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Monetary policy before and after the euro: Evidence from Greece*

by

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Abstract

We model Greek monetary policy in the 1990s and use our findings to address two interrelated questions. First, how was monetary policy conducted in the 1990s so that the hitherto highest-inflation EU country managed to join the euro by 2001? Second, how compatible is the current ECB monetary policy with Greek economic conditions? We find that Greek monetary policy in the 1990s was: (i) primarily determined by foreign (German/ECB) interest rates though still influenced, to some degree, by domestic fundamentals; (ii) involving non-linear output gap effects; (iii) subject to a deficit of credibility culminating in the 1998 devaluation. On the question of compatibility our findings depend on the value assumed for the equilibrium post-euro real interest rate and overall indicate both a reduction in the pre-euro risk premium and some degree of monetary policy incompatibility. Our analysis has policy implications for the new EU members and motivates further research on fast-growing EMU economies.

Keywords: monetary policy, reaction function, non-linear, compatibility, Greece, EMU.

JEL classification: C51, C52, E43, E58, F37

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1. INTRODUCTION

Following the launch of the European Economic and Monetary Union (EMU) in 1999 the focus of attention of the empirical literature on monetary policy in Europe has gradually been shifting from modelling national monetary policies towards that of the European Central Bank (see for example Gerlach and Schnabel 2000, Faust et al 2001, Mihov 2002, Domenech et al 2002, Surico 2003 and 2006, Gerdesmeier and Roffia 2003, Clausen and Hayo 2005 and Hayo and Hofmann 2006) The motivation underlying this shift is well-founded as the ECB is now the exclusive interest-rate setting authority within the EMU. However, there still exists enough motivation to study national monetary policies prior to the launch of the euro, not least for two reasons. First because not all EMU members started their journey towards euro-accession from the same position: In 1991, the year the Maastricht Treaty was signed, the European Union (EU) was an area of marked differences documented by a large literature on a European optimum currency area.[1] As a result, there now exists a pool of individual experiences of successful run-ups to the euro from which the ten countries that joined the EU in 2004, as well as Bulgaria and Romania that are set to join in 2007, could draw useful lessons.

Second, research on pre-euro monetary policies is useful for the purpose of assessing the compatibility of the ECB monetary policy with the economic requirements of individual member-states. The potential costs of a single monetary policy that is incompatible with domestic conditions have been highlighted by the founding authors of the Theory of Optimum Currency Areas as early as the 1960s (see e.g. Mundell 1961, McKinnon 1963, and Kenen 1969). Perhaps surprisingly the recent literature has largely overlooked the compatibility issue. A notable exception is the study by Hayo and Hofmann (HH, 2006). These authors model the Bundesbank and ECB policy reactions

[1] See, among others, Bayoumi and Eichengreen (1997) and the references therein.

functions, respectively for the pre- and post-euro periods, and use their findings to obtain counterfactual simulations of post-euro German interest rates under a hypothetical Bundesbank regime. By doing so they address the question as to whether, in view of the weak post-euro German growth rates, the Bundesbank would have set lower interest rates than the ECB.[2]

The analysis by HH is an important step towards bridging the existing literature gap on compatibility. In this paper, we focus on the last country to have joined the EMU in 2001, Greece. Within the context of the EMU, this is a country that is in every respect exactly in the opposite position compared to the German case considered by HH. Unlike Germany which is the EMU's largest economy with a solid low-inflation record, Greece is one of EMU's smaller economies that started its convergence effort in the early 1990s from double-digit inflation rates. Furthermore, during 2001-2005 Greece experienced high average growth rates (4.3% versus Germany's 0.7 %) and inflation rates almost double than the EMU average (3.5% versus Germany's 1.6%). In addition, since 2001 the convergence of inflation towards the EMU average observed throughout the 1990s has been discontinued and the inflation differential has even slightly increased. As a result, in contrast to the high real interest rates observed in Germany, since 2001 Greece has experienced real interest rates significantly lower than the EMU average (see section 2)

The above pose a couple of interesting questions. First, how was Greek monetary policy conducted in the 1990s so that the hitherto EU's worst inflation performer managed to join the single currency by 2001? Insights from the Greek experience may be useful for the new EU members whose relatively small size makes them more relevant to the Greek

[2] Hayo and Hoffman conclude that the ECB reacts similarly to movements of expected inflation but stronger to the output gap than the Bundesbank did. They argue, however, that the higher output gap coefficient found for the ECB may reflect a higher interest rate sensitivity of the German output gap rather than a higher weight attributed to output stabilisation by the ECB. Their estimated Bundesbank reaction function suggests that German interest rates would not have been lower under a hypothetical Bundesbank regime after 1999. However, when the Bundesbank reaction function is adjusted for the lower estimated real target real interest rate found for the ECB reaction function, this finding is reversed.

rather than the German example analysed by HH. Second, is the single monetary policy to any degree responsible for the post-euro maintenance of Greek inflation at levels double than the EMU average? Would, in other words, the Bank of Greece (BOG), in view of the high growth rates experienced by Greece in recent years, set interest rates higher than the ECB in an effort to control domestic inflation more effectively? A positive answer may motivate research on other fast-growing EMU countries such as Ireland and Spain and would also be relevant for the new EU members whose own productivity gains in recent years are well documented (see e.g. Taylor and Sarno, 2001).

Following HH our analysis involves estimates of the standard forward-looking linear monetary policy reaction functions adopted by Clarida et al (1998). These are consistent with theoretical models of monetary policy where the monetary authority has a quadratic loss function specified in terms of inflation and output as in Svensson (1997) and Ball (1999).[3] We extend the analysis by HH, however, by allowing for the more complex decision-making process captured by non-linear reaction functions accounting for output gap effects such as those found by Bec et al (2002) and Surico (2003, 2006). These correspond to theoretical models of monetary policy as in Orphanides and Wieldand (2000) where the policy-maker's loss function is a function of different kinds of economic shocks. We focus on 1991-2000 when Greece abolished all capital controls and implemented convergence programmes aiming to achieve EMU participation. Our analysis involves three steps. First, we model Greek monetary policy using linear and non-linear reaction functions such as those estimated by Martin and Milas (2004)[4] and use our findings to assess Greek monetary policy in the 1990s. Second, we replicate the counterfactual experiment of HH simulating post-euro Greek interest rates under a

[3] For further details see Clarida et al, 1998 p. 1037 and HH 2006, p. 654.
[4] Martin and Milas (2004) show that monetary policy in the UK is better captured by non-linear reaction functions where the transition variable is the size of the deviation of expected inflation from its target level.

hypothetical BOG regime. Finally, we use our out-of-sample interest rate forecasts to assess compatibility between the ECB policy and Greek economic conditions.

The remainder of the paper is structured as follows: Section 2 overviews monetary developments in Greece in the 1990s. Section 3 presents our methodology and empirical findings. Section 4 assesses Greek monetary policy in the 1990s. Section 5 presents and discusses the results of our counterfactual experiment. Finally, section 6 summarises.

2. MONETARY DEVELOPMENTS IN GREECE IN THE 1990s

The monetary policy framework is defined by policy goals; intermediate targets; operating targets; and policy instruments (see Walsh, 2000). The policy goal of the BOG in the 1990s was the meeting of the inflation criterion of the Maastricht Treaty. This was pursued through a strategy of intermediate exchange rate targets, known as the "strong-drachma" policy involving nominal depreciation of the Greek drachma against the ECU (the Euro after 1999) increasingly lower than the inflation differential between Greece and the EU average (see Figure 1(a)). At the same time the Greek authorities took gradual steps towards complying with the requirements of the Maastricht Treaty on central bank independence. These were concluded in December 1997, when the BOG was granted institutional independence in its conduct of monetary policy.

The main operational variable used by the BOG in the 1990s was the inter-bank money market rate, aiming to control liquidity in the domestic banking sector. To achieve its operational targets the BOG used a number of policy instruments, the main of which was its short-term day-to-day (overnight) interest rate.[5] Very closely correlated with the

[5] See Filippides et al (1995). Other policy instruments used by the BOG during 1991-2000 were open market operations involving auctions in the form of repurchasing agreements (repos) of government securities; increases in reserve requirements; interventions in the spot foreign exchange market, foreign exchange swaps; and credit facilities along with their respective interest rates (Lombard, discount and overdraft). The signalling role of these interest rates should not be underestimated; however, as their underlying facilities were activated not on the initiative of the BOG but of financial institutions, these instruments were not as flexible as the BOG money-market rate. For further discussion, see Mourmouras and Arghyrou (2000), chapter 3.

movements of the inter-bank money market rate (see Figure 1(b)), this was the most credible indicator about the general direction of Greek monetary policy. Despite sharp increases during speculative pressures in 1994 and 1997, both rates gradually declined and converged (but did not become equal before EMU accession) to the German and Eurozone money market rates. Throughout the 1990s, nominal interest rates remained higher than CPI inflation, resulting in a strongly restrictive monetary policy. The Greek real interest rate converged but remained higher than the German one throughout the 1990s (see Figure 1(c))[6] becoming equal to it and the EMU average just before EMU accession.

The strong drachma policy achieved inflation convergence but not full equalisation with the EMU average. This was accompanied by a steady decline in Greek long-term government bonds (see Figure 1(d)). At the same time, the strong-drachma policy caused a significant side effect, namely currency overvaluation. Figure 1(e) presents drachma's misalignment relative to its value predicted by purchasing power parity (PPP) and the flexile price monetary model (FPMM) as estimated by Arghyrou et al (2006). Since 1995, when a nearly-fixed exchange rate policy was introduced, the drachma became increasingly overvalued, leading to a significant deterioration in the Greek current account (see Figure 1(f)). The policy collapsed in March 1998 when the drachma was devalued against the ECU by 14 percent and became a member of the wide-band ($\pm$15%) ERM-II with a central parity of 357 drachmas per ECU. In 1998-2000, the BOG resumed a policy of exchange rate stability around this central parity, which was re-valued in 2000 to 340.75 drachmas per Euro, the rate at which Greece entered the EMU on 1/1/2001.

