Assessing the Greek monetary policy in the pre-EMU period through the 'lenses' of Taylor-type policy rules

Abstract

In the period between 1980 and the entrance into the Eurozone in 2001, the monetary policy in Greece went through several regimes, including: a decade of high and persistent inflation in the 1980s, a transition period in the early 1990s, the 'hard' Drachma period between 1995 and 1998, which make it an interesting case for research. This paper focuses on an empirical assessment of the conduct of monetary policy in Greece during the EMU convergence period. We estimate a number of simple and augmented specifications of Taylor-type instrument-based monetary policy rules. We also assess the presence of structural breaks and the potential for nonlinear instrument rules. The results are rather mixed and period-specific, which is not surprising, given the peculiar features of the Greek monetary policy during the period under scrutiny in this study.

1. Introduction

The main objective of this paper is to analyse the Greek monetary policy over the period 1980-2000, which precedes the admission of Greece in the European Monetary Union (EMU), using Taylor-type interest rate (or instrument) rules. Since John Taylor (1993) put forward his well-known rule, this rule has been widely used (both in its original form or various extensions) in an attempt not only to understand how monetary policy has historically been conducted, but also to gain insights into the various channels of the transmission mechanism of monetary policy.

We opt to focus on Greece because the Greek case is interesting for several reasons. Greece represents a typical example of a small economy and the period under examinations contains intervals characterised by high and persistent inflation (and stagflation, for the largest part), rapid disinflation and stabilization thereafter at low levels of the inflation rate. During the period under scrutiny in this paper, the central bank of Greece followed both a floating exchange initially and later an explicit exchange rate targeting regime and faced two speculative attacks on the Drachma during the twenty years considered in this study. Moreover, the conduct of monetary policy in Greece was faced with challenges raised by fiscal policy: at times, monetary policy actions have been used to finance government debt, leading to a certain degree of fiscal irresponsibility, while in some years monetary policy was accompanied by fiscal prudency and proved to be an anchor of stability. Acknowledging the potential of the Greek monetary policy in the pre-EMU era to offer an interesting case-study, this paper takes on the challenge and focuses on an attempt to assess the ability of instrument-based Taylor-type rules to capture the peculiar features of the Greek monetary policy in a historical perspective. We provide both a narrative and a more formal analysis, revolving around an empirical assessment employing a range of linear and nonlinear specifications.

The remainder of this paper is organized as follows. Section 2 conducts a selective review of the pertinent literature, shedding light on the classic debate focused on rules versus discretion in the conduct of monetary policy and providing a discussion of the original Taylor rule and its extensions. The review also covers the most common criticisms against simple instrument rules, while one of its sections (section 2.4) expands specifically upon the criticism against the linearity of Taylor-type rules. The third section of the paper provides a narrative analysis of the economic and political developments in Greece during the period under scrutiny in this paper. This provides the necessary, when examining monetary policy, context that will help explain the findings of the empirical analysis and sets the scene for this analysis, which is presented in Section 4. A number of different specifications of the Taylor-type policy rule are estimated for the whole sample period and several subsamples, chosen based on theoretical and policy-related considerations. The last section concludes.

2. A Selective Review of the Literature on Taylor-type Monetary Policy Rules

The original rule proposed in the seminal paper by Taylor (1993) is often characterised as simple and a certain degree of doubt is cast over its ability to capture the instrument-setting behaviour of monetary authorities. However, in spite of its perceived simplicity, the estimation of this rule is rather complex, due to several theoretical and practical issues. The case of Greece constitutes no exception in this respect as the empirical exercise conducted in Section 4 reveals. Eleftheriou (2003) carries out a thorough examination of the various aspects associated with the specification of the rule, including the choice of variables that enter the rule and the role played by them, their dating and computation.

Considerable interest has been devoted to the estimation of the Tayor rule, both in its original form and a number of extended/augmented specifications, for various economies and time periods. Therefore, there is a considerable body of research focused on this topic and the review conducted here inexorably needs to be restricted to a selection from this large number of studies. Therefore, we concentrate on a number of seminal studies upon which the empirical analysis conducted in Section 4 is built. We pay particular attention to the methodological approach employed in these studies.

2.1 Rules Versus Discretion in Monetary Policy

The *discretion versus rules* dilemma has been a central topic in theoretical and applied macroeconomics during the biggest part of the previous century. This debate focuses on whether the central banks should follow a specific rule for the determination of their instrument (usually, a short term bank rate) or act depending solely on the circumstances. The complexity though of this problem and the uncertainty about future economic developments made several researchers claim that no rule would be adequate enough for the task and thus discretion should be exercised in the conduct of monetary policy. Milton Friedman was among the first to advocate in favour of the monetary policy rules (with the money supply acting as instrument). Almost a decade later, it was the famous Lucas critique (1976), the seminar work of Kydland and Prescott (1977) and that of Barro and Gordon (1983) on time inconsistency and inflationary bias that advanced the rational expectations revolution and demonstrated how beneficial monetary policy rules could be. Also, advancements in technology, which enabled easier and more trustworthy gathering of statistical data and estimation of more complex models helped turning the tide. All the major developments in central banking over the last two decades have drawn on the theoretical research on the topic of rules versus discretion and evolved mainly around two pillars. The first one is increasing the credibility and accountability of monetary authorities, whilst the second one is reducing the uncertainty associated with level of the prevailing interest rates. Achieving instrument independence, becoming more transparent by publicly announcing their targets and expectations and by attempting to communicate their strategy both to the public and to the investors are important objectives of monetary authorities that aim at strengthening those pillars. The main economic rationale is that the expectations of the actors in the economy affect, to a large degree, the current state of the economy and the central bank can more reliably exert an impact on those expectations, when it is credible and acts in an environment with reduced uncertainty. Perhaps there is hardly a more relevant example than how only the statement of the president of the ECB, Mario Draghi, that "the ECB will do whatever it takes to preserve the euro" (26/07/2012), was enough to stabilize the havoc in the financial markets. In that framework monetary policy rules seemed to be well-suited, because they are a perfect tool for achieving the aforementioned goals. A monetary policy rule signals a credible central bank, which can easily be asked to account for deviations from the rule, and whose targets are clear, transparent and easily communicated to the society. A small caveat is that, in this context, the notion of a monetary policy rule resembles more the definition of Taylor's (1993) as a 'systematic policy' or Svensson's (1998) as a targeting rule. In other words, it is not an exact algebraic formulation but rather the commitment of the central bank to a clear monetary strategy and to a clear mid- and long-term target.

2.2 The Taylor Rule

Although as mentioned above, rules had been increasing popular and central banks had experimented with some of them when targeting the monetary base, they were complex, inflexible and often only relevant to a specific model of the economy. It was John Taylor, who, in 1993, first suggested that a simple algebraic equation, the now famous *Taylor rule*, could relatively accurately describe the monetary policy in the US from 1987 to 1992. The rule states that the central bank sets the nominal interest rate based on three terms. The first one is the inflation gap, namely the deviation of the current inflation from a target value, the second is the output gap, or the deviation of the current output from the underlying potential level and the third one is the natural interest rate in the economy.

$r = \pi + r^* + \alpha(\pi - \pi^*) + \beta(y - y^*)$ (2.1)

or

$r = \delta + (1 + \alpha)\pi + \beta(y - y^*)$, for $\delta = r^* - \alpha\pi^*$ (2.2)

where π is the inflation over the last 4 quarters, π^* the target inflation, r^* the equilibrium interest rate (in his seminal study, Taylor (1993) used 2%), y is the actual output and y^* the natural level of output (proxied inTaylor (op.cit) by the underlying trend of the GDP). Coefficients α and β capture the importance that the central bank attaches to inflation and output gap respectively. In his original paper, Taylor did not estimate these coefficients, but arbitrary chose what he believed to be sensible values, that is 0.5 for both coefficients. In the second form (illustrated in equation 2.2), one can clearly recognize what is known in the literature as the 'Taylor principle' (Woodford 2001). This is the proposition that, in order to stabilize the economy, monetary authorities should increase the interest rate more than the increase in inflation. This specification is usually referred to as the 'backward-looking rule', since the current value of the interest rate depends on the lagged values of inflation and output gap. An extension of the rule was proposed by Clarida et al. (1998), where the nominal funds rate depends on the gap between expected inflation and output and their corresponding target values, and is believed to better grasp the forward-looking behaviour of central banks:

$r_t^* = r^* + \beta(E(\pi_{t+k}|\Omega_t) - \pi^*) + \gamma E(y_{t+q}|\Omega_t)$ (2.3)

where Ω_t is the information set available to the central bank when the rate is set, π_{t+k} and y_{t+q} are the inflation and output gap at time $t + k$ and $t + q$ respectively.

It is generally accepted that the short term interest rate is usually partially adjusted towards the target level. This is known in the literature as interest rate smoothing and has been attributed to a number of reasons. The most prominent of these reasons are: monetary policy inertia (Woodford 1999), uncertainty due to noisy data (as argued in Orphanides, 2003), fear of causing disruption in financial markets (by affecting long-term rates) (Goodfriend, 1991)) or a series of serially correlated or persistent shocks (Rudebusch, 2002). In order to capture the interest smoothing phenomenon, a parameter ρ $(0 < \rho < 1)$ is added and short term interest rates are given by:

$r_t = (1 - \rho)r_t^* + \rho r_{t-1}$ (2.4)

2.3 Criticism of the simple Taylor rule

At this point a distinction needs to be made. By formulating a model of the economy, along with a loss function that captures the preferences of the monetary authorities, and solving afterwards the resulting system of equations, one can derive the optimal instrument rule for that specific model and loss function (selected contributions focusing on this include Clarida et al., 1999; Ball, 1999; Woodford, 2001 and more recently Ball et al., 2005). In a seminal paper, Clarida et al. (1999) proved that a forward looking Taylor-type specification can be an optimal policy rule under the assumptions of a symmetric quadratic loss function and a linear aggregate supply relation. In this paper, we do not focus on deriving optimal monetary policy rules, but use historical data in order to estimate Taylor-type rules, in order to provide insights into the conduct of monetary policy in Greece. While the majority of the arguments presented below apply to both categories, this is not always the case. The Taylor rule has faced a lot of criticism, both for econometrical and qualitative reasons. More specifically, Österholm (2005) and Bunzel and Enders (2005) argued that the federal funds rate and the inflation and output gaps are nonstationary series and moreover, they are not cointegrated. They argue that this yields a spurious regression and thus the results should not have any meaningful explanation. Bunzel and Enders (op.cit.) attempted to meet the cointegration requirement by searching for missing variables and different structural break dates, but their final result was the same, that the Taylor rule was not sound from an econometric point of view. Another issue is that there is no general agreement on either the measure of inflation or the inflation period that should enter the rule. Kozicki (1999) experimented by estimating the Taylor rule with four different measures of inflation (core CPI, year on year CPI, GDP price deflator and an average of private agents' expectations) and found significant variances in the outcome. Moreover, a lot of the ongoing debate is about whether central banks should take into consideration asset prices when calculating inflation and whether asset prices, especially financial assets and housing, better reflect the inflation expectations of the markets.

Regarding the estimation of the output gap the problem is twofold. The output estimates are often revised, which means that even if the rule were correct, the central bank's response would not be optimal, since at the time the data would not be valid. That has also been proved by analysing, from a historical perspective, the choices of the monetary authority using instrument rules like Taylor's. Orphanides (2003), for example, notes that the most probable explanation for the 'sub-optimal' policy of the FED under chairman Burns is the wrong estimation of the potential output of the economy. Moreover, Rotemberg and Woodford (1999) and Woodford (2001) prove, using a simplified Wickselian model, that the underlying GDP trend is not optimal as a proxy for the underlying growth rate, as that should be subject to shocks. Many alternatives have been suggested[3], but the problem of calculating the exact value is still to a large degree unsolved.

Another main point of discussion is which additional, if any, variables should be included in such simple instrument rules like Taylor's. The most suitable candidate is probably the exchange rate, but even in that case, its usefulness depends a lot on the exchange rate regime pursued by the central bank. In a fixed exchange rate regime for instance, the exchange rate could, as has been empirically proven and reported, be the decisive factor in the specification of the rule. On the other hand, as Taylor (1999) argued, the exchange rate is already included implicitly in the rule, since it affects the other variables through the channels of the monetary transmission mechanism. If asset prices are excluded from the measure of inflation, then they could be another suitable candidate[1]. Many researchers advocated that asset prices are quite often valuable indicators of expectations (Alchian and Klein, 1973 and Goodheart, 2001, among others). On the other hand, several studies recognize that asset prices are highly volatile and question their usefulness either due to a theoretical analysis (Vickers 1999 or

[1] The distinction between taking asset prices into consideration when calculating inflation and actually targeting asset prices is made clear by Vickers (1999). The former corresponds to current and future price stability whereas the latter involves acting more timely to changes in inflation.

Bernanke and Gertler, 1999, inter alia) or to empirical evidence (Filardo, 2000)[2]. It should be noted though, that in the inflation targeting framework, which the most advanced central banks nowadays use[3], asset prices might be utilized implicitly within the models that are used to forecast inflation.

A more qualitative argument is put forward by Svensson (2003) in a paper focusing on instrument rules in general, where he claims that Taylor-type rules cannot accurately describe the monetary policy of a central bank since an economy's complexity cannot be captured with only two variables. Moreover Svensson (op.cit.) argues that these rules are not even reliable guidelines, since it is not specified when it is appropriate to deviate from the rule[4]. In addition, Svensson (op. cit.) claims that committing to such a rule essentially means that the rule cannot be improved as more evidence (or additional information) is gathered regarding monetary policy and its transmission mechanism[5].

