect the conclusion with regards to the monetary policy stance. It was shown that the Taylor rule suggested that monetary policy over this period had largely been too accommodative regardless of which neutral rate assumption was made (when the BVAR-approach was assumed to be the correct one). Changing the assumption to a floating neutral rate only helps to strengthen this conclusion.

Looking at the peripheral-countries, changing to a floating neutral rate has a bigger impact than it had for the core countries. As for the period before the financial crisis, the neutral rates for these countries have fluctuated much more in the period following the crisis than what has been witnessed in the core countries as well. An exception could perhaps be made for Italy, although the neutral rate declined more here than for the core-economies, it did remain more stable than what was witnessed in the other peripheral-countries, never reaching negative values. A similar pattern is also visible when looking at the suggested interest rate paths, as Italy never reached negative values (when looking at the 1993-rule). This suggests that Italy may have fared better than its peripheral peers in the period following the financial crisis.

For the remaining peripheral-countries the suggested interest rate paths lie closer to the paths suggested when the neutral rate was changed in steps rather than when it was constant. The opposite result of what was found for the core-countries. This suggests that the decline in the neutral rate has been more severe for these countries than for the core, which supports the general perception that these are also the countries that have struggled the most following the financial crisis. All the peripheral countries, apart from Italy, have had neutral real rates dropping below 0% for some time during this time-period. The shortest period was experienced in Spain, which only lasted for five quarters without the rate ever dropping far below 0% (at the lowest it was estimated to be -0,16%). Another interesting aspect about the estimations for Spain is the fact that the suggested Taylor rate rises quite drastically towards the end of the time-period, almost reaching 2% at the end of 2015. Of course this could be adjusted as data is revised, but it could also be a sign that the outlook in Spain is improving. Looking at the neutral rate for Spain as well, this has also been steadily increasing since the end of 2013, and has for instance surpassed the rates of Germany, France and Italy in late 2015.

In Portugal, Ireland and Greece the addition of the floating neutral rate has contributed to enhancing drop in the suggested Taylor rates for these countries. All of these countries experienced quite dramatic declines in the neutral rate in this period. The interest rate path for Greece was particularly affected in this period, as Greece witnessed the by far most extreme drop in the neutral real rate. Portugal and Greece are also the only two of the peripheral countries still witnessing negative neutral rates at the end of the time-period, indicating that restoring growth in these two countries may have been harder than in the rest of the periphery. As previously mentioned, Portugal was struggling already before the crisis hit, so the events following the crisis only helped add to these struggles. From the Taylor rule one can also see that Portugal reaches a positive suggested rate only at the very end of the time-period. Greece is the only country with a Taylor-rate well below 0% at the end of the period. The erratic path of Ireland is only enhanced when the floating rate is added to the estimation. In previous estimations we have seen that Ireland has the highest suggested Taylor-rate due to inflated GDP figures resulting in an extremely positive business cycle in recent years. As the approach used by Belke & Klose (2016) assumes a strong connection between growth in potential GDP and the neutral real rate of interest, these inflated GDP figures also directly impacts the estimated neutral real rate for the country. The neutral rate of Ireland has been growing rapidly since the end of 2013, and had at the end of 2015 surpassed 7%, giving Ireland the by far highest neutral rate amongst all the Eurozone-members (as was also the case before the financial crisis). As was previously argued with respect to the estimated Taylor-rate for Ireland, one should perhaps be somewhat critical of the estimated neutral real rate for Ireland as well, for very much the same reasons. Although growth is reported to be improving in Ireland, these figures do seem to provide somewhat of a skewed image.

From these estimations the impact of the neutral real rate has been highlighted. The difference in this rate between the individual Eurozone members is apparent, and taking it into account has significance for the conclusions drawn from the suggested interest rate paths given by the Taylor-rule. Including a floating rate highlights that certain countries have remained more stable throughout the existence of the euro than others, with the stability mainly coming from the core. This deviation amongst countries, along with the negative trend in the neutral real rates implies that assuming a constant neutral rate for all countries would generate interest rate paths giving the wrong impression, although the constant neutral rate in fact did provide a fairly good approximation the core-countries. The error in assuming that all countries follow the fluctuations of the Eurozone as a whole is also visible when using the floating rate. This also stems from the core-countries remaining much more stable than the peripheral-countries, thus the reduction in the neutral rate suggested for the Eurozone is too large to properly reflect these countries. On the opposite side, the drop is too small to reflect some of the peripheral-countries, in particular Greece and Ireland.

4. Discussion

Our estimations of the suggested central bank interest rate paths according to the Taylor rule have shown that there have been significant differences between the different Eurozone member-countries. These differences, although somewhat sensitive to our alternative assumptions, have proven to be fairly robust to changes in both the reaction coefficients and to the neutral real rate of interest. The following section will discuss what information can be drawn from these results. In this discussion the focus should be on the Eurozone being a good approximation to an OCA or not, rather than perfectly constituting an OCA. The perfect synchronization and mobility of all input-factors which OCA theory stipulates is not a realistic measure in practice, especially considering that the Eurozone consists of so many different nations. This notion is important to keep in mind in the following discussion.

From these results, can we any see indications that the "one-size-fits-all" monetary policy of the ECB may not have been ideal, and that the inflexibility each country has experienced by not having its own monetary policy may have been of hindrance for a stable development for certain Eurozone-members? Or has the euro contributed to stabilization and left the member states in better shape to deal with the crisis than they independently would have managed? To further analyse the notion of the Eurozone as an OCA, the connection between deviations from the suggested interest rate path suggested by the Taylor rule and developments in other macro-variables will be further analysed.

Establishing the euro aimed at removing exchange rate risks and to thereby reduce transaction costs and increase planning and security for trans-border trade and investment. Achieving this would boost the single market and economic welfare through increased competition and economies of scale. If the introduction of the common currency was coupled with stability-oriented macroeconomic policies, the euro was thought to promote macroeconomic stability throughout the Eurozone. Also, in the presence of increased globalization, the euro was thought to give the European Union a stronger presence in the global economy.

4.1 The First Decade of the Euro – 1999-2008

Introducing a common currency was aimed at creating a stable environment for economic growth. Thus, at the infant stages of the euro, the debate was centred on convergence. For a common currency and monetary policy to function over time, you are dependent on economies operating under similar circumstances. This criterion entails, among other things, inflation rates, exchange rates, interest rates, and government deficits and debt. The importance of such factors was encompassed in the Maastricht Treaty of 1992, which stated explicit terms each country had to fulfil in order to be inducted into the Eurozone. These criteria were all criteria of nominal convergence.

With the exception of government debt, these nominal convergence criteria were virtually achieved upon completion of the Economic and Monetary Union (EMU). The successful convergence and the following period of prosperity and growth in the Eurozone resulted in the first decade of the euro being dubbed as a success (Mongelli & Wyplosz (2009)). During this first decade, inflation remained low and inflationary expectations remained well anchored. Also, interest rates remained low, unemployment declined and new jobs were created across most countries. There was also a markedly increase in trade of goods and services among Eurozone countries. Trade with countries outside the Eurozone also increased, so no protectionism towards Eurozone economies occurred (Mongelli (2013)).

In addition to nominal convergence, the Eurozone also experienced real convergence over this period with GDP per capita levels increasing more rapidly in the periphery, catching up with the core-countries. This real convergence was further fuelled by mass capital inflow to the peripheral-countries from the core-countries. These capital flows corresponded with increasing current account deficits in the periphery and surpluses in the core. The inflows of capital also coincided with accelerated growth rates for the periphery (Buti & Turrini (2015)). This is illustrated in figure 1, showing in particular strong growth for Spain, Portugal, Ireland and Greece, and also to some extent Italy. As a result of this increased activity in the periphery, a persistently higher inflation was also registered in the periphery compared to the core. These are both factors that are recognizable in the estimated Taylor rule interest rate paths. There was a common trend that in particular the peripheral countries had a suggested Taylor rate substantially higher than the actual policy rate.

Although peripheral-countries experienced accelerated growth rates, it has been suggested that this growth possibly was not sustainable over time. That the economic activity exceeded sustainable output trends over a longer period. As this activity boom persisted, the peripheral-countries lost their competitiveness compared to the core-countries. And investment in non-tradable sectors became increasingly profitable. Countries such as Spain and Ireland experienced large-scale bubbles in the housing sector.

Taylor (2007) argues quite strongly that the monetary policy in the US for the period leading up to the financial crisis was largely too loose. During the period 2003-2006 "the federal funds rate was well below what experience during the last two decades – the Great Moderation – would have prescribed". Furthermore, he argues that this extra-easy policy was responsible for accelerating the housing boom and, in the end, leading to the bust. In Taylor (2009) he underpins this argument by simulating a scenario where the Federal Funds rate had followed the suggested Taylor rate, which indicated a far smaller boom, and, consequently, a less severe bust.

Although not as adamant to the connection between deviations between the Taylor rate and housing price inflation, Ahrend et al. (2008) finds that the same relationship is present for the Eurozone-countries. Our estimations also give the same impression[29], looking at the connection between deviation from the Taylor rule and change in house prices indicates that the countries with the most persistent deviation from the Taylor rule are also the countries with the most accelerated increase in house prices. In general, this includes the peripheral-countries, with the exception of Portugal. One can also note that France, despite not having a large deviation from the Taylor rule for the period 2000-2009 did experience a period with major inflation in house prices. Ahrend et al. (2008) also find a strong correlation between mortgage lending, housing investment and construction investment and deviations from the Taylor rule as well. In fact, the correlation between house prices seems to be the weakest one (which they explain is due to differences in zoning restrictions in different countries, which should be uncorrelated with the stance in monetary policy). This highlights one of the problems the Eurozone faced in this period, to which no sufficient measures were taken before the bubble had burst. The deviations between counties also suggest that the "one-size-fits-all" monetary policy from the ECB this period did not suit all counties equally well. One

[29] See appendix 6.12 for relationship between housing price inflation and deviations from the Taylor rule.

point that can be made from this development is that the nominal convergence achieved prior to the introduction of the euro, did not seem to persist once the euro was introduced and capital started to flow more freely between countries. After this point in time, there was an increasing divergence between Eurozone members, as illustrated by the Taylor rule with respect to inflation and economic activity. Also, as mentioned, current account balances clearly diverged, despite the Eurozone as a whole improving in this respect.

These developments had been warned against before the euro was introduced. There were concerns as to whether the individual countries would be flexible enough to deal with asymmetric shocks. Suggestions had been made to launch the euro among a smaller group of countries initially, or put the launch on hold and wait for more convergence to take place.

The result after the first decade of the monetary union appears to have been mixed. Although growth increased among most countries, and inter-European trade increased forging stronger bonds between the European countries, this development came at the cost of imbalances building up between the member-countries.

4.2 After the Financial Crisis – 2009-2016

During its first decade, the Eurozone did experience real convergence. But at the same time structural divergence became a factor, meaning that the structure of the economy of the countries in the periphery of the Eurozone became increasingly different from that of the core countries. Countries became more specialized in certain industries. This might not be a desirable feat if the aim is to create an OCA. Countries more specialized in certain industries will become more exposed to shocks within this industry. Thus, when shocks occur, the strain on monetary policy may become severe. One factor that drove the specialization was the possibilities of economies of scale encouraged by the launch of the euro. A second force that contributed was the financial service and construction boom, which for the most part took place in the periphery. This came at the expense of other industries. Easily accessible and cheap credit from other large European banks led to a demand boom, which drove up domestic salaries in both the tradable and non-tradable sector. This resulted in rising price-levels, which made the tradable sector of the periphery less competitive. As a result of this specialization, the manufacturing sector in Spain, Portugal, Italy and Greece produce both fewer goods and in smaller quantities than before the introduction of the euro (Mongelli (2013)).

While the periphery-countries became increasingly concentrated around non-tradable goods and construction, the core-countries relied more on export and tradable activities. The increased specialization also meant that part of the current account deficit in some countries became structural. As is illustrated by looking at the current account balance as percent of GDP for the different Eurozone members[30]. Starting in 1999 we see that especially Spain, Portugal, Ireland and Greece persistently have a negative current account, this also holds true for Italy, although the deficit is substantially smaller there. The current account balance for these countries did not reach positive levels until around 2012Q2. This does provide indications towards these deficits not merely being of cyclical nature.

The revision of public finances in Greece starting in late 2009 acted as a trigger for the crisis in Europe following this build-up of imbalances. Initially, the concerns were about sustainability in Greece, but not long thereafter concerns about the financial health of other Eurozone countries also rose. As risk aversion rose, credit flows to the deficit-countries stopped. The imbalances that had built up resulted in the deficit-countries being hit the hardest by the financial crisis. Looking at the estimated Taylor rules one gets the same impression, with interest rates for, in particular, Spain, Ireland, Greece and Portugal indicating a negative interest rate as the preferred response for longer periods of time.

As the crisis hit differently across the members of the Eurozone, criticism of the Eurozone as an OCA previously raised by euro-pessimists were again brought forward. For instance, Krugman (2012) raises some strong criticism towards the economic framework of the Eurozone and how its implementation has left certain countries devoid of the flexibility to manoeuvre its way out of the crisis. As capital flows to the periphery stopped, the price levels and unit labour costs that had emerged in the periphery was out of synch with the same levels in the core. This left the Eurozone with a major adjustment problem. The kind of problem, Krugman argues, OCA theory had warned would become extremely demanding to handle without the option of currency devaluation. For a country with an independent monetary policy, a solution to such a problem as the one witnessed in the Eurozone would be to devaluate its currency. This will reduce relative wages in the country, and should ultimately increase competitiveness. This is considered a much easier measure to implement than internal devaluation. Internal devaluation is an option that aims to restore

[30] For graphical illustration of the development in current accounts see appendix 6.13.

competitiveness through reducing labour costs, mainly wages – wage rigidity will here be a problem, getting acceptance for potentially reduced wages.

Making matters worse for the Eurozone, than for instance the US, during the crisis were the lack of the two main factors that should be present in an OCA, the first of which was labour mobility. High labour mobility from the countries that were hit the hardest to the core would have helped regain full employment (or at least employment close to the pre-crisis level) by reducing the size of the labour force. This factor has proven not to be present in the Eurozone. Labour is in principle free to move across borders, but whether such movements actually take place is a whole different story.

The other factor missing from the Eurozone was fiscal integration. The lack of a fiscal union to accompany the monetary union in the Eurozone is a point that has also been stressed by others criticizing the Eurozone as an OCA. This lack of integration meant that the countries experiencing the most severe shocks could only receive compensation at a regional level (here we consider the individual Eurozone members as regions and the Eurozone as a whole the federal level). In comparison, as Krugman stresses, the US economy has fiscal integration, which resulted in the states being hit the hardest from the financial crisis, also experienced increased compensation from the rest of the country. Another factor was the crisis in the banking sector. In the US, bank deposits are guaranteed for at a federal level, as a result, bank bailouts does not become a burden on state governments. Europe does not have this integration, and during the crisis governments had to take on private debt to rescue banks. Being forced to take on private debt at a regional level, alongside reduced revenues and increased public spending resulted in soaring public debt-levels. This surge in public debt-levels has resulted in the solvency of certain countries being questioned. In particular Spain, Portugal, Greece and Ireland have witnessed drastic increases to their public debt levels. Italy may not have had the same dramatic increase, but is still among the countries with the highest debt-to-GDP ratio in the Eurozone.

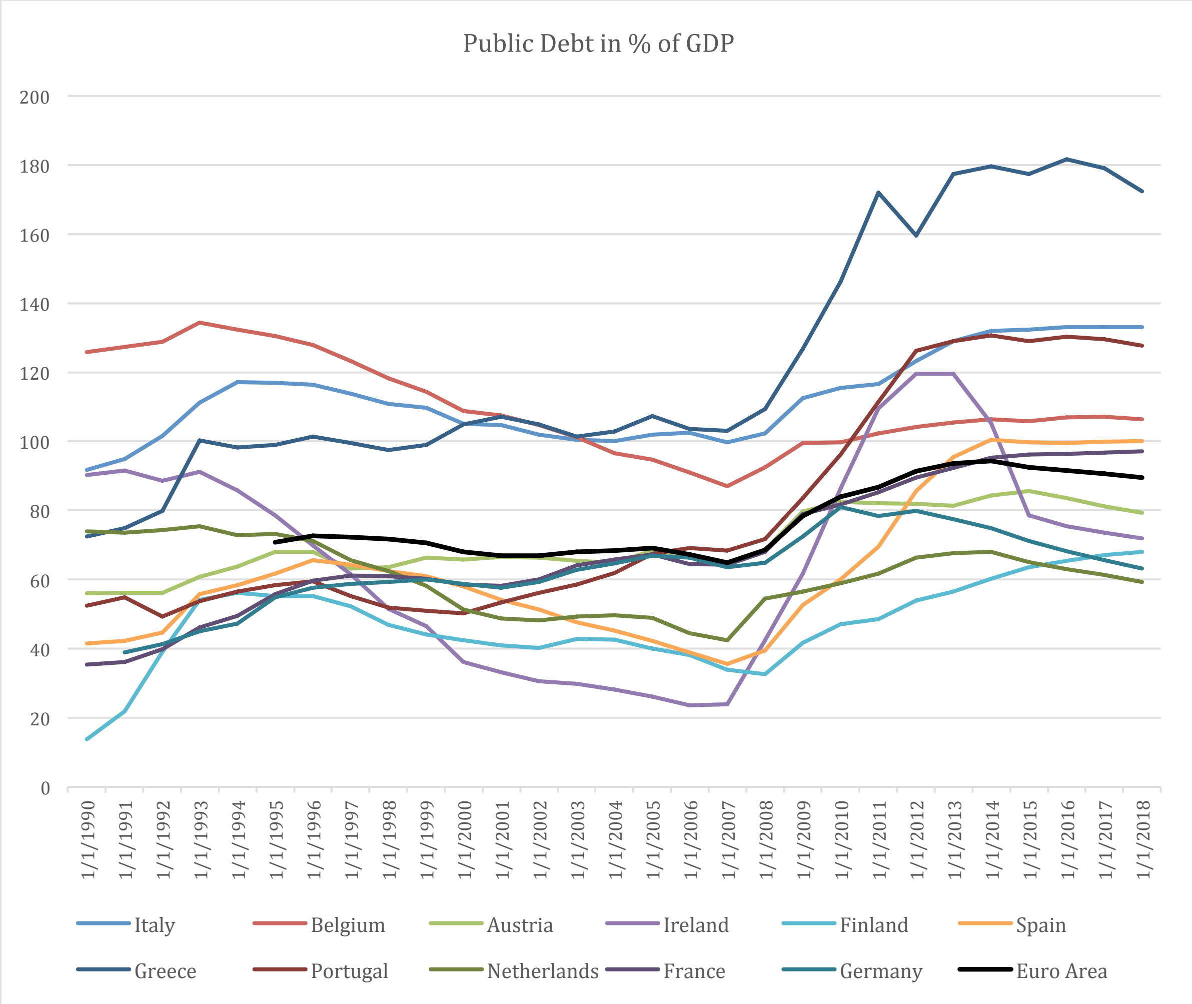

Figure 11 - Public debt-to-GDP ratio for the Eurozone members

Another problem arising from the rapidly increasing public debt-levels is the so called "doom loops". This term describes a situation where weak banks are dragging down their government, while weak governments are dragging down their nations' banks. The fear that the government may default on their debt results in confidence in banks holding much sovereign debt being undermined, as a bank becomes ever more reliant on the government's good performance the more invested it gets in one government's debt (Farhi & Tirole (2016) & Wallace (2016)).