Following accession to the EMU in 2001, a number of important changes have occurred. Although the Greek long-term government bond yield has fully converged to

[6] Real interest rates have been calculated using the Fisher equation $1+ r_t = (1+i_t)/(1+\pi^e_t)$ where r, i and π^e_t respectively denote real interest rate, nominal interest rate and the inflation rate expected over an one-year period. Following Clarida et al (1998), expected inflation is approximated by the actual inflation rate subsequently recorded over a period of twelve months.

that of Germany and the EMU average, the high real interest rates of the 1990s have been succeeded by Greek real interest rates lower than the EMU average, taking increasingly negative values since late 2001. Inflation convergence has been discontinued and the inflation differential against the EMU average has even slightly increased. This has resulted in further overvaluation of the Greek real exchange rate which is likely to have contributed towards the record-high current account deficit values observed since 2001.

3. MODELLING METHODOLOGY AND EMPIRICAL RESULTS

3.1. Linear models of monetary policy

Our benchmark model is the standard linear specification proposed by Clarida et al (1998) where the short-term nominal interest rate r_t is given as a weighted average of a target level r^*_t and its own lagged value, i.e. $r_t = (1-r)\, r^*_t + r\, r_{t-1} + v_t$ where r denotes the degree of interest rate smoothing ($0 \leq r < 1$), The target rate is given by $r^*_t = \bar{r} + b\, (\mathrm{E}\,[p_{t+n} / \Omega_t] - p^*) + g\, (\mathrm{E}\,[y_t / \Omega_t] - y^*_t)$, where $\bar{r}$ is the long-run equilibrium nominal interest rate; $\mathrm{E}\,[p_{t+n}/\Omega_t]$ the inflation rate expected n periods ahead of the current period t, Ω_t the information set available at t; p^* the target inflation rate; y_t current output; y^* the target level of output, defined as full employment output, and v_t a white noise policy shock term. If $b > 1$ ($b < 1$), monetary policy is inflation-averse (inflation-accommodating); if $g > 0$ ($g = 0$) monetary authorities are (are not) concerned with output stabilisation. By replacing (2) in (1), defining $a \equiv \bar{r} - b\, p^*$, replacing forecasted by actual (realised) values and defining e_t as a white noise error term, Clarida et al obtain

$$r_t = (1-r)\, a + r\, r_{t-1} + (1-r)\, b\, p_{t+n} + (1-r)\, g\, (y - y^*)_t + e_t \qquad (1)$$

This can econometrically be estimated as

$$r_t = a + b_1\, r_{t-1} + b_2\, p_{t+n} + b_3\, (y - y^*)_t + e_t \qquad (2)$$

Equation (2) can be used to retrieve the target level of interest rate r^*_t by setting $\bar{r} = a / (1- b_1)$, $b = b_2 / (1-b_1)$ and $g = b_3 / (1- b_1)$. Furthermore, given that $a \equiv \bar{r} - b\, p^*$ and $\bar{r} = \overline{rr} + p^*$, it follows that $a \equiv \overline{rr} + (1-b)\, p^*$ and $p^* = (\overline{rr} - a)/ (b-1)$. These relations can be used to recover estimates of the central bank's target inflation rate p^* as well as the economy's equilibrium real interest rate $\overline{rr}$.

We estimate (2) using quarterly data for 1991-2000, the period covered by the Greek convergence programmes We define r_t to be the Greek three-month inter-bank money market rate, taken by the ECB Databank provided by Datastream. This is very highly correlated with the BOG overnight interest rate (see Figure 1(b))[7] but also accounts for the effect of the rest of the monetary policy instruments used to influence liquidity conditions (see footnote 5). As such, it reflects more accurately the overall Greek monetary policy stance. We define annual inflation p_t as D_4p_t, the percentage increase in Greek CPI relative to the same quarter of the previous year and p_{t+n} as D_4p_{t+1}.[8],[9] Due to lack of a consistent quarterly data set for Greek GDP, we follow Clarida et al (1998) and approximate y_t using the index of manufacturing production excluding construction.[10],[11]

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[7] The only exceptions are 1994(2) and 1997(4) when the BOG, in an effort to discourage speculative attacks, raised its intervention rate to three-digit levels.

[8] Figure 1(b) suggests that for the period covered by our sample, r and D_4p_t are not stationary. This, however, is more of a sample rather than a population property, as unit root tests on longer series for Greek CPI inflation and nominal (deposit) interest rates suggest that r and D_4p_t are stationary. More generally, the ambiguity with regards to the order of integration of these variables is a well-debated issue in the empirical literature, with the prevailing view being that inflation and nominal interest rates are stationary. For further discussion on this point see Clarida et al (1998, footnote 9) and Martin and Milas (2004).

[9] Using D_4p_{t+4} does not affect the nature of the results.

[10] This approximation appears to be very accurate, as the correlation coefficient for the annual series of manufacturing production and the real volume of GDP is 0.98 for the period 1949-2000 and 0.93 for the period covered by our analysis (1991-2000).

[11] Our analysis is subject to the caveats associated with output gap uncertainty and possible errors in output gap measurement. Smets (2002) argues that output gap uncertainty has a significant effect on the efficient response coefficients in restricted instrument rules such as the Taylor rule, reducing the response of monetary policy to the estimated output gap relative to inflation. Ehrmann and Smets (2003) argue that under optimal monetary policy, output gap uncertainty leads to persistent deviations between the actual and perceived output gap in response to supply and cost-push shocks. However, a simple policy rule such as the Taylor (1993) rule continues to perform well as long as the output gap is optimally estimated. Under such conditions, it is optimal to appoint a relatively more conservative central banker, attaching a lower weight on

We fit a Hodrick- Prescott (1997) filter into y_t to obtain an estimate y^*_t,[12] which we then use to obtain the output gap series (y-y^*) depicted in Figure 2. To avoid simultaneity between variables, we estimate (4) using the two-stage instrumental variables method.[13],[14] Also, to avoid simultaneity between y and r, and due to the time lags in publishing industrial output data, we use the first lag of (y-y^*).[15] Our findings are reported in Table 1, col. (a), with their long-run counterparts in Table 2, row (a). We obtain an average degree of interest rate smoothing. The coefficient of expected inflation in the long-run target reaction function is greater than unity, suggesting non-accommodating monetary policy. However, in contrast to theoretical expectations, we obtain a non-significant, negative output gap term (y-y^*).[16]

For countries following exchange rate targets, as Greece did in the 1990s, Clarida et al extend equation (2) to account for the interest rate of the country to whose currency the exchange rate target refers. We thus re-estimate (2) including a foreign interest rate series defined as the German day-to-day money rate for the period 1990-1998; and the

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output stabilisation. For further discussion, see Smets (2002), Ehrmann and Smets (2003) and the references therein.

[12] We also calculated potential output running a regression of actual output on a linear and a quadratic trend, as in Clarida et al (1998). The series we obtained was highly similar to the one produced by the Hodrick and Prescott (1997) filter, with the correlation coefficient between the two series estimated at 0.91.

[13] This is similar to the Generalised Maximum Likelihood (GMM) methodology and has the advantage of being able to handle endogeneity among regressors using limited information, especially in behavioural models such as those we estimate (see Hendry and Doornik 2001, p. 167). Like the IV, the GMM method is also making use of instruments but it is more suitable when the form of the data density is known and the sample size is sufficiently large (see Hendry and Doornik 2001, p. 183). Given the relatively small number of observations available for our analysis and the large number of parameters to be estimated (especially in the case of the non-linear models), the 2-stage IV method was preferred. The results of the estimations remain robust when the equations are estimated using the OLS method (available upon request).

[14] The instruments used for our IV estimations have as follows: the first and fourth lag of r; the first lag of the output gap (y-y^*); the first four lags of the foreign interest rate r^f; the first four lags of the Greek real exchange rate vis-à-vis the Euro (the ECU prior to 1999); the first lag of drachma's forward rate vis-à-vis the Euro (the ECU prior to 1999); and two intercept dummy variables taking the value of unity for 1994(2) and 1997(4) respectively; zero otherwise. The latter normalise the effects of the speculative attacks experienced by the drachma during those quarters.

[15] The results are not sensitive to the use of $(y\text{-}y^*)_t$ rather than $(y\text{-}y^*)_{t-1}$

[16] Our empirical findings are unaffected by the two interest rate spikes of Figure 1(b) in 1994(2) and 1997(4), as all models estimated in Table 1 (as well as all the rest of the models presented later in the paper) are estimated using intercept dummies neutralizing the effect of these two outliers. Excluding these dummies does not change the qualitative nature of the results but results in residuals' non-normality

three-month EMU money market thereafter (r^f_{t-1}), lagged for one period.[17] The estimates of the extended model are reported in Table 1, col. (b) with their long-run counterparts in Table 2, row (b). The degree of interest rate smoothing remains average; r^f_{t-1} appears to have had a significant effect on Greek monetary policy, much stronger than that of expected inflation. The extended model results in a lower regression standard error, although the output gap remains insignificant with a negative sign. These results are very similar to those obtained by Clarida et al for France, Italy and the UK and suggest that Greek monetary policy in the 1990s was shadowing Bundesbank's policy in an effort to "borrow" the latter's credibility.

