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before and after the euro

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The monetary policy rules in EU-15: before and after the euro

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Abstract

The objective of this paper is to identify empirically the logic behind short-term interest rates setting of: 1) the monetary authorities of the 15 EU countries before the launch of the European Monetary Union (EMU) and 2) the European Central Bank (ECB) and the central banks of the non-EMU participants since 1999. We find that the Taylor rule, based on the response to inflation and to the output gap, is a reasonable description of the interest rate setting for only a few economies. In addition, the foreign interest rate and the long-term interest rate are often crucial to explain short-term interest rate developments. On the contrary, the impact of other variables often proposed in the literature (exchange rates, monetary growth and asset prices) is negligible. The application of single-equation analysis to Euro area aggregate data to identify the ECB policy rule seems to suffer econometric deficiencies. Besides, we find some evidence indicating that the ECB considers also national information for its decision-making and consequently that the ECB interest-rate rule can be revealed in quasi-panel setting.

Keywords: monetary policy, Taylor rule, European Monetary Union, panel data

JEL Classification: E52, E58

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1. Introduction

An intensive research effort in the area of empirics of monetary policy rules started in the 1990's with the seminal paper of Taylor (1993). The Taylor rule (TR) suggests that the variability of the US federal fund rate can be explained as a linear combination of the deviations of the inflation rate from its target value (variable of price stability) and of the output from its potential value (variable of real economic activity). The subsequent empirical studies claim that an augmented version of the TR (including interest-rate smoothing and response to some additional variables) provides a reasonable description of the interest rate setting in other economies (Clarida *et al.*, 1998). Although vast empirical evidence is available for the major economies like the US, the UK or Germany, there is an important gap in our understanding of what drives the short-term interest rate dynamics in smaller economies.

The establishment of the European Monetary Union (EMU) represented a challenge to identify the policy rule of the European Central Bank (ECB). Early studies used meta-data of an artificial Euro area from the period preceding 1999 (Peersman and Smets, 1999, Gerlach and Schnabel, 2000). The availability of data permitted the study of actual ECB policy rule only recently (e.g. Surico, 2003, Fourcans and Vranceanu, 2004, 2007, Fendel and Frenkel, 2006). A disconcerting feature of the latter research is that the estimates of the basic coefficients, like the response to inflation, are very dispersed across studies. This is rather surprising given that the results obtained for the US are much less heterogeneous despite greater diversity of empirical frameworks employed.[1] All the studies for the ECB are based on union-wide aggregated data, which is consistent with the official ECB policy but may cause diverse econometric problems, which we discuss later.

It is important to stress that empirical analysis of monetary policy rules aims at approximation of monetary policy rather than being real description of the policy conduct. Moreover, it has several limitations. First, the historic data used for estimation are only imperfect approximation of information available at time of a policy decision (Orphanides, 2001). Second, the linear specification of the empirical model can be too simplified since there can be an asymmetric response to some variables (Dolado *et al.*, 2005). Third, if the

[1] While most studies for the ECB use simple time-invariant specification of the Taylor rule sometimes augmented by some additional variables, the empirical studies of the FED interest rate setting range from single-equation estimation of time invariant model a la Taylor rule to complex methods that allow for the time variance of the model parameters. Some studies test the nonlinearity of policy rules while other use real-time data.

rules are estimated over longer periods, it is preferable to allow for the time-variance of the response coefficients (Valente, 2003). As the Taylor-type regression is an empirical approximation of monetary policy rather than being real description of the policy conduct, we do not aspire to present an actual policy rule for each central bank but rather to reveal the way in which short-term interest rates, as the main monetary policy instrument, responded to the main macroeconomic variables.

The main objective of this paper is an empirical identification of interest rate rules that have been pursued by monetary authorities in the original 15 EU members. We have carried out an estimation of an augmented version of the TR for each of then 15 EU members before the launch of EMU (1992-1998) and a common estimation for the EMU members in the posterior period (1999-2006). This focus permits us to effectively compare monetary policy rules of different countries and assess the effects of the EMU launch in both the EU countries that have adopted the euro as a national currency as well as those that have not.

We have identified well-specified representation of interest rate rules for all the countries. Nevertheless, we have found that the benchmark TR is not a good description of the interest rate setting in many countries. We also show that the foreign interest rate has a substantial effect on the domestic interest rate dynamics. Our research indicates that the short-term interest rate responds sometimes also to the long-term interest rates because the latter may bear information on inflation expectations. We note that other variables proposed in related literature (exchange rates, monetary growth and asset prices) have rather negligible impact. Finally, we have found some evidence that the ECB does not base its decisions only on the union-wide variables but also considers national developments. In particular, the inflation dispersion across countries seems to have effect on the ECB monetary policy.