Looking at other macroeconomic variables there does appear to be a connection between how they have developed over the lifespan of the euro and the deviations from the Taylor rule for the separate countries. The connection between the deviation from the Taylor rule and house price inflation/investment in housing prior to the financial crisis is particularly striking, indicating that the massive inflow of capital and surging growth rates in the peripheral-countries allowed for a bubble to build up. In order for real convergence between the core and the periphery to take place, the ECB allowed for higher inflation rates in this region while growth rates rose. However, as it turns out, structural convergence did not follow as a consequence of nominal and real convergence. Rather, this period witnessed what can be described as structural divergence. This is for instance visible in the growing current account deficits in the periphery along with growing surpluses in the core.

When the crisis hit, the periphery was hit the hardest, given that their economy was now largely based on non-tradable goods, and their growth largely being based on the accessibility of cheap credit from the core, this, in hindsight, makes sense, as the credit flow from the core stopped. This left the periphery with labour costs out of proportion and a competitive disadvantage compared to the core, where the economy had become increasingly biased towards export-driven growth. The Taylor rule estimations give this indication, where the peripheral-countries quite clearly were in need of a lower nominal interest rate than the core-countries. This again gives evidence towards the notion that a one-size-fits-all monetary policy does not fit the Eurozone much better now than it did before the financial crisis.

All in all, this provides arguments towards the claim that the Eurozone was not an OCA when the euro was first introduced, a claim made by many both before the euro was launched, and in periods after. But it may also indicate that the Eurozone is not much closer to constituting an OCA as of today.

Belke & Verheyen (2013) continue along the same line as Krugman by stating; “under the prevailing structure and membership, the Eurozone simply does not work successfully”. Their analysis tries to capture the potential effects of countries leaving the Eurozone and going back to their national currencies, separating them into “strong” and “weak” countries, where the weak countries are those experiencing the most pressing financial distress. What they consider to be the most likely scenario is for a weak country to secede the euro. However, leaving the euro comes at substantial cost. The country reverting back to its old currency would regain the monetary policy flexibility that it gave up when joining the Eurozone, but they also argue that the notion that a country would immediately regain competitiveness through devaluation of its new currency is not overly realistic. The argument for this is protectionism amongst remaining Eurozone members, implying that as the currency of the seceding country devaluates, it is not an unlikely scenario for the Eurozone to impose tariffs on exports from the departing country. Also, if seceding from the euro, a country must leave the European Union as well, leaving the country without any trade agreement with Europe. These effects may partly explain why we have yet to see any country taking the drastic step of leaving the Eurozone in a bid to improve their situation.

The other scenario is for a strong country to secede the euro (focusing on Germany), which they suggest is less likely than the previous case. In such an event, the currency of the country leaving is expected to appreciate relative to the euro. They do argue that a strong country leaving would find itself in a much stronger position than a weak country. For instance, the value of public debt denominated in euro would decrease. Negative consequences are again the prospect of leaving the European Union and also losing influence over the monetary policy stance in the Eurozone, of which Germany currently have a strong voice. Also, if this scenario were to ever become a reality, the possibility of a fully-fledged dissolution of the Eurozone would become more realistic as the euro would lose its pillar of stability.

With the crisis unfolding and the divergence amongst the Eurozone members becoming visible to a much greater extent than before, it is easy to focus on the doom and gloom surrounding the prospects of the Eurozone. Witnessing the peripheral-countries struggling to navigate out of the slump, the euro-pessimists gain a lot of ammunition to support their claims of the Eurozone being a project doomed to fail. However, there is also a strong case to be made in support of the Eurozone in the wake of the financial crisis.

Regling et al (2010) concludes quite clearly that the euro has proven that it is a viable project that is here to stay, giving a somewhat different perspective than what was provided by Krugman (2012). Where others have argued that the lack of monetary flexibility worsened the effects of the financial crisis, Regling et al. argue that the euro limited the impact the crisis had on Europe in several ways. The first factor was that with the common currency, exchange rate and interest rate volatility among the Eurozone-members, which used to be a problem in the past, was removed. The macroeconomic framework of the Eurozone was stability-oriented, resulting in less volatile inflation and interest rates, as well as output fluctuations being reduced. Without the euro in place, they argue, such fluctuations would have become much more severe. Also, the ECB has managed to respond swiftly and decisively in managing liquidity, adopting an accommodative monetary policy stance and taking unconventional measures to ensure that banks were able to refinance themselves. These measures also contributed in mitigating the risk of a systemic crisis in the banking sector. The accessibility of liquidity during the crisis also shielded smaller, less credible, pre-euro currencies against liquidity strains during this period.

However, despite the stabilizing effect the euro had during the crisis, they as well point to the weaknesses of the Eurozone, as discussed previously, and the need for reforms to make the euro viable. They especially focus on the need for improved financial governance and structural reforms for the periphery to regain competitiveness. With respect to the current account deficits, these are argued to be the result of a successful catching-up period for the peripheral-countries. As can be seen from the graphs, the deficit countries have reduced their current account deficits in the years following the crisis. This comes as a result of domestic demand being reduced giving a fall to the prices of non-tradables, making investment in tradable goods more profitable again[31].

Mongelli (2013) also argues strongly in favour of the viability of the Eurozone, and claims that although the Eurozone does not constitute an OCA akin to what we see in the US, there is now a transformation progressing in the Eurozone. This transformation, with the reforms it sets out to implement, may result in the Eurozone scoring much higher under various OCA criteria in the not too distant future. For instance, the implementation of the Banking Union (European Commission (2015)) will provide a better crisis management framework for Eurozone sovereigns and banks. The Banking Union as of 2012 gives the ECB the responsibility as the central supervisor of financial institutions in the Eurozone. This supervisory system was set up as a response to the realization that national policy tools were not sufficient for countries being more interdependent through a common currency. Having a common rulebook for financial institutions to avoid irresponsible behaviour as well as providing common supervisory and resolution mechanisms is thought to, in time, ensure overall stability and transparency to the Eurozone financial sector, which will restore confidence in banks and support growth across all EU economies.

Mongelli also argues that the effects of national reforms may start to become visible in the stressed countries. For instance, internal devaluation, which Krugman argued would be very difficult to implement, have contributed to a rebound in exports among stressed countries as well as narrowing current account deficits. However, he also points out that the Eurozone

[31] See also Tressel & Wang (2014) for in-depth analysis on the development of the current accounts of the peripheral countries.

members have become more heterogeneous with especially manufacturing activities being reduced in some of the countries. From an OCA standpoint, this development is a direct hindrance, as homogeneity is one of the main criteria to ensure symmetric reactions to economic shocks and monetary policy actions. In this respect he points to the need for some countries to reinvent themselves, the ability of certain countries to reinvent themselves and become less specialized is likely to prove very important in the years to come.

So although the euro have received a fair bit of criticism since its birth and especially following the financial crisis, there may also be signs that the events that transpired following this period of financial turmoil have left the Eurozone more aware of its flaws. The success of the reforms imposed since then may perhaps already be showing their effects, as one can also see from our estimated Taylor rules. Although the peripheral-countries find themselves with lower suggested interest rates than the core-countries, they do trend upwards for Spain, Portugal and Greece at the end of the time-period. This could perhaps be an indication of improvement amongst the periphery and the Eurozone as a whole.

4.3 Developments in the Neutral Real Rate of Interest

As the magnitude of the neutral real rate of interest did have some implications for the conclusions drawn from the interest rate paths, it seems relevant to devote some space to discuss the developments of this variable and how it affects the Eurozone. As previously discussed, having a good approximation of the neutral real rate of interest is critical for the policymakers if they are to conduct appropriate monetary policy and reach the inflation target over time and ensure full capacity utilization. This section will be dedicated to investigate whether or not there has been any change to the correlation of the neutral real rates between the countries, and also whether or not they seem to have converged over the lifespan of the euro.

Since the beginning of the 1970s, the three biggest economies have had a correlated slightly downwards-sloping trend[32]. Along with these countries, this is also a trend visible for the smaller three core-countries – Austria, Belgium and the Netherlands – especially since the early 1990s. What really separates these countries from the remaining five is the degree of

[32] See appendix 6.14 for the graphical illustration.

stability in the neutral real rate. Although the downwards-sloping trend is also visible amongst the peripheral-countries, the volatility appears much larger in here. What also separates the more volatile countries from the stable ones is that the negative trend has not persisted as long. Spain and Portugal in fact exhibit a positive trend until the early 1990s, Ireland and Greece until the early 2000s, and Finland until 2006. Previously the estimates of Constâncio (2016) were used to estimate Taylor rules, here a linear trend of the neutral real rate of interest for the Eurozone from 2009 to 2016 is presented. This linear trend is clearly downwards sloping and thus exhibits the same traits as is seen among all countries in the Eurozone for this late period (one exception could be made for Ireland, which as previously argued presents somewhat of a unique case for the period following the financial crisis). However, what is important to point out is that although all countries could be said to exhibit a downwards-sloping trend, the degree of which it is downwards sloping differs between the individual countries. It is the peripheral-countries that clearly have the most negative trend to their neutral rates, and thus contributes negatively to the rate for the Eurozone as a whole.

Mundell (1961) proposed four homogeneity criteria that must be fulfilled for a region to qualify as an OCA. According to the first criteria, the economies should be roughly similar and synchronized. If the economies truly are roughly synchronized, there should be a high degree of correlation between the neutral real rates in the different economies.

Figure 12 illustrates the degree of correlation between the individual member states. To further show how the correlations between the different countries have developed over time, the full time-period has been split into three periods. As eleven countries are analysed, this provides 55 correlation coefficients for each time-period.

On the right hand side of the diagram we find the correlation for the entire time-period. Almost half of the correlations are above 90%, and there is only one negative observation, which is between Portugal and Finland. 19 correlations are between 60%-80%, while only three are between 80%-90%. Whether these correlation results are high enough for the region to be considered an OCA is a question of definition.

Looking at the diagram from left to right, we see the developments in correlation during three time-periods. A positive development in number of higher correlations will then indicate that the different economies are becoming more synchronized. From 1990-1998 to 1999-2008 the number of 90+ correlations triples, which indicates that the economies have indeed become more synchronized over this period. Also, it is important to note the high degrees of negative correlation in the shorter time periods compared to the entire period. This is due to the limited time length of the periods and vanishes when looking at the period as a whole. It is, though, a reminder of the credibility of the results, which are meant to be illustrative.

Although the economies were becoming more synchronized during the first decade of the euro, this trend is reversed following the financial crisis. Although correlation is reduced, the economies still exhibit a stronger correlation in this last period than they did before the introduction of the euro.

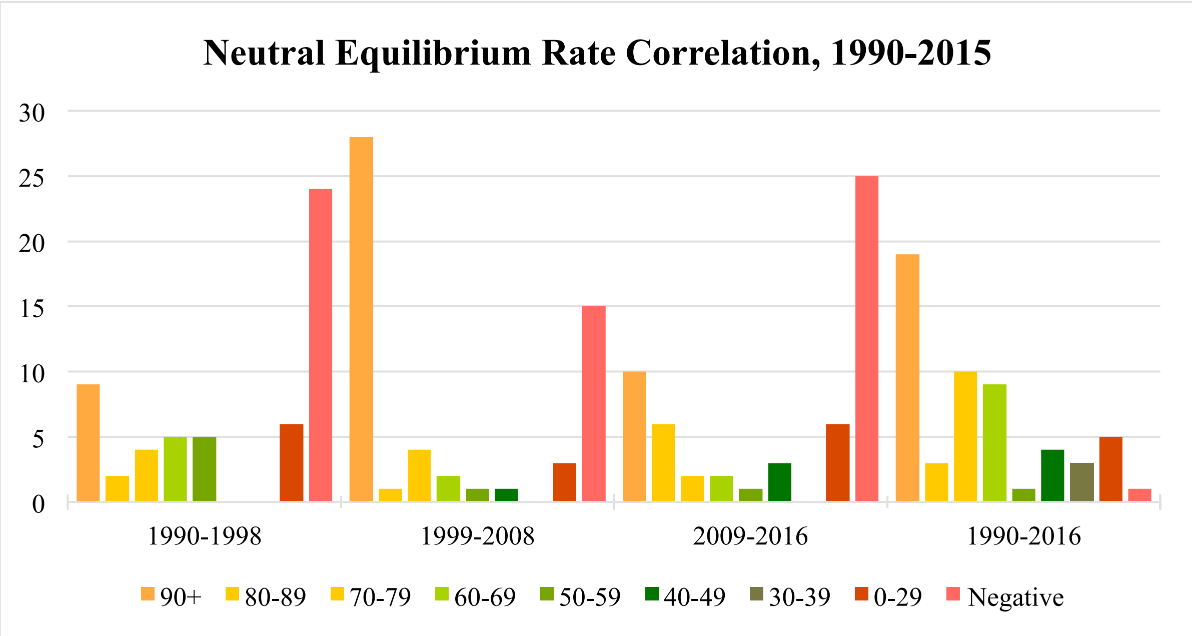

Figure 12 - Development in correlation amongst the Eurozone member states.

Figure 13 present the period before the euro as far back as there were available data. Greece is not included in this presentation due to lack of data (series did not start until 1990). This figure confirms what was alluded in figure 12, which is that the economies seem to be more synchronized after the launch of the euro than before. The biggest difference is the enormous increase in 90+ correlations, and the following similar decrease in the number of negative correlations.

Again, these figures are designed to illustrate the point that the different economies in the Eurozone are becoming more synchronized, although some differences still persist. This makes conducting a common monetary policy all the more challenging. The homogeneity criteria described by Mundell, if fulfilled, will ensure that the different regions react the same way to a change in monetary policy. An unsynchronized union will be vulnerable to asymmetric shocks, and the reversed trend of synchronization amongst regions after the financial crisis might be a result of an unfulfilled homogeneity criteria.

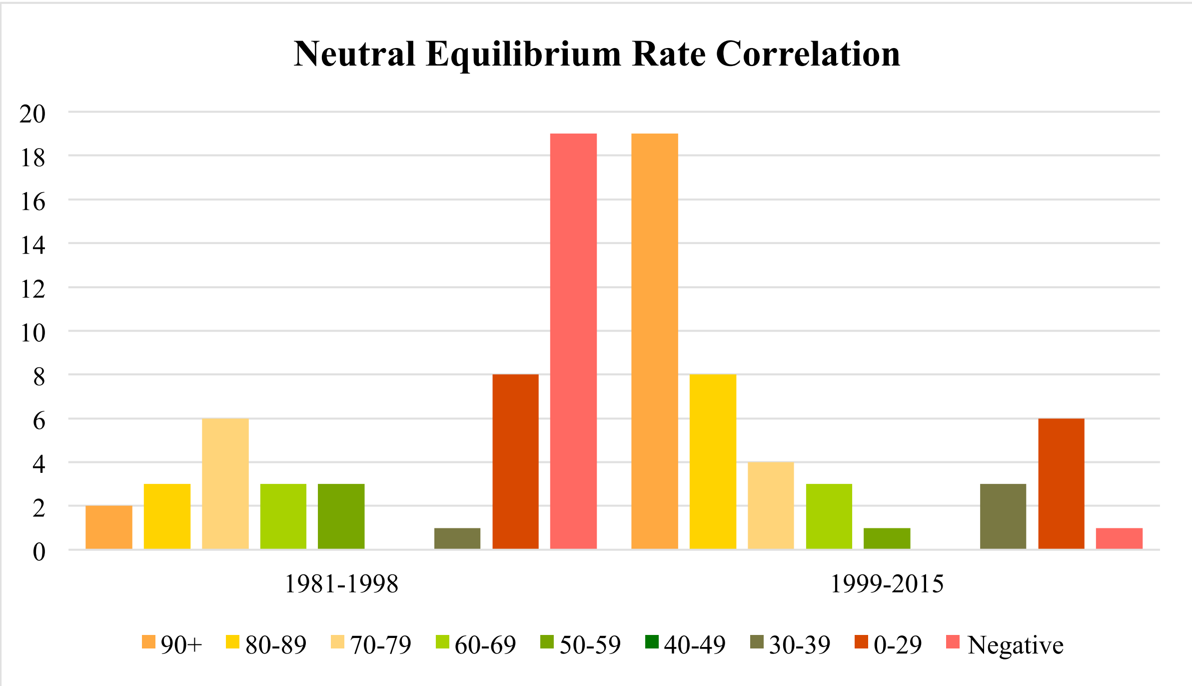

Figure 13 - Correlation between the member states over the entire time-period.