3.2. Non-linear models of monetary policy

3.2.1. Linear reaction functions modified for sign and size output gap effects

We now seek further insights about the conduct of Greek monetary policy in the 1990s by testing for non-linearities in interest rates relating to the output gap such as those found by Bec et al (2002) and Surico (2003, 2006).[18] More specifically we estimate:

$$r_t = a + b_1 r_{t-1} + b_2 p_{t+n} + b_3 r^f_{t-1} + b_4 (y - y^*)_{t-1} + b_5 (y - y^*)^2_{t-3} + b_6 (y - y^*)^3_{t-3} + u_t \quad (3)$$

$$r_t = a + b_1 r_{t-1} + b_2 p_{t+n} + b_3 r^f_{t-1} + b_4 (y - y^*)^+_{t-3} + b_5 (y - y^*)^-_{t-3} + u_t \quad (4)$$

$$r_t = a + b_1 r_{t-1} + b_2 p_{t+n} + b_3 r^f_{t-1} + b_4 (y - y^*)^+_{t-3} + b_5 (y - y^*)^-_{t-3} + b_6 (y - y^*)^2_{t-3} + b_7 (y - y^*)^3_{t-3} + u_t \quad (5)$$

Equation (3) is the Escribano-Granger (1998) model, which allows for different monetary policy reaction during periods of small and large deviations of y from y^* (output gap size effects). Equation (4) is the Granger and Lee (1989) model, where $(y - y^*)^+ = (y - y^*)$ when $(y - y^*) > 0$, zero otherwise; and $(y - y^*)^- = (y - y^*)$ when $(y - y^*) < 0$, zero otherwise. This allows for different reaction during periods of relatively high and

[17] The data favoured the first lag, rather than the contemporaneous value of r^f

[18] In line with the analysis in Martin and Milas (2004), we also estimated equations (3), (4) and (5) testing for non-linearities relating to expected inflation. We did not find any evidence of such effects.

relatively low aggregate demand (output gap sign effects). Finally equation (5) is a composite model which allows for both kinds of effects.[19]

The results are reported in Table 1, columns (c) to (e) with their long-run counterparts in rows (c) to (e) of Table 2. In all cases we obtain a small to relatively medium degree of interest rate smoothing and a statistically significant expected inflation term. All models suggest that the pre-dominant factor influencing Greek monetary policy in the 1990s was r^f with an estimated coefficient higher than unity. They also indicate the presence of sign and/or size output gap effects: Although in the composite model reported in Table 1, col. (e), both the size- and sign-effects restrictions are not significant at the 5% level, when tested separately, in column (c) and (d) both restrictions are highly significant. Introducing size and/or sign effects reduces the regression standard error. However, the output gap term remain wrongly-signed; and all three equations present autocorrelation.

3.2.2. Formal tests for non-linear interest rate behaviour

We now test formally for non-linearities in Greek interest rates using the approach proposed by of Saikonnen and Luukkonen (1988), Luukkonen et al (1988), Granger and Teräsvirta (1993) and Teräsvirta (1994). This is based on estimating (6) below:

$$r_t = g_{00} + \sum_{j=1}^{f} \left(g_{0j} r_{t-j} + g_{1j} r_{t-j} r_{t-d} + g_{2j} r_{t-j} r_{t-d}^2 + g_{3j} r_{t-j} r_{t-d}^3 \right) + g_4\, r_{t-d}^2 + g_5\, r_{t-d}^3 + n_t \qquad (6)$$

Linearity is described by H_0: $[g_{1j} = g_{2j} = g_{3j} = g_4 = g_5 = 0]$ for all $j \in (1,2...f)$, where d is a delay parameter and $v(t) \sim niid\ (0,\sigma^2)$. H_0 can be tested using an LM-type test, estimated for all plausible values of d. The value of f is determined through inspection of

[19] The output gap terms testing for size and sign effects are the third rather than the first lagged values. This is due to the results obtained when testing formally for non-linearities in interest rate behaviour (see below).

the partial autocorrelation function of r_t.[20] Linearity is rejected if any of the resulting LM-statistics is statistically significant. The optimum value of d is the one with the highest LM score. The Partial Autocorrelation Function of r_t (not presented due to space constraints) suggested $f = 1$. Given the quarterly frequency of our data we set d = 1...4. All LM statistics in Table 3 are significant, with the highest LM-score obtained for d=3. We conclude that r_t presents non-linear behaviour which we proceed to model formally below.

3.2.3. Non-linear reaction functions

We now estimate three non-linear models similar to those in Martin and Milas (2004) capturing output gap effects in monetary policy.[21] First we estimate the Logistic Smooth Threshold Error Correction Model (L-STECM) given by equations (7) to (10):

$$r_t = q_t\, r_{1t} + (1-q_t)\, r_{2t} + e_t \qquad (7)$$

$$r_{1t} = k_1 + b_{11}\, r_{t-1} + b_{12}\, p_{t+n} + b_{13}\,(y-y^*)_{t-1} + b_{14}\, r^f_{t-1} + u_{1t} \qquad (8)$$

$$r_{2t} = k_2 + b_{21}\, r_{t-1} + b_{22}\, p_{t+n} + b_{23}\,(y-y^*)_{t-1} + b_{24}\, r^f_{t-1} + u_{2t} \qquad (9)$$

$$q_t = pr\left\{t \geq (y-y^*)_{t-d}\right\} = 1 - \frac{1}{1+e^{-s\,[(y-y^*)_{t-d}-t\,]}} \qquad (10)$$

The L-STECM distinguishes between a lower ($r_{Lt} = r_{1t}$) and an upper ($r_{Ut}=r_{2t}$) regime, where the output gap respectively takes values below and above a critical threshold t. Equation (7) models interest rates as a weighted average of r_1 and r_2. The regime weight q is given by (10) as the probability that the transition variable $(y-y^*)_{t-d}$ is below t, where the parameter σ denotes the speed of transition between the two

[20] Granger and Teräsvirta (1993) and Teräsvirta (1994) advise against choosing f using information criteria such as the Akaike, since this may induce a downward bias.

[21] A thorough discussion of these models can be found in van Dijk et al. (2002). The transition variable used by Martin and Milas is expected inflation. We estimated non-linear models using expected, current and past inflation rates as a transition variable but did not obtain any statistically significant results.

regimes.[22] An alternative model is the Quadratic Logistic STECM (QL-STECM), which replaces (10) by (14) below:

$$q_t = pr\ \{\ t^L \leq (y-y^*)_{t-d} \leq t^U\ \} = 1 - \frac{1}{1+e^{-s\,[(y-y^*)_{t-d}-t^L][(y-y^*)_{t-d}-t^U]}} \qquad (11)$$

The QL-STECM distinguishes between an inner ($r_{\mathrm{I}t} = r_{1t}$) and an outer ($r_{\mathrm{O}t} = r_{2t}$) regime where the output gap respectively takes values inside and outside a band, defined by an upper and a lower critical threshold value, t^{L} and t^{U} respectively. Equation (11) denotes the probability of $(y–y^*)_{t-d}$ being in the inner regime modelled using the quadratic function. Finally, a third model is the 3-regime STECM. This modifies (7) by (12) and replaces (10) by (13) and (14) below:

$$r_t = q_{1t}\, r_{1t} + (1–q_{2t})\, r_{2t} + (1–q_{1t}–q_{2t})\, r_{3t} + e_{\mathrm{t}} \qquad (12)$$

$$q_{1t} = pr\ \{\ t^L \leq (y-y^*)_{t-d} \leq t^U\ \} = 1 - \frac{1}{1+e^{-s\,[u(y-y^*)_{t-d}-t^L][(y-y^*)_{t-d}-t^U]}} \qquad (13)$$

$$q_{2t} = pr\ \{\ t^L \geq (y-y^*)_{t-d}\ \} = 1 - \frac{1}{1+e^{-s\,[(y-y^*)_{t-d}-t^U]}} \qquad (14)$$

The 3-regime STECM allows for three separate policy rules: one in the inner regime, when output is close to its natural rate ($r_{\mathrm{I}t} = r_{1t}$); another in the lower regime, when output is away from equilibrium in a state of relatively low aggregate demand ($r_{\mathrm{L}t} = r_{2t}$); and a third in the upper regime, when output is away from its steady state and in a state of relatively high aggregate demand ($r_{\mathrm{U}t} = r_{3t}$). The interest rate is given by (12) as a weighted average of these three regimes, with q_1 in (13) and q_2 in (14) the probability of $(y–y^*)_{t-d}$ being respectively in the inner and lower regime.

The parsimonious estimates of the L-STECM, QL-STECM and 3-regime STECM, obtained after the elimination of all statistically insignificant parameters, are reported in

[22] In practise, σ is usually estimated very imprecisely as the likelihood function in (13) is very insensitive to this parameter (see the detailed discussion on this point in van Dijk et al., 2002).