The rest of the paper is organized as follows: the next section reviews the econometric framework; Section 3 presents our dataset and the results of the basic time series analysis; Section 4 summarizes the empirical results on the short-term interest rate setting in pre-EMU period, and; Section 5 covers the results on the monetary policy rule of the ECB and of countries outside the Euro area since the EMU launch. We conclude in Section 6.

2. Empirical approach

2.1 Country level analysis

Different forms of the monetary policy rules that deliver desirable outcomes in terms macroeconomic stabilization were derived in the theoretical literature on optimal monetary policy (Taylor, 1999). The empirical research mostly stems from the specification proposed by Clarida *et al*. (1998):

$$i_t^* = \bar{i} + \beta\left(E\left[\pi_{t+s}\left|\Omega_t\right.\right] - \pi_{t+s}^*\right) + \gamma\left(E\left[y_{t+k}\left|\Omega_t\right.\right]\right) + \varepsilon_t \qquad (1)$$

where i_t^* is the short-term interest rate (set by the central bank), $\bar{i}$ is the nominal equilibrium interest rate, consisting of the real equilibrium interest rate and the inflation target π^*. The deviation of the actual interest rate from the equilibrium rate is driven by the response of the central bank to the deviation of the inflation forecast π_{t+s} from the target value π_{t+s}^* (*s* periods ahead) and by the deviation of actual output from its potential value (the output gap) y_{t+k}. $E[\ ]$ is the expectation operator, Ω_t represents the information set available at the time of policy decision and ε_t is a disturbance term. Judd and Rudebusch (1998) observed that it is common practice in most central banks to smooth the interest rate changes over time so as not to have any disruptive effects on the economy. Clarida *et al*. (1998) suggested modelling this policy inertia by simple partial adjustment mechanism:

$$i_t = \rho i_{t-1} + (1-\rho) i_t^* + \upsilon_t \qquad (2)$$

where the actual interest rate i_t is a combination of the interest rate target i_t^* implied from the policy rule and the lagged value (usually one period) of the interest rate i_{t-1}. ρ is the smoothing coefficient. The existence of interest rate smoothing has been confirmed by most empirical studies, although there is disagreement about the origins of this effect. Rudebusch (2002) argues that a substantial size of the smoothing coefficient ρ is not consistent with the practical difficulties to predict the interest rate changes. His explanation is that the smoothing parameter is overestimated, which is usually due to the omission relevant variables in the regression model.[2] Therefore, some variables can influence the monetary policy stance, although they are not directly proclaimed to be monetary policy objectives. These additional variables can be linked to the policy objectives (the inflation rate) as their predictors (the long-term interest rate, asset prices). Besides, the monetary policy can be constrained by

[2] See Appendix

foreign interest rate or the exchange rate developments. In our case, the existence of the Exchange Rate Mechanism (ERM), where the participating countries limited the exchange rate fluctuations, admittedly restricted the interest rate setting.[3] Moreover, it is likely that small countries follow the lead of dominant economies and adjust their interest rate in consideration of the monetary decisions of the latter ones. To take these effects into account, we augment the specification used for empirical analysis with additional variables, in particular the foreign interest rate, exchange rate, asset prices, monetary growth and the long-term interest rate.[4] Therefore, our empirical model can be written:

$$i_t^* = \rho i_{t-1} + (1-\rho)\left\{\bar{i} + \beta\left(E\left[\pi_{t+s} \middle| \Omega_t\right] - \pi_{t+s}^*\right) + \gamma\left(E\left[y_{t+k} \middle| \Omega_t\right]\right) + \delta\left(E\left[x_{t+m} \middle| \Omega_t\right]\right)\right\} + \upsilon_t \quad (3)$$

which is a combination of equations (1) and (2) with x_{t+m} representing the additional variables. The unobserved forecast variables are typically eliminated and substituted by the realized variables for the empirical estimation. We assume that only the inflation rate enters as an expected value since only this variable is usually forecasted by the central banks. The substitution of the inflation expectation by its realized value gives rise to endogeneity as the inflation forecast error becomes part of the error term υ_t. Consequently, we use GMM estimator with the orthogonality condition that can be written:

$$\left[i_t^* - \rho i_{t-1} - (1-\rho)\alpha - (1-\rho)\beta\pi_{t+s} - (1-\rho)\gamma y_{t+k} - (1-\rho)\gamma y_{t+m} - (1-\rho)\delta x_{t+m} \middle| \Omega_t\right] = 0 \quad (4)$$

where the nominal equilibrium exchange rate $\bar{i}$ is substituted by generic intercept α.[5] The instrument set Ω_t is the information set available to the central bank at the time *t*. We use two lags of all variables in each regression as instruments. We have set $s = 1$ in the benchmark forward-looking specification but test also the possibility that the central bank is rather backward-looking in inflation ($s = -1$). The other variables always enter with present or past values ($k = -1$, $m \leq 0$).[6] The weighting matrix is chosen in accordance with the Newey and West (1997) covariance estimator, which is robust to the presence of heteroscedasticity and

[3] Our estimation period start in 1992 just before the intervention exchange rate margins of the ERM participans were widened to ±15% around the bilateral central parities from original ±2.5%.