Another aspect of the neutral rates one should consider is whether they seem to be converging or not. For the Eurozone as a whole, the ECB has an explicit inflation target of 2%. Achieving this goal for the Eurozone is one thing, but in order to ensure a roughly similar inflation rate in each individual country, the ECB is dependent on the neutral rates of each individual country converging over time. As previously discussed, the problems of diverging economies and loss of competitiveness will persist if the neutral rates differ by a large margin. Large differences would imply that the ECB would have to make a choice between allowing for inflation above target in some countries, or leaving some with below-target inflation-rate and output-level.

From the time-series the core-countries seem to have been converged towards a common rate already before the introduction of the euro. Additionally, Italy has also remained relatively close to the core-countries up until the financial crisis hit. In the case of Spain and Finland, we see that these countries had the opposite trends in their neutral rates after the introduction of the euro, but with the same result. Spain was trending downwards while Finland was trending upwards, but both seemed to stabilize once they reached rates similar to those of the core-countries. Looking at the three remaining countries, it does not seem apparent that they were converging towards a common neutral real rate before the financial crisis hit. Portugal was evidently struggling to maintain a positive neutral rate, while Ireland and Greece were operation at a much higher pace than its Eurozone-peers. But overall, it appears as though a convergence in the neutral rate was happening across the Eurozone over the first decade, with eight of the eleven countries approaching roughly the same neutral rate.

As the change in correlation between the periods 1999-2008 and 2009-2016 indicates, this convergence was reversed following the financial crisis. Where in particular Spain and Italy started to diverge from Germany, France and the other core-countries, indicating that although convergence did happen during the first decade, other structural developments left Spain and Italy more vulnerable than the core-countries when the crisis hit. Finland has also experienced an increased divergence since the crisis. As for Portugal, Ireland and Greece, they all reached neutral rates significantly below zero, but as noted earlier, these were also the countries with the least convergence prior to the crisis. This divergence following the crisis left the ECB in a difficult situation, as the common policy rate left some countries, primarily the core, with a too low interest rate, while the same rate was too high for the peripheral-countries.

However, it does seem as though Italy and Spain have started to converge towards the core-countries again at the end of the time-series. This result is in keeping with the results in Fries et al. (2016), which jointly estimated the neutral rates of the four largest Eurozone economies. They also found a trend of divergence following the crisis, resulting in a monetary policy stance too expansionary for the core-countries, but at the same time too restrictive for the periphery. They conclude that the unconventional monetary policy measures since 2014 have contributed to restore convergence and achieve a neutral monetary policy stance for the major economies in the Eurozone. This result was also visible in the estimated interest rate paths, as one can see Italy and towards the end of the time-series both Spain and Portugal with suggested Taylor rates not only close to the actual policy rate, but also closer to the suggested rates for the core countries.

Although there are still some differences that need to be attended too, the return to convergence following the crisis could indicate that measures taken following the crisis and the effect of structural reforms put forward are starting to show their effect. If this convergence is maintained going forward, this could indicate a favourable future for the Eurozone.

5. Conclusion

This thesis has investigated the notion of the Eurozone constituting a good approximation to an OCA. This has been done through a relatively simplistic Taylor rule, used to evaluate the difference in suggested monetary policy among the member states.

The analysis has shown that the suggested interest rate paths during the first decade of the Eurozone, leading up to the financial crisis, clearly deviated among the individual countries. In particular, there was a striking difference between the core- and the peripheral-countries. During this first decade, estimations show that the policy rate set by the ECB was much closer to the suggested rates of the core-countries, where in particular Germany, France and Belgium had close fits. As for the peripheral-countries, the Taylor rules suggested that monetary policy was largely too accommodative during this period. The results for the first decade of the Eurozone have proven to be robust to different specifications of reaction-coefficients and measures of the neutral real rate of interest.

In the period after the financial crisis there are still discrepancies in the suggested nominal rates among the member states. However, the conclusion is somewhat altered compared to the first decade. During this period, it seems as though the monetary policy has been too accommodative for the core-countries, whilst being too strict for the periphery. This result was slightly more sensitive to the assumption made for the neutral real rate, but both when assuming a constant and a floating neutral real rate this conclusion holds.

Assuming a varying neutral real rate for the Eurozone as a whole was the approach that provided a somewhat different conclusion to the two approaches mentioned above. Results from this estimation indicated monetary policy generally being either too strict or neutral across the member states in the aftermath of the financial crisis. This result highlights another challenge for the Eurozone, which is the neutral real rate of interest among the member states. Estimations have shown that this rate has remained much more stable and converged in the core-countries throughout the entire period, and that the initial assumption of a constant neutral real rate of 2% for these countries in fact was a fairly good assumption. However, in the peripheral-countries the fluctuations of the neutral real rate have been far greater over the entire period. If such discrepancies in the neutral real rates persist, it will be a major challenge for the ECB, as they aim to reach a common inflation target for the Eurozone as a whole.

As the discussion showed, the discrepancy in the suggested nominal interest rate paths is also recognizable in the development in other variables over the decade, such as house price inflation and current account deficits. Although a causal relationship between the variables is not claimed, the connection appears striking. Thus, to claim that the Eurozone did not constitute an OCA at the time of introduction of the euro seem like a relatively safe claim to make. This is also a claim that has been made by several others, Krugman (2012), for instance, raises strong critique towards the sustainability of the Eurozone. Mongelli (2013), despite being positive on behalf of the future of the euro, also discusses how the Eurozone as it was originally established was not sustainable.

Following the crisis there are still discrepancies among the suggested nominal rates for each member state. Especially looking at the Taylor rates where a floating neutral real rate is utilized highlights how well the different countries have coped with the financial crisis and also how the imbalances that had built up prior to the crisis left an ever-greater strain on the common monetary policy, leaving the nominal rate of interest too low for the core but at the same time too high for the periphery. Judging from these results it does not appear as though the Eurozone has gotten much closer to constituting a good approximation to an OCA following the financial crisis either. Rather, the financial crisis functioned as a trigger for the imbalances that had built up during the first decade.

On the notion of any member states being implicitly prioritized by the ECB when the policy rate is decided, we do not find any clear evidence to make such claims. Our analysis of the infant stages of the Eurozone suggest that the core-countries were much better suited to the monetary policy of the ECB than the periphery, which could have suggested that core, with Germany and France in particular, were given priority. This, however, does not appear to be the case when looking at the period following the financial crisis. Looking at the monetary policy of the ECB in the aftermath of the financial crisis, it appears as though stability to the real economy for the Eurozone as a whole has been prioritized, which, as mentioned, has resulted in a monetary policy stance that is too accommodative for the core.

However, the result that the Eurozone does not appear to be a good approximation to an OCA as of today does not mean it cannot evolve into one in the future. This seems to be the hope for the future of the euro – the structural reforms put in place will hopefully contribute towards increased homogeneity among the member states such that a common monetary policy will become sustainable. Looking at the end of the time-series, it does appear as though some of the countries that have experienced the most severe struggles are now starting to see an upswing, this is evident both in the estimated Taylor rules and in the neutral real rate of interest. The question that remains is whether or not this convergence will persist, or if it will turn out to carry the same traits as the convergence witnessed leading up to the financial crisis, i.e. structural imbalances persisting.

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6. Appendix

6.1 Estimated Taylor Rule Reaction Coefficients for the Eurozone

By rewriting equation [2.1], we get the following equation, which can be estimated:

$$ECBr = r^* + \pi^* + \beta(\pi_t - \pi^*) + \gamma(y_t - y_t^*) + \epsilon_t$$

ECBr is the dependent variable in the regression, and is to be explained by the independent (explanatory) variables on the right-hand side. Here $\beta = (1 + \mu)$. The Taylor principle will be upheld as long as $\beta > 1$. Instead of assuming a constant neutral real interest rate at 2%, this estimation will also provide us with an estimate of the neutral real interest rate that reflect the real economy in a better way. In this regression we will assume a constant inflation target of 2% as in the original work of Taylor.

When estimating the reaction coefficients for the Eurozone as a whole we utilize the same OLS-approach as in Kahn (2012). When utilizing OLS one of the critical assumptions to provide unbiased and consistent coefficients is that all explanatory variables must be strictly exogenous. Mathematically, this is formulated as:

$$E(\epsilon_t|X) = 0\,, t = 1,2, \dots, n$$

Which states that for each t, the expected value of the error ϵ_t, given the explanatory variables for all time periods, is zero. This is commonly called the zero conditional mean assumption. In addition you require the model you are regressing to be linear in parameters and that no perfect collinearity exist between the independent variables. Furthermore it is required that the error term in the regression is serially uncorrelated and that, conditional on the explanatory variable X, have constant variance for all t[33].

Autocorrelation and heteroskedasticity will not affect our coefficient and render them inconsistent. However, the presence of autocorrelation does imply that the OLS-regression is no longer efficient. Also, the variance of the coefficient estimates become biased, this makes

[33] The assumptions of heteroskedasticity and serialcorrelation (or autocorrelation), see Wooldridge (2009).

standard t- and p-statistics invalid which may result in a null hypothesis being wrongly accepted or rejected. We tested for autocorrelation using a Durbin-Watson test. The results proved a high degree of autocorrelation in our time series. There are several ways of correcting for autocorrelation. As we are utilizing the same approach as in Kahn (2012) we run the OLS regression with Newey-West standard errors. These standard errors are consistent in the presence of both autocorrelation and heteroskedasticity. When using this approach you have to decide the number of lags that the error term is assumed to correlate against. The number of lags can be decided based on a rule of thumb[34]. Using this rule of thumb we set the number of lags in our regression equal to four.

Durbin Watson test

The test was conducted on quarterly data under normal OLS regression. DW_p^n, where n= number of observations and p= the number of parameters in our model. DW=2 is equal to no autocorrelation being present. The result from our test was the following:

$$DW_3^{67} = 0{,}135$$

The Estimated Taylor Rule

Estimating the Taylor rule for the Eurozone as a whole using Newey-West standard errors provided the following results (Here $\lambda = 1.600$ is assumed):

```
Regression with Newey-West standard errors      Number of obs     =        67
maximum lag: 4                                  F(  2,         64) =     34.87
                                                Prob > F          =    0.0000
```

ECBr	Coef.	Newey-West Std. Err.	t	P>|t|	[95% Conf.	Interval]
inflationgap	1.258936	.5994426	2.10	0.040	.0614118	2.45646
og1600	.638836	.1027631	6.22	0.000	.433543	.8441289
_cons	.0281019	.0019017	14.78	0.000	.0243029	.031901

[34] Newey and West (1987) recommending taking the number of lags to be the integer part of $4(n/100)^{2/9}$.

From this regression we have that:

$$\beta = inflationgap$$

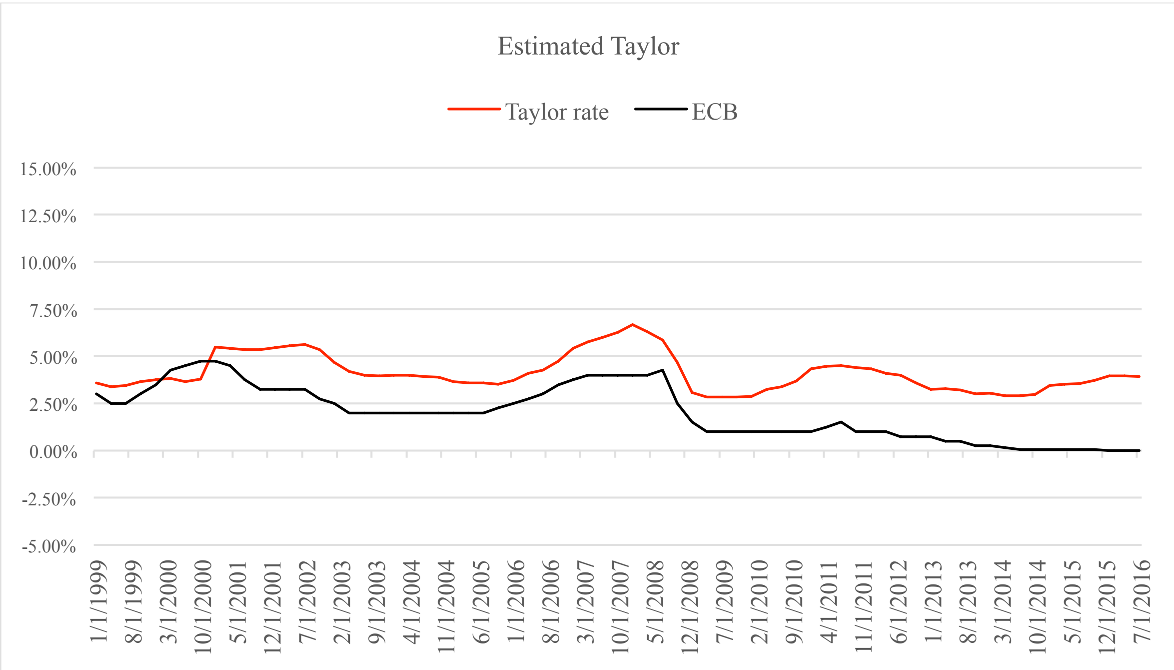
$$\gamma = og1600$$

$$r^* = cons$$

Utilizing the reaction coefficients from the regression above gives us the following Taylor rule for the Eurozone:

$$i_t = 2{,}81\% + \pi_t + 0.26(\pi_t - 2) + 0.64(y_t - y^*) + \epsilon_t$$

Compared to the original Taylor rules we see that this estimation suggests a smaller reaction to the inflation gap. With respect to the output gap, the change in reaction is small compared to Taylor 1993. Applying this rule to the data for the Eurozone provided the following result:



The estimated Taylor reaction coefficients does not provide any new insights as to what was suggested by the original Taylor-rules for the Eurozone. Since 2000 the policy rate has been consistently lower than what has been suggested by Taylor. What is perhaps somewhat unexpected is that the measures for deviation between the two interest rates actually increases by utilizing these reaction coefficients instead of those suggested in Taylor (1993) or Taylor (1999). Also, when utilizing this form of regression we found that the choice of λ-value for the output gap had a major influence. Using $\lambda = 1.600$ yielded the results above, whilst using $\lambda = 40.000$ in fact gave us a β-value below 1. Assuming such a reaction coefficient would be in violation of the Taylor principle, as an increase in inflation would lead to a less than one for one increase in the real interest rate. One should also not that the standard errors for the estimates are rather large, in particular for the output-gap, suggesting the estimates may be somewhat unstable. Adding the instability of the estimates to the fact that the results were so close to the original Taylor rules (thus not providing us with any new information), led us to not impose these coefficients on the rest of our analysis, and rather use the original Taylor-rule specifications (in the process also making it easier on ourselves to compare our results with other papers as the original Taylor-rule is what is most commonly used).

Estimated Taylor Rule With $\lambda = 40.000$

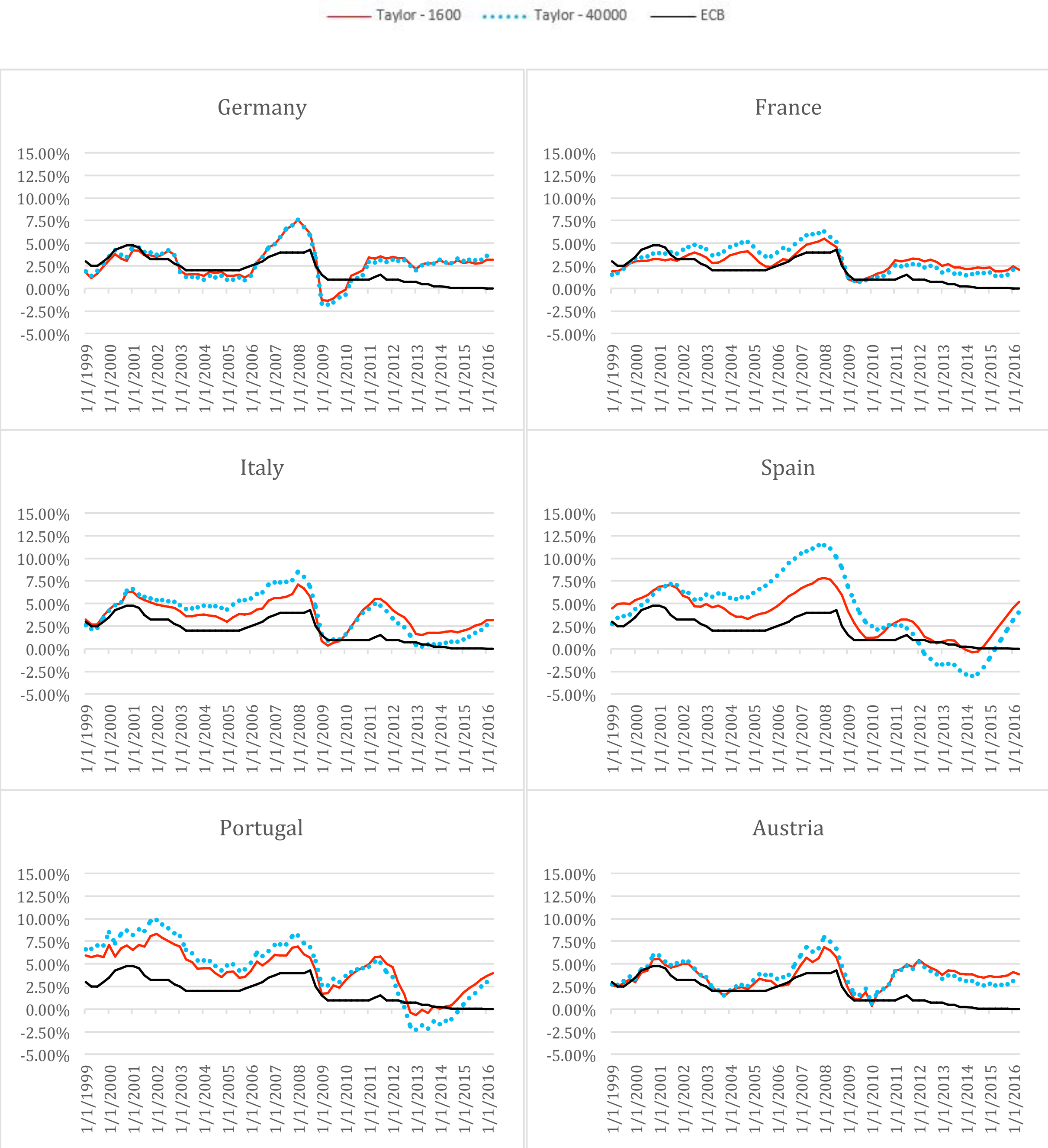
```
Regression with Newey-West standard errors      Number of obs     =         67
maximum lag: 4                                  F(  2,        64) =      47.36
                                                Prob > F          =     0.0000
```