Table 1, columns (f), (g) and (h) respectively, with their long-run counterparts in rows (f), (g) and (h) of Table 2. In line with the results of our linearity tests we set d =3. The results are similar for all three models, including statistically significant regime thresholds[23] and an average degree of interest rate smoothing. For the L-STECM, monetary policy in the lower regime is determined by the foreign interest rate with an estimated coefficient well above unity. In the upper regime the only determinant of monetary policy is expected inflation with a long-run estimated coefficient equal to 0.85. For the QL-STECM, within the inner regime the sole determinant of monetary policy is the foreign interest rate, with short- and long-run coefficients well above unity. In the outer regime monetary policy is determined by expected inflation, with a long-run estimated coefficient equal to 0.95. Finally, for the 3-regime STECM model, in the inner regime monetary policy is determined exclusively by foreign interest rates, with short- and long-run coefficients significantly higher than unity; in the outer regimes, lower and upper, monetary policy is determined by expected inflation, with coefficients very similar to those of the QL-STECM outer regime (0.98 and 0.89 respectively). The properties of the non-linear models are superior to their linear counterparts, as they pass all misspecification tests and produce significantly lower regression standard errors.[24]

4. GREEK MONETARY POLICY IN THE 1990s: AN ASSESSMENT

4.1. Was Greek monetary policy in the 1990s inflation-averse?

The findings of the previous section can be summarised as follows: First, in the 1990s Greek monetary policy was primarily determined by foreign interest rates (German

[23] The absolute value of these thresholds is rather small. However, we should not forget that we have approximated total output using the index of industrial production. Therefore, it is the qualitative rather than the quantitative aspect of these estimates which are of interest to our analysis.

[24] In line with their linear counterparts the L-STECM, QL-STECM and 3-regime STECM models presented in Table 1 have been estimated including two intercept dummies accounting for the sharp increases of the Greek money market rate during the speculative attacks in 1994(2) and 1997(4). The inclusion of these dummies ensures that the non-linearities identified by our analysis are genuine and not the reflection of outlier observations (see Engle et al, 2005).

up to 1998, EMU thereafter). Second, in the 1990s the BOG maintained some independence in the contact of monetary policy, as domestic inflation and output continued to determine, to some degree, Greek interest rates. During periods of non-overheating (according to the L-STECM), or periods when output was close to its potential level (according to the QL-STECM), the determinant of Greek monetary policy was the foreign interest rate. In periods of overheating (or periods when output was away from its potential level), the determinant of Greek interest rates was expected inflation.

In this second regime, it is not entirely clear whether monetary policy was inflation-averse or not. In all but one models in Table 2, the estimated coefficients of $\Delta_4 p^e$ take value below unity, suggesting inflation accommodation. However, for our preferred non-linear models, these estimates are close to unity, which falls within one standard error from the estimated coefficients. Given the relatively small size of our sample, it is difficult to reject beyond reasonable doubt that the BOG was not taking the necessary measures to keep inflation in control. Such a conclusion would in any case be difficult to reconcile with the reduction in inflation depicted in Figure 1(b). At any event, Figure 2 suggests that the economy was typically in the former regime. This is further evidence according to which Greek monetary policy in the 1990s was primarily determined by foreign interest rates. This "strong-drachma" policy aimed at reducing inflation expectations and actual inflation by importing credibility from abroad. However, as we argue below, whether this objective was met is a debatable subject.

4.2. Policy credibility and the 1998 devaluation

The argument about limited policy credibility follows straight from Uncovered Interest Parity (UIP). This states that under full capital mobility, market rationality and no country-specific risk, at the current spot exchange rate the domestic nominal interest rate equals the sum of the foreign nominal interest rate plus any expected capital gains on the foreign currency ($r_t = r^f_t + \Delta s^e_t$, where Δs^e_t is the expected change in the log of the spot exchange rate). Under perfectly credible fixed exchange rates $\Delta s^e_t = 0$, so UIP reduces to a one-to-one relation between domestic and foreign interest rates ($r_t = r^f_t$). If in a well-specified monetary policy reaction function the coefficient of r^f is higher than unity (as in Tables 1 and 2), the domestic central bank reacts to changes in r^f more than proportionally. This implies that markets expect, in a risk-adjusted sense, a capital gain on the foreign currency.

Risk-adjusted expected gains on the foreign currency may be due to fundamental overvaluation of the domestic currency, resulting in simple (not adjusted for risk) devaluation expectations ($\Delta s^e_t > 0$); or/and to a perceived risk of inflationary monetary policy (in pursue, for example, of temporary output gains). In the first case, the domestic interest rate accounts for the sum of the foreign interest rate plus the expected capital gain on the foreign currency (not adjusted for risk) both multiplied by unity ($r_t = r^f_t + \Delta s^e_t$).[25] In the second case, account should also should be taken of the risk premium (pr) markets demand to hold assets denominated in domestic currency ($r_t = pr_t + r^f_t + \Delta s^e_t$). In this second case, the unity coefficients on r^f and Δs^e_t are maintained, but the UIP hypothesis, which assumes no country-specific risk, does not hold. These questions may be addressed using an empirical test of UIP involving estimation of equation (18) below

$$r_t = a + b_1 r^f_t + b_2 \Delta s^e_t + u_t \qquad (15)$$

[25] UIP is a non-arbitrage condition in foreign exchange markets and, like any non-arbitrage condition, does not imply any specific causality pattern among its variables. This has two important implications: first, the UIP equation is not a suitable framework of analysis for studying the determinants of interest rates; for that purpose, a monetary policy reaction function, such as those presented in Tables 1 and 2 is required; second, UIP is consistent with any mechanism determining expected capital gains on the foreign currency, i.e. with any fundamentals' based model of exchange rate determination, including the PPP model we use below.

where u_t is a zero-mean random error term. Estimating (15) presupposes a measure of exchange rate expectations Δs^e_t, a rather tricky issue in empirical research.[26] As mentioned in section 2, however, Arghyrou et al (2006) find that for the drachma-euro (ECU prior to 1999) exchange rate PPP is upheld as a long-run equilibrium condition. In that case, approximating Δs^e_t using the estimated PPP-misalignment term depicted in Figure 1(e) is a plausible assumption. If this were to capture Δs^e_t accurately, equation (15) should upheld the unity restrictions b_1=b_2=1. If, in addition we obtain a =0, we would conclude that UIP holds and we would assess the sustainability of the strong-drachma policy at any point in time by the value of the PPP misalignment term. If on the other hand a >0, UIP would be rejected on the basis of the existence of a country-specific risk premium, which would suggest credibility problems for Greek monetary policy throughout the 1990s.

Table 4 presents estimates of equation (15) using three different estimation techniques, namely OLS, Autoregressive LS and an Autoregressive Distributed Lag model accounting for endogeneity among the variables.[27] As Δs^e_t is defined as the deviation of drachma's exchange rate against the ECU (the Euro after 1999) from its PPP-consistent value, r^f_t is defined as the 3-month money market rate observed in the EMU area for the whole of the period 1990(1)-2000(4). In all cases the unity restrictions b_1=b_2=1 are upheld[28] and we obtain a >0, suggesting the existence of a positive risk premium in the

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[26] UIP tests are joint-hypothesis tests, as they simultaneously test for UIP and the hypothesis underlying the definition of exchange rate expectations Δs^e_t. The latter is often substituted by the forward premium (see e.g. Sarno and Taylor, 2002). This approach is primarily used in the international finance literature to test for FOREX market efficiency. We believe that for the purpose of our analysis, where the emphasis is on the role of macroeconomic factors on exchange rate and interest rate determination, replacing Δs^e_t with the estimated misalignment term is more suitable to acquire insights relevant to the questions we seek to address.

[27] Inder (1993, p.68) suggests that estimating an autoregressive distributed lag model and re-parameterising it to yield the static (long-run) equation produces precise estimates of long-run parameters and valid t-statistics, even in the presence of endogenous explanatory variables.

[28] We also estimated equation (15) using the FPMM misalignment term depicted in Figure 1(e). We obtained correctly signed coefficients and a statistically significant positive risk premium term (albeit slightly lower than the values reported in Table 4). However, using the FPMM misalignment term did not validate the theoretically expected unity coefficients. From that point of view, the PPP misalignment term seems to be more suitable to approximate exchange rate expectations.

range of 9 to 11 percent. These findings are robust to restricting the estimation sample to the period covering from 1994 to the announcement of the Greek accession to the EMU in 2000[29] which suggests that the average risk premium demanded on drachma denominated assets did not decline along with inflation in the course of the 1990s.[30]

Overall, when combined with the findings reported in Tables 1 and 2, Table 4 provides valuable insights with regards to the credibility of the strong drachma policy and the causes of its collapse in 1998. Prior to 1995 the BOG did not actually quantify its exchange rate targets; it was simply stating publicly its intention to link Greek monetary policy to the one of Germany. So, the higher-than-unity coefficients of r^f in the reaction functions in Tables 1 and 2 do not necessarily imply that Greek monetary policy during 1990-1994 was not credible.[31] Actually, Figure 1(e) suggests that during that period the drachma was undervalued against the euro and the Greek current account was improving. As a result, the high real interest rates in 1991-1994 were not due to risk originating from currency overvaluation or excessive current account deficits. If so, what underpinned them? Table 4 suggests that these were due to a significant risk premium, i.e. a low degree of market credibility attached to the strong drachma policy. Low credibility was very likely the result of previous experience with the stop-and-go nature of Greek macroeconomic policies in the 1980s (see Alogoskoufis 1995) including two drachma devaluations of 1983 and 1985, and the confusing signals sent by the limited only progress authorities achieved in promoting structural reforms (see e.g. Chalikias 1996).

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[29] The results are available upon request.

[30] We have also tested for the existence of a risk premium in Greek interest rate differentials by testing for a unit root in the series of the nominal interest rate differential between Greece and the EMU average. The results were consistent with those of our estimated UIP equations, as the nominal interest rate differential was found to stationary around a positive mean value approximately equal to 7 per cent (the results are available upon request).

[31] A credible monetary policy involving exchange rate targets is not necessarily inconsistent with the existence of depreciation expectations, as long as the implemented exchange rate target allows for some depreciation of the home currency against the foreign one; the rate of expected depreciation of the domestic currency is not higher than the rate of depreciation allowed by the implemented exchange rate target; and no significant risk premium exists on assets denominated in domestic currency. As we argue below, these conditions were not met in the case of Greece in the 1990s.