[4] These additional variables were proposed both in theoretic and empirical studies on the monetary policy rules (Clarida et al., 1998, Mehra, 2001, Rigobon and Sack, 2003).

[5] This is a common practice given that nominal equilibrium interest rate is not observable. The estimate of the intercept serves in the standard TR for a derivation of the real equilibrium interest rate, provided we know the inflation target, or conversely, the implied inflation target can be derived if we know the real equilibrium interest rate. Nevertheless, this derivation is rather problematic in practice as neither real equilibrium interest rate nor the actual inflation target is always known and both variables can vary in time. Crespo-Cuaresma et al. (2004) provided an evidence on the time-variance of the real equilibrium interest rate in the Euro area.

[6] Although the targeting horizon is usually 1 year, we use inflation realization in the following quarter because the identification in GMM requires strong correlation between regressors and instruments. Two lags of inflation

autocorrelation of unknown form (HAC Consistent Covariances). As we have always more instruments than estimated parameters, we can perform the Sargan-Hansen J-test of over-identifying restrictions to confirm the overall validity of the model.

The Taylor principle postulates that the inflation response coefficient β shall be higher than unity, which implies that the central bank must increase the nominal interest rate more than the inflation increase in order to achieve an increase of the real interest rate. Clarida *et al*. (2000) concluded that compliance with this principle is a basic prerequisite for the monetary policy to have stabilizing effect. However, the interpretation of the Taylor principle for open economies is less straightforward because of the exchange rate channel and additional external constraints. The theoretic models of small economy proposed that the pertinence of the principle depends on the intensity of the exchange rate pass through; the currency being used to set prices of imported goods or the price index being considered by the monetary authority (Linnemann and Schabert, 2006).

2.2 EMU analysis

The estimation of equation (3) can also be applied to the aggregated data of the Euro area with the aim of obtaining an indication of the ECB policy rule. However, the previous studies that followed this approach obtained very disperse results for the size of inflation coefficient β. On the contrary, most studies agreed that the ECB is forward-looking in inflation. Fourcans and Vraceanu (2007) is the most recent empirical study on the ECB policy rule. They use monthly data for the same period, as we do, (1999-2006) finding an insignificant response to contemporaneous inflation but very strong response to expected inflation. However, it is likely that their results are subject to omission bias. First, the estimate of the smoothing parameter ρ is very close to unity, suggesting very strong policy inertia (problem raised by Rudebusch, 2002). Second, the implied long-term inflation coefficient has a very unusual value close to four. In our study we have used quarterly data and allowed the ECB interest rate setting to be affected by the additional variables as in the country-level analysis. More importantly, given the heterogeneity of the Euro area, and consequently the policy transmission, it is possible that the ECB reflects this heterogeneity in the policy decisions. As Angelini et al. (2008) put it "…, the fact that the objectives of policy (the loss function) are defined exclusively in terms of union-wide variables does not imply that the decision-making process (the policy rule) should also rely exclusively on union-wide variables." The inflation

used as instruments, have rather weak correlation with forth inflation lead. Next to inflation, we treat for precautionary reasons all the other variables as endogenous.

rates differ significantly between the EMU members while the aggregated EMU inflation is the main policy objective. Therefore, a simple way to see if the ECB considers the national information is to test the sensitivity of the short-term interest rate to the inflation dispersion across the Euro area. For this reason, we include the cross-country inflation calculated from the individual inflation series as an additional regressor.