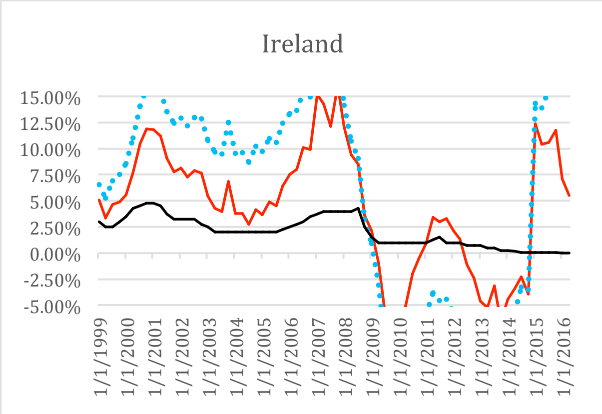
ECBr	Coef.	Newey-West Std. Err.	t	P>|t|	[95% Conf.	Interval]
inflationgap	.5224158	.5727703	0.91	0.365	-.6218243	1.666656
og40000	.5963185	.0814832	7.32	0.000	.433537	.7591
_cons	.0226773	.0017798	12.74	0.000	.0191219	.0262328

Measures of Deviation for the Estimated Taylor Rule (With $\lambda = 1.600$)

	Estimated Taylor		
	Average Absolute Deviation	Mean Square Error	Root Mean Square Error
Whole sample	2,169%	0,055%	2,348%
1999-2008	1,605%	0,030%	1,722%
2009-2016	2,896%	0,088%	2,967%

6.2 The 1999 Taylor Rule – Constant Neutral Rate




Ireland
15.00%
12.50%
10.00%
7.50%
5.00%
2.50%
0.00%
-2.50%
-5.00%
1/1/1999
1/1/2000
1/1/2001
1/1/2002
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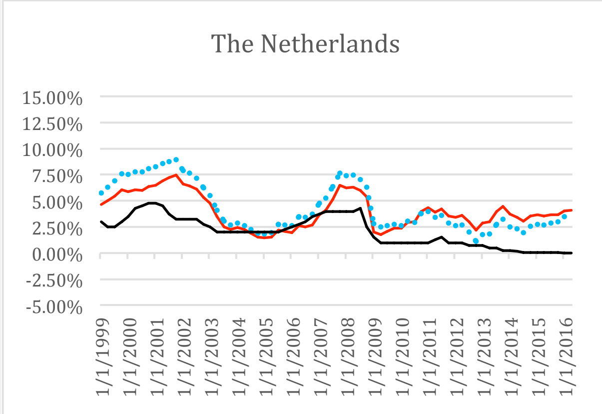
1/1/2016


The Netherlands
15.00%
12.50%
10.00%
7.50%
5.00%
2.50%
0.00%
-2.50%
-5.00%
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
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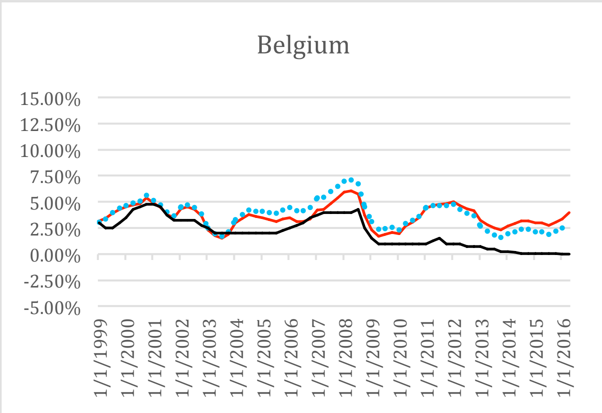
Belgium
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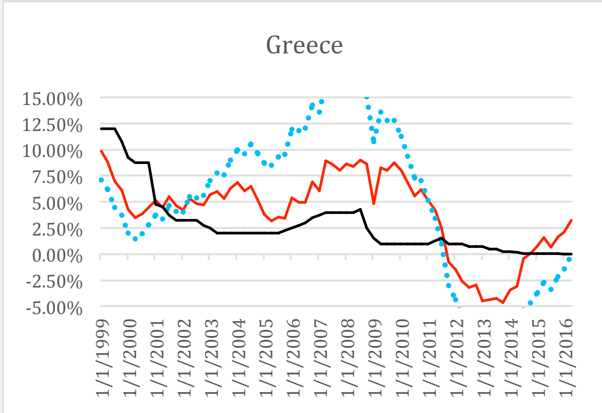
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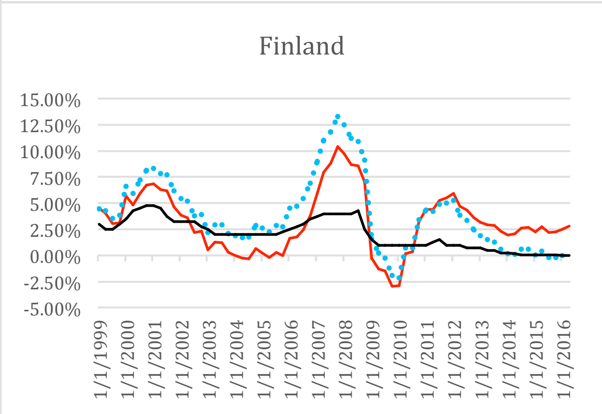
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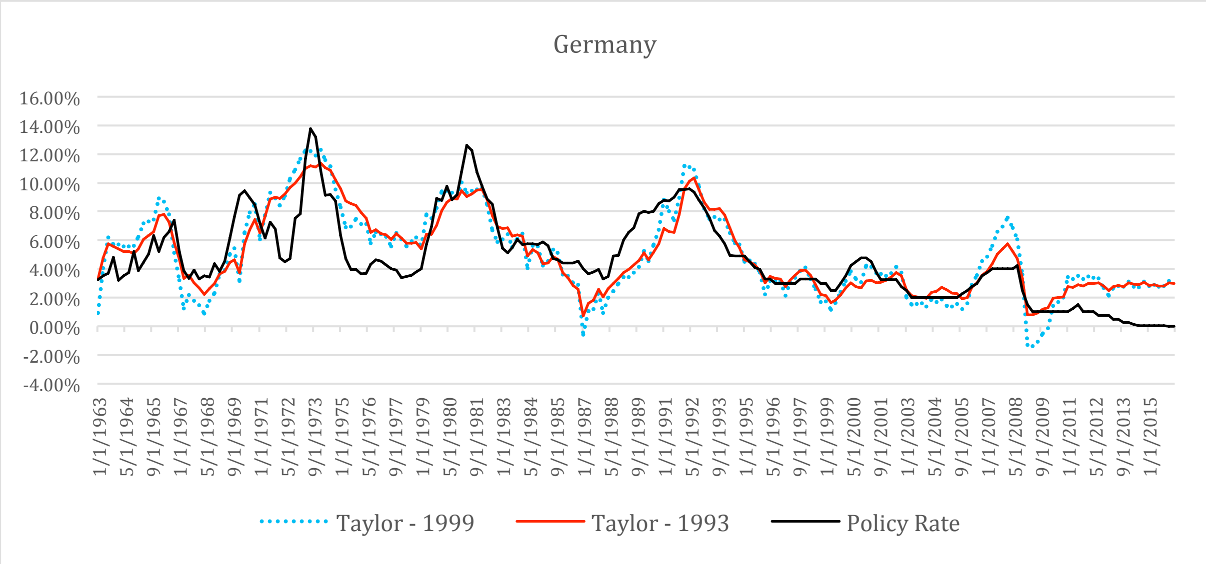
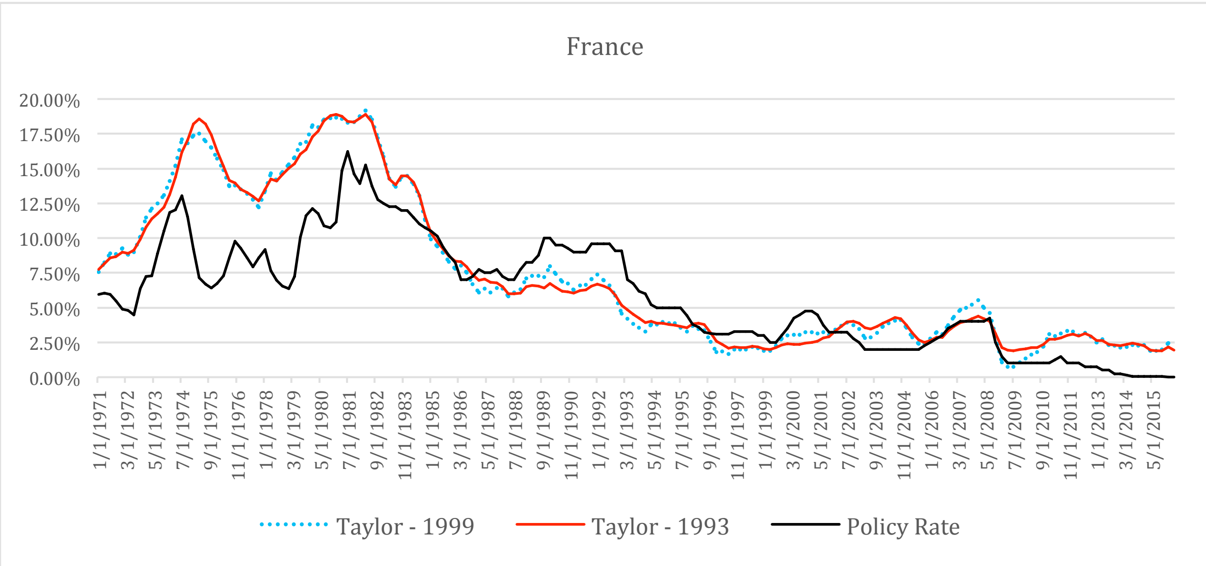
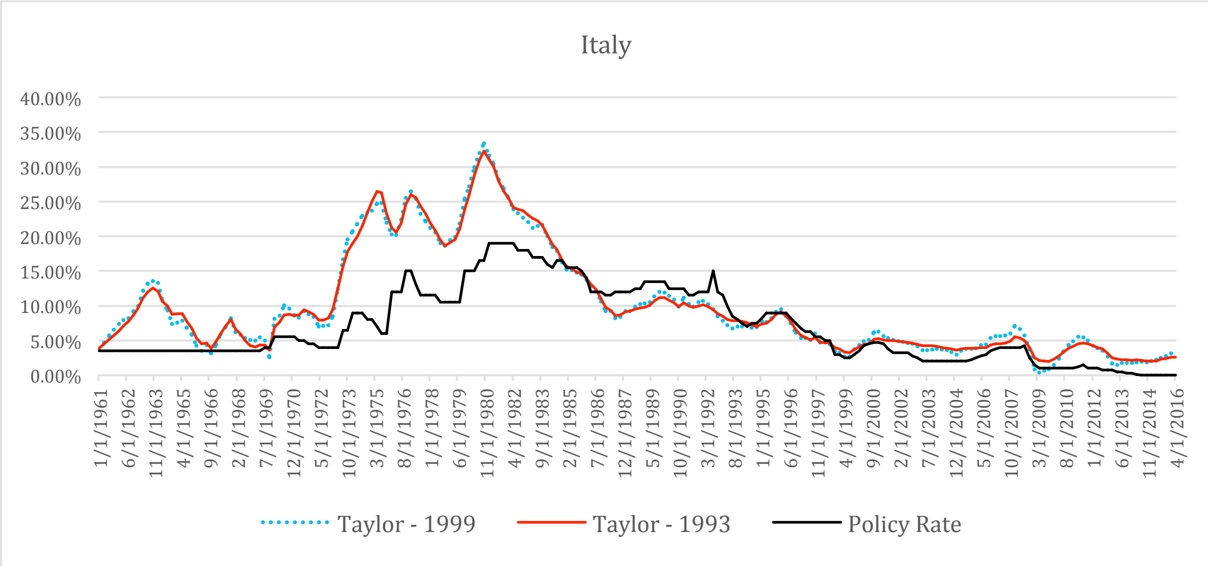
1/1/2013
1/1/2014
1/1/2015
1/1/2016

6.3 Taylor Rules Showing the Full Time-Series



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20.00%
15.00%
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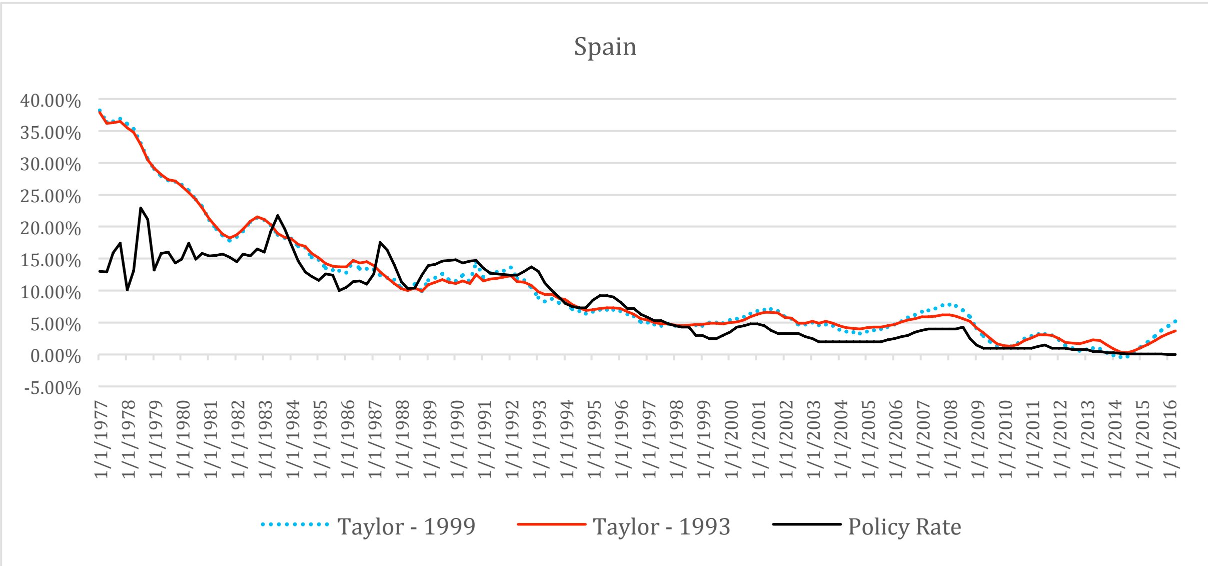
Taylor - 1999
Taylor - 1993
Policy Rate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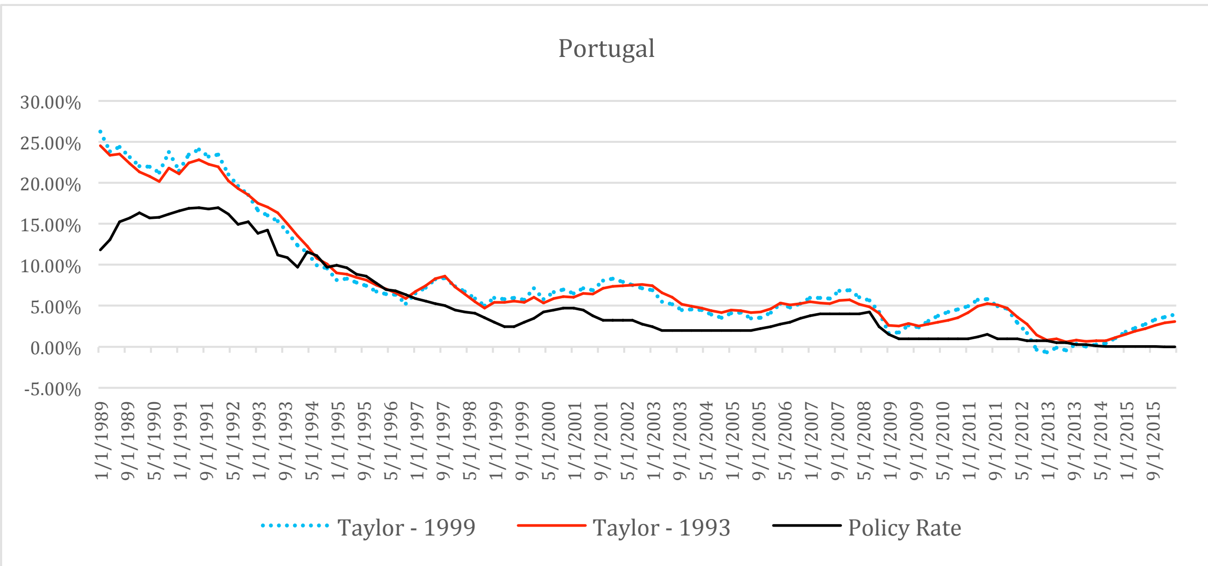
Taylor - 1999
Taylor - 1993
Policy Rate