2.4 The Potential for Nonlinearity in Monetary Policy Rules

The strongest argument against such simple instrument rules is most likely their linear structure, which is implied by the assumption of quadratic preferences and linear structure of the economy. The arguments against the linearity of the rule are twofold. The first, which is based on theoretical and more recently empirical basis, is that the policymaker might have asymmetric preferences (Cukierman and Muscatelli, 2002; Nobay and Peel, 2003; Surico, 2004). It is quite plausible that monetary authorities do not equally weigh recessions and expansions, positive and negative deviations from the inflation target and the magnitude of those deviations. As the former FED vice president states (Blinder 2007): "*In most situations the central bank will take far more political heat when it tightens pre-emptively to avoid higher inflation, than when it eases pre-emptively to avoid higher unemployment*". Essentially this implies that even an independent central bank is less likely to raise the rates in the face of decreasing unemployment than the opposite. A more theoretical argument, put forward by Tversky and Kahneman (1991) is supported by psychology and claims that people, when deciding under uncertainty, value more prospective losses than gains.

Even in the case where the loss function of the central bank is quadratic (which is suggestive of symmetric preferences) the exiting empirical evidence suggests that the macroeconomic structure of an economy might not be linear (Nobay, and Peel 2000, Schaling 2004, Dolado et al. 2005). As Blinder (2007) argues, it might be too costly to fight inflation if it deviates only a little from the long-term target; instead, the central bank should wait until the next positive shock. In other words, the trade-off between inflation and output is not constant and increases as the inflation gap decreases. Moreover, as Taylor and Davradakis (2006) point out, there might be nonlinearities in the business cycle since the effects of shocks to monetary policy appear to be more severe during recessions than expansions.

2.5 Empirical evidence

This paper focuses on Taylor-type rules estimated using historical *ex post* data. This involves studying past monetary policy through the 'lenses' of a policy rule. This kind of analysis is not only useful from

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[2] The whole debate is inextricably linked with the question of whether asset prices reflect fundamentals or their level is the result of a generating bubble. Vickers very eloquently notes that targeting asset prices would mean going 'bubble-hunting'.

[3] England(1992), Sweden(1993), Canada(1991), New Zealand(1990) among them. FED does not explicitly follow an inflation targeting strategy, but its former chairman Ben Bernanke is among its greatest advocates. ECB follows a 2-pillar strategy and one of those pillars corresponds to inflation targeting.

[4] This argument is based on Taylor's (1993) initial work, where he notes that there are periods where discretion is necessary.

[5] Woodford (1999) countered this argument with the notion of timeless commitment. Essentially this means only to commit to a regime that would have been optimal 'long' ago.

a historical perspective, but also provides insights into the mistakes of the past, what went wrong and how it could have been avoided[6]. The first part of this section provides a detailed summary of the most influential studies, which is followed by a brief overview of basics contributions to the field in the second part. The first empirical evidence comes naturally from the paper that also introduced the rule. Taylor (1993) analysed how the rule he proposed fits with the monetary policy of the FED during the period 1987 – 1992 and found that the monetary policy pursued then shadowed his rule. Nevertheless he specified that such simple equations cannot be blindly followed and offered two case study examples, when discretion would be necessary, namely the oil price shock of 1990 and the unification of Germany. Taylor (1999) published a more thorough analysis of monetary policy in the U.S. for two main periods. The first one, 1879 – 1914, is defined by the gold standard and the second, 1955 – 1997, contains the Bretton- Woods fixed and the subsequent flexible exchange rate regimes. In order to qualitatively validate his results, Taylor (op. cit.) also describes the economic background of those periods. Also, in contrast to Friedman and Schwartz (1963), who also studied monetary history in the US, a short-term interest rate replaced the money stock as the instrument of the policy rule that was used in their analysis. More specifically, by starting from the standard quantity theory of money equation and making a series of assumptions about the relation between money velocity, interest rate and the price level, Taylor (op. cit.) derives the following linear equation:

$r = \pi + gy + h(\pi - \pi^*) + r^f$ or $r = (1 + h)\pi + gy + r^f - h\pi^*$ (2.5)

where $r^f - h\pi^*$ is the intercept term, r is the interest rate, r^f the estimate of the equilibrium interest rate of the economy, π and π^* the current and target inflation respectively and y the output gap. Taylor (1993) claims that the above rule can describe the past monetary policy with the tuning of the parameters depending on the respective regime. The famous Taylor rule (op.cit.) is characterised by: $g = h = 0.5$, $\pi^* = 2$ and $r^f = 2$.

Based on the results of his analysis, Taylor distinguishes three different periods. The first one, when the interest rate was not responsive to the changes of the inflations, is from 1897 to 1914. During this interval, monetary policy was not effective in stabilizing the economy, with deflation until 1914 and significant fluctuations of output and inflation thereafter. The second period is from 1960 to 1979 when the interest rates were more responsive, but not compatible with the Taylor principle. In those years the fluctuations of output were smaller, but the inflation was persistent. Taking into consideration the negative effect on inflation of the end of Bretton Woods, Taylor ranks that period as the second worse. Finally the last one is from 1986-1997, when the short-term interest rate is more responsive, making this period the most successful period with both the inflation and the fluctuations of the output gap being stable and low. Afterwards the author identifies two major 'mistakes' of the monetary policy, in the sense that the instrument differs significantly from what two arbitrary chosen benchmark rules would suggest. The two rules are the simple Taylor rule (where $g = h = 0.5$) and a second one, where the responsiveness of the monetary instrument is greater with respect to the output gap (as illustrated by a value of $g = 1$). The two identified 'mistakes' are in the beginning of the 60s, when the monetary policy was unnecessarily too tight and in the late 60s and early 70s, when the policy was very loose, always in comparison with what the rules indicated. A third questionable period is from 1982 to 1984, when the rate should have been significantly lower. However, Taylor (op. cit.), taking into consideration the economic background, suggests that the deviation from the rules was explainable due to a transition from one policy rule to another.

Judd and Rudebusch (1998) also critically review the monetary policy in the US from 1970 to 1998 based on historical data, using a dynamic version of the Taylor rule. They distinguish three roughly

[6] While that kind of analysis can give us insight on how potential mistakes could have been avoided, it does not mean that the monetary authorities at the time 'got it wrong'. For that kind of analysis we need to use real time (ex-ante) data as in Orphanides (2001).

equal time periods, each of which covers the FED chairmanship of Arthur Burns (1970 - 1978), Paul Volcker (1979 - 1987) and Alan Greenspan (1987 - 1998) respectively. More specifically, starting from the usual Taylor-type rule the authors added another term representing a lagged output gap, so the final specification of the rule employed by them has the following specification:

$$i_t^* = \pi_t + r^* + \lambda_1(\pi_t - \pi^*) + \lambda_2 y_t + \lambda_3 y_{t-1} \quad (2.6)$$

At the next step and in order to capture the dynamic adjustment, they estimate the specification $\Delta i_t = \gamma(i_t^* - i_{t-1}) + \rho\Delta i_{t-1}$ with the two terms corresponding to the smoothing of the interest rate (first term) and maintaining to some degree the previous adjustment (second term). After substitutions, Judd and Rudebusch (op. cit.) estimate the following equation:

$$\Delta i_t = \gamma\alpha - \gamma i_{t-1} + \gamma(1+\lambda_1)\pi_t + \gamma\lambda_2 y_t + \gamma\lambda_3 y_{t-1} + \rho\Delta i_{t-1} \quad (2.7)$$

where $\alpha = r^* - \lambda_1\pi^*$. From the estimated values of the coefficients α and λ_1 a relation between the target inflation and natural level of the interest rate was extracted. Analytically in their OLS regression, Judd and Rudebusch (op. cit.) found that during the Greenspan period, the lagged output gap term is not significant, the response to the inflation gap is 0.54, close to what Taylor suggested, and that the weight of the GDP gap coefficient is 0.99. This is, in accordance with the findings of other papers (for example Rudebusch and Svensson, 1998) and higher than Taylor's suggestion of 0.5. Also, the inflation target and the real equilibrium rate varied from 1.8 to 2.8%, which is near Taylor's assumption of 2%.

For the Volcker era, the parameter ρ (which captures the lagged adjustment) is insignificant and the weight of the inflation gap is again very close to 0.5. In general though, the regression was much less precise with a standard error of 1.31% compared to only 0.27% for the Greenspan period. The authors suggest that this can be explained: because of the high inflation of the time, the Fed had a clear purpose and didn't care about tuning its reaction function, until inflation was lower. As a consequence the inflation target also varies a lot between -0.1% and 6.4%.

The most difficult to explain results are obtained for the period corresponding to Arthur Burns' chairmanship. Interestingly, the inflation gap coefficient proved to be insignificant, or in other words real interest rates were not adjusted to the changes in inflation. Theoretically, that would suggest an inflation-accommodating policy, which is also verified by the empirical evidence. According to Judd and Rudebusch (op. cit.), this is probably the result of the mis-estimated level of the natural level of unemployment of the US economy, which was later revised upwards.

An important historical analysis was conducted by Clarida, Gali and Gertler (1998), who performed a similar analysis on the monetary history of the US from 1960 - 1996, dividing the sample in the period pre and after Volcker Chairmanship. Their study is the most established reference among the papers that estimate Taylor-type interest rate rules. In contrast though with the approach followed in Judd and Rudebusch (1998), they estimated a simple forward looking rule. If the equilibrium real interest rate is given by $rr_t^* \equiv r^* - \pi^*$ and the real target rate is given by $rr_t^* \equiv r^* - E(\pi_{t+k}|\Omega_\mathrm{t})$ the implied real rate rule is given by:

$$rr_t^* = rr^* + (\beta - 1)(E(\pi_{t,k}|\Omega_\mathrm{t} - \pi^*) + \gamma E(x_{t,q}|\Omega_\mathrm{t}) \ (2.8)$$

where $\pi_{t,k}$ is the inflation rate between periods t and $t+k$ and $x_{t,q}$ is a measure of the average output gap between t and $t+q$. When in equation (2.8) above, $\beta > 1$, the Taylor principle is satisfied and the policy tends to be stabilizing. Furthermore the authors add a parameter ρ, representing the degree of interest rate smoothing and by using orthogonality properties they end up estimating the following specification using the Generalized Method of Moments (GMM):

$$E\{[r_t - (1-\rho)(rr^* - (\beta-1)\pi^* + \beta\pi_{t+k} + \gamma x_{t+q}) + \rho(L)r_{t-1}]z_t\} = 0 \quad (2.9)$$

where z_t is a vector of known instruments ($z_t \in \Omega_t$)and $\rho(L) = \rho_1 + \rho_2 L + \cdots + \rho_n L^{n-1}$, $\rho = \rho(1)$. Similar to the approach followed by Judd and Rudebusch (op. cit.) , the equilibrium rate and the target inflation are jointly estimated, but in order to isolate the target inflation the authors approximate the equilibrium real rate with the average of the samples. For the initial set of results, the horizon for the inflation and output gap is one quarter (k = q = 1) and two lagged terms of the interest rate are used (n = 2). The results showed that all the parameters are significant in both cases. More specifically, the coefficient for the inflation gap was, as expected, below 1 (0.83) for the pre-Volcker interval and much larger than 1 (more exactly, 2.15) thereafter. Also the estimated inflation target was 4.24% for the early period and 3.58% for the Volcker-Greenspan chairmanship. Finally, the ρ parameter was 0.68 and 0.79 for each period respectively, which shows a significant degree of interest rate smoothing, or, as the authors stated, significant interest rate inertia.

In the next step a robustness analysis is performed. Firstly, alternative measures for the inflation and the output gap and alternative horizons for the target variables are tested, without any major deviations from the basic specification. Secondly, Clarida et al. (op. cit.) divide the samples based on the chairmanship and estimate the parameters again, allowing in that way for the inflation target π* to vary among subsamples. They also estimate the reaction function for the period 1983 - 1996, which corresponds to the Greenspan and Volcker years after the rapid disinflation of 1980-1982, when in addition to inflation the Federal Reserve targeted non-borrowed reserves. The results in those cases verify also the robustness of the results, with the only notable change being the fact that for the after 1982 period the coefficient of the output gap becomes insignificant. The latter could hint that the Fed applied a "pure inflation strategy" policy. Finally, thirdly a backward-looking rule (with k = q = -1) was also estimated for the sub-periods. As before, the key qualitative findings remain intact.

A similar approach to that of Clarida et al. (1998) and Judd and Rudebusch (1998) is implemented for the UK by Nelson (2000). He divided the 1972-1997 interval in 7 different periods, based on the (different in each case) regime of the Bank of England, and for each such period he estimated both a backward- and a forward-looking rule. In contrast with the other approaches though, Nelson does not analyse the intercept term, stating instead the ex post real rate for each of the sub-periods. In addition he estimated a simple Taylor rule for the whole sample, but found the regression to have a poor and econometrically questionable fit.

The backward-looking rule, which contains lags of inflation, output gap and interest rate with the latter representing the interest rate smoothing, is the following:

$$R_t = k + \sum_{i=1}^{j} a_i \Delta_4 p_{t-i} + \sum_{i=1}^{j} b_i \widetilde{y_{t-i}} + \sum_{i=1}^{j} c_i R_{t-i} + e_t \quad (2.10)$$

The forward-looking rule, which was estimated with the method of instrumental variables is:

$$R_t = k + a_0 E_{t-1}\Delta_4 p_t + a_{-1} E_{t-1}\Delta_4 p_{t+1} + \cdots + a_{-4} E_{t-1}\Delta_4 p_{t+4} + b_0 E_{t-1}\widetilde{y}_t + \sum_{i=1}^{j} c_i R_{t-i} + e_t \quad (2.11)$$

The first period under examination was from July 1972 till June 1976 and covered the floating exchange rate regime till the end of the pre-monetary targeting era. During this period only the parameters for the backward-looking rule proved to be significant, with values of 0.14 for the inflation gap and 0.59 for the output gap. Qualitatively it seems that monetary policy reacted mainly to the lagged value of the output performance and only marginally to inflation. July 1976 until April 1979 corresponds to the period of monetary targeting before the election of the Conservative government. Here the estimation of the backward-looking rule was not helpful, since all the parameters proved to be insignificant. In the final regression for the forward-looking rule, after deleting the insignificant parameters, the most significant coefficient is the expected annual inflation nine months ahead with a weight of 0.62. Also, evidence of interest rate smoothing was present. Because of the depreciation of the British Pound in 1976, Nelson (op. cit.) attempted to add a lagged money growth and exchange rate terms in the regression. Both parameters proved significant, without at the same time altering the weight of the response to inflation. That could indicate a tighter monetary policy, but after examining the real interest rate, which was on average negative throughout that period, Nelson concludes that the monetary authorities continued to follow an inflation accommodating policy.