Moreover, it is possible that the dispersion of the results obtained in previous studies with Euro-area data is directly related to the time series aggregation. Monforte and Siviero (2008) argue against the use of the aggregated Euro-area data as if they referred to one single, relatively homogeneous economy for reasons of the aggregation bias. Therefore, a panel approach that uses the original national series can be a viable option.[7] However, the use of the panel analysis for the identification of the ECB policy rule is not straightforward. Unlike in the pre-EMU period, the common monetary policy implies also a common short-term interest rate for all the Euro area. Yet, if we pursue the idea that the ECB may be concerned with national developments, we can write an equation linking the policy instrument (the Euro area short-term interest rate) to the national variables (for simplification we consider only the inflation rates):

$$i_t = \beta_i \pi_{i,t} + ... + \beta_N \pi_{N,t} + \varepsilon_t \tag{5}$$

where β_i is the response coefficient to the country specific inflation π_{it} (where i = 1,..N). Unfortunately, this relationship cannot be empirically estimated given the elevated number of regressors and presumable correlation between them. Consequently, we propose the following system:

$$\begin{aligned} i_t &= \beta_i \pi_{i,t} + \tau_i z_t + \varepsilon_{i,t} \\ &\cdots\cdots \\ &\cdots\cdots \\ i_t &= \beta_N \pi_{N,t} + \tau_N z_t + \varepsilon_{N,t} \end{aligned} \tag{6}$$

where β_i is again the response coefficient to the country specific inflation π_{it} (i = 1,..N). τ_i is the coefficient (vector) corresponding to compound variable (vector) z_t, which represents the inflation rates of all the countries in the Euro area (including country i).[8] If we restrict the

[7] Ruth (2004) showed that an estimation of reaction function for the artificial Euro area (1993-1998) from pooled data gave superior results (in terms of forecasts in longer-horizon) compared to reaction functions based on aggregated data.

[8] Given that inflation rate of a country i represents only a small part of the compound variable z_t, it can be assumed that z_t and π_{it} are not very strongly correlated. Although the estimation of marginal response β_i to inflation of each country would be of major interest, that elevated number of variables in z_t does not make it

slope coefficients β_i and τ_i to be homogenous across all N equations, we obtain quasi-panel representation that can be written as:[9]

$$i_t = \beta\pi_{it} + \tau z_t + \varepsilon_{it} \tag{7}$$

Because z_t does not vary across cross-sectional units, it represents a period fixed effect. The same logic can be applied also to other variables that are observed for each county and we can write the panel counterpart to the single-equation model (3) as:

$$i_t^* = \rho i_{t-1} + (1-\rho)\left\{\alpha + \beta\pi_{i,t+s} + \gamma y_{i,t+k} + \delta x_{i,t+m} + \tau z_t\right\} + \upsilon_{i,t} \tag{8}$$

where $i = 1,...,N$ is the cross-section dimension, $t = 1,...,T$ is the time dimension, and the expectations terms are substituted by realized values. z_t is the period fixed effect and $\upsilon_{i,t}$ follows a one-way error component model:

$$\upsilon_{it} = \mu_i + \zeta_{it} \tag{9}$$

where $\mu_i \sim IID\left(0,\sigma_\mu^2\right)$ represents cross-section fixed effect and $\zeta_{it} \sim IID\left(0,\sigma_\zeta^2\right)$ is an error term.[10]

There are a few additional econometric issues related to dynamic panels. It has been shown that a dynamic panel with fixed effect estimated by traditional methods (OLS) gives biased results because of the correlation between the lagged dependent variable and the error term (Nickel, 1981). Therefore, we have used a GMM estimator for dynamic panels (Arellano and Bond, 1991 or Arellano and Bover, 1995) consisting in the transformation of the model (differentiation or forward orthogonal differences) and in the expansion of the instruments. We have also combined the estimation of the transformed equation with untransformed instruments (in levels instead of differences or orthogonal deviations) in order to obtain estimates with the smallest variances (Arellano, 1989). For the panel estimation, up to 4 lags of endogenous and exogenous variables of each specification have been used as instruments.

feasible. In addition, besides inflation we would have no include also all the other variables like the output gap, the foreign interest rate or the long-term interest rate.

[9] The assumption of coefficient homogeneity across cross section is in principle problematic in macroeconomic studies. In practice, the potential bias is at least partially mitigated by the introduction of cross-section fixed effects.

[10] We keep the period fixed effect outside the error term and therefore use a one-way rather than a two-way error component model because. Due to the presence of lagged dependent variable, we have to employ dynamic panel estimators that were developed for only for one-way error component models.

3. Data and basic time-series analysis

3.1 Data description

Our dataset consists of quarterly data of each EU country from 1992 to 2006 and aggregated data for the Euro area from 1999 to 2006.[11] The principal data sources were *OECD* (Economic Outlook and Main Economic Indicators), *Eurostat* and *the European Central Bank* (Statistic Data Warehouse).