Portugal
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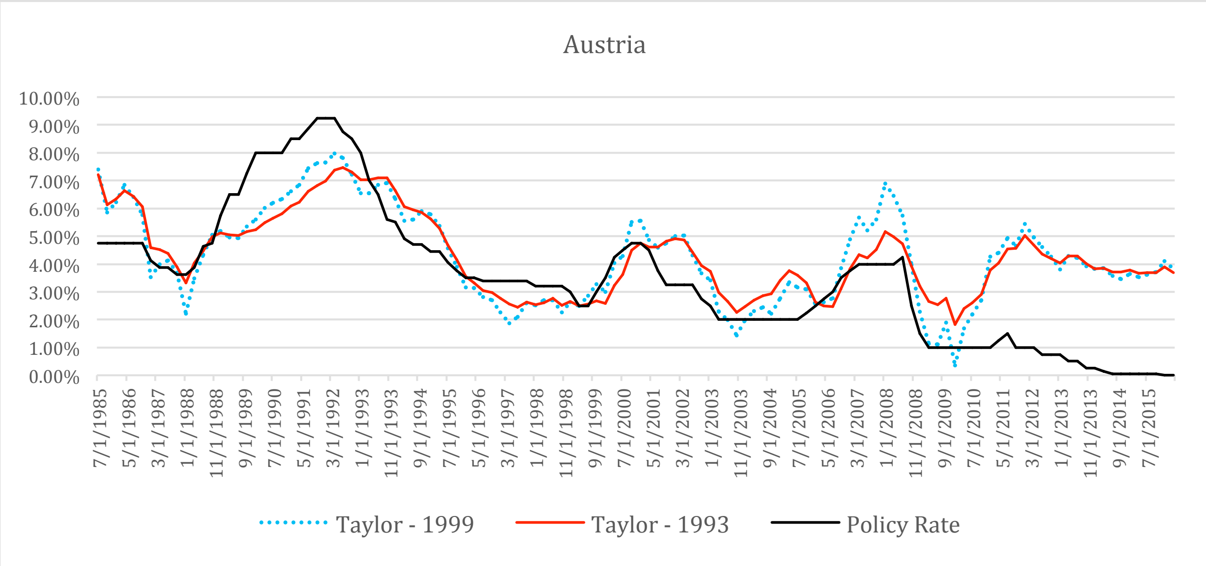
Taylor - 1999
Taylor - 1993
Policy Rate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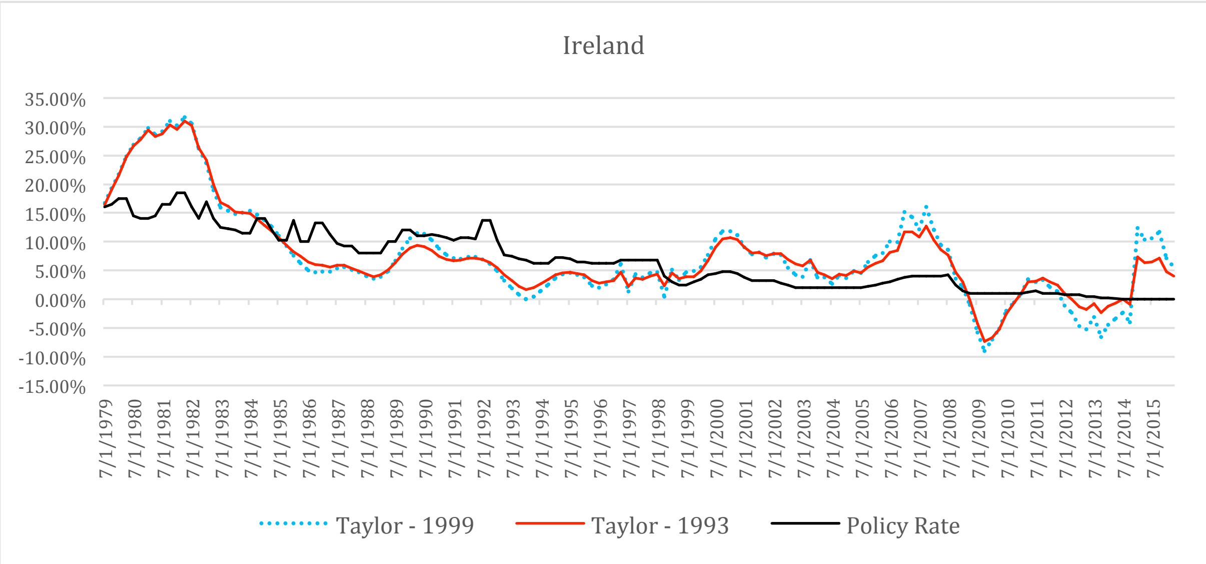
7/1/2015
Taylor - 1999
Taylor - 1993
Policy Rate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-10.00%
-15.00%
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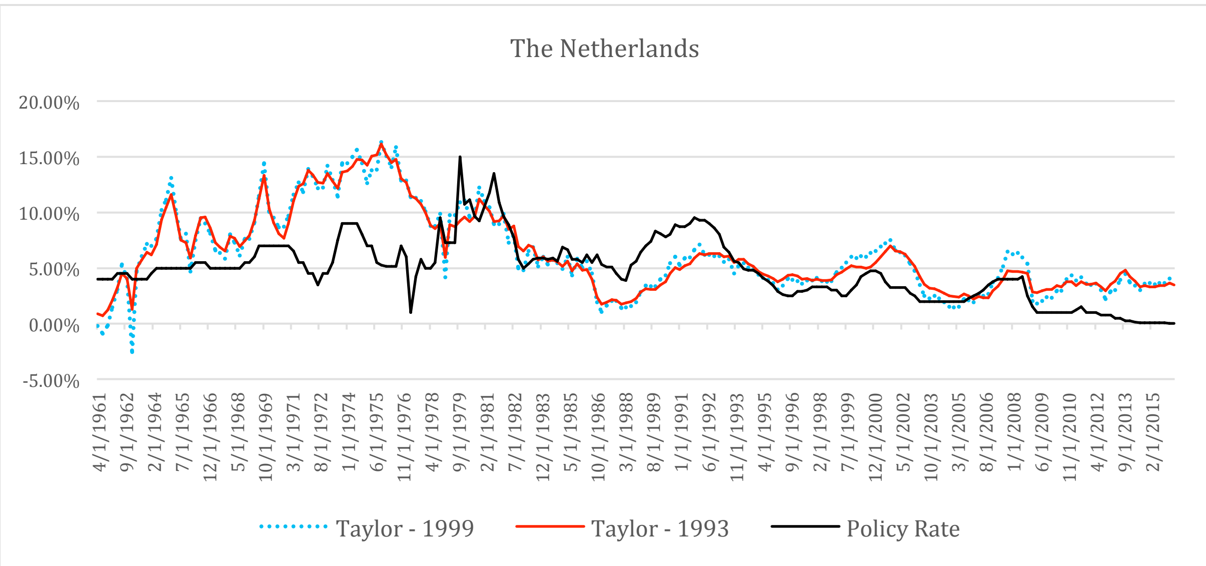
Taylor - 1999
Taylor - 1993
Policy Rate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8/1/1972
1/1/1974
6/1/1975
11/1/1976
4/1/1978
9/1/1979
2/1/1981
7/1/1982
12/1/1983
5/1/1985
10/1/1986
3/1/1988
8/1/1989
1/1/1991
6/1/1992
11/1/1993
4/1/1995
9/1/1996
2/1/1998
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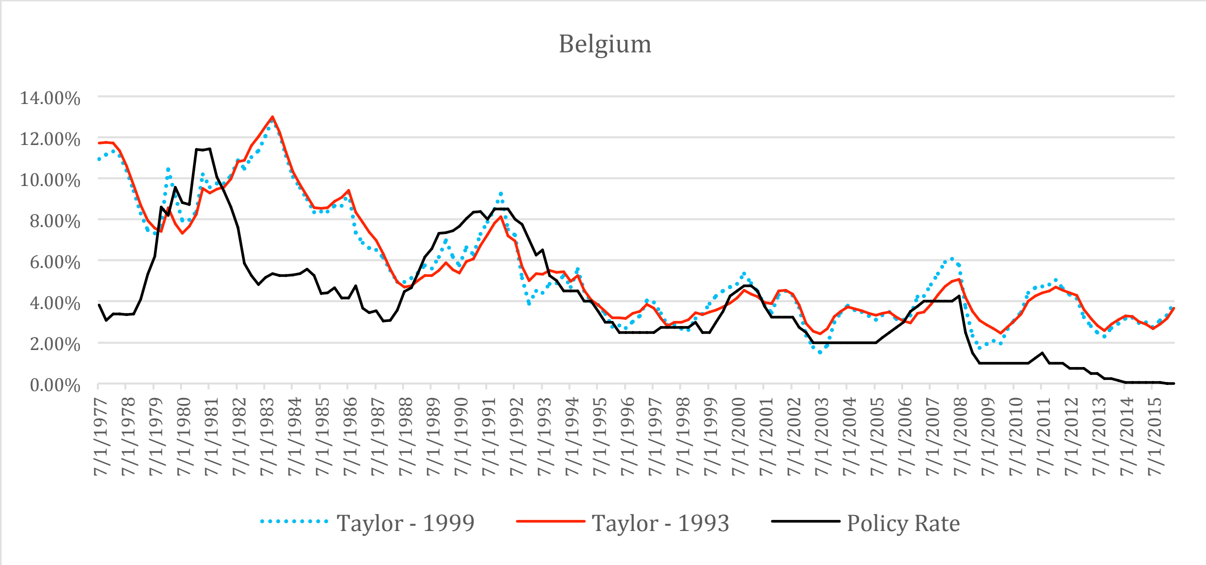
3/1/2005
8/1/2006
1/1/2008
6/1/2009
11/1/2010
4/1/2012
9/1/2013
2/1/2015
Taylor - 1999
Taylor - 1993
Policy Rate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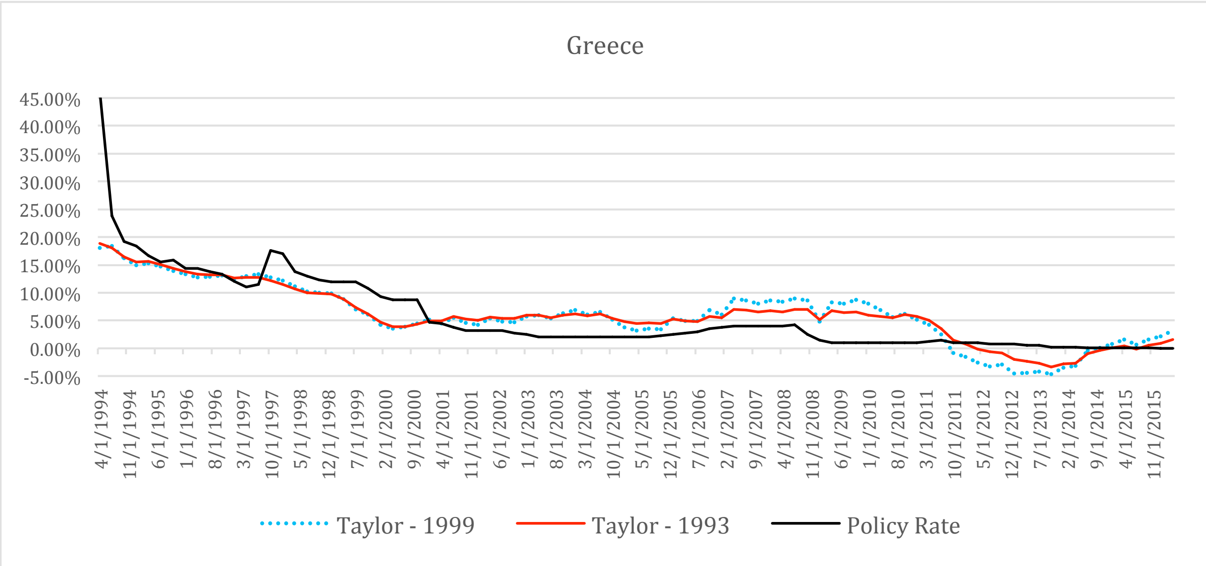
Taylor - 1999
Taylor - 1993
Policy Rate


Greece
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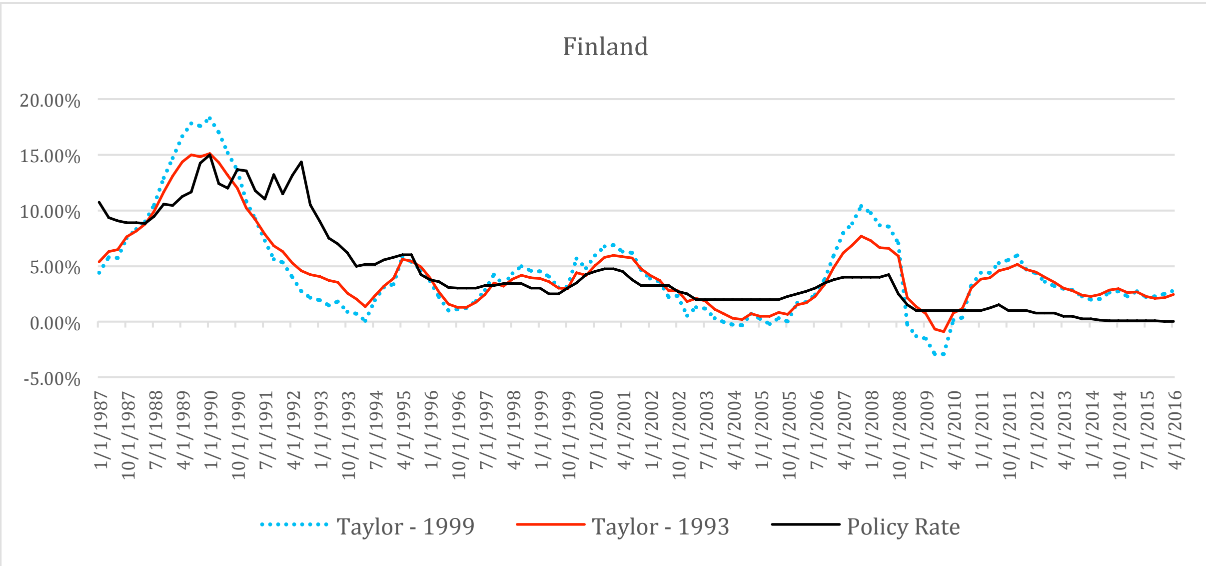
Taylor - 1999
Taylor - 1993
Policy Rate


Finland
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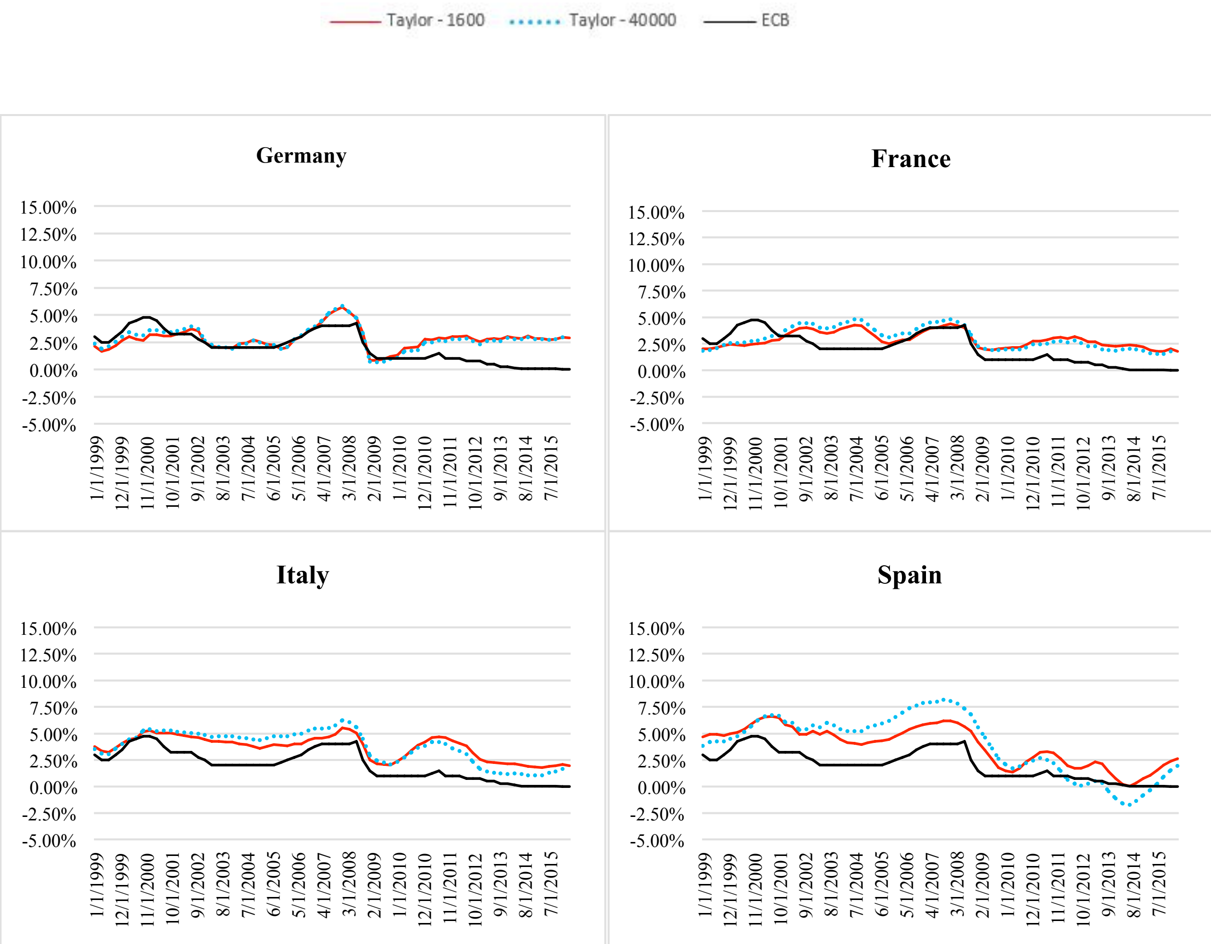
0.00%
-5.00%
1/1/1987 10/1/1987 7/1/1988 4/1/1989 1/1/1990 10/1/1990 7/1/1991 4/1/1992 1/1/1993 10/1/1993 7/1/1994 4/1/1995 1/1/1996 10/1/1996 7/1/1997 4/1/1998 1/1/1999 10/1/1999 7/1/2000 4/1/2001 1/1/2002 10/1/2002 7/1/2003 4/1/2004 1/1/2005 10/1/2005 7/1/2006 4/1/2007 1/1/2008 10/1/2008 7/1/2009 4/1/2010 1/1/2011 10/1/2011 7/1/2012 4/1/2013 1/1/2014 10/1/2014 7/1/2015 4/1/2016
Taylor - 1999
Taylor - 1993
Policy Rate