The period after the election of Margaret Thatcher (May 1979 to February 1987) was largely characterized by the Medium Term Financial Strategy (MTFS) adopted in March 1980 and the targeting of M3, which was abandoned in October 1985. The regressions showed a significant amount of interest rate smoothing, with the corresponding parameter having a value of 0.33. The results from both backward and forward-looking rules were very similar to all the parameters having values between 0.16 and 0.34. By combining all regressors, Nelson (op. cit.) identified that monetary policy responded mostly to the estimated current inflation in comparison to the expectation of its future values. More specifically, the coefficients were 0.38 and 0.15 on inflation and output gap respectively. Those results were heavily unexpected, since they are contradictory to the Taylor's(1999) and Clarida's et al. (1998) results for the US, according to which, periods of disinflation were characterized by a larger than unity weight on the inflation gap. Nelson identifies the reason for this in the unusually high level of the real interest rates in that period, which far exceeded the equilibrium rate. Graphically, that means that although the slope of the rule was not steep enough, the intercept parameter was quite large and that was the disinflationary force. The fourth period is from March 1987 to September 1990 and corresponds to the informal linking of the British Pound to the Deutsche Mark. During that period both rules contained an extra parameter reflecting the response to the German nominal rate. That parameter proved to be the most important (value 1.11), while at the same time there was evidence of significant interest rate smoothing. The output gap also had a positive coefficient but all the related to inflation parameters were insignificant. Moreover the real ex post interest rate was high (5.76%) and the nominal rate was considerable higher than the German one. Thus Nelson (op. cit.) notes the paradox of a monetary policy that seemed 'tight', but with a rising inflation at the same time. As a possible explanation the author states that the high rates of monetary growth for that period could have been the source for the exploding inflation. The final interval for the estimation is characterized by the inflation targeting regime, prior to instrument independence of the Bank of England (October 1992 to April 1997).The estimated parameters of the backward looking rule proved to be negative and insignificant. The regression for the second rule after maintaining only the significant variables, showed a weight of 1.27 and 0.47 for the inflation and output gap, values which seem in accordance with the rest of the research and close to the values in Taylor's original paper for the US monetary policy. Nelson concludes that the most important lesson from his analysis is probably that a restrictive monetary policy is not necessary characterized by a strong response to the inflation gap, but could also mean a significant increase in the average real rate, which is possible in the short-run due to inflation inertia.

The above studies are among the first and most influential examinations of how simple instruments rules like the Taylor-type rules can be used to analyse monetary policy based on historical data. Other similar investigations focused on Europe include: Peersman and Smets (1998), Gerlach and Schnaber (2000) and more recently Eleutheriou et al. (2006). An important and increasing part of the literature examines how nonlinear specifications can be used in order to study the monetary policy over the last years. A first simple approach consists of formulating augmented instrument rules by adding nonlinear terms to the linear specifications. Such rules are presented below (Dolado et al., 2000), where the target variable is the output gap. Similar rules can be constructed for all of the variables of the regression.

The first rule allows for a completely different response when the variable under examination (target variable) is above or below a certain threshold, dampening in that way the effects of potential asymmetries in the monetary policy. The second rule allows for a different degree of response to the target variable, which captures, for example, the empirical evidence of the inflation having a greater weight as it deviates more from the target.

$$r_t = \alpha + \beta_1 r_{t-1} + \beta_2 \pi_{t+n} + \beta_3 (y_t - y^*)^+_{t-3} + \beta_4 (y_t - y^*)^-_{t-3} + \beta_s r^f_{t-1} + u_t \quad (2.12)$$

$$r_t = \alpha + \beta_1 r_{t-1} + \beta_2 \pi_{t+n} + \beta_3 (y_t - y^*)_{t-3} + \beta_4 (y_t - y^*)^2_{t-3} + \beta_5 (y_t - y^*)^3_{t-3} + \beta_6 r^f_{t-1} + u_t \quad (2.13)$$

The second and possibly most commonly employed approach consists in specifying a Smooth Transition Autoregressive model (STAR, Teräsvirta, 1994; Granger and Teräsvirta, 1993). This is a generalization of the regime switching threshold autoregressive (TAR) model (Tong, 1990) and allows for a gradual adjustment between the regimes. Its representation is provided in equation (2.14) below:

STAR: $y_t = \beta_o + \sum_{j=1}^{p} \beta_j y_{t-j} + (\beta_0^* + \sum_{j=1}^{p} \beta_j^* y_{t-j}) G(s_t;\ \gamma, c) + \varepsilon_t$ (2.14)

or, more general, with linear algebra and rearranging:

STAR/STR: $y_t = \varphi_1' x_t \big(1 - G(s_t;\ \gamma, c)\big) + \varphi_2' x_t \big(1 - G(s_t;\ \gamma, c)\big) + \varepsilon_t$ (2.15)

Where ε_t is a white noise error term and G is the transition function, which governs the transition between regimes. Two of the most commonly used transition functions are:

Logistic: $G(s_t;\ \gamma, c) = (1 - exp\{-\gamma(s_t - c)\})^{-1}$ (2.16)

Exponential: $G(s_t;\ \gamma, c) = 1 - exp\{-\gamma(s_t - c)^2\}$ (2.17)

in which case the model are named LSTAR and ESTAR respectively and their main difference is that the LSTAR models describe asymmetric, while the ESTAR models imply a symmetric behaviour. Parameter γ $(\gamma > 0)$ controls how smoothly the value of the transition function changes and consequently it controls the speed of the transition between the modelled regimes. The variable s_t is the transition variable and is, in the context of the STAR models, a lagged autoregressive term, y_{t-j}. While γ controls the speed of the adjustment, the deviation of the transition variable from a threshold (represented by the constant c) controls its 'direction'. If exogenous variables are included (meaning that x_t does not necessarily contain lagged values of the dependent variable) then the resulting model is the Smooth Transition Regression model (STR - Teräsvirta, 1996) and Equation 2-15 describes that model as well. Testing linearity specifically against STAR models is relatively simple and (following Luukkonen et al 1988) involves a Taylor series approximation of the transition function and a Lagrange Multiplier (LM) statistic on the resulting linear auxiliary regression. The estimation of the rest of the parameters is usually performed with nonlinear least square (NLS) regression, usually combined with a grid search in order to determine suitable initial values for the coefficients γ and c. A full step by step analysis of testing and building a model of the STAR family is described in van Dijk et al. (2002).

The property of describing two (or more) regimes and gradually switching among them has made STAR models quite useful for describing different aspects of monetary policy. ESTAR models, thanks to their nonlinear mean-reverting property, have proved to be especially useful in different parts of exchange rate analysis. Michael et al. (1997), Taylor et al. (2001) and Kilian and Taylor (2003) provide empirical evidence that the ESTAR model fits reasonably well the deviations from the Purchasing Power Parity (PPP). Kilian and Taylor (2003) again with the help of an ESTAR model confirm those results and research whether those non-linearities were one of the reasons for the dominance of the random walk when it came to forecasting exchange rates. They conclude that although over a 3-year horizon the models explain adequately the exchange rate fluctuations, over the shorter the random walk is still unbeatable. By fitting an ESTAR model, Taylor and Peel (2000) provide empirical evidence of a nonlinear mean-reverting relationship for the deviation of nominal exchange rates from the underlying monetary fundamentals.

A more relevant to the present study scenario is the approach of Martin and Milas (2004) who analysed the monetary policy in the UK over the period 1972-2000 and estimated the following STR specification:

$$i_t = \alpha + \theta_t M_{1t} + (1 - \theta_t) M_{0t},$$

where M_{1t} and $M_{0t}$are typical forward looking Taylor rules and θ_t is the transition function, which in that case, is the Quadratic Logistic Function:

$$\theta_t = (1 - [1 + exp\{-\gamma(\pi_{t+1} - \pi^L)(\pi_{t+1} - \pi^U)\}])^{-1}$$

In that scenario rule M_{1t} corresponds to the 'inner' regime ($\pi^L < \pi_{t+1} < \pi^U$and M_{0t} to the 'outer' regime. Each time, depending on the transition variable (expected inflation) there is a gradual adjustment towards one of the regimes. A novel feature of the approach pursued by Martin and Milas (op. cit.) is that the transition variable is not a lagged value but a forward-looking one. A similar approach is employed by Arghyrou (2006) for the interest rates in Greece from 1990 to 2000. Bec et al. (2000) shadow Clarida's et al. (1998) approach, but they fit a STR model (with logistic transition function and lagged output gap as the transition variable) instead of a plain forward looking rule. Bec et al. (op.cit.), Martin and Milas (2004) and Arghyrou (2006) found that the STR family of models provides better results than the simple Taylor rules. A more recent and thorough comparison between the linear and STR-type nonlinear Taylor rules for three central banks, namely the FED, ECB and the Bank of England, was conducted by Castro (2008). What distinguished his approach from that of the others who apply a nonlinear modelling framework is the addition of a term that corresponds to asset prices, which is found to be significant only in the case of the ECB.

Another study that employs STR models is that by Bruggemann and Riedel(2011), who study inflation in the UK from 1970 to 2006 using both linear Taylor-type rules and nonlinear STR models. Instead of distinguishing between two distinct regimes, they divide the model’s specification into two parts: a linear part and a nonlinear one. Moreover, by combining the linear and nonlinear effects for each variable, they estimate a time-varying equivalent for every term.

Building on the assumption that a central bank has recession and inflation avoidance preferences, Cukierman and Muscatelli (2008) construct a complex STR model in which both inflation and output gap behave in an asymmetric, but independent of each other, way:

$$i_t^* = \alpha + \beta_1 \pi_{t,1} + \gamma_1 x_{t,1} + \beta_2 (\pi_{t,1} - \pi^*) \tanh[\varphi_\pi (\pi_{t,1} - \pi^*)] + \gamma_2 x_{t,1} \tanh[\varphi_x (x_{t,1})]$$

The transition function they used by Cukierman and Muscatelli (op. cit.) is the hyperbolic tangent function and the transition thresholds are the inflation targets and zero respectively.

Other approaches for modelling nonlinearities include Markov switching (MS) and artificial neural network (ANN) methods. The ANN models are mainly used for forecasting and not analysis of monetary policy because the procedure of reaching the final outcome is obscured[7] and no intuitive conclusions can be drawn. On the other hand, MS models can provide meaningful insights (Assenmacher-Wesche,

[7] It is commonly stated that the processing stage in neural network models takes place in a black box.

2006), but two other shortcomings arise. More specifically, with forward looking specifications, an endogeneity bias arises (since for their estimation instrumental variable techniques are not used) and more importantly the regime switches are assumed to happen instantaneously and not gradually as it is usually desired.

Finally, most of the studies on monetary policy, which are based on historical data, assume that the coefficients in the regression of the instrument rule remain constant throughout the period under examination. In order to overcome this issue, the period is usually divided into subsamples based on considerations such as example explicit changes in regimes or chairmanships). STR models can provide a solution (Bruggemann and Riedel (op.cit.)); however they assume a specific transition function. Kim and Nelson (2006) introduced an innovative method to estimate a forward-looking specification with time-varying parameters. According to this method, the coefficients of the rule are assumed to follow a random walk and the relation of the endogenous regressors with their instruments is assumed to time-vary as well[8].

Regarding monetary policy in Greece, the most thorough historical analysis, which covers the last two centuries is carried out buy Lazaretou (2003). Alogoskoufis (1995), along with the political background, examines the fiscal and monetary reasons for the increase in inflation and its effects for the period 1970 to 1992. In general, the largest part of the research focuses on inflation, since the rapid disinflation is considered the most significant success of Greek monetary policy. Important contributions include Garganas and Tavlas (2001), who examine the performance of inflation under different regimes from 1975 to 2000, Hondroyiannis and Lazaretou (2004), who studied inflation persistence on Greece from 1975 to 2003, and Gibson and Lazaretou (2001), who, assuming that inflation is cyclical, investigate possible leading indicators of inflation based on data from 1954-1998. A more general description of the monetary transmission mechanism in Greece is provided by Brissimis et al. (2001) and finally Papaspyrou (2004) reviews the convergence effort towards the monetary intergration from the perspective of Greece. However, the only relevant, in the sense of using Taylor-type rules, to the present work is, from what we gathered, the research of Arghyrou (2006), who studied the monetary policy in Greece during the 90's and investigated whether it was compatible with the ECB monetary policy after the admission of Greece to the Eurozone. Arghyrou (op. cit.) estimates a forward-looking rule similar to the one in Clarida et al. (1998). The 3-month interbank rate is used as the short-term nominal interest rate and the industrial production, excluding construction, is used as a proxy for the output. Arghyrou notes that the results showed a moderate interest smoothing, a weight on expected inflation marginally larger than 1and a negative and insignificant coefficient attached to the output term. When a one period lagged foreign interest rate term is added, the results were similar in respect to the output gap term and the degree of interest smoothing. However on the other hand the regression seemed more accurate (smaller standard error) and it was estimated that the Bank of Greece responded mostly to the exchange rate changes (with a coefficient of 1.11), rather than to inflation (0.577). Arghyrou (op. cit.) also estimates linear models that allow for different reaction functions similar to those shown in equations (2.12) and (2.13). However the results did not add anything to the previous analysis. Arghyrou (op. cit.), in order to investigate for potential non linearity in the relationship between interest rates and output, estimates STR models with logistic and quadratic-logistic reaction functions. The results confirmed that the reaction function of the Bank of Greece mainly responded to the foreign interest rates. Though, at less frequent intervals, during which the output gap was large (overheated economy), the nonlinear models suggested that the weight on expected inflation was the determining factor. Finally in the last part of his research, the author compares the monetary policy of the ECB to that of the monetary authority of Greece, by producing out of sample forecasts of the implied policy implemented by the Bank of Greece during the period 2001-2006. The author concludes that even after taking into consideration the lower natural real

[8] Due to the time-varying parameters, the GMM cannot be used for the estimation. For different approaches see Kim and Nelson (2006) and Baxa et al. (2014).

interest rate during the years after the admission to the Eurozone, the Greek rate would have been about two times higher than the EMU one.