This outlook took a turn to the worse in 1995 when the BOG introduced a fixed exchange rate regime. Given the maintenance of a declining yet still positive inflation differential against the EMU average (see Figure 1(a)), the peg of the drachma to the ECU led to increasing overvaluation of the Greek drachma (see Figure 1(e)) which, in turn, resulted to a substantial deterioration of the Greek current account (see Figure 1(f)).[32] Thus, in addition to low credibility, markets developed increasing devaluation expectations, leading to a significant increase in the real interest rate. The policy collapsed in March 1998 when all these factors reached a peak and the Greek currency was devalued against the Euro by 14%. This is very close to the sum of the constant terms approximating the risk premium reported in Table 4 and the value of the PPP-misalignment term observed just before the devaluation (see Figure 1(e)).[33]

4.3. Summing-up: Greece at the time of joining the Euro

Where do the above leave our discussion on Greek monetary policy in the 1990s? In 1991, CPI inflation in Greece was above 20 %; by the end of 2000, it was down to 4 %, enabling Greece to join the EMU. This is a significant success. In the process, however, the Greek economy suffered serious side effects and suffered from credibility problems which eventually lead to the policy's collapse. Mourmouras and Arghyrou (2000) argue that it would have perhaps been preferable for Greece to pursue EMU participation through a more balanced macroeconomic policy mix, involving an inflation targeting monetary policy framework rather than exchange rate targets, a more determined fiscal consolidation effort and more active promotion of structural reforms. But as far as Greek

[32] For a detailed analysis on the role of real exchange rate overvaluation on Greek imports and exports see Arghyrou and Bazina (2003).

[33] The fact that the devaluation of March 1998 took place four months after the South-East Asia financial crisis of autumn 1997 lends itself to the hypothesis that it was the result of contagion effects. Our findings here when combined with those in Arghyrou et al (2006) reject this hypothesis. The latter study finds that by 1997(4) the size of drachma's overvaluation had grown enough so that a critical threshold triggering devaluation was surpassed. Overall, our findings suggest that the Greek devaluation of 1998 was country-specific and more relevant to the second-generation currency crisis model of Obstfeld (1996).

monetary authorities are concerned, fiscal policy and structural reforms were policy areas beyond their control. Hence, given the general macroeconomic framework within which it had to operate, monetary policy in the 1990s can be judged to have achieved an overall positive policy outcome.

5. THE BANK OF GREECE AND THE ECB: A COUNTERFACTUAL ANALYSIS

We now address the question of compatibility between the ECB monetary policy and domestic Greek economic conditions. We do so using the counterfactual experiment used by HH for Germany. This consists of comparing the interest rates set by the ECB against the out-of-sample forecasts provided by the equations reported in Table 2 for the Greek target interest rate calculated for the period following Greece's accession to the EMU i.e. 2001(1)-2006(1).[34] The results are reported in Table 5. All models provide average forecasts approximately four times higher than the actual ECB rate. These remain robust when the models in Tables 1 and 2 are estimated with a sample restricted to the period from 1994 to the date of announcement of Greece's accession to the EMU in 2000.[35]

The difference between the actual ECB and projected Greek target interest rates may reflect two potential effects. According to the first Greece needs a monetary policy tighter than the one followed by the ECB. This may be so because in 2001-2005 the Greek economy grew significantly faster than the EMU average, in which case Greece needed higher nominal interest rates to control inflation more effectively. Instead, according to

[34]This counterfactual is based on a number of assumptions about the state of the world that would have prevailed had Greece not entered the EMU in 2001. Such assumptions are by definition subject to questioning. However, given Greece's small size, it is plausible to assume that without Greece in the EMU, the interest rate policy of the ECB would not have been significantly different. Also, it is plausible to assume had Greece not entered the EMU in 2001, the BOG would have continued to be concerned with output and inflation stabilisation. Finally, it is important to note that as Clarida et al (1998, p. 1058) emphasize for their own analysis on Italy, France and the UK, our counterfactual analysis does not account for the effects of EMU on Greek output and expected inflation. For that purpose, it would be necessary to specify a complete macroeconomic model, which exceeds the scope of studies like the present one. We do, however, address the possibility of the elimination of the identified risk premium in the post-euro period (see section 5 below).

[35] To preserve space these estimates are not reported but are available upon request.

this explanation, the low interest rates set by the ECB over-stimulated Greek domestic demand, fuelled inflationary pressures, increased real exchange rate overvaluation and, ultimately, resulted in historically high current account deficit levels.

The second effect may be the elimination of the risk premium embodied in Greek interest in the 1990s, caused by the replacement of the Greek drachma by the euro. This would imply that the out-of-sample forecasts in Table 4 are driven by the high constant coefficients reported in Table 2, which are now not applicable due to the change in the monetary policy regime. In that case, the difference recorded in Table 5 would reflect the credibility gains caused by Greece's accession to the euro. Such credibility gains may in the short-run result in excessively low interest rates, an increase in inflation and higher-than-normal current account deficits (see e.g. Giavazzi and Spaventa, 1990). In the medium-term, however, the subsequent competitiveness losses result in lower inflation so that the economy eventually settles in sustainable current account deficits. [36]

The movements of Greek inflation and current account since 2001 are observationally consistent with both explanations discussed above. Furthermore, the two effects are not necessarily mutually exclusive, in which case what we actually observe may be a combination of both. As a result, for a more definite assessment to be possible it will be necessary to collect further data as years go by. In the meantime, however, we may obtain some tentative indications as to which of the two effects may be more applicable by replicating the analysis by HH on Germany. HH (p. 656) modify their target interest rate projections by adjusting the constant of their estimated pre-euro Bundesbank reaction function for a lower equilibrium EMU real interest rate ($\overline{rr}_{EMU}$) and a target inflation rate

[36] The model by Giavazzi and Spaventa relates to countries that fix credibly their exchange rates in the context of the Exchange Rate Mechanism (ERM). Their conclusions must be stronger for countries joining the EMU as the replacement of national currencies by the euro implies a zero probability of a currency crisis during the intermediate period between the short-run increase in inflation and current account deficit and the point in time these effects are reversed in the medium-term.

equal to ECB's inflation objective of 2% (p^*_{ECB}).[37] The adjusted constant is then given by $a^{adj} \equiv \overline{rr}_{EMU} + (1-b)\, p^*_{ECB}$, where b is the coefficient of expected inflation in the estimated pre-euro Bundesbank monetary policy reaction function. Following Clarida et al (1998, p.1046), we set $\overline{rr}_{EMU}$ equal to the average value of the quarterly rr_{EMU} series following the introduction of the euro, i.e. 1999(1)-2005(4). This yields $\overline{rr}_{EMU} = 1\%$ which is very close to the 1.28% HH derive formally for the period 1999(1)-2003(5) (monthly data).

The results of our counterfactual experiment with the adjusted constant values are presented in Figure 3. For presentation clarity we only present projections for the base line model and the L-STECM which is the model producing the best data fit (lowest regression standard error) in Table 1.[38] For the L-STECM the adjusted constant is calculated using the coefficient of inflation in the upper regime, which describes pre-euro monetary policy under non-normal (overheating) conditions.[39] Setting $\overline{rr}_{EMU} = 1\%$ and $p^*_{ECB} = 2\%$ yields a^{adj} equal to 0.9% and 1.3% for the base line and L-STECM models respectively. These are significantly lower than the constant terms reported in Table 2 and reasonably close to the 0.78% calculated by HH for the Bundesbank. The adjusted constant coefficient produces a significant reduction in the value of our out-of-sample forecasts compared to the models with unadjusted constants. The adjusted projections, however, still remain higher than the actual EMU rates by a factor approximately equal to two (see also Table

[37] The choice of HH to set the values of the target real interest and inflation rates equal to those of the EMU average for the post-euro period makes intuitive sense. The loss of monetary independence implies that a national target inflation rate higher than that of the union's average would result in accumulating competitiveness losses leading to unsustainable current account imbalances. Also, a national target real interest rate higher than the union's average would result in inferior national government borrowing terms and increased real cost of servicing public debt relative to the union's average.

[38] The average projections of the rest of the models in Table 2 are very close to those of the two models (based line and L-STECM) reported in Figure 3. The results are available upon request.

[39] In the context of this experiment, the lower regime of the L-STECM is not relevant as the sole determinant of pre-euro monetary policy in that regime was found to be r^f.

4). Overall, our findings indicate that both a reduction in the pre-euro risk-premium and some degree of monetary policy incompatibility may exist since 2001.

6. SUMMARY

In a recent paper Hayo and Hofmann (HH, 2006) use the forward-looking specification in Clarida et al (1998) to model monetary policy in Germany and the ECB respectively for the pre- and post-euro eras. HH use their findings to compare the ECB conduct of monetary policy with that of the Bundesbank and assess the degree of compatibility between the interest rates set by the ECB since 1999 and the needs of the German economy. In this paper we focus on one of the small EMU economies, Greece, whose pre- and post-euro inflation and growth performance are markedly different from those of Germany. Our analysis extends the one by HH as it also allows for the more complex monetary policy decision-making process accounting for output gap effects such as those identified by Bec et al (2002) and Surico (2003, 2006) captured using non-linear models such as those used in Martin and Milas (2004).