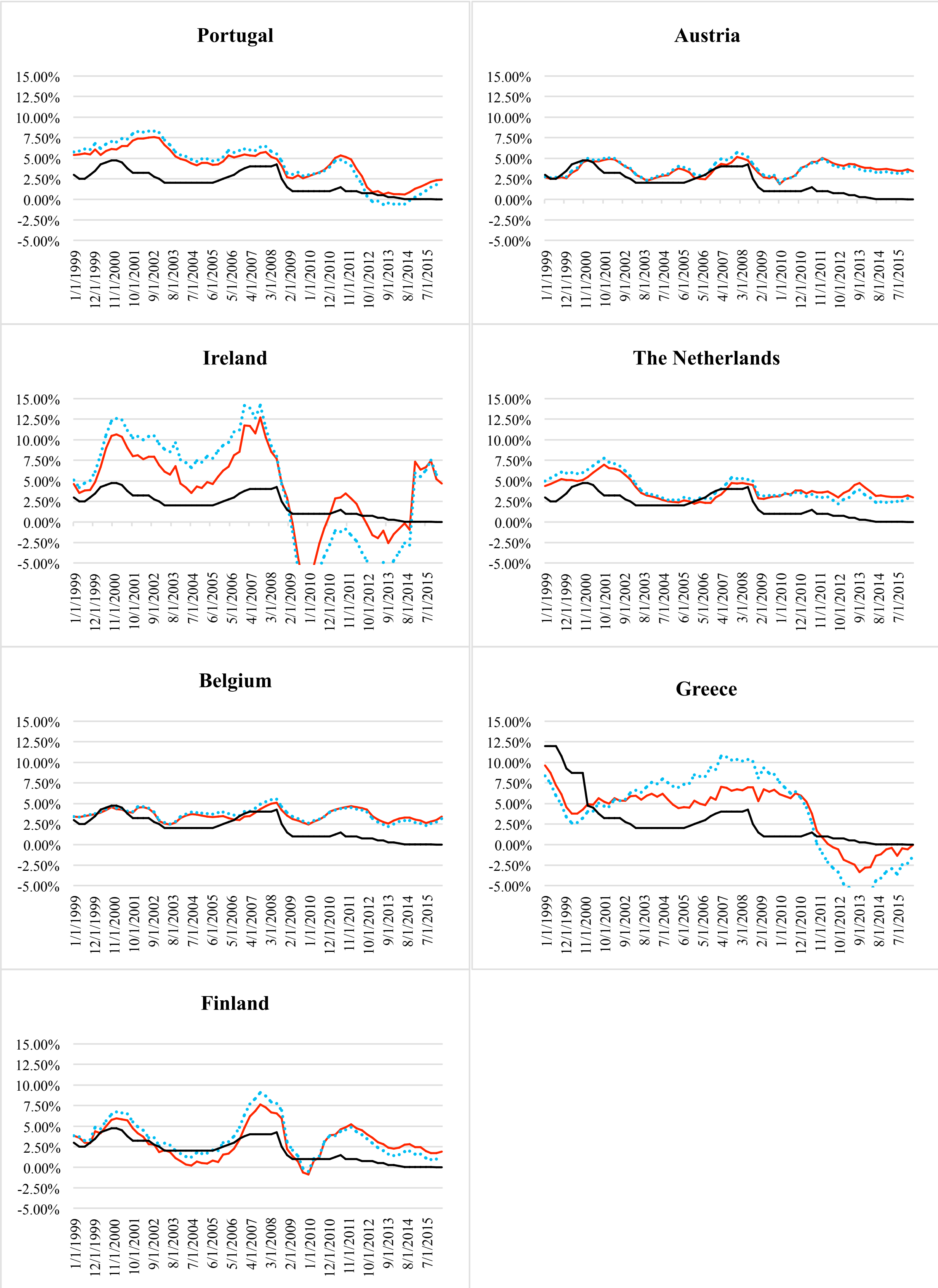
6.4 Measures of deviation for the Eurozone

As the difference between λ=1.600 and λ=40.000 was relatively small, we only present measures of deviations for λ=1.600.

	Average Absolute Deviation		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole Sample	1,375%	1,392%	0,024%	0,027%	1,550%	1,645%
1999 – 2008	0,941%	1,107%	0,012%	0,017%	1,085%	1,313%
2009-2016	1,935%	1,761%	0,040%	0,040%	1,996%	1,994%

6.5 Robustness-test for the 1993 Taylor-rule




Portugal
Austria
Ireland
The Netherlands
Belgium
Greece
Finland
15.00%
12.50%
10.00%
7.50%
5.00%
2.50%
0.00%
-2.50%
-5.00%
1/1/1999
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6/1/2005
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4/1/2007
3/1/2008
2/1/2009
1/1/2010
12/1/2010
11/1/2011
10/1/2012
9/1/2013
8/1/2014
7/1/2015

These figures show the estimated interest rate path when using estimates for future GDP values to correct for the problems related to the end-points of the time-series when using the HP-filter to estimate potential output. The robustness-test has only been performed on the 1993 Taylor-rule as doing the same effects can be assumed for the end-points for the 1999-rule. We see that Greece appears to be affected by these future values of GDP to a somewhat larger extent than the other member states. The other member states appear to have suggested interest rate paths that remain largely the same as when no estimates of future GDP values were included in the analysis.

6.6 Measures of Deviation for the Separate Countries

As the difference between λ=1.600 and λ=40.000 was relatively small, we only present measures of deviations for λ=1.600.

Germany	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	1,417%	1,585%	0,033%	0,038%	1,814%	1,938%
1999-2016	1,169%	1,497%	0,023%	0,032%	1,516%	1,801%
1999-2008	0,631%	0,942%	0,007%	0,015%	0,836%	1,244%
2009-2016	1,887%	2,237%	0,044%	0,055%	2,106%	2,346%

Spain	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	3,310%	3,308%	0,319%	0,327%	5,652%	5,715%
1999-2016	1,844%	1,927%	0,040%	0,050%	2,003%	2,238%
1999-2008	2,151%	2,375%	0,049%	0,061%	2,217%	2,475%
2009-2016	1,435%	1,328%	0,028%	0,035%	1,676%	1,876%

Portugal	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,681%	2,928%	0,113%	0,136%	3,357%	3,683%
1999-2016	2,244%	2,423%	0,064%	0,074%	2,529%	2,720%
1999-2008	2,514%	2,676%	0,075%	0,082%	2,744%	2,860%
2009-2016	1,884%	2,086%	0,049%	0,064%	2,208%	2,522%

Belgium	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,138%	2,016%	0,085%	0,077%	2,910%	2,774%
1999-2016	1,628%	1,608%	0,039%	0,039%	1,976%	1,983%
1999-2008	0,785%	0,851%	0,009%	0,010%	0,923%	1,025%
2009-2016	2,753%	2,618%	0,080%	0,078%	2,824%	2,789%

France	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,457%	2,446%	0,113%	0,109%	3,361%	3,308%
1999-2016	1,297%	1,204%	0,023%	0,020%	1,508%	1,414%
1999-2008	0,967%	0,879%	0,015%	0,011%	1,238%	1,038%
2009-2016	1,737%	1,639%	0,033%	0,032%	1,806%	1,797%

Italy	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	3,757%	3,798%	0,300%	0,306%	5,477%	5,532%
1999-2016	1,674%	1,741%	0,034%	0,039%	1,857%	1,976%
1999-2008	1,271%	1,454%	0,020%	0,024%	1,412%	1,564%
2009-2016	2,211%	2,125%	0,054%	0,059%	2,321%	2,419%

Finland	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	1,939%	2,629%	0,065%	0,112%	2,540%	3,342%
1999-2016	1,700%	2,300%	0,041%	0,071%	2,022%	2,667%
1999-2008	1,272%	2,008%	0,025%	0,063%	1,572%	2,518%
2009-2016	2,270%	2,690%	0,062%	0,081%	2,499%	2,854%

Netherlands	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,726%	2,775%	0,127%	0,132%	3,570%	3,635%
1999-2016	1,989%	2,049%	0,053%	0,057%	2,308%	2,385%
1999-2008	1,340%	1,584%	0,028%	0,039%	1,676%	1,967%
2009-2016	2,854%	2,669%	0,087%	0,081%	2,947%	2,849%

Austria	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	1,477%	1,431%	0,035%	0,035%	1,879%	1,860%
1999-2016	1,731%	1,707%	0,048%	0,049%	2,188%	2,223%
1999-2008	0,760%	0,832%	0,008%	0,012%	0,920%	1,075%
2009-2016	3,025%	2,873%	0,100%	0,100%	3,168%	3,161%

Ireland	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	4,247%	4,814%	0,275%	0,353%	5,245%	5,941%
1999-2016	3,653%	4,658%	0,184%	0,313%	4,285%	5,597%
1999-2008	4,061%	4,548%	0,202%	0,284%	4,494%	5,333%
2009-2016	3,109%	4,805%	0,159%	0,352%	3,990%	5,931%

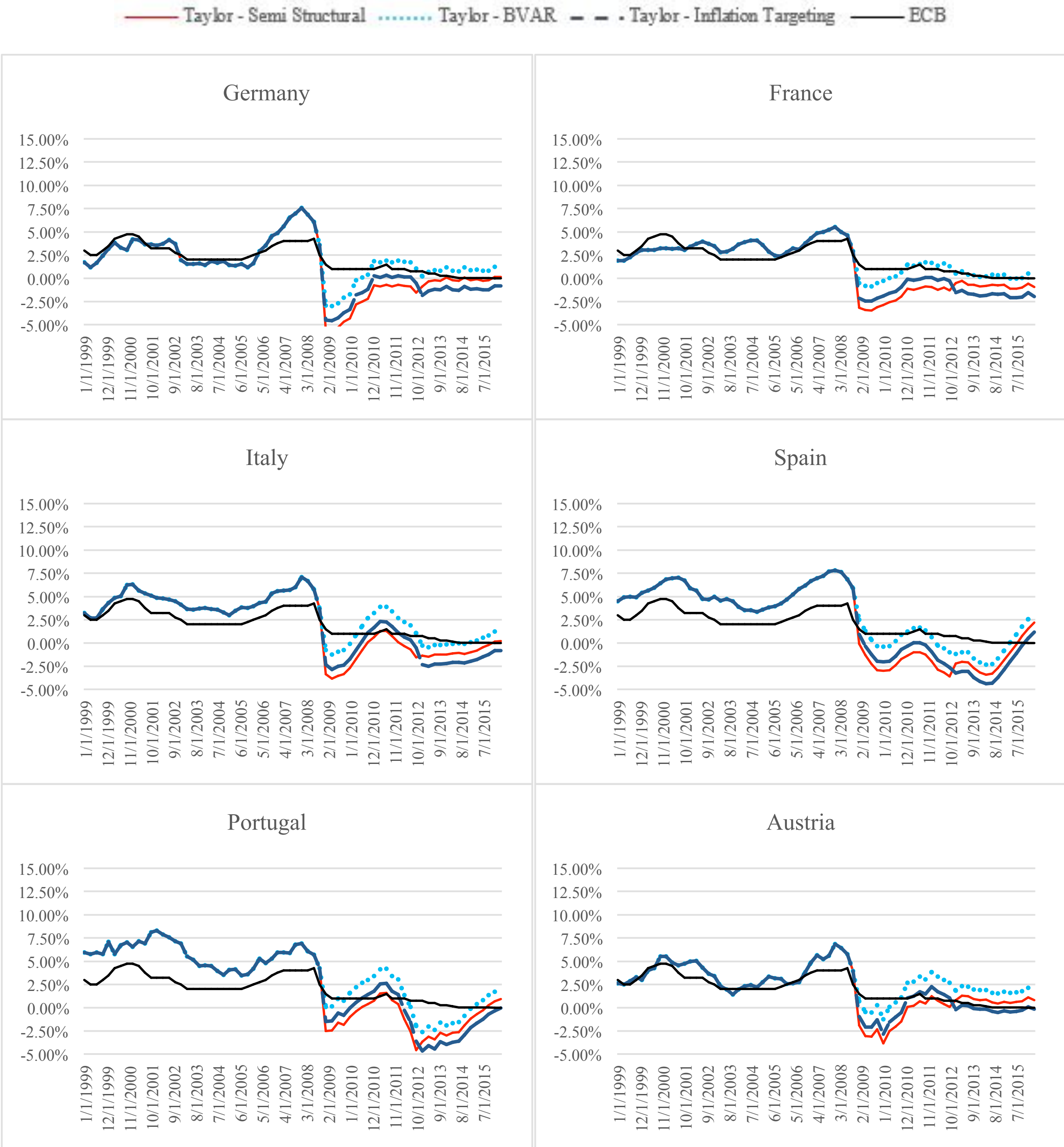
Greece	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,974%	3,439%	0,181%	0,220%	4,251%	4,691%
1999-2016	2,820%	3,377%	0,102%	0,147%	3,191%	3,834%
1999-2008	2,981%	3,195%	0,101%	0,126%	3,186%	3,549%
2009-2016	2,606%	3,619%	0,102%	0,175%	3,197%	4,184%

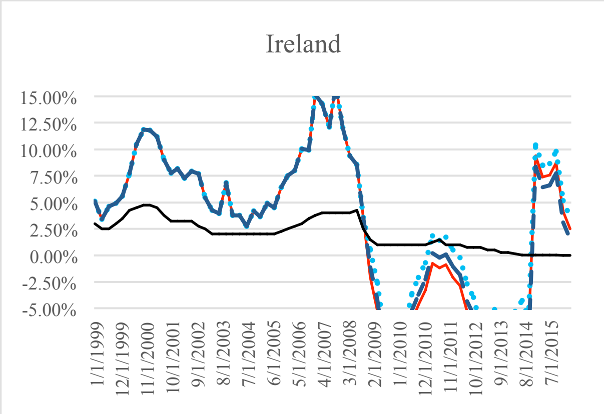
6.7 Measures of Deviation for the Eurozone R* Changed in Steps

As the difference between λ=1.600 and λ=40.000 was relatively small, we only present measures of deviations for λ=1.600.

	Semi structural		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
1999-2016						
AAD	1,266 %	1,452 %	0,701 %	0,973 %	1,252 %	1,423 %
MSE	0,023 %	0,032 %	0,008 %	0,013 %	0,020 %	0,028 %
RMSE	1,511 %	1,788 %	0,871 %	1,152 %	1,397 %	1,670 %
1999-2008						
AAD	0,941 %	1,107 %	0,941 %	1,107 %	0,941 %	1,107 %
MSE	0,012 %	0,017 %	0,012 %	0,018 %	0,012 %	0,017 %
RMSE	1,085 %	1,313 %	1,089 %	1,340 %	1,085 %	1,313 %
2009-2016						
AAD	1,685 %	1,896 %	0,391 %	0,801 %	1,652 %	1,832 %
MSE	0,037 %	0,051 %	0,002 %	0,008 %	0,029 %	0,042 %
RMSE	1,925 %	2,258 %	0,467 %	0,904 %	1,717 %	2,040 %

6.8 The 1999 Taylor Rule With R* Changed in Steps




Ireland
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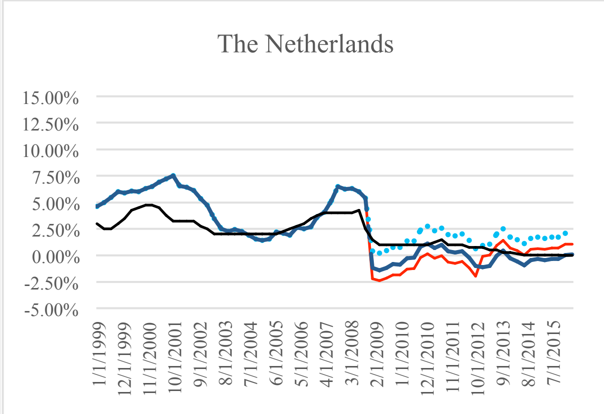
7/1/2015


The Netherlands
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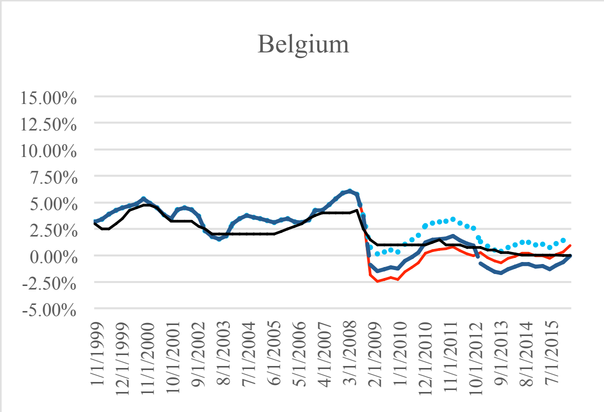
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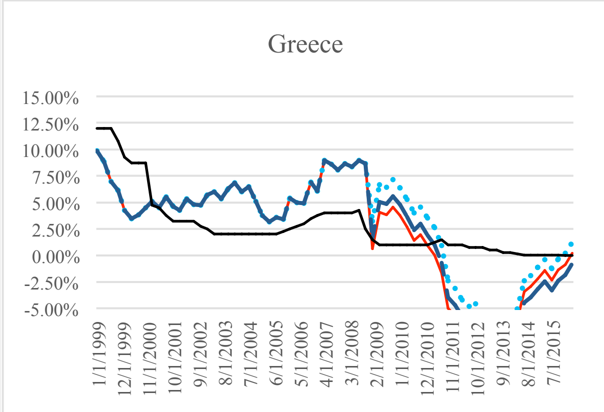
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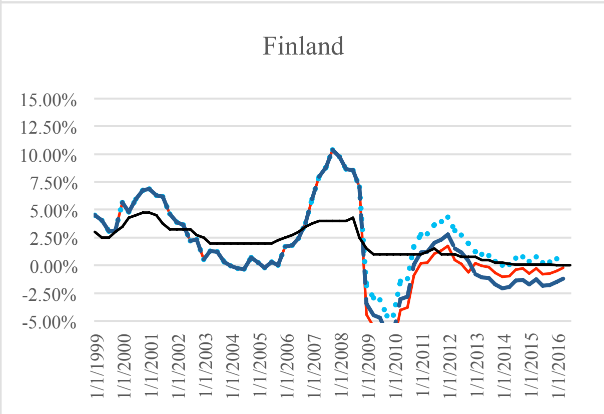
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6.9 The Laubach-Williams Model

The neutral rates of interest used in Section 3.2.2.2 are estimated using the Laubach-Williams model. The neutral rates of interest are the results from Belke & Klose (2016), who estimated the neutral rates of interest for twelve countries in the Eurozone.