The short-term interest rate (the dependent variable in all specifications) is 3-month interbank interest rate (overnight interbank interest rate has been used for robustness check). The measures of the explanatory variables are as follows. *The inflation rate* is measured as a yearly change in harmonized consumption price index (HCPI, calculated by Eurostat). *The long-term interest rate* is government bond yield with 10 years maturity.[12] *The output gap* is the difference between the logarithm of the current value of the seasonally adjusted GDP in millions of euros in 1995 prices (the industrial production index has been used for robustness check) and the trend value obtained by Hodrick-Prescott filter (the smoothing parameter set to 1600). *Exchange rate change* is represented by a yearly change of the real effective exchange rate index (REER). The nominal exchange rate of the euro against the US dollar has been additionally used in the panel analysis for the EMU. *Monetary growth* is a yearly change in a seasonally adjusted M3 aggregate (common definition by Eurostat). Since 1999 this variable is available only for the whole Euro area. *Asset price change* is a yearly or querterly change in the share index of local stock exchange. This variable is not available for all the sample countries over the entire period.

3.2 Testing for unit roots

The first empirical studies on monetary policy rules were often conducted under an untested assumption of stationarity of all variables in the regression. Some recent contributions found that some of the main variables in policy rules (the inflation rate, interest rates) had unit root and proposed a estimation in cointegrating framework (Gerlach-Kristen, 2003, Ruth, 2004).

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[11] The estimation period from 1992 onward was chosen since certain orderliness in the monetary policy of EU members, as a result of approval of the Maastricht Criteria and clear orientation towards the forthcoming adoption of the common currency applied in this period. However, the beginning of the period was marked by the crisis of the Exchange Rate Mechanism (ERM) of the European Monetary System, which resulted in widening of fluctuation margins among the participating currencies to ±15% in 1993.

[12] The interest rates with maturities longer then one year are believed to be immune to liquidity effects and reflect the economic fundaments and the time premium. For this reason they may contain information about the long-term inflation expectations.

First, we have employed *single unit root tests*, in particular Augmented Dickey-Fuller test (ADF), Phillips-Perron (1988) test (PP) and Kwiatkowski-Phillips-Schmidt-Shin (1992) test (KPSS), to evaluate the type of underlying process of each time series. The construction of some variables (the output gap, change of the real effective exchange rate, change of stock index) implies their stationarity, which was also confirmed by all three tests. The results for short-term and long-term interest rates and inflation rates were more ambiguous (depending on the test used and the assumption made about the presence of a constant term and a deterministic trend in the tested equation).[13]

It has been known for some time that the unit root tests have low power when they are applied to short samples (the tests are biased towards the null hypothesis and sensitive to structural breaks). This problem may have affected our results as the time span of our series is relatively short (maximum 60 observations). Consequently, we have made use of the panel structure of our dataset (15 cross sections) and employed panel unit root tests to overcome this limitation. These tests use the cross-sectional variation of the data to achieve a higher power than single-equation unit root tests. We have used 6 *panel unit root tests*.[14] LLC (Levin, Lin and Chu, 2002), Breitung (2000) and Hadri (2000) tests assume that the unit root process is the same across all cross-sections. The tested null hypothesis is that all the series have unit root in the case of LLC and Breitung tests (they are derived from individual ADF tests), and that all series are stationary in the case of Hadri test (this test is a generalization of individual KPSS test). IPS test (Im, Pesaran and Shin, 2003) and two Fischer-type tests: Fischer ADF test and Fisher PP test (Maddala and Wu, 1999 and Choi, 2001) are less restrictive and allow that the integration order of each cross section differs. The Fischer-type tests are based on the combination of p-values of the individual unit root tests and seem to be the most appropriate as they allow most cross-sectional heterogeneity. The results of the unit root test for selected variables appear in Table 1.[15]

[13] We do not report these results here.

[14] All the tests assume a cross-sectional independence. The tests considering the cross-sectional dependencies are still relatively underdeveloped.

[15] The lag length was set for all tests according to the Schwarz information criterion (SIC).We have also employed the Akaike information Criterion (AIC) and Hannah-Quinn information criterion (HQ), which implied often different lag structure but did not alter the final test results.

Table 1.: Results of panel unit root tests for the inflation rate (HCPI), short-term (STIR) and long-term (LTIR) interest rates

HCPI	no const.,no trend		const.,no trend		const.,trend	
Unit root test	Stat.	P-value	Stat.	P-value	Stat.	P-value
LLC t-stat.	-6.48	0.00	-4.67	0.00	-1.28	0.10
Breitung t-stat.	-4.52	0.00	-0.28	0.39	-0.03	0.49
Hadri Z-stat.			12.31	0.00	11.83	0.00
IPS W-stat.			-5.55	0.00	-1.81	0.03
ADF - Fisher $\chi 2$-stat.	90.44	0.00	89.14	0.00	43.94	0.05
PP - Fisher $\chi 2$-stat.	107.35	0.00	99.95	0.00	45.68	0.03