Our analysis addresses two interrelated questions. First, how was Greek monetary policy conducted in the 1990s so that the EU highest-inflation country in the 1990s managed to join the euro by 2001? Second, how compatible is the ECB monetary policy with current Greek economic conditions? Would, in other words, the Bank of Greece (BOG), given the high growth rates experienced by Greece in recent years, set interest rates higher the ECB in an effort to control domestic inflation more effectively? Our findings can be summarised as follows: First, in the 1990s Greek monetary policy was primarily determined by foreign interest rates (German up to 1998, ECB thereafter). Second, domestic fundamentals continued to determine, to some degree, Greek monetary policy. Third, Greek monetary policy was subject to non-linear output gap effects. Fourth, the exchange rate targets pursued in the 1990s were characterised by a deficit of credibility which contributed significantly to drachma's devaluation in 1998.

On the question of compatibility our findings depend on the value assumed for the equilibrium Greek real interest rate for the post-euro period. All estimated pre-euro monetary policy reaction functions provide out-of-sample forecasts for the Greek target money market rate approximately four times higher than the actual EMU money market rate. However, when we account for a lower equilibrium real interest rate during the post-euro period the difference is substantially reduced to a factor approximately equal to two Overall, our findings indicate that both a reduction in the pre-euro risk-premium embodied in Greek interest rates and some degree of monetary policy incompatibility may be in existence since 2001.

Our analysis motivates similar research on EMU members such as Ireland and Spain who share Greece's post-euro high growth rates, in which case the question of monetary policy compatibility is particularly relevant. Our findings are also relevant to the new EU members which, like Greece, are predominantly small, open economies. The Greek experience suggests that it is possible for a monetary policy based on exchange rate targets to result in inflation reduction and, ultimately, EMU accession. At the same time, however, it suggests that such a policy may result in significant side-effects leading to credibility problems and destabilising exchange rate turbulence. It is thus possible for a monetary policy framework based on formal inflation targets, accompanied by fiscal restraint and structural reforms, to provide a better platform for the current EMU-outs to pursue EMU participation. Countries such as the Czech Republic, Hungary, Poland, Slovakia and Slovenia have indeed adopted such a policy framework which, in the case of Slovenia, has already delivered admission to the EMU.

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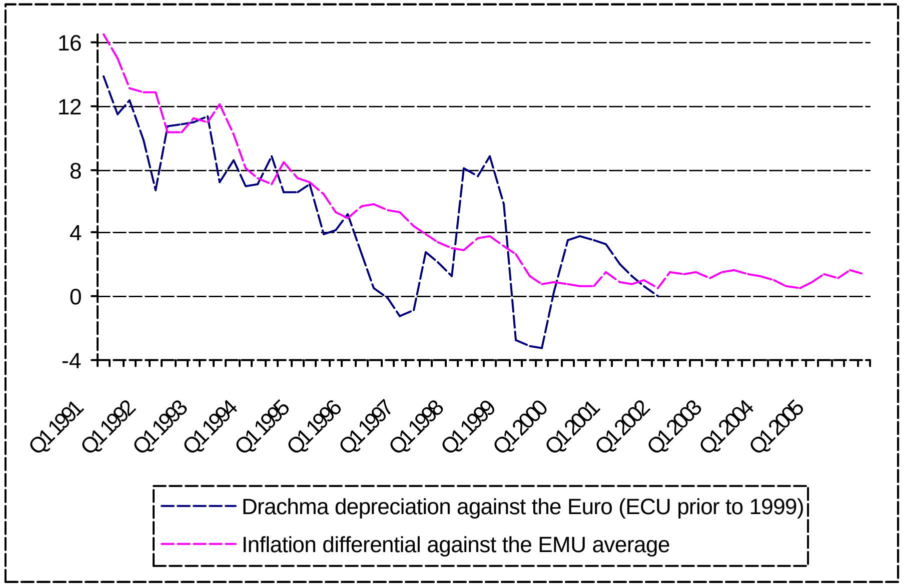
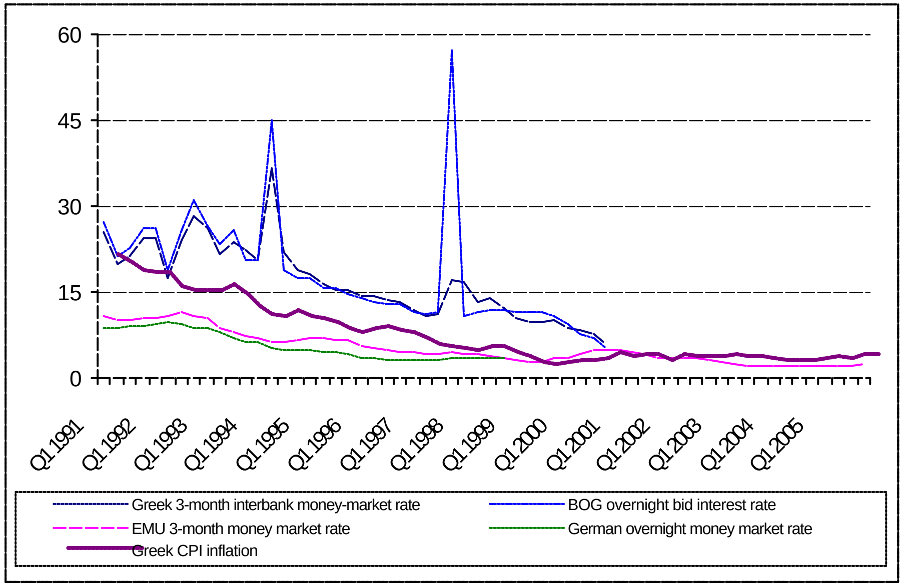
Figure 1: Monetary developments in Greece

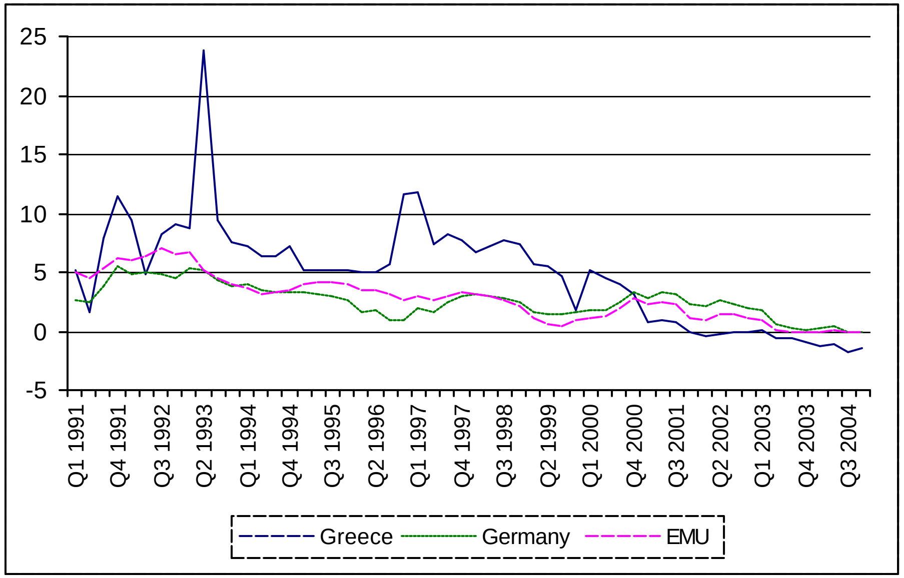
(a) Drachma depreciation against the Euro and inflation differential against the EMU average



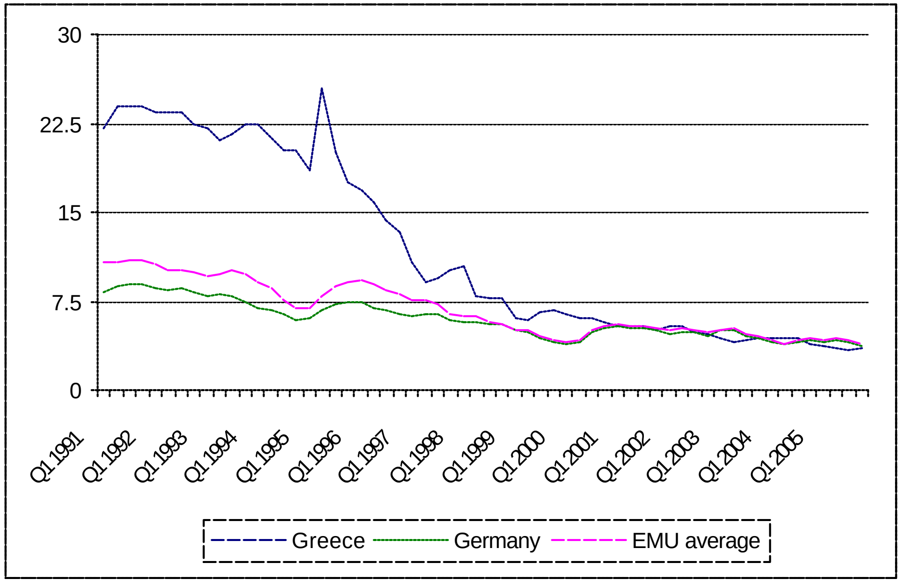
(b) CPI inflation and money market interest rates