The Laubach-Williams model jointly estimates the neutral rate of interest, potential output and its trend growth rate, and the relationship between these variables by using a filter technique called the Kalman-filter, from Kalman (1960). The Kalman-filter is a linear quadratic estimation technique in form of an algorithm that uses observations over time to produce estimates of unknown variables. Increasing the length of the time-series will make the filter able to produce more precise estimates. The filter-technique shares the same endpoint-weakness as the HP-filter, and therefore it is more fitted as a backward-looking filter than a real-time neutral rate of interest estimator.

The Laubach-Williams model also consists of several signal equations. Belke & Klose (2016) use the IS- and Phillips-curves as signal equations, along with three state-equations and several lags-effects. See Belke & Klose (2016) for additional explanation of the model and assumptions made in order to estimate the neutral rates of interest in the Eurozone. See Laubach & Williams (2003) for a more thorough explanation of the model.

6.10 Measures of Deviation For the Separate Countries With R* Changed in Steps

As the difference between λ=1.600 and λ=40.000 was relatively small, we only present measures of deviations for λ=1.600.

Germany	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	1,932 %	2,051 %	1,786 %	1,930 %	1,922 %	2,038 %
MSE	0,064 %	0,071 %	0,057 %	0,062 %	0,061 %	0,068 %
RMSE	2,526 %	2,664 %	2,387 %	2,499 %	2,469 %	2,599 %
1999-2016						
AAD	1,140 %	1,433 %	0,695 %	1,064 %	1,111 %	1,394 %
MSE	0,029 %	0,047 %	0,008 %	0,021 %	0,020 %	0,036 %
RMSE	1,689 %	2,159 %	0,878 %	1,434 %	1,409 %	1,900 %
1999-2008						
AAD	0,631 %	0,942 %	0,631 %	0,977 %	0,631 %	0,942 %
MSE	0,007 %	0,015 %	0,007 %	0,016 %	0,007 %	0,015 %
RMSE	0,836 %	1,244 %	0,836 %	1,244 %	0,836 %	1,244 %
2009-2016						
AAD	1,819 %	2,087 %	0,780 %	1,225 %	1,750 %	1,995 %
MSE	0,057 %	0,088 %	0,009 %	0,027 %	0,037 %	0,064 %
RMSE	2,392 %	2,968 %	0,932 %	1,653 %	1,924 %	2,522 %

Spain	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	3,850 %	3,941 %	3,562 %	3,667 %	3,825 %	3,895 %
MSE	0,410 %	0,419 %	0,400 %	0,408 %	0,408 %	0,418 %
RMSE	6,402 %	6,473 %	6,324 %	6,384 %	6,391 %	6,462 %
1999-2016						
AAD	2,201 %	2,515 %	1,551 %	1,896 %	2,145 %	2,409 %
MSE	0,054 %	0,071 %	0,032 %	0,045 %	0,051 %	0,067 %
RMSE	2,331 %	2,658 %	1,780 %	2,115 %	2,261 %	2,594 %
1999-2008						
AAD	2,151 %	2,375 %	2,151 %	2,375 %	2,151 %	2,375 %
MSE	0,049 %	0,061 %	0,049 %	0,061 %	0,049 %	0,061 %
RMSE	2,217 %	2,475 %	2,217 %	2,475 %	2,217 %	2,475 %
2009-2016						
AAD	2,268 %	2,701 %	0,752 %	1,258 %	2,138 %	2,455 %
MSE	0,061 %	0,083 %	0,008 %	0,023 %	0,054 %	0,075 %
RMSE	2,474 %	2,883 %	0,918 %	1,505 %	2,319 %	2,744 %

Portugal	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	3,231 %	3,376 %	3,033 %	3,265 %	3,257 %	3,405 %
MSE	0,168 %	0,193 %	0,161 %	0,186 %	0,170 %	0,195 %
RMSE	4,101 %	4,395 %	4,015 %	4,308 %	4,123 %	4,419 %
1999-2016						
AAD	2,192 %	2,381 %	1,880 %	2,208 %	2,233 %	2,427 %
MSE	0,061 %	0,073 %	0,050 %	0,061 %	0,064 %	0,076 %
RMSE	2,463 %	2,701 %	2,230 %	2,472 %	2,520 %	2,762 %
1999-2008						
AAD	2,514 %	2,676 %	2,514 %	2,676 %	2,514 %	2,676 %
MSE	0,075 %	0,082 %	0,075 %	0,082 %	0,075 %	0,082 %
RMSE	2,744 %	2,860 %	2,744 %	2,860 %	2,744 %	2,860 %
2009-2016						
AAD	1,764 %	1,989 %	1,035 %	1,584 %	1,858 %	2,095 %
MSE	0,041 %	0,061 %	0,016 %	0,034 %	0,048 %	0,069 %
RMSE	2,028 %	2,474 %	1,251 %	1,832 %	2,186 %	2,626 %

Belgium	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	2,366 %	2,406 %	2,371 %	2,398 %	2,361 %	2,410 %
MSE	0,129 %	0,123 %	0,129 %	0,121 %	0,128 %	0,122 %
RMSE	3,597 %	3,508 %	3,588 %	3,483 %	3,582 %	3,490 %
1999-2016						
AAD	0,866 %	0,970 %	0,877 %	0,952 %	0,857 %	0,980 %
MSE	0,012 %	0,017 %	0,011 %	0,013 %	0,010 %	0,014 %
RMSE	1,101 %	1,299 %	1,035 %	1,139 %	0,985 %	1,182 %
1999-2008						
AAD	0,785 %	0,851 %	0,785 %	0,851 %	0,785 %	0,851 %
MSE	0,009 %	0,010 %	0,009 %	0,010 %	0,009 %	0,010 %
RMSE	0,923 %	1,025 %	0,923 %	1,025 %	0,923 %	1,025 %
2009-2016						
AAD	0,974 %	1,129 %	1,000 %	1,086 %	0,952 %	1,153 %
MSE	0,017 %	0,025 %	0,014 %	0,016 %	0,011 %	0,019 %
RMSE	1,302 %	1,592 %	1,168 %	1,275 %	1,063 %	1,364 %

Ireland	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	4,270 %	4,980 %	3,998 %	4,702 %	4,176 %	4,885 %
MSE	0,324 %	0,408 %	0,298 %	0,378 %	0,316 %	0,399 %
RMSE	5,693 %	6,386 %	5,460 %	6,145 %	5,624 %	6,316 %
1999-2016						
AAD	4,378 %	5,473 %	3,801 %	4,885 %	4,178 %	5,273 %
MSE	0,249 %	0,394 %	0,194 %	0,330 %	0,233 %	0,376 %
RMSE	4,993 %	6,280 %	4,408 %	5,749 %	4,825 %	6,128 %
1999-2008						
AAD	4,061 %	4,548 %	4,061 %	4,548 %	4,061 %	4,548 %
MSE	0,202 %	0,284 %	0,202 %	0,284 %	0,202 %	0,284 %
RMSE	4,494 %	5,333 %	4,494 %	5,333 %	4,494 %	5,333 %
2009-2016						
AAD	4,800 %	6,707 %	3,455 %	5,335 %	4,333 %	6,240 %
MSE	0,312 %	0,541 %	0,184 %	0,392 %	0,274 %	0,497 %
RMSE	5,589 %	7,356 %	4,290 %	6,260 %	5,233 %	7,050 %

France	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	3,000 %	2,961 %	2,742 %	2,715 %	2,989 %	2,950 %
MSE	0,182 %	0,181 %	0,175 %	0,172 %	0,180 %	0,178 %
RMSE	4,267 %	4,249 %	4,181 %	4,146 %	4,247 %	4,223 %
1999-2016						
AAD	1,368 %	1,387 %	0,696 %	0,747 %	1,339 %	1,358 %
MSE	0,028 %	0,031 %	0,009 %	0,009 %	0,024 %	0,026 %
RMSE	1,684 %	1,771 %	0,974 %	0,948 %	1,547 %	1,601 %
1999-2008						
AAD	0,967 %	0,879 %	0,967 %	0,879 %	0,967 %	0,879 %
MSE	0,015 %	0,011 %	0,015 %	0,011 %	0,015 %	0,011 %
RMSE	1,238 %	1,038 %	1,238 %	1,038 %	1,238 %	1,038 %
2009-2016						
AAD	1,903 %	2,064 %	0,336 %	0,570 %	1,836 %	1,997 %
MSE	0,046 %	0,059 %	0,002 %	0,007 %	0,035 %	0,045 %
RMSE	2,139 %	2,426 %	0,416 %	0,812 %	1,881 %	2,132 %

Italy	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	4,415 %	4,482 %	4,310 %	4,411 %	4,411 %	4,501 %
MSE	0,423 %	0,431 %	0,420 %	0,428 %	0,422 %	0,431 %
RMSE	6,501 %	6,568 %	6,481 %	6,539 %	6,500 %	6,565 %
1999-2016						
AAD	1,339 %	1,544 %	1,005 %	1,318 %	1,324 %	1,602 %
MSE	0,023 %	0,035 %	0,015 %	0,022 %	0,023 %	0,033 %
RMSE	1,523 %	1,859 %	1,213 %	1,492 %	1,504 %	1,822 %
1999-2008						
AAD	1,271 %	1,454 %	1,271 %	1,454 %	1,271 %	1,454 %
MSE	0,020 %	0,024 %	0,020 %	0,024 %	0,020 %	0,024 %
RMSE	1,412 %	1,564 %	1,412 %	1,564 %	1,412 %	1,564 %
2009-2016						
AAD	1,429 %	1,664 %	0,650 %	1,136 %	1,394 %	1,801 %
MSE	0,028 %	0,048 %	0,008 %	0,019 %	0,026 %	0,045 %
RMSE	1,659 %	2,191 %	0,881 %	1,392 %	1,618 %	2,118 %

Finland	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	1,685 %	2,413 %	1,566 %	2,314 %	1,711 %	2,457 %
MSE	0,052 %	0,108 %	0,043 %	0,094 %	0,049 %	0,103 %
RMSE	2,280 %	3,283 %	2,071 %	3,069 %	2,213 %	3,214 %
1999-2016						
AAD	1,432 %	2,038 %	1,232 %	1,873 %	1,477 %	2,114 %
MSE	0,039 %	0,082 %	0,024 %	0,059 %	0,034 %	0,074 %
RMSE	1,974 %	2,862 %	1,537 %	2,428 %	1,840 %	2,726 %
1999-2008						
AAD	1,272 %	2,008 %	1,272 %	2,008 %	1,272 %	2,008 %
MSE	0,025 %	0,063 %	0,025 %	0,063 %	0,025 %	0,063 %
RMSE	1,572 %	2,518 %	1,572 %	2,518 %	1,572 %	2,518 %
2009-2016						
AAD	1,646 %	2,079 %	1,178 %	1,693 %	1,749 %	2,255 %
MSE	0,058 %	0,107 %	0,022 %	0,053 %	0,046 %	0,089 %
RMSE	2,408 %	3,264 %	1,488 %	2,302 %	2,147 %	2,981 %

The Netherlands	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	3,070 %	3,143 %	3,046 %	3,095 %	2,998 %	3,071 %
MSE	0,181 %	0,186 %	0,180 %	0,184 %	0,179 %	0,184 %
RMSE	4,258 %	4,318 %	4,246 %	4,294 %	4,233 %	4,291 %
1999-2016						
AAD	1,318 %	1,532 %	1,241 %	1,380 %	1,090 %	1,305 %
MSE	0,026 %	0,036 %	0,023 %	0,029 %	0,019 %	0,028 %
RMSE	1,605 %	1,887 %	1,506 %	1,701 %	1,384 %	1,677 %
1999-2008						
AAD	1,340 %	1,584 %	1,340 %	1,584 %	1,340 %	1,584 %
MSE	0,028 %	0,039 %	0,028 %	0,039 %	0,028 %	0,039 %
RMSE	1,676 %	1,967 %	1,676 %	1,967 %	1,676 %	1,967 %
2009-2016						
AAD	1,288 %	1,464 %	1,108 %	1,108 %	0,755 %	0,934 %
MSE	0,023 %	0,031 %	0,015 %	0,016 %	0,007 %	0,014 %
RMSE	1,504 %	1,774 %	1,243 %	1,262 %	0,849 %	1,183 %

Austria	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	1,311 %	1,302 %	1,332 %	1,348 %	1,180 %	1,203 %
MSE	0,028 %	0,030 %	0,028 %	0,028 %	0,025 %	0,026 %
RMSE	1,678 %	1,740 %	1,674 %	1,669 %	1,567 %	1,611 %
1999-2016						
AAD	0,968 %	1,079 %	1,005 %	1,162 %	0,736 %	0,904 %
MSE	0,015 %	0,023 %	0,015 %	0,019 %	0,009 %	0,016 %
RMSE	1,221 %	1,525 %	1,212 %	1,378 %	0,924 %	1,249 %
1999-2008						
AAD	0,760 %	0,832 %	0,760 %	0,832 %	0,760 %	0,832 %
MSE	0,008 %	0,012 %	0,008 %	0,012 %	0,008 %	0,012 %
RMSE	0,920 %	1,075 %	0,920 %	1,075 %	0,920 %	1,075 %
2009-2016						
AAD	1,244 %	1,408 %	1,331 %	1,602 %	0,703 %	0,999 %
MSE	0,024 %	0,039 %	0,023 %	0,029 %	0,009 %	0,021 %
RMSE	1,534 %	1,970 %	1,516 %	1,700 %	0,930 %	1,449 %

Greece	*Semi structural*		*BVAR*		*Inflation targeting*	
	1993	1999	1993	1999	1993	1999
Whole sample						
AAD	3,136 %	3,461 %	3,076 %	3,391 %	3,317 %	3,615 %
MSE	0,180 %	0,224 %	0,168 %	0,208 %	0,192 %	0,235 %
RMSE	4,243 %	4,733 %	4,098 %	4,565 %	4,380 %	4,845 %
1999-2016						
AAD	3,039 %	3,495 %	2,963 %	3,406 %	3,269 %	3,690 %
MSE	0,119 %	0,171 %	0,103 %	0,152 %	0,134 %	0,185 %
RMSE	3,443 %	4,140 %	3,213 %	3,893 %	3,655 %	4,301 %
1999-2008						
AAD	2,981 %	3,195 %	2,981 %	3,195 %	2,981 %	3,195 %
MSE	0,101 %	0,126 %	0,101 %	0,126 %	0,101 %	0,126 %
RMSE	3,186 %	3,549 %	3,186 %	3,549 %	3,186 %	3,549 %
2009-2016						
AAD	3,116 %	3,894 %	2,939 %	3,688 %	3,652 %	4,350 %
MSE	0,141 %	0,232 %	0,106 %	0,186 %	0,176 %	0,264 %
RMSE	3,760 %	4,816 %	3,249 %	4,308 %	4,201 %	5,135 %

6.11 Measures of Deviation With a Floating Neutral Real Rate of Interest

As the difference between λ=1.600 and λ=40.000 was relatively small, we only present measures of deviations for λ=1.600.