STIR	no const.,no trend		const.,no trend		const.,trend	
Unit root test	Stat.	P-value	Stat.	P-value	Stat.	P-value
LLC t-stat.	-9.18	0.00	-7.41	0.00	-1.77	0.04
Breitung t-stat.	-8.05	0.00	3.36	1.00	3.68	1.00
Hadri Z-stat.			16.93	0.00	11.47	0.00
IPS W-stat.			-4.82	0.00	-0.24	0.41
ADF - Fisher $\chi 2$-stat.	132.47	0.00	74.96	0.00	33.27	0.31
PP - Fisher $\chi 2$-stat.	149.07	0.00	74.71	0.00	18.06	0.96

LTIR	no const.,no trend		const.,no trend		const.,trend	
Unit root test	Stat.	P-value	Stat.	P-value	Stat.	P-value
LLC t-stat.	-7.89	0.00	-5.00	0.00	-1.36	0.09
Breitung t-stat.	-4.33	0.00	0.55	0.71	1.04	0.85
Hadri Z-stat.			17.28	0.00	11.99	0.00
IPS W-stat.			-1.79	0.04	-4.03	0.00
ADF - Fisher $\chi 2$-stat.	107.91	0.00	37.10	0.17	73.88	0.00
PP - Fisher $\chi 2$-stat.	114.17	0.00	29.32	0.50	29.53	0.49

Notes: Probabilities for Fisher tests are computed using an asymptotic Fisher $\chi 2$ distribution. All other tests assume asymptotic normality

The stationarity of the output gap, exchange rate change, asset price change and change of the money stock were confirmed, as expected, by all tests. The results for interest rates varied slightly with the specification of the tested equation, in particular whether a constant term and a deterministic trend were included or not.[16] If we assume that the data generating process of neither inflation rates nor interest rates contains a deterministic trend as seems logical, most of the tests point to stationarity of both inflation rates and interest rates. These findings are consistent with results of other papers on the properties of the time series in question using panel unit root tests (Culver and Pappel,1997, Wu and Chen, 2001). Given these results, we have employed in all case estimation in levels.[17]

[16] IPS and Hadri tests require by construction the inclusion of individual constant terms that is why the corresponding spaces in the Table 1 remain empty.

[17] Although panel unit root tests confirmed stationarity of most variables, some of the individual time series appear in a shorter period non-stationary. The possibility of spurious results of our regression analysis is

The interpretation of inflation and interest rates as nonstationary processes, where any shock has permanent effect, would imply that both variables could take very elevated or, on the contrary, negative values for relatively long periods, which is apparently not consistent with the observed reality. For nominal interest rates there exists in principle a zero lower bound and inflation rates took negative values only in very few occasions.

There are additional policy implications of these findings. To begin, the stationarity of nominal interest rates supports the validity of the uncovered interest rate parity hypothesis (if interest rates are stationary so are interest rate differentials, while exchange rate changes themselves are stationary). Consequently, the role of central banks is rather constrained by international financial markets. Secondly, the stationarity of both the inflation rates and the nominal interest rate imply that the real interest rates are stationary without the need for cointegration between the first two variables as was usually searched for in many previous studies. Finally, the stationarity of inflation rates implies that the shocks have only a temporary effect, which supports the argument against the need for excessive responses to inflation increases in an effort to assure price stability.

3.3 Granger causality testing in interest rates

Macroeconomic variables often influence one another. The path of some exogenous variables in the regression (the inflation rate, the output gap) is endogenously influenced by the monetary policy actions. Whereas the response lags of domestic macroeconomic variables to interest rate changes are well-documented,[18] the influence of foreign interest rates on domestic ones and the relationship between domestic short-term and long-term interest rates is more obscure. To justify the inclusion of foreign interest rates and domestic long-term interest rates into our augmented TR, we have first employed the Granger causality test.

For the period 1992-98 we have performed a Granger causality test to determine whether the German interest rate drove the interest rate dynamics of the remaining 14 EU member countries (confirmed for all EU members except Italy, Portugal, the UK) and whether the US interest rate Granger-caused the interest rates developments of Germany and the UK (confirmed). *For the period 1999-2006* we have tested whether the Euro interest rate Granger-caused the interest rate of Denmark, Sweden and the UK (rejected for the UK) and whether

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mitigated by the dynamic structure of the model. The residuals autocorrelation, always accompanying the spurious regression, was always rejected in the specification with the highest explanatory power.

[18] Moreover, we have used in some cases the lagged values of these variable as regressors or instrumented them by their lagged values in order to avoid any reversal causality.

the US interest rate Granger-caused the interest rate developments of the Euro area and the UK (confirmed).[19] These results are mostly consistent with the common wisdom and confirm that the foreign interest rate can be reasonably included as exogenous variable for the monetary policy rule estimation.