(c) Real interest rates



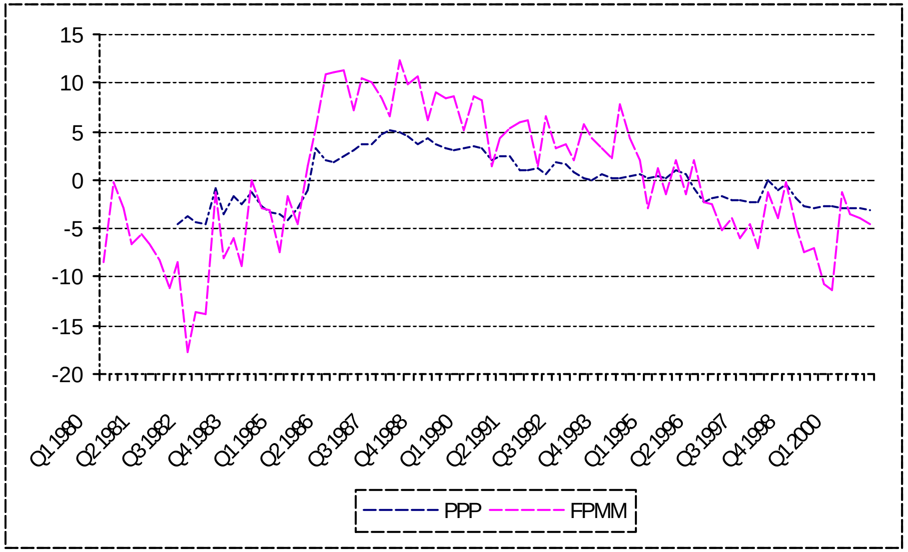
(d) Long-term government bond yields



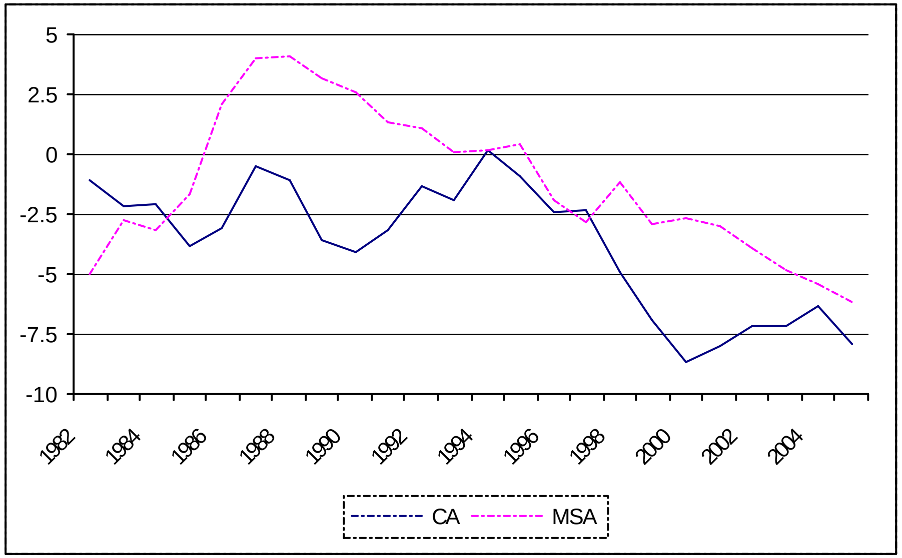
Sources: International Financial Statistics and Eurostat

Figure 1 (continued) : Monetary developments in Greece

(e) Drachma misalignment relative to its PPP- and FPMM-consistent value



(f) Current account balance (CA, % in GDP) versus PPP-misalignment (MSA)



Sources: Arghyrou, Boinet and Martin (2006) and International Financial Statistcis

Figure 2: Output gap measure (y-y*) and estimated regime thresholds of the L-STECM and QL-STECM models

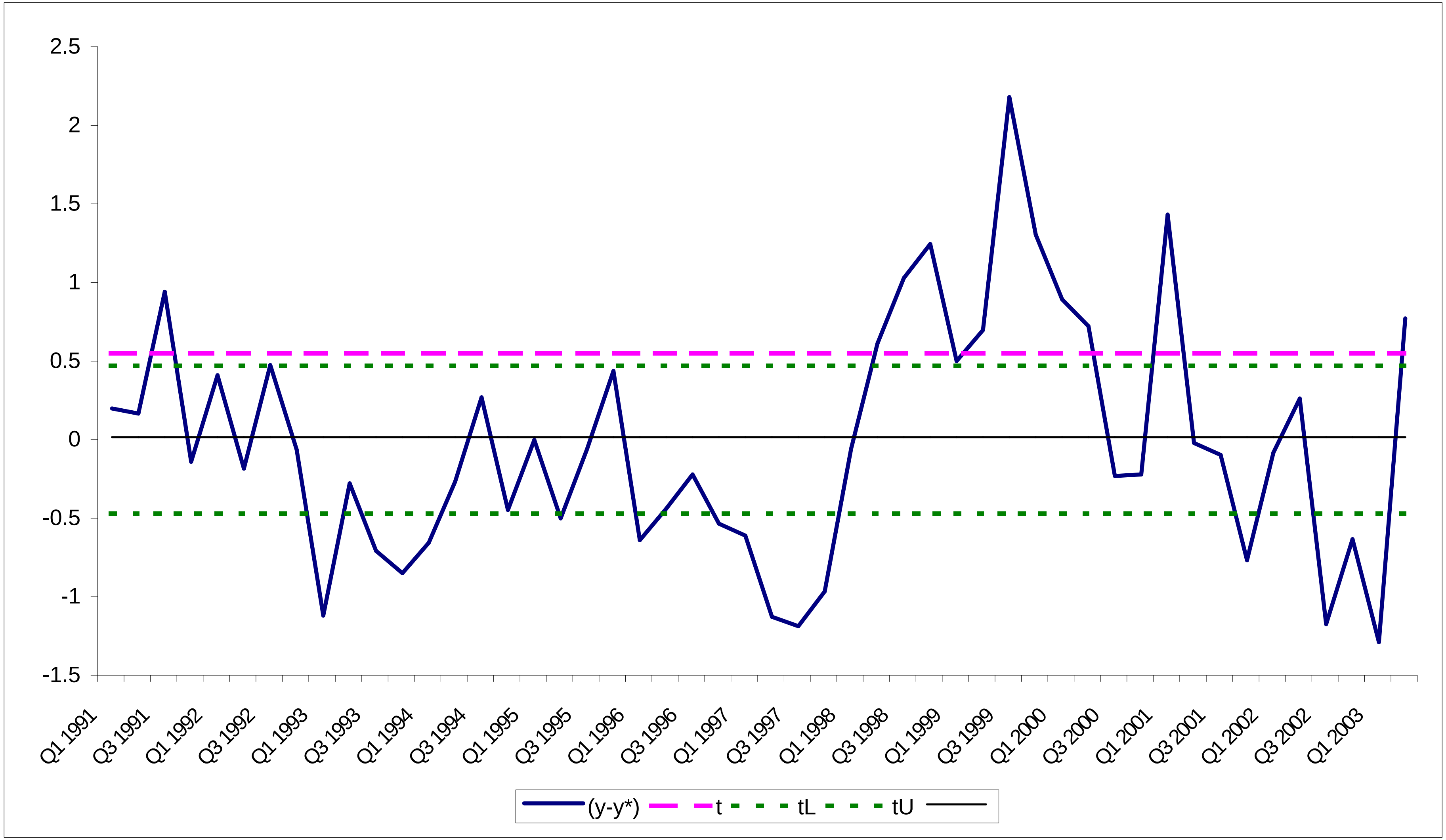
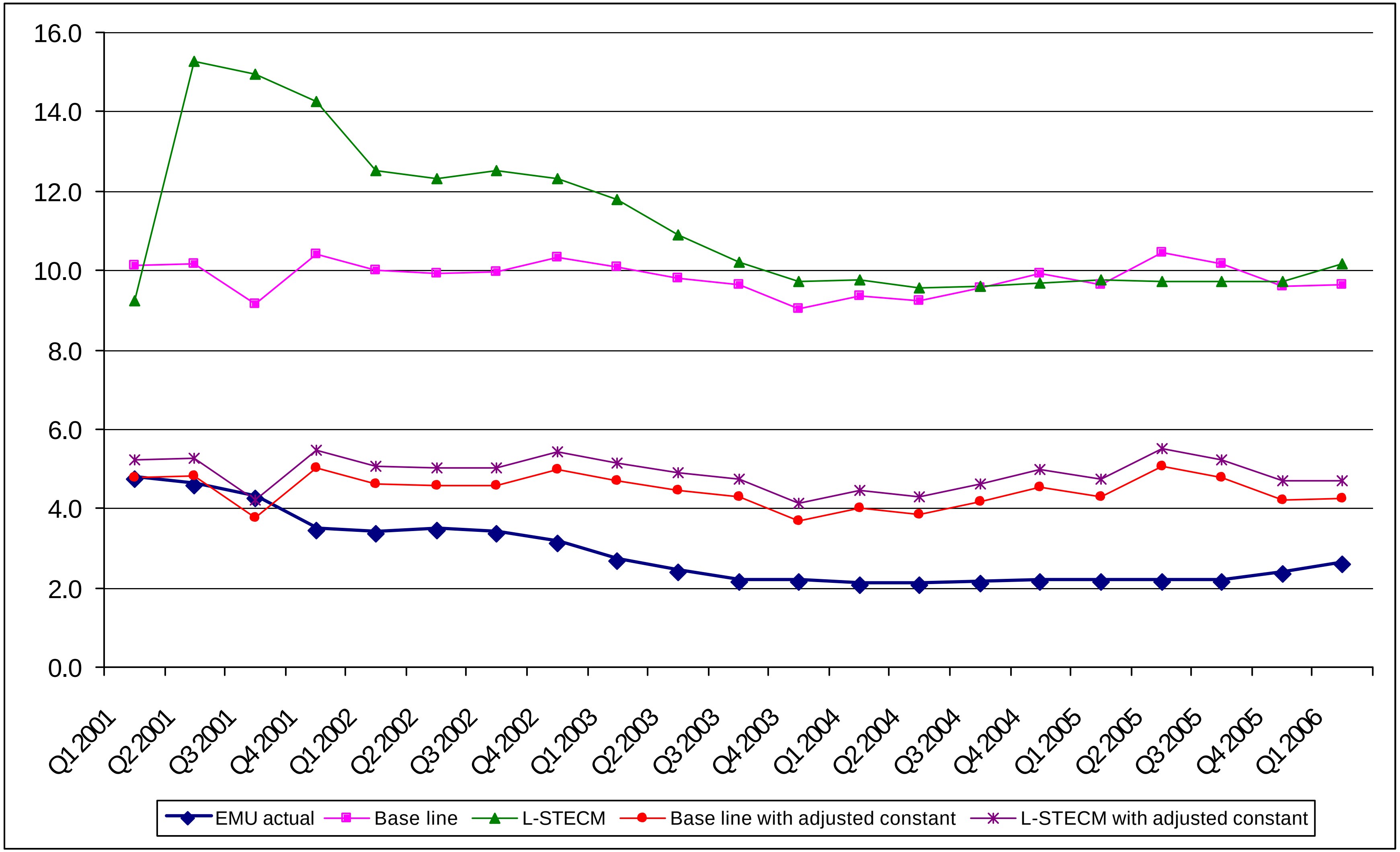