The literature regarding monetary rules is voluminous and this literature review discusses only a selection of contributions. A more thorough review of the Taylor rule can be found Asso et al. (2010). The research though is still on-going and expanding. On the forefront are issues regarding rules under uncertainty (over the natural unemployment rate (NAIRU), equilibrium real interest rate and interest rate inertia) and the zero lower bound (ZLB). While the liquidity trap is not a new phenomenon (as it was present in the Great Depression in the US and more recently in the 90s and early in the century in Japan), the aftermath of the financial crisis of 2007 left a large part of the developed economies near the ZLB, which has spurred a new round of research. An overview can be found in Taylor (2010) and the references therein.

3 An Overview of Social, Political and Economic Developments in Greece past 1970

A survey on the macroeconomic policy of Greece during the last part of the 20th century would not be complete without briefly describing the social and political background. While the political cycle always influences more or less the way in which a country is governed, this phenomenon appeared more intense in Greece during the period under examination, not least because of the political instability. For that reason, when appropriate, along with the macroeconomic policy review, the relative political context will be presented as well.

In general researchers divide the monetary 'behaviour' of Greece into two main and one transition period. The first one is from 1974 to 1990 when, with the exception of a small window from 1985 to 1987, a stabilization program was implemented. During those years the Greek economy performed very poorly and was characterized by a very high inflation, poor growth rates, large deficits and large and negative trade balance. Moreover, stagflation was present from 1979-1984. The second period is broadly from 1994 to 2001, year of the entrance of Greece to the Eurozone. Rapid disinflation took place with high and consistent growth rates at the same time. The authorities followed a monetary policy with the nominal exchange rate as an anchor, a relative restricted fiscal policy and the labour market and the financial system were deregulated. The transition period covers the years 1990 to 1994, when inflation dropped significantly, the financial regulatory reforms moved faster but the growth rate was near zero.

Greece was the last country, among the EU members, to re-establish democracy after the fall of the military dictatorship in 1974. The country was still, to a large extent, divided with a large degree of discord and discrimination among the plebeian and patricians that the former regime had created. The governments during the rest of the decade, in an attempt to re-distribute the wealth, followed a policy which included nationalizations and large increases to the real wages. That policy combined with the increasing expenditures for defence lead to increased government spending.

From a monetary perspective, after the collapse of the Bretton-Woods system the drachma was pegged to the dollar and significantly devalued against it until 1975, when it started floating against a basket of currencies (Lazaretou, 2003). The sliding is apparent in graph as the real effective exchange rate (REER) over that period keeps deteriorating. As Alogoskoufis (1995) describes, the 'overheating' of the economy due to the expansionary monetary policy, along with the oil crisis of 1973, pushed inflation to high levels. In general, although the economy had slowed down, the growth rate remained comparable to the average growth rate in Europe, mainly thanks to an increase in the exports to the Middle East (Lolos, 2003). The structural deficiencies of the economy kept slowing down the growth rate, the real interest rate was consistently negative, in order to be easier for the governments to finance their deficits, and as a result the oil crises of 1979 pushed the inflation even higher, above 20% (see Figure 3-2 below).

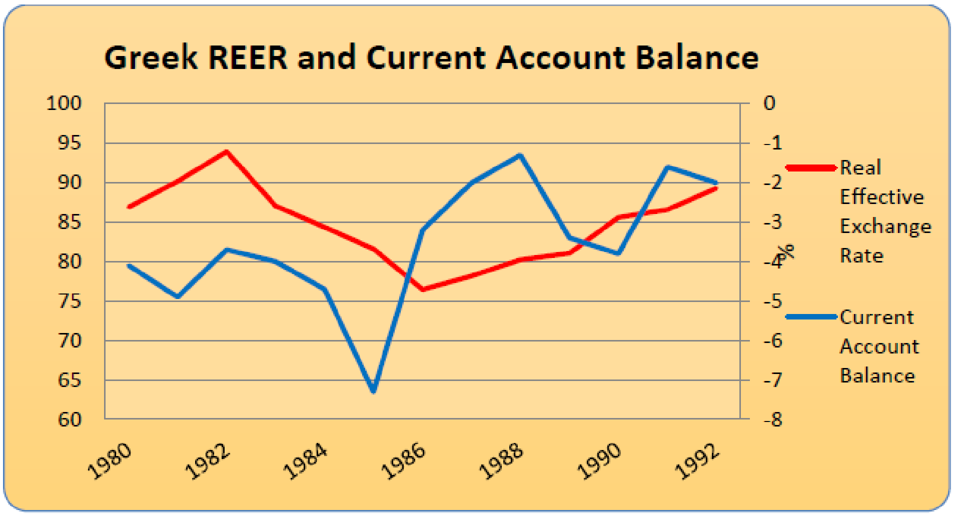


Figure 3-1 Real Effective Exchange Rate and Current Account Balance 1980-1992

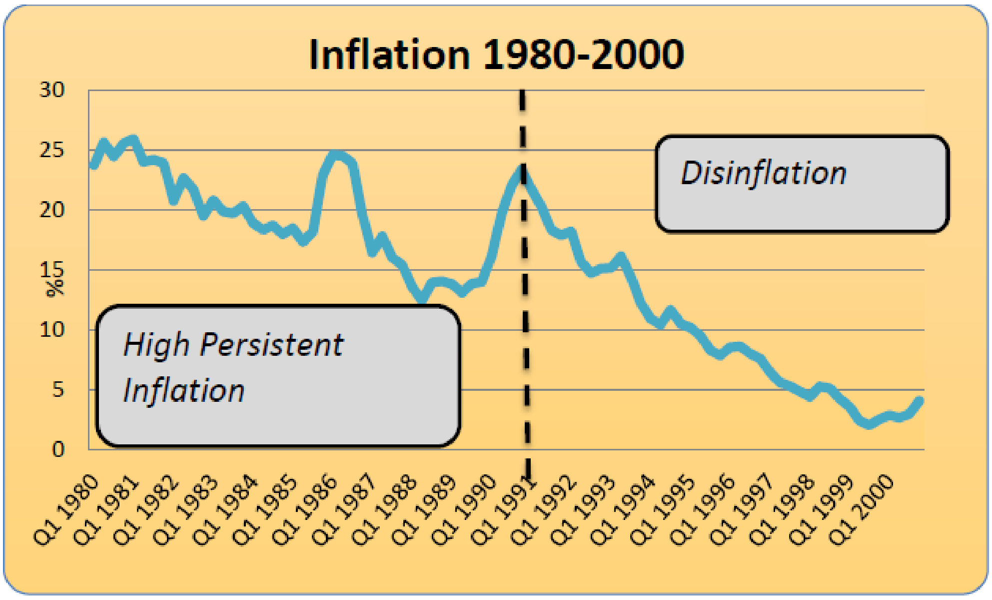


Figure 3-2 Inflation 1980-2000

The elections of 1981 were won by the socialist party under the promise of a society with less inequality and fairer income policy. So in the following years the minimum wage was significantly increased (by 40%), the nationalizations continued and more importantly an automatic wage indexation system was implemented. As Garganas and Tavlas (2002) state, this indexation worked as a multiplying mechanism and through that mechanism, an initial inflation push could affect wages and confine inflation to higher levels". The fiscal deficit, which was already increased the pre-election year, kept increasing (Figure 3-3) and reached 10% at 1985. Those deficits were financed mostly by printing money[9], which also contributed to the high inflation rate. Regarding monetary policy, in 1982 the Currency Committee was disbanded and most of its responsibilities were transferred to the Bank of Greece, which in 1983 started targeting M3 instead of M0. The price control methods though were strengthened and the deregulations of the financial markets were almost stagnant. In the meantime Greece joined the European Union in 1981, which meant that the economy was suddenly competing with more advanced

[9] Alogoskoufis (1995) notes that segniorage was also an important source of income.

and restriction-free economies. In addition, the competitiveness gap kept widening as well, due to the fact that the real wages kept increasing faster than the productivity gains since the nominal exchange rate didn't depreciate in such a degree to compensate for the inflation differentiation among Greece and its trade partners (although the drachma devalued in 1983 by 15% against ECU). As a result the current account balance kept worsening as is evident from Figure 3-1 above.

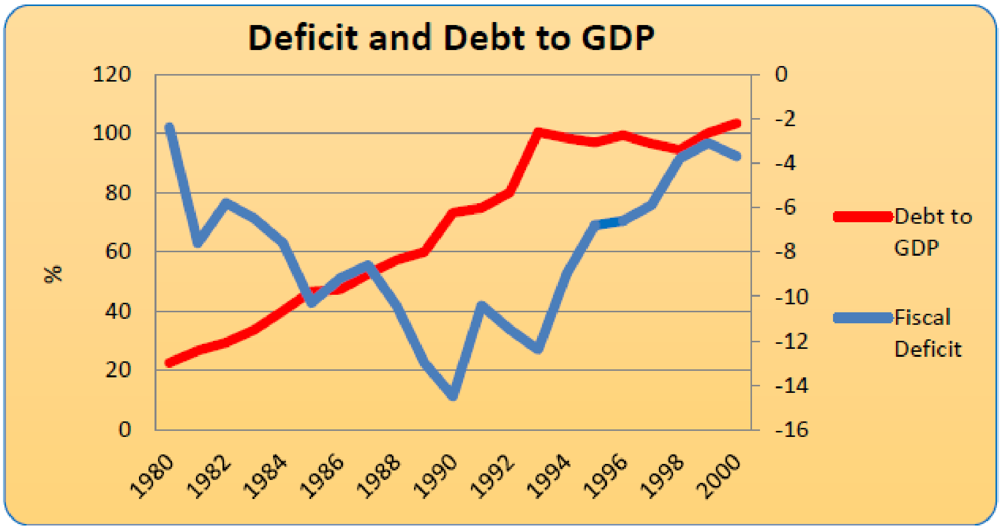


Figure 3-3 Deficit and Debt to GDP

As the economy kept deteriorating, after the elections of 1985 the government announced a two-year stabilization program. The drachma devalued by 15% in order to increase competitiveness, the public expenditure was reduced, the real wages fell and the monetary and fiscal policy became tighter. The program was implemented as planned and at the end of 1987, the deficit had decreased, the account balance had improved and the inflation had stopped accelerating and fell to almost 15%, 4% of which is attributed to the introduce for the first time of VAT. Moreover, Hall and Zondilos (2002) note that the reforms during those years had long lasting effects on the dynamics of inflation.

Unfortunately the stabilization program didn't continue after 1987, due to social unrest on the one hand and the political cycle on the other, as the elections grew closer. Even worse the long lasting political instability in 1989 caused all the main indexes to deteriorate and inflation jumped again above 20% at the beginning of 1990.

The period from 1990-1993 is referred to as a transition period by most analysts. The reason is that the years before 1990 were characterized by high inflation and negative or low growth and the years after 1994 by disinflation, low inflation thereafter and strong growth rates. In 1991 another stabilization plan was put into motion and the account balance and inflation were significantly reduced. That occurred mainly due to a strict income policy (wage indexation was cancelled among other measures), since the reforms to the labour market and financial sector in general did not accelerate as planned. Once more though the forthcoming elections put a stop to the program and in 1993 the policy was relaxed. As a result the convergence program, which was submitted by the government in March 1993 in order to achieve an on time entry to the EMU was abandoned a few months later.

The most long-lasting and successful stabilization and convergence effort started in 1994. The country complied with the requirements of the Maastricht treaty, meaning that it could no longer finance its debt by printing money. Also the final restrictions on capital flow were lifted and by 1995 the economy had been in a large part deregulated, an effort that had lasted more than a decade. The monetary policy was based on what was called the "strong Drachma" dogma, an exchange rate targeting regime, which was announced in 1995. The Bank of Greece used for the first time the nominal exchange rate[10] of the Drachma versus ECU as its anchor and set as its primary target to keep it stable (less than 3% variability)[11]. At the same time the fiscal policy was equally strict partly in order to also fulfil the regarding deficit and debt Maastricht criteria and partly in order to provide added credibility to the monetary policy.

The above mix of policies succeeded to put the public finance in order and bring the inflation low, and more specifically by 1997 the deficit was 4% and inflation less than 5%. The process was not without obstacles though and especially two of them stand out. The first one was the increase in the current account balance gap, which reached 6% in 1997 (Figure 3-4). As Lazaretou (2003) notes, the limited depreciation of the Drachma did not fully accommodate the inflation differentials between Greece and the average of EU and thus it lead to a significant increase to the real effective exchange rate, as the graph below shows. An immediate consequence was a competitiveness loss, which was estimated as the main reason of the increase of the current account gap. It should be noted though, that the Bank of Greece and researchers like Papazoglou (1999) find that the competitiveness loss was not as large as the appreciation perhaps implied, because it didn't take under consideration the long-term reduce at the cost of raw material, which in the case of a small open economy as Greece's was quite important.

The second problem was caused by large capital inflows and outflows and three incidents stand out. The first one was the capital outflows in 1994, just before the lift of the last restrictions for the capital movements, when it was expected they would be accompanied by devaluation. As Brissimis et al. (2002) describe, the authorities responded by rushing the lifting of the restriction, along with increasing significantly the short term interest rates (spike shown in Figure 3-5) and sub charging the overdrafts for the banks from their current account with the central bank.