The other relationship we have tested was whether the long-term interest rate drove in the Granger sense the short-term interest rate dynamic within each country. *For the period 1992-98* this causality was confirmed for Denmark, Finland, France, Italy and Spain and *for the period 1999-2006* for Sweden and the UK. For the EMU we have tested whether the long-term interest rate of each EMU member (different for each country but highly correlated) drove the euro short-term interest rate fluctuations, which was confirmed for all EMU members except Greece.[20] Consequently, the long-term interest rate that is believed to contain information about the long-term inflation expectations was included as an exogenous variable in the monetary policy rule specification of some countries.

4. Monetary policy rules during the pre-EMU period (1992-1998)

We have estimated as a benchmark and starting point the simple static backward-looking TR. The OLS estimates appear in Table 2**.**[21]

Table 2. OLS estimates of simple backward-looking TR for EU-15 (1992-1998)

Country	α (const.)		β (π_{t-1})		γ (y_{t-1})		R^2	LB
AUT	**2.41**	(0.41)	**1.26**	(0.14)	**1.54**	(0.22)	0.88	0.01
BEL	-0.40	(1.18)	**2.96**	(0.57)	0.52	(0.32)	0.48	0.00
DEU	**1.71**	(0.26)	**1.30**	(0.08)	**0.49**	(0.17)	0.91	0.02
DNK	**9.56**	(5.05)	-1.61	(2.47)	-0.23	(0.86)	0.00	0.00
ESP	0.77	(0.99)	**1.92**	(0.22)	0.09	(0.28)	0.75	0.00
FIN	**1.86**	(0.72)	**2.28**	(0.43)	**-0.67**	(0.29)	0.66	0.00
FRA	**3.45**	(1.04)	**1.71**	(0.54)	**2.03**	(0.43)	0.69	0.00
GBR	**3.36**	(0.45)	**0.79**	(0.27)	**-1.61**	(0.45)	0.57	0.00
GRC	**5.47**	(0.86)	**1.03**	(0.07)	-0.39	(0.24)	0.87	0.00
IRE	5.36	(3.02)	1.37	(1.21)	0.90	(0.67)	0.10	0.00
ITA	**2.57**	(1.04)	**1.64**	(0.24)	0.53	(0.36)	0.69	0.00
LUX	**2.08**	(0.78)	**1.72**	(0.31)	**0.37**	(0.16)	0.81	0.00
NLD	-1.21	(1.67)	**2.65**	(0.62)	**0.49**	(0.40)	0.70	0.00
PRT	**1.75**	(0.60)	**1.49**	(0.10)	-0.30	(0.18)	0.90	0.09
SWE	**5.54**	(0.19)	**0.57**	(0.08)	**1.47**	(0.15)	0.93	0.17

Note: Standard errors in parenthesis. Coefficients statistically significant at 5% in bold. LB is p-value of Ljung-Box test for 1. order serial correlation in residuals.

[19] We have applied the test with 1 to 3 lags. The detailed results are not reported here.
[20] We have applied the test with 1 and 2 lags. The detailed results are not reported here.
[21] In the whole text we have used the following country abbreviations: AUT – Austria, BEL – Belgium, DEU – Germany, DNK – Denmark, ESP – Spain, FIN – Finland, FRA – France, GBR – the United Kingdom, GRC – Greece, IRE – Ireland, ITA – Italy, LUX – Luxembourg, NLD – the Netherlands, PRT – Portugal, SWE – Sweden.

Most of the coefficients have the expected sign and are statistically significant; the inflation coefficient is higher than unity and output gap coefficients present lower magnitude but are still in a reasonable range. However, the reported LB statistic points to residual autocorrelation and thus inconsistency of the OLS estimates for most countries. Therefore, simple TR does not seems to give a good account on the short-term interest rate dynamics.

Table 3 shows the GMM estimates of the specification with the highest explanatory value for each of the 15 EU members in the pre-EMU period. For determination of this specification we have used the following procedure: first, we have estimated forward-looking specification with inflation and output gap only; second, we have allowed for the interest rate smoothing; third, we have added the foreign interest rate. These three specifications were also estimated as backward-looking in inflation. We have chosen from these six specifications the one with the best fit and augmented it subsequently with each additional variable x_{t+m} (exchange rate, asset prices, monetary growth, and the long-term interest rate). The reported rules with the highest explanatory power for each country have been chosen from these 8 specifications on grounds of a reasonability of estimates, an overall fit, a lack of autocorrelation, and compliance with the Sargan-Hansen over-identifying restriction test.[22]