Figure 3: Actual EMU versus calculated Greek target 3-month money market rates, 2001(1)-2006(1)



Source for EMU 3-month money market rates European Central Bank; Greek target interest rates calcluated based on findings in Table 2

Table 1: Monetary policy reaction functions

	Linear models					Non-linear models							
	(a)	(b)	(c)	(d)	(e)	(f)		(g)		(h)		
	Base line	Base line with r^f	Size output gap effects	Sign output gap effects	Size and sign output gap effects	Sign output gap effects (L-STECM)		Size output gap effects (QL-STECM)		Size and sign output gap effects (3-regime STECM)		
						R_L-Lower	R_U-Upper	R_I- Inner	R_O-Outer	R_L-Lower	R_I-Inner	R_U-Upper
Constant	0.041 (0.011)	0.031 (0.012)	0.037 (0.011)	0.050 (0.011)	0.046 (0.011)	0.039 (0.009)		0.044 (0.008)		0.048 (0.009)		
r_{t-1}	0.348 (0.089)	0.308 (0.089)	0.325 (0.083)	0.266 (0.086)	0.221 (0.084)	0.256 (0.069)	0.358 (0.155)	0.221 (0.139)	0.321 (0.069)	0.303 (0.074)	0.145 (0.211)	0.255 (0.142)
$D_4\ p^e$	0.681 (0.107)	0.399 (0.173)	0.437 (0.162)	0.346 (0.153)	0.441 (0.149)		0.544 (0.196)		0.642 (0.102)	0.680 (0.134)		0.660 (0.173)
$(y\text{-}y^*)_{t-1}$	-0.009 (0.539)	-0.030 (0.514)	0.217 (0.471)									
r^f_{t-1}		0.769 (0.377)	0.663 (0.356)	0.894 (0.356)	0.884 (0.336)	1.578 (0.201)		1.571 (0.341)			1.565 (0.494)	
$(y\text{-}y^*)^2_{t-3}$			-1.054 (0.335)		-0.568 (0.947)							
$(y\text{-}y^*)^3_{t-3}$			15.43 (17.08)		59.16 (25.18)							
$(y\text{-}y^*)^+_{t-3}$				-2.477 (0.734)	-2.791 (1.779)							
$(y\text{-}y^*)^-_{t-3}$				1.629 (0.826)	-0.609 (2.184)							
τ						0.0055 (0.0016)						
τ^U								0.0047 (0.0012)		0.0047 (0.0008)		
τ^L								-0.0047 (0.0018)		-0.0043 (0.0020)		
Reg. SE	0.0223	0.0215	0.0193	0.0186	0.0176	0.0140		0.0154		0.0157		
AR	1.95 [0.14]	1.88 [0.15]	3.82 [0.02]	3.68 [0.02]	2.88 [0.05]	0.63 [0.60]		0.79 [0.51]		0.71 [0.56]		
ARCH	1.03 [0.40]	0.77 [0.52]	0.68 [0.57]	1.74 [0.18]	1.27 [0.31]	0.31 [0.81]		0.42 [0.74]		0.58 [0.63]		
Norm	9.44 [0.01]	7.20 [0.03]	10.88 [0.00]	7.95 [0.02]	12.17 [0.00]	4.07 [0.13]		2.80 [0.24]		1.28 [0.53]		
Hetero	1.06 [0.42]	0.89 [0.55]	1.16 [0.38]	1.01 [0.47]	0.85 [0.62]	0.80 [0.66]		0.39 [0.96]		0.38 [0.97]		
Inst. valid.	14.64 [0.15]	11.20 [0.26]	14.23 [0.11]	10.00 [0.35]	10.67 [0.30]	n.a.		n.a.		n.a.		
F-test for output-gap size effects			4.97 [0.01]		0.34 [0.56]							
F-test for output -gap sign effect				10.77 [0.00]	2.83 [0.07]							

NOTES: Numbers in parentheses are standard errors, p-values in square brackets. AR is the Lagrange Multiplier F-test for second order residual serial correlation; ARCH is the Autoregressive Conditional Heteroskedasticity F-test; Norm is the Normality Chi-square Bera-Jarque test for residuals' non-normality; Hetero is an F-test for heteroskedasticity; Inst. valid. is the Sargant Chi-square test for instruments' validity. The output of the econometric programme used for estimating non-linear models (Pc-Give) does not report instrument validity tests in non-linear algorithms.

Table 2: Target monetary policy reaction functions

Equation	col. in Table 1	$\bar{r}$	$D_4 p^e$	$(y\text{-}y^*)_{t\text{-}1}$	$r^f_{t\text{-}1}$	$(y\text{-}y^*)^+_{t\text{-}3}$	$(y\text{-}y^*)^-_{t\text{-}3}$	$(y\text{-}y^*)^2_{t\text{-}3}$	$(y\text{-}y^*)^3_{t\text{-}3}$
Base line	(a)	0.063	1.044	-0.130					
Base line with r^f	(b)	0.048	0.577	-0.043	1.111				
With size output gap effects	(c)	0.055	0.647	0.311	1.139			-1.555	22.86
With sign output gap effects	(d)	0.068	0.471		1.218	-3.375	2.219		
With sign and size output gap effects	(e)	0.059	0.566		1.135	-3.583	-0.781	-0.729	75.94
With sign output gap effects (L-STECM)	(f)								
Lower regime R_L		0.052			2.121				
Upper regime R_U		0.061	0.847						
With size output gap effects (QL-STECM)	(g)								
Inner regime R_I		0.056			2.016				
Outer regime R_O		0.065	0.946						
With sign and size output gap effects (3-reg STECM)	(h)								
Lower regime R_L		0.069	0.975						
Inner regime R_I		0.056			1.830				
Upper regime R_U		0.064	0.886						

Table 3: Linearity tests on Greek three-month money market rates

d	*LM F-test [p-value]*
1	4.62[0.00]**
2	2.91[0.03]*
3	4.76 [0.00]**
4	2.60 [0.04]*

Note: The Table reports the F-scores of the LM test in equation (6); * and ** denote statistical significance at the 5 and 1 per cent level respectively

Table 4: Uncovered Interest Parity equations

	(a) OLS	(b) Autoregressive LS	(c) Autoregressive Distributed Lag
α	0.098 (0.025)	0.107 (0.031)	0.089 (0.029)
β_1	1.087 (0.349)	1.046 (0.427)	1.197 (0.39)
β_2	1.005 (0.540)	1.448 (0.607)	1.091 (0.510)
R^2	0.76	N/A	0.86
Regression Std Error	0.0326	0.0275	0.0251
AR	3.92 [0.02]	N/A	1.45 [025]
ARCH	1.50 [0.23]	0.57 [0.64]	0.34 [0.80]
Normality	1.35 [0.51]	6.11 [0.05]	4.97 [0.08]
Hetero	3.48 [0.01]	2.00 [0.11]	0.77 [0.64]
RESET	8.59 [0.00]	1.63 [0.17]	1.34 [0.25]
Chi-square test H_0: $\beta_1 = \beta_2 = 0$	0.26 [0.88]	1.67 [0.44]	1.60 [0.45]

NOTES: The results reported in column (c) are based on the estimation of an unrestricted Autoregressive Distributed Lag (ADL) model which is re-parameterized to yield the reported static equation; standard errors in parentheses, p-values in square brackets. AR is the Lagrange Multiplier F- test for residual serial correlation of up to fifth order. ARCH is an F-test for Autoregressive Conditional Heteroskedasticity. Normality is the Bera-Jarque Chi-square test for residuals' normality. Hetero is an F-test for residuals' heteroskedasticity. RESET is an F-test for functional form. All equations have been estimated including an intercept dummy variable taking the value of 1 for 1994(2), zero otherwise.

Table 5: EMU actual versus out of sample forecasts for Greek three-month money market rates

	Average value 2001(1)-2006(1)	*Ratio of projected Greek to actual EMU rate*
Actual EMU 3-month money market rate	2.8	1.0
Forecast for Greek 3-month money market rate		
Base line	9.8	3.7
Base line with r^f	10.0	3.7
With sign output gap effects	10.2	3.9
With size output gap effects	11.0	4.1
With sign and size output gap effects	11.9	4.3
L-STECM	11.1	4.1
QL-STECM	10.5	3.9
3-regime STECM	10.7	4.0
Forecast for Greek 3-month money rate with adjusted constant		
Base line	4.4	1.7
L-STECM	4.9	1.9