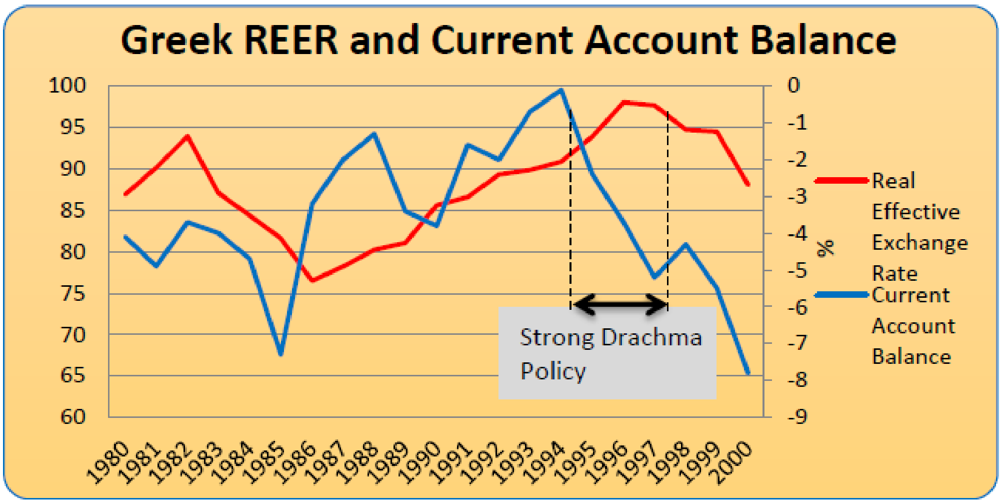


Figure 3-4 Real Effective Exchange Rate and Current Account Balance 1980-2000

The next incident was the large capital inflows from 1995 until 1997, caused by prevailing high real interest rates. Those flows could increase the monetary base and put downward pressure to the nominal interest rates. That threatened the long term policy goals, which forced the Bank of Greece to take measures (such as the increased reserves requirement) to absorb the excess liquidity. Similar

[10] The Bank implicitly targeted the exchange rate from 1989.
[11] Garganas and Tavlas specify that a secondary target was the restraint of the monetary base, measured by M3.

capital flows took place in 1999 when it seemed likely that Greece would enter the Eurozone in 2001 with the Bank of Greece acting similarly and swiftly[12].

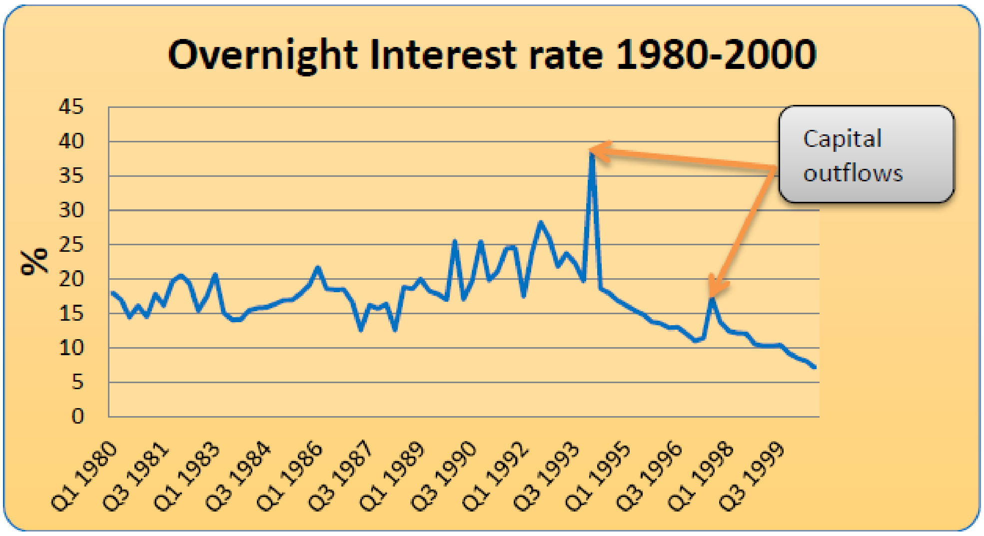


Figure 3-5 Overnight Interest Rate 1980-2000

The third and most significant incident occurred in 1997 when the capital flow was turned, partly due to the financial crisis in Asia and partly due to the belief of the financial markets that a devaluation of the Drachma was imminent (Papademos, 2007). The perception that the exchange rate was not sustainable was followed by a speculative attack at the Drachma and was the most serious threat to the convergence program. The Bank of Greece increased the interest rate to very high levels in an attempt to defend the exchange rate and shortly after the solution was given by the entry to the ERM mechanism with a devaluation at the same time of 12.3%.

The strategy proved to be successful in two fronts, as the speculative attacks stopped and Greece stayed on track regarding the fulfilment of the entry criteria. The entrance to the ERM, which was a pre-requisite of the Maastricht treaty, along with the instrument independence, which was granted to the Bank of Greece at the same time, lead to a credibility gain for the monetary policy. At the same time, it was a firm demonstration of the dedication and commitment of Greece to the long term target of entering the Eurozone[13]. The devaluation had a minor effect on inflation, but the high interest rates (Garganas and Tavlas (2001) document real rates of 8% and 9% shortly after), the tight fiscal policy and the strong growth rate absorbed the extra pressure.

Finally the appendix describes the major monetary developments towards the entrance to the Euro. It is mostly based on Voridis et al. (2003), Lazaretou (2003) and Papapetrou (2004).

[12] Mprisimis et al. (2002) describe analytically the actions of the Bank of Greece.

[13] Apart from the significantly improved macroeconomic measures, an extra parameter that fend off the attacks on Drachma was, oddly, the absence of an alternative plausible scenario, as it meant the only choice was to stay on track. According to some researchers like Artis (2001) that was a characteristic difference when the UK left the EMS. At the time there was a perfectly viable alternative scenario, which the markets favoured.

4 Policy rules in practice: the case of Greece

4.1 The data

The period under examination is from 1980 to 2000, as the data before 1980 were not available or, in some cases, reliable. When an instrument rule was estimated for an interval longer than nine years, quarterly data were used. In contrast, in order to perform analysis on shorter intervals we switched to monthly. Since, in that case data for the real GDP were not available, the industrial production excluding construction was used as proxy. The source for the overnight interest rate was the Bank of Greece and for the other variables the database Datastream. Inflation was measured by the yearly CPI index and the foreign interest rate was the German day-to-day rate until 1998 and the 3- month EMU money rate afterwards. In order to get the underlying output trend a Hodrick–Prescott filter (the smoothing parameter λ = 1600) was applied to quarterly real GDP (or accordingly monthly industrial production) data and the output gap was constructed as the percentage deviation of the latter from its implied trend. In addition the stationarity of interest rates is a subject under debate, since it appears they are stationary over the whole sample, but not always over smaller samples (Clarida et al., 1998).

In the first part of the analysis different specifications of Taylor rules were estimated, both backward- and forward-looking. The former were estimated by OLS, while for the latter the Generalized Methods of Moments (Hansen 1982) was the preferred solution[14]. In all cases, the instruments used for the GMM were the 1-4 lags of the inflation, output gap, interest rate, the exchange rate vis-a-vis ECU, the 3 month treasury bills and finally two dummy variables correcting for the outliers due to events such as speculative attacks) at the second quarter in 1994 and the 4th in 1997. When a foreign interest rate is among the regressors, the instruments also include the 1-4 lags of the foreign day to day interest rate.

Following the approach of Nelson (2000), we do not interpret the intercept terms as the sum of equilibrium interest rate and target inflation. Any possible insights from the above decomposition would be questionable since, as it will be discussed below, the monetary policy did not hold such a prominent role in confiding inflation. Furthermore the data are revised so the notion of implicit inflation target would be invalid anyway. Finally even if the data were the real time data, the implicit target would probably still be biased, since the models that are used to represent the economy and the transmission channels of the monetary policy have evolved a lot and changed the weight each parameter holds in planning the monetary policy.

In the second part of the analysis, a series of structural break tests were used to validate the theoretical background for the fragmentation of the whole period into sub-periods with distinct characteristics. At the next stage, nonlinear tests and not linear rules were estimated. Finally the robustness of our results is evaluated.

[14] Since the samples were not large, the TSLS was also used, but the results were not satisfactory, as they did not provide any insights (usually most of the parameters were insignificant). That could perhaps be attributed to the presence of heteroskedasticity, but the results didn't improve even after correcting for it. The results are available upon request.

4.2 Linear Taylor-type rules

4.2.1 Full sample period

Table 4.1 presents the results for three backward- and three forward-looking specifications that returned the most sensible outcome. The naive rule is the usual Taylor rule, serving as a benchmark. It provided better results when the lagged real GDP was included, but even in that case the latter remained insignificant. Also the coefficient of inflation was only 0.369, while the Durbin- Watson statistic indicated the presence of autocorrelation.

If some degree of interest rate smoothing is added to the rule, the main statistics improve but the R-squared remains rather low and the standard error of the regression large. Qualitative the results are of no importance, as the smoothing coefficient is too large (0.537), the response to the output gap remains insignificant and the response to inflation only 0.188. It should be noted here, that when extra parameters were used in the regression, such as the yearly change in M3 or foreign interest rates, they ended up being insignificant without significantly affecting the other coefficients. The third backward looking Taylor type rule is the specification proposed by Judd and Rudebusch (1998). Also in that case no noteworthy insights can be drawn from the results. Important coefficients are insignificant and also the parameter delta that indicates the 'momentum' from last period's change is negative, meaning the rates are moving into a different direction.

1980-2000	*Naive*	*Smoothing*	*Judd-Rudebusch*	*Forward1*	*Forward2*	*Forward-Nelson*
C	11.82(1.15)	5.16(1.54)	3.036 (1.62)	4.23 (1.27)	4.95 (1.12)	3.9 (1.15)
Inflation	0.37(0.073)	0.188(0.07)	0.15 (0.06)	-	-	insignificant
Inflation(2)	-	-	-	-	-	insignificant
Inflation(3)	-	-	-	-	-	1.2 (0.42)
Inflation(4)	-	-	-	0.18(0.05)	insignificant	-0.92 (0.39)
Output Gap	-	-	insignificant	insignificant	0.275(0.087)	0.295 (0.17) *
Output Gap(-1)	insignificant	insignificant	insignificant	0.2 (0.07)	insignificant	insignificant
Smoothing(-1)	-	0.537 (0.096)	0.69 (0.1)	0.59(0.09)	0.51(0.076)	0.33 (0.09)
Smoothing(-2)	-	-	-	-	-	0.26 (0.07)
Foreign Rate	-		-	-	0.46(0.15)	insignificant
Delta	-	-	-0.321 (0.11)	-	-	-
R-squared	0.253939	0.471	0.531956	-	-	-
Prob(J-statistic)	-	-	-	0.87	0.855895	0.93713
S.E. of regression	4.4068	3.735	3.56	3.879459	3.742466	4.003311
Durbin-Watson	0.940419	2.356353	2.220243	2.419852	2.398758	2.098345
ARCH	0.102[0.75]	1.825[0.181]	0.405[0.526]	2.04[0.16]]	1.322[0.254]	0.108[0.74]

*NOTES: * indicates significance at 10%*
ARCH is the F-test with p-values in square brackets

Table 4-1: Estimated policy rules over the period 1980-2000

With respect to the forward looking rules, the first rule we estimate is the most common forward looking specification, initially proposed by Clarida et al. (1998) and the second is modified to include a term corresponding to the German interest rates. The third resembles Nelson's (2000) approach, in the sense that it includes terms of the expected inflation for the four following quarters and not only for the fourth one.

As a general comment the estimates are rather contradictory. The foreign interest rate is highly significant in one rule, but insignificant for the other. Also, in two rules the contemporary output gap term was included in the regression, while in the third rule the lagged term ended up being more significant. On the other hand, the long term response to inflation was similar, when the German rate was not included in the regression or it was deemed insignificant. Also all 3 specifications showed a rather large degree of interest rate smoothing (more than 0.5 in all cases). Finally in all cases the SE was significant, near four.

It is therefore obvious that the monetary policy in Greece during 1980-2000 cannot be described using a single Taylor-type rule. The absence of a promising result is positive in the sense that it was the expected outcome. As explained in the previous sections the whole sample contains two clearly distinct parts, before and after 1990. Even more, smaller samples, such as that corresponding to the stabilization program of 1985, add potentially major disturbances to the estimation, so a single regression would not be expected to be accurate.

4.2.2 The 1980-1989 period

At the next step the analysis is restricted at the period 1980-1989, which corresponds to a period with high and persistent inflation. The results with the corresponding long term solutions are shown at the following tables. As before, the specifications with the best performance were chosen.

The first apparent observation for the backward looking rules is that they are a better fit. The R squared is still low, but the SEs are halved and the Durbin-Watson stats are closer to 2. Most importantly though, all 3 rules are consistent with each other. All indicate that the term related to inflation is insignificant and the coefficient of the lagged output gap is significant and between 0.38 (naive) and 0.6 (the other 2). The contemporary output gap was insignificant and was dropped at the earlier stage of the regression. This might be in contrast with some of the relevant literature, according to which, the central bank might have internal information about the major macroeconomic measures before the official announcement, so it is not uncommon to respond to the contemporary and not the lagged term of output. Taking into consideration though both the questioning integrity of the Greek national statistical service (ESYE)[15] and the lack, at the time, of appropriate mechanisms for gathering statistics, our findings seem appropriate.

A disconcerting at first sight figure is the large intercept term. If we proxy the equilibrium real rate with the average prevailing real interest rate (-2.3%)[16], then the rule with the smoothing adjustment would give a target inflation around 18%. Given the high and persistent inflation throughout the decade (with

[15]This is based on 3 generally accepted assumptions. Firstly, during the 80s the employees of the statistical service used to change depending on the elected government. Secondly, the disagreements with EUROSTAT in a series of matters, with the latest being the deficit for the years 2007-2009, are well documented. Thirdly, only in 2010 was ESYE reconstructed into ELSTAT (Greek Statistical Authority) and was granted independence from the relevant ministry.

[16] The estimated constant term $c=\alpha(1-\rho)$ and α= average real rate + (1 - β) * target inflation. For the long run: *target inflation = (real rates - c)/(β-1).*

[21] In that case the instruments included also the 1-4 lags of the German overnight interest rate, which seemed to have a significant effect .

an average of 19.5%) that number seems plausible. Still, it should be taken with a grain of salt, if not discarded altogether, for reasons stated earlier.