Germany	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	1,484%	1,591%	0,035%	0,038%	1,881%	1,950%
1999-2015	0,960%	1,346%	0,013%	0,023%	1,148%	1,529%
1999-2008	0,792%	1,125%	0,010%	0,017%	0,999%	1,320%
2009-2015	1,200%	1,661%	0,018%	0,032%	1,331%	1,785%

Spain	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	3,325%	3,425%	0,250%	0,256%	5,000%	5,058%
1999-2015	2,187%	2,497%	0,066%	0,080%	2,566%	2,836%
1999-2008	3,100%	3,325%	0,104%	0,120%	3,219%	3,465%
2009-2015	0,883%	1,315%	0,012%	0,024%	1,092%	1,541%

Portugal	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	3,260%	3,488%	0,191%	0,210%	4,372%	4,580%
1999-2015	1,525%	1,848%	0,038%	0,054%	1,948%	2,328%
1999-2008	1,296%	1,507%	0,034%	0,041%	1,848%	2,036%
2009-2015	1,851%	2,336%	0,043%	0,072%	2,084%	2,690%

Belgium	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	1,802%	1,680%	0,065%	0,057%	2,548%	2,393%
1999-2015	1,077%	1,032%	0,018%	0,017%	1,329%	1,319%
1999-2008	0,579%	0,615%	0,005%	0,005%	0,683%	0,729%
2009-2015	1,790%	1,628%	0,036%	0,035%	1,903%	1,862%

Ireland	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	6,560%	7,170%	0,667%	0,781%	8,169%	8,839%
1999-2015	8,850%	9,764%	1,030%	1,237%	10,150%	11,124%
1999-2008	11,455%	11,942%	1,429%	1,593%	11,952%	12,622%
2009-2015	5,129%	6,652%	0,461%	0,729%	6,791%	8,539%

France	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,776%	2,794%	0,155%	0,152%	3,936%	3,899%
1999-2015	0,978%	0,937%	0,014%	0,011%	1,173%	1,067%
1999-2008	0,993%	0,916%	0,016%	0,011%	1,248%	1,058%
2009-2015	0,957%	0,967%	0,011%	0,012%	1,055%	1,080%

Italy	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	3,831%	3,904%	0,375%	0,377%	6,123%	6,140%
1999-2015	0,968%	1,188%	0,014%	0,020%	1,172%	1,402%
1999-2008	1,125%	1,303%	0,017%	0,022%	1,293%	1,469%
2009-2015	0,743%	1,023%	0,009%	0,017%	0,974%	1,299%

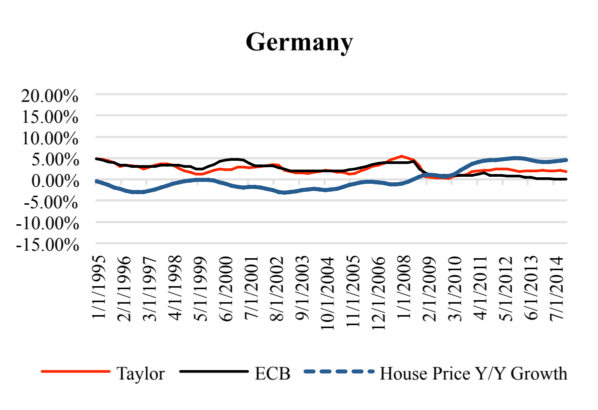
Finland	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,383%	3,024%	0,100%	0,157%	3,169%	3,968%
1999-2015	1,655%	2,179%	0,043%	0,078%	2,067%	2,800%
1999-2008	1,622%	2,332%	0,042%	0,088%	2,057%	2,973%
2009-2015	1,702%	1,960%	0,043%	0,064%	2,082%	2,534%

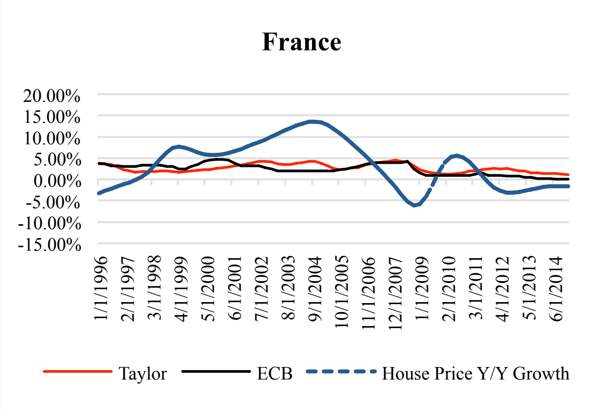
Netherlands	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	2,715%	2,700%	0,125%	0,125%	3,543%	3,532%
1999-2015	1,845%	1,917%	0,045%	0,051%	2,124%	2,261%
1999-2008	1,759%	2,043%	0,048%	0,064%	2,198%	2,526%
2009-2015	1,969%	1,736%	0,040%	0,033%	2,012%	1,815%

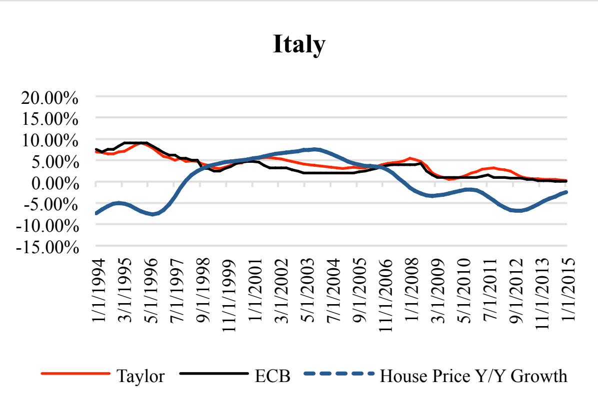
Austria	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	1,275%	1,314%	0,025%	0,027%	1,577%	1,649%
1999-2015	1,567%	1,674%	0,035%	0,040%	1,863%	1,994%
1999-2008	1,159%	1,371%	0,020%	0,029%	1,412%	1,700%
2009-2015	2,150%	2,107%	0,056%	0,055%	2,363%	2,351%

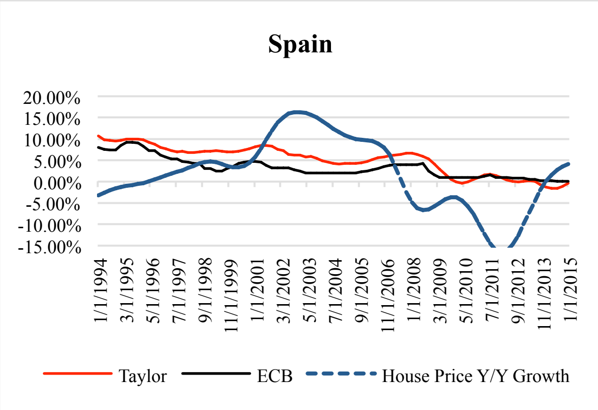
Greece	*Average Absolute Deviation*		*Mean Square Error*		*Root Mean Square Error*	
	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999	Taylor 1993	Taylor 1999
Whole sample	5,321%	5,711%	0,473%	0,559%	6,877%	7,479%
1999-2015	5,727%	6,191%	0,451%	0,554%	6,712%	7,442%
1999-2008	4,789%	5,002%	0,254%	0,286%	5,045%	5,347%
2009-2015	7,068%	7,889%	0,731%	0,937%	8,547%	9,678%

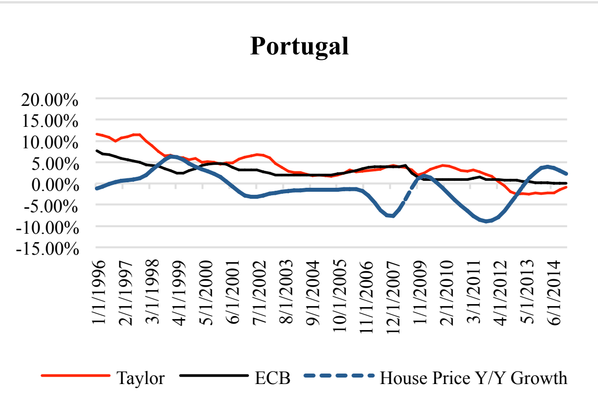
6.12 Housing Price Inflation

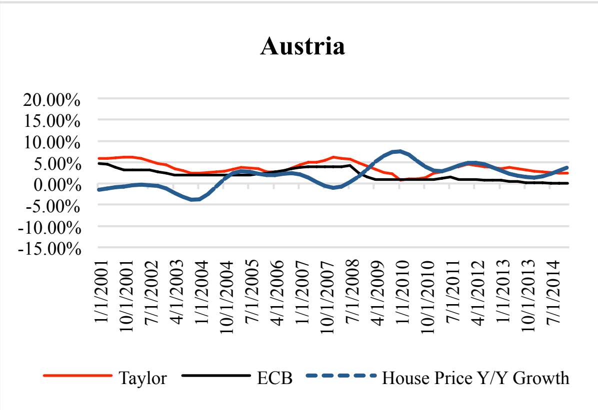


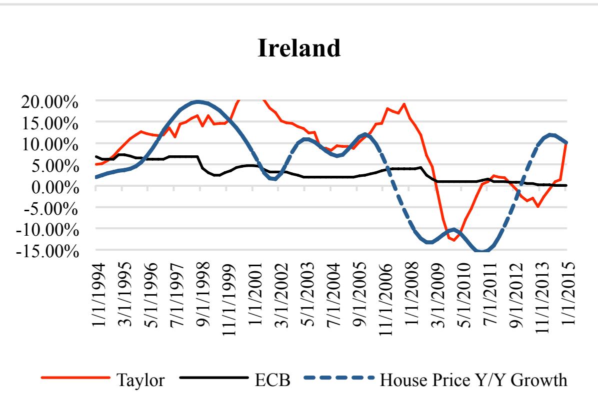


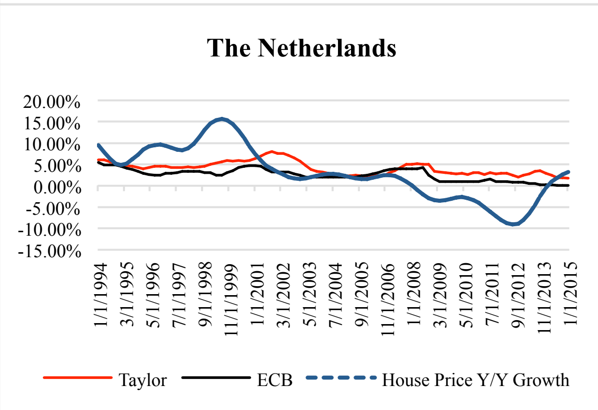


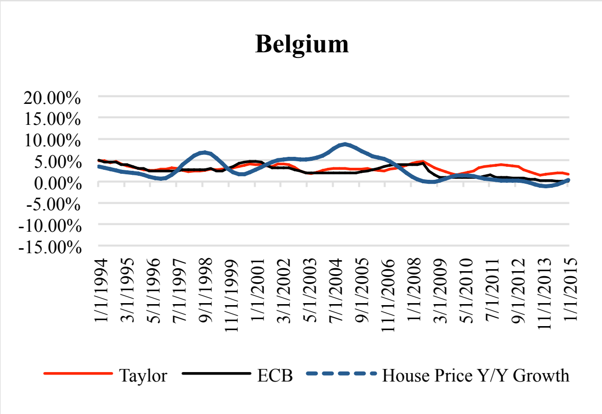


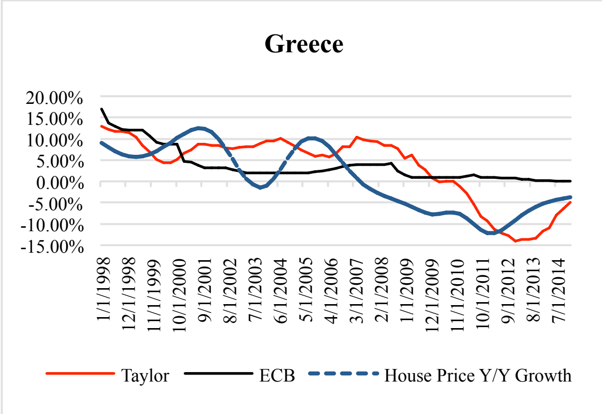









Belgium
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
1/1/1994
3/1/1995
5/1/1996
7/1/1997
9/1/1998
11/1/1999
1/1/2001
3/1/2002
5/1/2003
7/1/2004
9/1/2005
11/1/2006
1/1/2008
3/1/2009
5/1/2010
7/1/2011
9/1/2012
11/1/2013
1/1/2015
Taylor
ECB
House Price Y/Y Growth


Greece
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
1/1/1998
12/1/1998
11/1/1999
10/1/2000
9/1/2001
8/1/2002
7/1/2003
6/1/2004
5/1/2005
4/1/2006
3/1/2007
2/1/2008
1/1/2009
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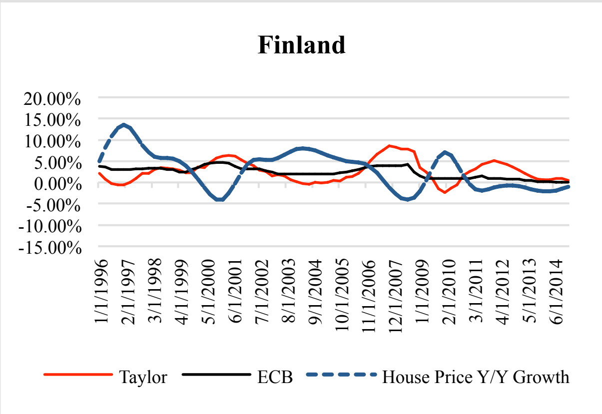
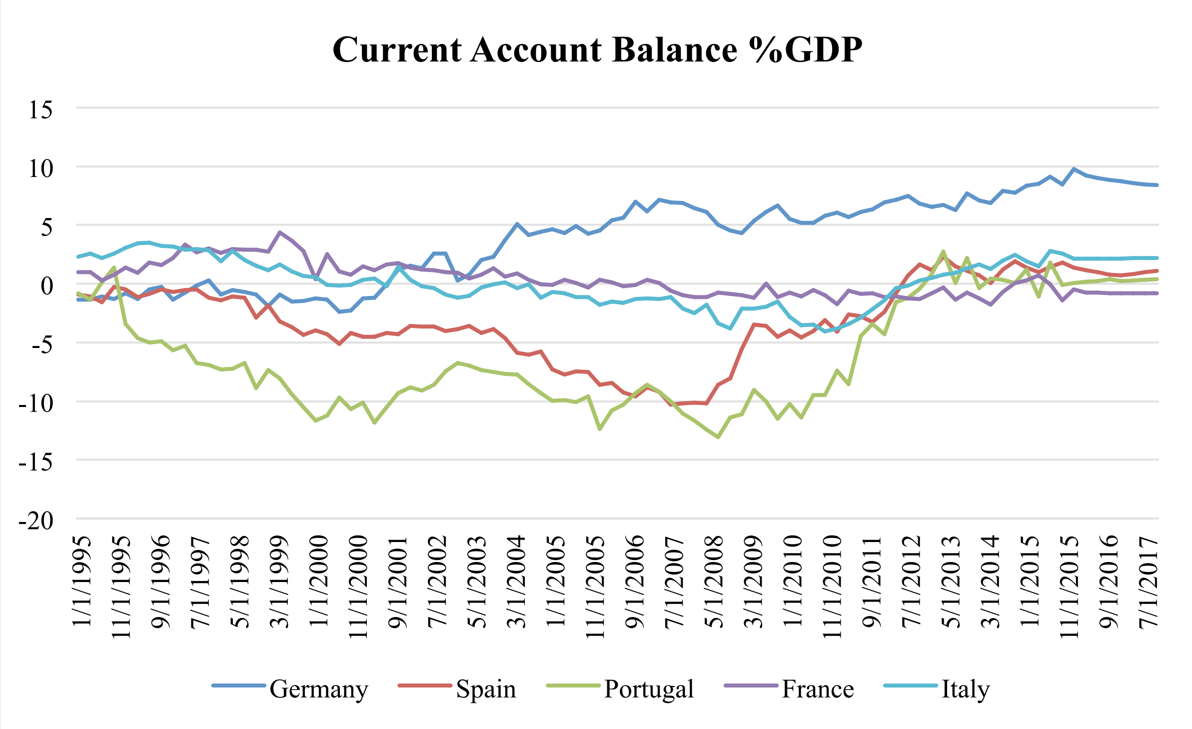
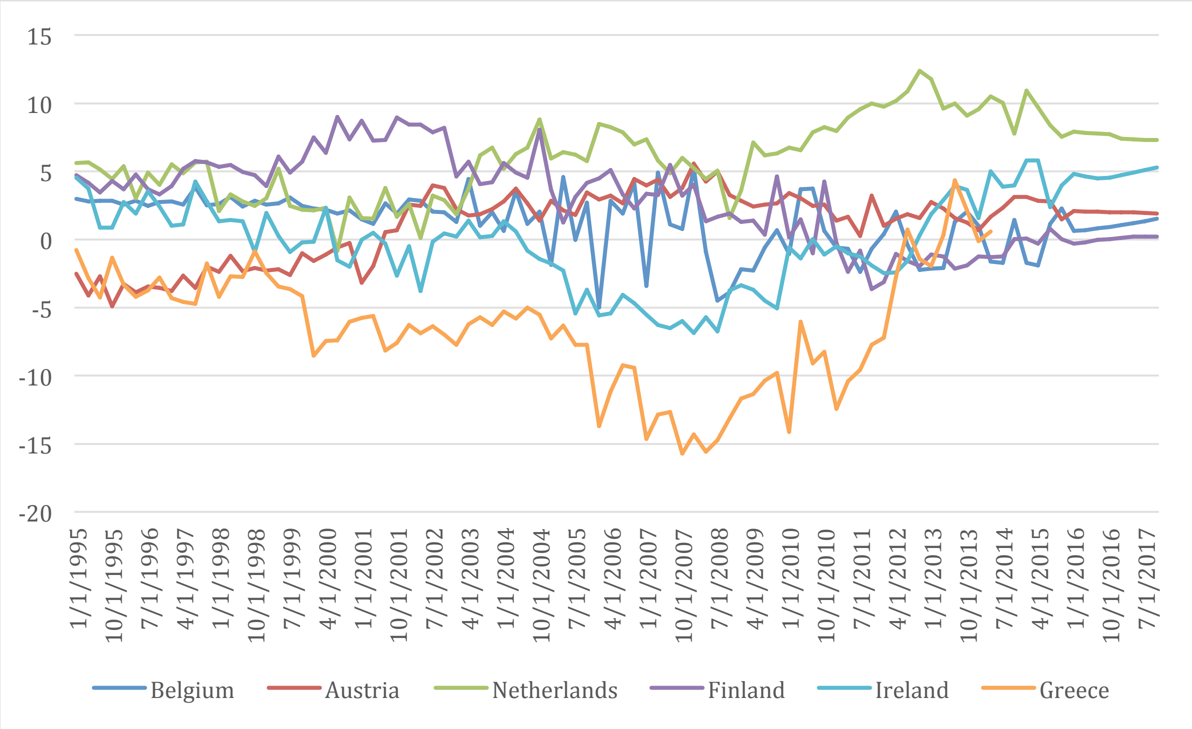
8/1/2013
7/1/2014
Taylor
ECB
House Price Y/Y Growth


Finland
20.00%
15.00%
10.00%
5.00%
0.00%
-5.00%
-10.00%
-15.00%
1/1/1996
2/1/1997
3/1/1998
4/1/1999
5/1/2000
6/1/2001
7/1/2002
8/1/2003
9/1/2004
10/1/2005
11/1/2006
12/1/2007
1/1/2009
2/1/2010
3/1/2011
4/1/2012
5/1/2013
6/1/2014
Taylor
ECB
House Price Y/Y Growth

6.13 Current Account Balance as % of GDP





6.14 Neutral Real Interest Rates