1980-1989	*Naive*	*Smoothing*	*Judd-Rudebusch*	*Forward1*	*Forward2*	*Forward-Nelson*
C	15.98(1.717)	10.93(2.83)	10.63(3.26)	9.71(1.2)	9.57(1.07)	9.3(1.185)
Inflation	insignificant	insignificant	insignificant	-	-	insignificant
Inflation(2)	-	-	-	-	-	0.142(0.035)
Inflation(3)	-	-	-	-	-	insignificant
Inflation(4)	-	-	-	0.123(0.037)	0.0598(0.02)	insignificant
Output Gap	-	-	insignificant	-	insignificant	insignificant
Output Gap(-1)	0.384(0.14)	0.349(0.134)	0.373(0.139)	0.345(0.033)	0.363(0.033)	0.306(0.049)
Smoothing(-1)	-	0.318(0.146)	0.37(0.18)	0.3(0.046)	0.2625(0.057)	0.31 (0.044)
Smoothing(-2)	-	-	-	-	0.1(0.051)*	insignificant
Foreign Rate	-		-	-	insignificant	-
Delta	-	-	insignificant	-	-	-
R-squared	0.215	0.3168	0.3315	-	-	-
Prob(J-statistic)	-	-	-	0.96	0.97	0.95
S.E. of regression	1.999	1.894	1.94	1.955	1.9826	1.9699
Durbin-Watson	1.593	2.3263	2.24	2.224	2.2	2.2199
ARCH	0.477 [0.49]	0.274 [0.6]	0.034 [0.85]	0.0002[0.98]	0.0015[0.968]	0.258[0.615]

*NOTES: * indicates significance at 10%*
ARCH is the F-test with p-values in square brackets

Table 4-2 Estimated Rules 1980-1989

1980-1989	*Naive*	*Smoothing*	*Judd-Rudebusch*	*Forward1*	*Forward2*	*Forward-Nelson*
Const	15.98	16.02639296	16.87301587	13.87142857	15.01176471	13.47826087
Inflation	insignificant	insignificant	insignificant	0.175714286	0.093803922	0.205797101
Output	0.384	0.511730205	0.592063492	0.492857143	0.569411765	0.443478261
DM	-	-	-	-	insignificant	-

Table 4-3 Long Term Response 1980-1989

The same conclusions can be drawn for the forward looking rules. They are consistent with each other and with similar results with the backward-looking specifications. More specifically, the smoothing term, the standard error and the Durbin-Watson stat are in the same range as previously. Also the contemporary output gap term is discarded as insignificant and a weight of 0.45-0.57 is returned for the coefficient of the lagged one. The new finding is that a very small weight is given to the expected inflation one year ahead (less than 0.2). In addition, when gradually ignoring the non-significant terms, the last regression showed that the most important expected inflation term was the one two quarters ahead. Finally, as expected, the term regarding the overnight German interest rate was insignificant, since it was irrelevant to the time period under examination. The same result was though gained when the federal funds rate was used in the regression.

4.2.3 The 1990-2000 period

In the next step we examine how the different specifications suit the monetary policy during the period 1990 - 2000. Starting with the backward looking rules the most important observation is once again the consistency. All three rules indicated a related to the output gap insignificant term and a near 0.8 long term weight to the inflation term. Including the dummy variables to control for the speculative attacks that led to very high interest rates, improves the fit of the regressions, as the R squared and standard errors are significantly better. On the other hand though, the decrease of the Durbin- Watson statistic might hint the addition of some serial correlation. In general though, it seems rather puzzling that such a rapid disflation took place without fulfilling the Taylor principle, since the long-term response to inflation was clearly smaller than 1.

A logical explanation emerges when the forward looking rules are taken into consideration. Initially the first rule is partially in line with the previous rules, since it indicates similar degree of interest rate smoothing and long term response to inflation. But when the German day to day rate is included in the regressions, it is by a long margin the most important variable with the long-term weight being larger than 2.2. That was partially expected, since the bank of Greece followed an exchange rate regime during the largest part of the 90's and used the German rates as the main anchor in an attempt to gain credibility. Nevertheless, the magnitude of the coefficient, which was combined by a negative response to the output gap, was rather unexpected and should be further investigated.

1990 - 2000	Naive	Smoothing	Judd-Rudebusch	Forward1	Forward2	Forward-Nelson
C	9.168(1.373) {8.4(0.952)}	5.915(1,969) {5.546(1.295)}	4.03(2.28)	6.507(0.362)	4.794(0.595)	3.6725(0.7445)
Inflation	0.7518(0.113) {0.761(0.078)}	0.553(0.153) {0.555(0.099)}	0.4(0.168)	-	-	-1.492(0.2168)
Inflation(1)	-	-	-	-	-	2.6356(0.287)
Inflation(2)	-	-	-	-	-	-1.218(0.1489)
Inflation(3)	-	-	-	-	-	insignificant
Inflation(4)	-	-	-	0.547(0.038)	-insignificant	insignificant
Output Gap	-	-	insignificant	-	-	insignificant
Output Gap(-1)	-insignificant	-insignificant	insignificant	-0.336(0.1)	-0.29(0.081)	-0.4752(0.089)
Smoothing(-1)	-	0.333(0.15) {0.29(0.097)}	0.506(0.184)	0.32(0.0297)	0.1405(0.033)	0.202(0.0358)
Smoothing(-2)	-	-	-	-	0.0963(0.03)	0.1354(0.0433)
Foreign Rate	-		-	-	1.7169(0.18)	1.5488(0.2525)
Delta	-	-	insignificant	-	-	-
R-squared	0.5159 {0.7884}	0.5689 {0.8228}	0.5962	-	-	-
Prob(J-statistic)	-	-	-	0.95	0.99	0.96836
S.E. of regression	4.655 {3.1555}	4.447 {2.8794}	4.416	4.5835	4.3541	4.2419
Durbin-Watson	1.4188 {0.981}	2.21 {1.71122}	2.1866	2.224	2.2224	2.225
ARCH	0.0387[0.845]	0.085[0.77]	0.006[0.936]	0.018[0.89]	0.099[0.753]	0.057[0.812]

NOTES: Terms in {} are after using the dummy variables to control for the two outliers
ARCH is the F-test with p-values in square brackets

Table 4-4 Estimated Rules 1990-2000

1990 - 2000	Naive	Smoothing	Judd-Rudebusch	Forward1	Forward2[21]	Forward-Nelson
Const	9.168	8.868065967	8.157894737	9.555066079	6.281446541	5.542559614
Inflation	0.7518	0.829085457	0.809716599	0.803230543	insignificant	-0.112284938
Output	insignificant	insignificant	insignificant	-0.49339207	-0.379979036	-0.717174766
DM	-	-	-	-	2.249606918	2.337458497

Table 4-5 Long-Term Response 1990-2000

4.2.4 1990-1993: the transition period

In general, as was described in the previous section, the three-year period between the political instability of 1989-1990 and the elections of 1993 is considered a transition period. Therefore we attempted to investigate how a Taylor-type rule fits the monetary policy over this period. One backward and two forward-looking rules were used and after dropping the insignificant terms the results are shown at the following tables.

Due to the very small sample we used monthly data, which adds a bias to the estimation, since the real GDP was proxied by the industrial production excluding construction. Figure 4-1 below shows the underlying trend after applying a Hodrick-Prescott filter to the industrial production and the real GDP respectively. During the whole sample the two measures are heavily correlated (0.878), but during the sub-sample under investigation there is a strong negative correlation (-0.9), which could possibly complicate the results.

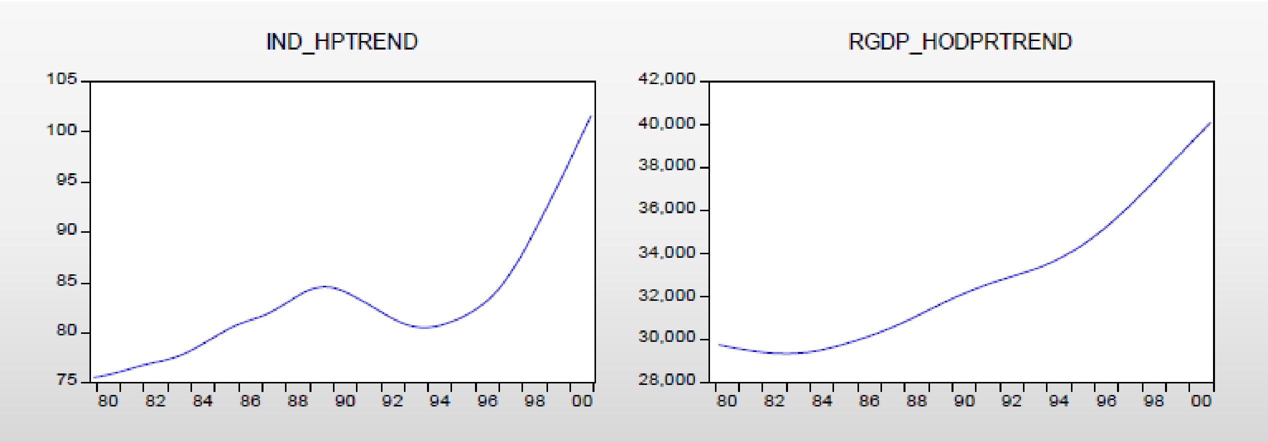


Figure 4-1 Industrial Production and Real GDP relation

1990 - 1993	*Smoothing*	*Forward1*	*Forward-Nelson*
C	15.883(1.415)	20.87(1.73)	16.9365(2.283)
Inflation	-0.18(0.0626)	-1.2586(0.199)	-0.765(0.128)
Inflation(1)	-	1.069(0.284)	0.463(0.225)
Inflation(2)	-	0.685(0.232)	0.795(0.212)
Inflation(3)	-	insignificant	-0.735(0.191)
Inflation(4)	-	-0.7587(0.149)	insignificant
Output Gap	-	insignificant	-0.116(0.052)
Output Gap(-1)	-insignificant	0.0816(0.049)*	0.0933(0.0547)*
Smoothing(-1)	0.428(0.037)	0.435(0.04)	0.476(0.0237)
Smoothing(-2)	-	-0.169(0.0484)	-0.221(0.0535)
Foreign Rate	-	-	0.48
Prob(J-statistic)	0.998	0.995	0.99
S.E. of regression	4.011	4.1026	4.1243
Durbin-Watson stat	1.841	2.2049	2.039748
ARCH	0.187 [0.667]	0.0327 [0.857]	0.099 [0.7539]

*NOTES: * indicates significance at 10%*

ARCH is the F-test with p-values in square brackets

The instruments were the same as for the quarterly data but with lags 1-4,6,9,12

Table 4-6 Estimated Rules 1990-1993

1990 - 1993	*Smoothing*	*Forward1*	*Forward-Nelson*
Const	27.767	28.43324	22.73355705
Inflation	-0.315	-0.36	-0.324832215
Output	insignificant	-0.49339	-0.030469799
DM	-	-	0.644295302

Table 4-7 Long Term Response 1990-1993

A quick overview of the estimations leads to the conclusion that the regressions are unstable and no safe conclusions can be drawn. One can argue that the foreign interest, when added to the regression, is still the decisive parameter, but the coefficient is not large enough and moreover the constant term on the forward looking rules is abnormally high indicating a possible mis-specification. The coefficients at the first rule seem more sensible, but the long term response to inflation is still only 0.83, which contradicts the Taylor principle, especially if we take into consideration that inflation dropped during that period from around 23% to 12%.

The foreign interest rate most likely had a significant effect[17] during the disflation, but the most probable explanation can be found in the actual level of the real interest rate. During the previous decade the average real interest rate was -2.3% and had increased to 4.84% the period under examination. As Nelson (2000) notes in his investigation of UK monetary policy using Taylor type rules, while the *movements* of the nominal interest rate relative to inflation were not indicative of an aggressively anti- inflationary policy, the average prevailing *level* of interest rates was consistent with a restrictive monetary policy. The graph below shows the overnight interest rate with respect to inflation.

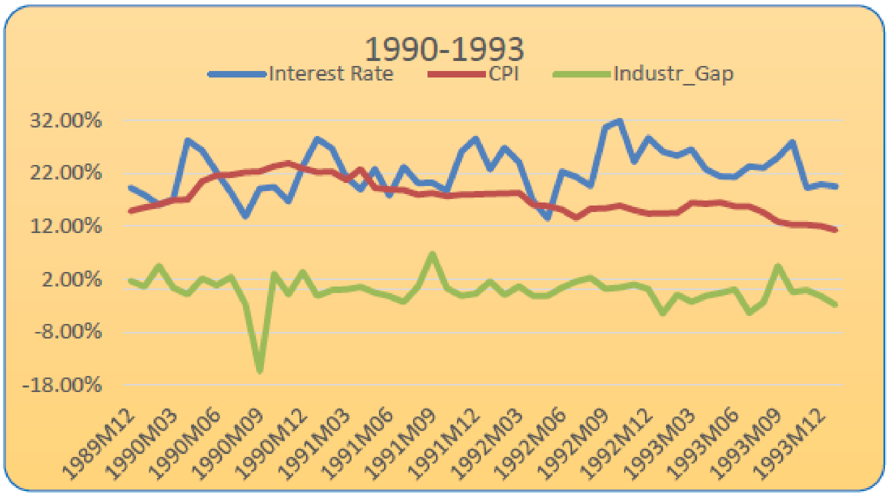


Figure 4-2 1990-1993: Interest Rate, CPI, GDP Gap

4.2.5 19905-March 1998: the period of the hard Drachma policy

The investigation of the 'Hard Drachma' policy regime is rather straightforward. As the results presented in the following tables suggest (after the insignificant terms have been discarded), the foreign interest rate is by far the most important parameter with a long term weight around 2.8. A slight unexpected observation is that the German day to day rate dwarfs the other variables so much that in essence the interest rate smoothing parameter ends up being insignificant.

[17] especially since 1990 the Bank of Greece was implicitly targeting the exchange rate

One rather puzzling outcome is that the long run response to inflation is negative. The final coefficient though is very close to zero, which simply indicates the in-significance of the inflation term with respect to the German rates. In order to validate that assumption, the third column presents the same regression but the only regressors are the inflation and output gap. As expected the corresponding value is positive and significantly above zero. Still though it is not in line with the Taylor principle, which should not come as a surprise since during that period the most important determinant of the monetary policy was the foreign interest rate and not the inflation (that misspecification probably explains the high ARCH test statistic).

1995 - 1998 March	*Forward1*	*Forward-Nelson*	Reference
C	4.078(0.295)	4.389(0.2135)	6.981754(0.503)
Inflation	-	-0.228(0.117)*	-0.246(0.16)*
Inflation(1)	-	0.68(0.178)	1.19(0.133)
Inflation(2)	-	insignificant	-0.6563(0.1523)
Inflation(3)	-	-0.968(0.14)	insignificant
Inflation(4)	-0.147(0.042)	0.394(0.0746)	insignificant
Output Gap(-1)	-0.1376(0.0257)	-0.159(0.02)	insignificant
Smoothing(-1)	0.076(0.0464)*	insignificant	0.36636(0.0305)
Foreign Rate	2.689(0.17)	2.847(0.0984)	-
Prob(J-statistic)	0.999	0.999	0.9981
S.E. of regression	2.013	2.0549	2.29034
Durbin-Watson stat	2.0349	1.9956	2.154219
ARCH	1.62 [0.21]	0.5271 [0.4725]	10.226 [0.0289]

*NOTES: * indicates significance at 10%*
ARCH is the Ftest with p-values in square brackets

Table 4-8 Estimated Rules 1995-1998 ('Hard Drachma' Policy)

1995 - 1998 March	Forward1	Forward-Nelson	Reference
Const	4.413419913	4.389	11.01848
Inflation	-0.16	-0.12	0.45504
Output	-0.15	-0.16	insignificant
DM	2.91017316	2.847	-

Table 4-9 Table 4-10 Long Term Response 1995-1998 ('Hard Drachma' Policy)

4.3 Structural Breaks

As mentioned earlier the fragmentation of the Greek monetary policy in three main periods is widely accepted and in accordance with the qualitative analysis that was briefly described in the previous section. Nevertheless, in order to provide quantitative evidence a series of tests that detect structural breaks were performed. The Bai & Perron (2003) algorithm, which was applied here, builds upon the Bai & Perron (1998) test for multiple breaks and detects the optimal break points given the number of breaks. It is valid for OLS regressions and the selection is based on the BIC criterion[18]. The algorithm uses dynamic programming and recursively calculates the Residual Sum of Squares. Here, the regression with the smoothing parameter over the whole sample was chosen and the test was run

[18] Bai and Perron argued that the BIC provides better results than the AIC.

with and without the dummy variables. The results are presented at the following table, where m corresponds to the number of breaks, h, to the minimum size of the sample (compared to the initial) and the optimal solution is highlighted.

No Dummy Variables					
No of Breaks	Break-Dates			RSS	BIC
0	-	-	-	4841.464	1458.636
1	1994(5)	-	-	4059.287	1442.815
2	1990(3)	1994(6)	-	3524.371	1435.581
3	1990(3)	1994(7)	1997(11)	3472.7	1459.474

Table 4-11 Bai & Perron – Regression without Dummies

With Dummy Variables (h=0.2)						
No of Breaks	Break-Dates				RSS	BIC
0	-	-	-	-	6550.4	1538.509
1	1994(4)	-	-	-	2838.727	1365.843
2	1989(11)	1994(4)	-	-	2636.2	1380.667
3	1985(10)	1989(11)	1994(4)	-	2615.347	1411.746

Table 4-12 Bai & Perron – Regression with Dummies, H=0.2

With Dummy Variables (h=0.15)						
No of Breaks	Break-Dates				RSS	BIC
1	1994(4)	-	-	-	2838.727	1365.843
2	1994(4)	1997(5)	-	-	1637.529	1263.534
3	1990(10)	1994(4)	1997(5)	-	1412.145	1260.139
4	1983(7)	1990(10)	1994(4)	1997(5)	1382.573	1287.965

Table 4-13 Bai & Perron – Regression with Dummies – H=0.15

As Bai & Perron (1998, 2003) and the example in Zeileis et al. (2003) indicate the BIC might not provide the best available solution. So the hypothesis is further tested here by calculating and plotting the sequence of F statistics. The horizontal line corresponds to the 5% significance of supF[19] statistic (Andrews 1993) test. The following graph contains the results from the regression without the dummy variables and shows that the optimal breakpoint (maximum F-statistics) is in May 1994. Including them, the result remains the same.

Finally a Zivot-Andrews (1992) test was also applied on the residuals of the second forward-looking rule. The results below demonstrate that a structural break is found in July 1994, which is consistent with the previous results.

[19] The test is also referred to as Quandt's test and can be approximated as a series of Chow tests.

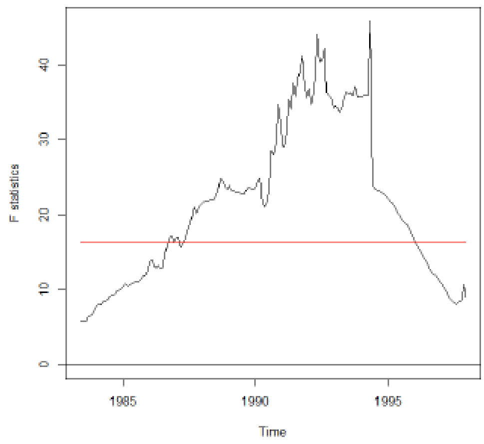


Figure 0-3 Andrews supF test

The common result of all the above tests was the evidence towards a structural break of the time series around the middle of 1994, which, taking into consideration the lag of the effect of monetary policy seems in perfect agreement with the theoretical background. Moreover, when the optimal solution contains three breaks (see Table 4-13 with h = 0.15), those are in November 1990, April 1994 and May 1997. Those dates correspond almost perfectly to the beginning (1990) and end (1994) of the transition period and the speculative attack that preceded the devaluation at entrance into the ERM.

4.4 Investigating the presence of nonlinear features

In the next step we examine the potential for non-linearities in the overnight interest rate time series. The analysis is once more restricted to the 1995-1998 period. The main reason behind the decision not to model the previous years is that there was no consistency in the way monetary policy was exercised, which the linear analysis also confirmed. On one hand, the financial market was heavily regulated and on the other hand the monetary policy was mainly a tool for the politicians to achieve short-lived fiscal targets. That means that even if non-linearities were to be identified, it would most likely be spurious. An additional incentive behind the choice is the analysis of the fixed exchange regime. Under that regime the hardest part of the disinflation occurred (from mid to low inflation) and it is of special interest to try to decompose the applied policies.

4.4.1 Nonlinearity tests

The first test we conduct is the BDS test (Brock, Dechert, and Scheickman 1991), which checks the iid assumption for the residuals of a fitted model and thus searches for unexplained dependence. In that way the test can detect how well specified the model is and if the data are pre-whitened[20] it can provide evidence of non-linearity in the time series. The next test is the-neural network type (with a single hidden layer) Teräsvirta test and the third is the Tsay's test (1986) for non-linearity in the mean.

[20] The test was applied both to the residuals from a AR(p) model and to the residuals from the forward-Nelson rule from table 4.8 and the results were roughly the same.

Dimension	BDS Statistic	Std. Error	z-Statistic	Normal Prob.	Bootstrap Prob.
2	0.110912	0.018793	5.901849	0.0000	0.0000
3	0.185822	0.030626	6.067368	0.0000	0.0000
4	0.199142	0.037430	5.320451	0.0000	0.0008
5	0.186394	0.040064	4.652413	0.0000	0.0018
6	0.145103	0.039702	3.654804	0.0003	0.0090

Table 4-14 BDS test for Unexplained Dependence

Linearity Tests	Tsay	Teraesvirta
Test Statistic	11.78	28.4317
p-values	0.001632	6.70E-07

Table 4-15 Tsay, Teraesvirta Linearity Tests

4.4.2 The Augmented Taylor rule

All three tests strongly hint that there is unexplained non-linearity in the data and so we try to identify it at the final step of the analysis. Following the approach of Dolado et al. (2000) we estimate the augmented Taylor-type rules shown in equations (2.12) and (2.13):

$$r_t = \alpha + \beta_1 r_{t-1} + \beta_2 \pi_{t+n} + \beta_3 (y_t - y^*)^+_{t-3} + \beta_4 (y_t - y^*)^-_{t-3} + \beta_5 r^f_{t-1} + u_t \quad (2.12)$$

$$r_t = \alpha + \beta_1 r_{t-1} + \beta_2 \pi_{t+n} + \beta_3 (y_t - y^*)_{t-3} + \beta_4 (y_t - y^*)^2_{t-3} + \beta_5 (y_t - y^*)^3_{t-3} + \beta_6 r^f_{t-1} + u_t \quad (2.13)$$

The first rule is estimated only with the output gap as the target variable, for the same reason that we decided not to specify and estimate any smooth regression models (SRM). During the period under examination, the Bank of Greece did not explicitly follow any alternatives other than the exchange rate regime. In addition, the monetary policy had a clear and stable direction and both the inflation and the foreign interest rate exhibited a downward trend for almost the whole sample. Also the long term inflation target was mandated by the Maastricht criteria and was below the contemporary value for the greater part of the sample. Under those circumstances there is not a suitable, in the sense of holding explanatory power, threshold or equivalently a suitable transition variable and thus the relative models would prove fruitless[21].

The results are presented below in Tables 4-16 and 4-17, where the first and second column corresponds to the above nonlinear rules and the third column to the combined effects. The most unexpected, and suspicious for two main reasons results[22] were chosen, in order to examine the underlying cause. The first and foremost is the negative smoothing parameter. That means that the Central Bank not only does not smooth its adjustments, but that those are negative correlated with the previous values. This could indicate endogeneity bias, perhaps a significant variable for that time-period is omitted and the impact is absorbed by the lagged interest rate term, since the same problem does not manifest in biggest samples. An intuitive explanation could be that the smoothing parameter is an over fitting for the period under examination, since the Bank of Greece sets the short term rates almost exclusively based on the German rates which are already smoothed by the Bundesbank.

[21] Examples, where those models would be useful with our data, would be modelling the 'velocity' with which the central bank reduces the rates or the accelerating rate of inflation as Arango and Gonzalez (2001) do for Colombia (not to be confused with the *non-accelerating inflation rate of unemployment - NAIRU)*. In that case the lagged difference of the interest rate would be a possible candidate.

[22] The results were similar and equally puzzling when inflation was used as the target variable.

Another possibility could be the small amount of sample (which becomes even smaller as the horizon for inflation increases) combined with the different dynamics when working with monthly data. The regressions are not robust with respect to the chosen lag of industrial production gap, as its selection significantly affects the results (albeit the qualitative analysis not so much, since the mutual significance of the parameters remains similar). This is in contrast with the work of Gerdesmeier and Roffia (2003) that found that switching to quarterly data didn't significantly change the results. On the other hand though, they fit Taylor-type rules for the whole Eurozone, which means the data were less subject to monthly deviations. Furthermore, although, as noted before, the underlying trends of the industrial and real GDP data are correlated (Figure 4-1), when the respective gaps are examined the correlation diminishes (0.55), which confirms, that the former fluctuates significant more. Even under those limitations and caveats, the non-linear rules lead to regressions with considerably smaller SE, although the output gap remained wrongly signed. On the down side, inspection of the correlogram (Figure 4-5) hints to increased serial correlation, although the heteroskedasticity and autocorrelation consistent estimator (HAC - Newey-West 1987) was used for the GMM estimation.

1995-1998 March	*Asymmetries*	*Magnitude*	*Combined effect*
C	3.578665(0.26572)	4.785326(0.2281)	4.711681(0.1258)
Smoothing	-0.365917(0.0406)	-0.337835(0.0091)	-0.340664(0.0074)
Inflation (5)	0.550781(0.0884)	0.204448*(0.1139)	0.240847(0.0664)
Inflation (6)	1.330717(0.2151)	1.110674(0.13197)	1.090289(0.0794)
Inflation (7)	-1.617688(0.28927)	-0.925061(0.0716)	-0.938525(0.051)
Inflation (8)	0.675693(0.17667)	0.301712(0.0698)	0.307735(0.0716)
Output Gap (-3)	-	-0.286596(0.02119)	-
Output Gap +(-3)	0.732438(0.05772)	-	-
Output Gap -(-3)	-1.769296(0.1176)	-	-0.501316(0.0195)
Output Gap ^2(-3)	-	0.274145(0.01)	0.192716(0.0037)
Output Gap ^3(-3)	-	0.005157(0.0013)	-0.002485(0.0005)
Foreign Rate	2.085449(0.1471)	2.328385(0.0801)	2.31241(0.0526)
Prob(J-statistic)	0.9960	0.99	0.9991
S.E. of regression	0.94	0.64	0.63
Durbin-Watson stat	2.39	1.83	1.96

Table 4-16 Augmented Taylor Rules

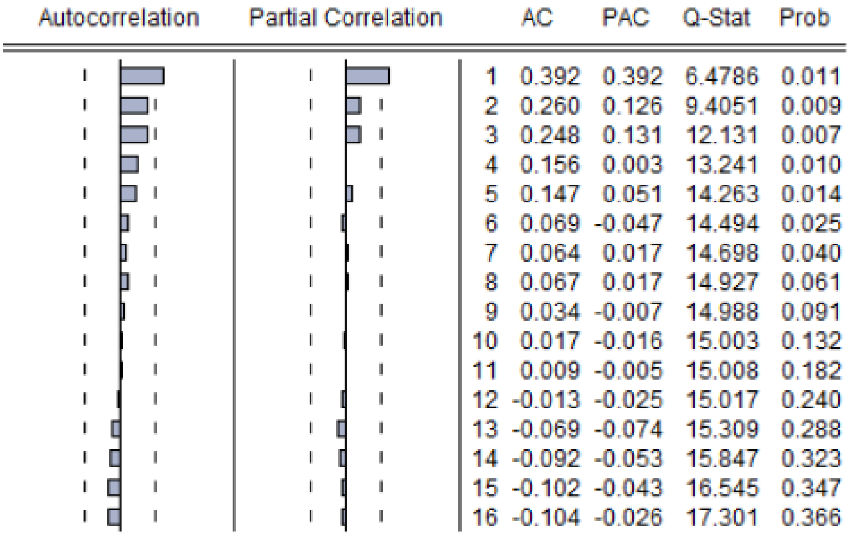
and their long-term equivalent:

1995 - 1998 March	*Asymmetries*	*Magnitude*	*Combined effect*
Const	2.62	3.60	3.52
Inflation	0.75	0.52	0.52
Output	-	-0.21	-
Output(+)	0.54	-	-
Output(-)	-1.30	-	-0.37
Output^2	-	0.20	0.14
Output^3	-	0.00	0.00
DM	1.53	1.73	1.72

Table 4-17 Long-Term Response Augmented Taylor Rules

4.4.2 Smooth Transition Autoregressive (STAR) specification

Partly in order to validate our assumptions about the (in)appropriateness of smooth transition models and partly in order to avoid the instability that working with monthly data introduced, we specified a STAR model. In order to keep things as simple as possible and because the ESTAR was disregarded a priori due to implying symmetric realizations, the LSTAR was the preferred model. Also one and two AR terms were chosen by studying the PACF[23]. The results are reported in Table 4-18.



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.392	0.392	6.4786	0.011
		2	0.260	0.126	9.4051	0.009
		3	0.248	0.131	12.131	0.007
		4	0.156	0.003	13.241	0.010
		5	0.147	0.051	14.263	0.014
		6	0.069	-0.047	14.494	0.025
		7	0.064	0.017	14.698	0.040
		8	0.067	0.017	14.927	0.061
		9	0.034	-0.007	14.988	0.091
		10	0.017	-0.016	15.003	0.132
		11	0.009	-0.005	15.008	0.182
		12	-0.013	-0.025	15.017	0.240
		13	-0.069	-0.074	15.309	0.288
		14	-0.092	-0.053	15.847	0.323
		15	-0.102	-0.043	16.545	0.347
		16	-0.104	-0.026	17.301	0.366

Figure 4-5 Correlogram for Interest Rate 1995-1998

[23] The procedure is described in van Dijk et all (2002). A series of simple LM tests are performed to choose the parameters.

Transition Variable	Threshold	γ	Low Regime			High Regime			Residual Variance
			const	ϕ1	ϕ2	const	ϕ1	ϕ2	
CPI	5.378	49.23	18.477***	-0.198	-	-18.59***	1.187***	-	2.7
German Interest Rate	3.151	1439	0.3265	2.115***	-1.154**	13.654*	-2.28***	1.326***	1.09
Industrial gap	-2.03	100	-7.13	1.79***	-	17.46***	-1.567***	-	2.73

*NOTES: * indicates significance at 5%*
*** indicates significance at 1%*

Table 4-18 LSTAR Model

In Figure 4-19 below each of the above threshold values are marked with dashed horizontal lines. From that graph we can observe more clearly that the only meaningful transition variable is the foreign interest rate, which is also confirmed by the low standard error. But in that case the very large γ parameter indicates that the change between the two regimes is not smooth, but rather instantaneous.

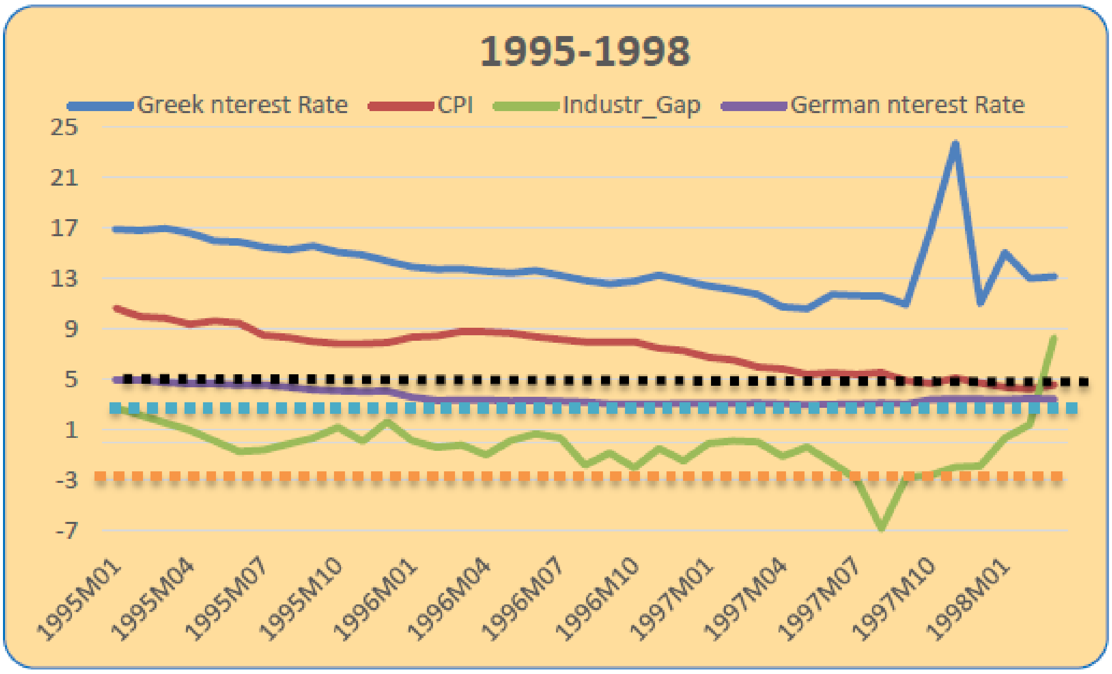


Figure 4-19: LSTAR variables

4.5 Robustness of the results

In this section we assess the robustness of the specifications we estimated so far by considering alternative measures of the variables included in the representation of the policy rule.

- *Inflation*

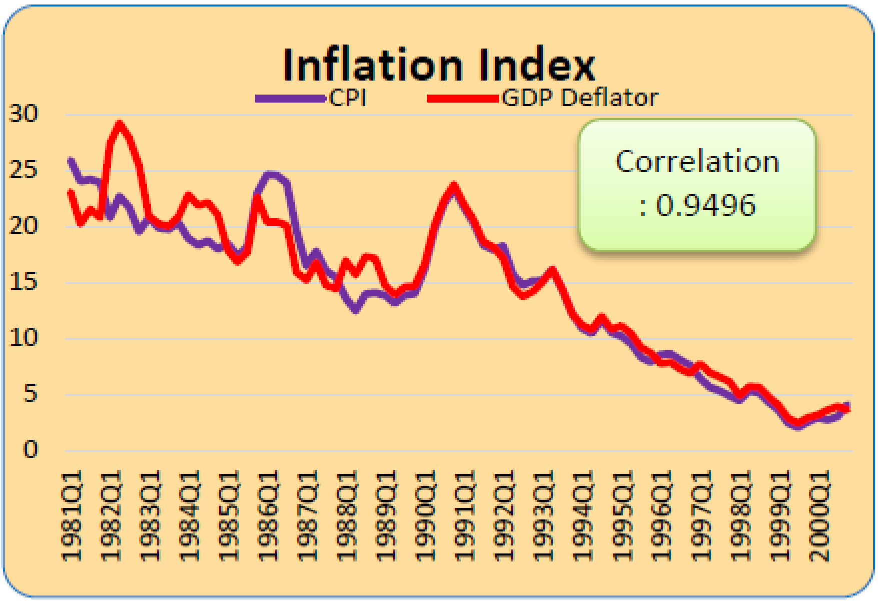


Figure 4-20: Alternative Inflation measures (indexes)

The GDP deflator was also considered as an alternative measure of inflation and the regressions proved to be robust. Figure 4.20 shows how both inflation measures progressed throughout the period under investigation and the main observation is that they evolved quite similarly after 1990.

- *Real GDP trend*

As described earlier, one of the criticisms against Taylor rule is the uncertainty regarding the underlying level of real GDP. The above specified rules proved to be robust when the latter was approximated by fitting a quadratic trend instead of applying the Hodrick-Prescott filter. Figure 4-21 below shows the development of those measures, along with a fitted linear trend.

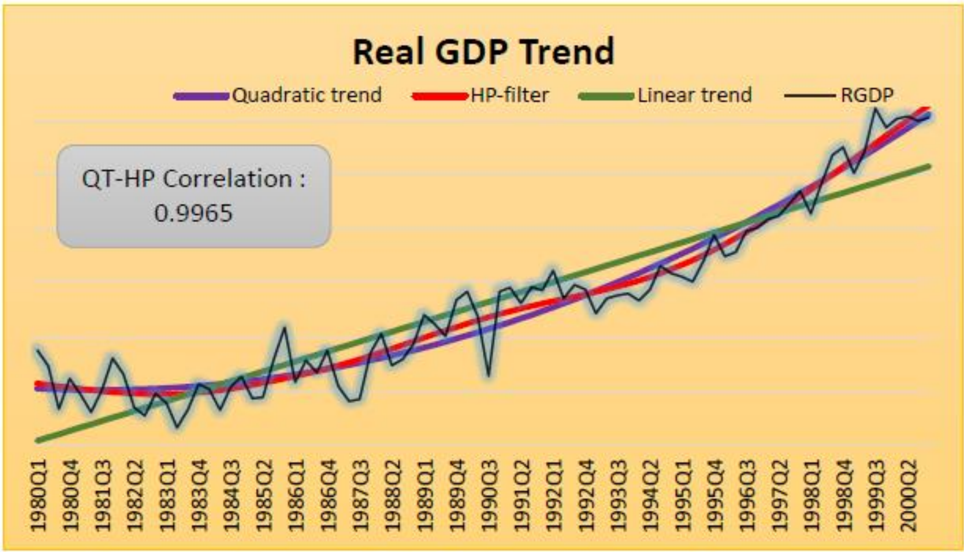


Figure 4-21: Alternative measures of real potential GDP

- *Instruments*

The estimated regressions were also robust with regard to the instruments that were used. More specifically the results were not significantly altered when more lags of the instruments were used.

- *Data frequency (Quarterly versus Monthly Data)*

Finally, the estimations provided similar long-term responses when monthly data were used instead of quarterly. That happened despite the fact, that as explained in the previous section the regressions with monthly data over short periods were less stable.

5 Concluding remarks

Simple instrument rules, despite the criticism, can be useful in helping us shed light on the main characteristics of that mechanism. In that context, instrument-based Taylor-type rules are actively used in analysing ex-post how monetary policy was conducted in the past and through that analysis get an insight into the art of monetary policy.

In this paper, Taylor-type instruments rules were estimated for the Greek economy for the period 1980-2000. The results were mixed, albeit not unexpected. On the positive side, structural breaks were identified in perfect accordance with the insights from the narrative analysis we carried out prior to the formal econometric assessment. Moreover, the foreign interest rate was confirmed to be the main determinant of the Greek interest rates after 1994 and results suggest that this rate was the anchor that led to rapid deflation and consistent low inflation afterwards. On the other hand, the analysis based on monthly data was unstable and no reliable rule was estimated for the period before 1990. However, the latter should not necessarily be considered a failure of the model, since the descriptive analysis also supports a monetary policy without a long-term plan.

A considerable body of research has been devoted to ascertain how compatible is the monetary policy among the most 'significant' central banks (FED, Bank of England, Bundesbank, ECB), but it would also be very interesting to conduct a similar project regarding smaller countries with similar characteristics. In Europe, comparing the cases of Greece, Portugal and Ireland could be a challenging avenue for further research. Moreover, such a research would be useful for countries that are going through a convergence process in order to enter the EMU. Finally, more specifically for Greece, a useful extension of the present work would consist of including a variable corresponding to the deviation of actual monetary growth from the target value in the specification of the rule.

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Appendix: Key steps towards Greece's entrance in the EMU: a synopsis of monetary policy events in Greece, 1975-2001

Key notes towards the Euro			
Year	**Important Events**	**Primary Objective**	**Secondary Objective**
1975 - 1980	Rapid sliding depreciation of the drachma. Uncoupling from the dollar and float against a basket of currencies	M0	-
1981	Entry to the EU. Elections	M0 (17.2%)	-
1982	Abolition of the Currency Committee	M0 (24.0%)	-
1983	Drachma' s devaluation (16%). A crisis in the balance of payments, stagflationary developments	M3 (26.1%)	-
1984	Pre-election year	M3 (22.0%)	-
1985	Drachma' s devaluation (15%). Two-year stabilization programme	M3 (23.5%)	-
1986	Begin of Financial liberalization and deregulation. The process was gradual and was completed in1994	M3 (20.0%)	-
1987		M3 (15.5%)	-
1988	Abandonment of the stabilization programme. Pre-election year	M3 (14%-16%)	-
1989	Political instability - repeated elections	M3 (18%-20%)	Exchange rate monitoring
1990	Disflation is the primary target	M3 (19%-21%)	The depreciation of the drachma must not compensate fully for inflation differentials between Greece and remaining EU countries/trading partners in general
1991	Stabilization plan 1991-1993. M3: Redefined to include repos	M3 (14%-16%)	
1992		M3 (9%-12%)	
1993	First convergence programme of Greece 1993-98	M3 (9%-12%)	
1994	Revised convergence programme of Greece, 1994-99. Financial Liberalization completed	M3 (8%-11%)	
1995	'Hard drachma' policy	The exchange rate of the drachma vis-à-vis the ECU shall be maintained broadly stable on average over the year, as envisaged in the Revised Convergence Programme (June 1994)	M3 (7%-9%) M4(11%-13%)
1996			M3 (6%-9%) M4 (9%-12%)
1997	Central Bank Independence. Mandate to attain monetary and price stability.		M3 (6%-9%) M4 (8%-11%)
1998	Entry in the Exchange Rate Mechanism at a central rate of 357 GRD per ECU corresponding to a 12.3% devaluation against the previous exchange rate		M3 (6%-9%)
1999	Third stage of EMU. ERM II replaced ERM. Entry at the ERM II (at a central rate of 353.109 per ECU)		M4N (7%-9%)
2000	GRD central rate was revalued by 3.5% in order to limit the required degree of depreciation for the market rate to reach its central rate		M4N (5%-7%)
2001	Greece joined the euro area at a central rate of 340.75 GRD per euro		