Table 3. GMM estimates of the monetary policy rule specification with the highest explanatory power for EU-15 (1992-1998)

Country	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1}, π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1}, x_t*)	R^2	LB	J-stat.
DEU	**0.55** (0.11)	**0.82** (0.32)	**0.60*** (0.17)	**0.43** (0.13)			0.96	0.60	0.75
GBR (REER)	**0.78** (0.04)	**0.69** (0.22)	**0.27** (0.04)	**0.15** (0.07)		**0.04** (0.01)	0.87	0.95	0.68
AUT (REER)		**0.24** (0.09)	0.00 (0.05)	**0.14** (0.06)	**0.96** (0.03)	**-0.06*** (0.01)	0.99	0.14	0.59
BEL		**-0.52** (0.18)	**0.46** (0.15)	**-0.21** (0.08)	**0.95** (0.05)		0.95	0.49	0.82
DNK	**0.58** (0.09)	-1.08 (0.71)	0.49 (0.36)	0.11 (0.17)	**0.50** (0.09)		0.86	0.10	0.78
FIN (LTIR)	**0.48** (0.11)	-1.47 (0.54)	-0.05 (0.11)	**0.34** (0.09)	**0.61** (0.20)	**0.19** (0.05)	0.94	0.33	0.96
IRE (MA)		-3.65 (1.51)	0.58 (0.48)	**1.08** (0.17)	**1.95** (0.16)	**0.10*** (0.03)	0.68	0.18	0.51
NLD		-0.23 (0.38)	**0.38** (0.14)	**0.24** (0.10)	**0.84** (0.02)		0.99	0.43	0.90
ESP (LTIR)	**0.38** (0.09)	**-0.97** (0.41)	0.05 (0.21)	**0.32** (0.06)	**0.35** (0.10)	**0.44** (0.13)	0.97	0.06	0.93
FRA (MA)		0.10 (0.27)	**1.02** (0.11)	-0.02 (0.16)	**0.79** (0.03)	**0.09*** (0.02)	0.95	0.93	0.77
LUX	**0.49** (0.11)	**0.83** (0.21)	0.32* (0.19)	**0.18** (0.05)	**0.27** (0.09)		0.96	0.72	0.80
ITA (REER)	**0.54** (0.06)	0.05 (0.38)	**0.69*** (0.15)	**0.32** (0.11)	**0.28** (0.07)	**0.04** (0.01)	0.91	0.89	0.90
SWE (REER)		**2.33** (0.61)	**1.15*** (0.29)	**0.56** (0.20)	**0.89** (0.09)	**0.16** (0.01)	0.85	0.94	0.73
GRC (SHI)	**0.81** (0.09)	-2.10 (1.25)	**0.49*** (0.10)	**-0.45** (0.15)		**0.05*** (0.01)	0.95	0.23	0.60
PRT (REER)	**0.41** (0.15)	0.38 (0.41)	**0.90*** (0.27)	**-0.84** (0.27)		**0.21** (0.07)	0.94	0.55	1.00

Notes: Standard errors in parenthesis. Coefficients statistically significant at 5% in bold. LB is p-value of Ljung-Box test for 1. order serial correlation in residuals. J-stat is p-value of Sargan-Hansen over-identification test. Additional variables *x* in parenthesis: REER - real effective exchange rate, MA – monetary growth, LTIR – long-term interest rate, SHI – change in asset prices.

[22] The detailed results of analysis for each country are reported in the Appendix II.

In principle we have identified *four different types of rules* marked by the importance of the foreign interest rate and the countries are grouped in Table 3. accordingly. The interest rate rules of *Germany* and *the UK* represented typical rules of large economies, where domestic variables play the major role, and both of them resemble the original TR. Countries in the second group (*Austria*, *Belgium*, *Denmark*, *Finland*, *Ireland*, and *the Netherlands*) seem to have followed the monetary policy of Bundesbank very rigidly. The response to the German interest rate is close to unity and the response to their main domestic variables is very limited.[23] For the third group of countries (*France*, *Spain*, *Italy*, *Luxembourg* and *Sweden*) we have found a positive reaction to the German interest rate, which is lower than unity (in the long-term) and the response to domestic variables is more substantial.[24] In the last group (*Portugal* and *Greece*) we have not found any statistically significant reaction to the German interest rate and the interest rate rules are defined in terms of domestic variables, in particular the inflation rate. The response to domestic inflation (that reached during this period substantially higher levels than in other EU countries) is very strong. In both countries we have always found negative and statistically significant reaction to the output gap. This can be related to the nosiness of this variable.

There are some general observations. In cases where we have confirmed a significant response to the domestic inflation rate, the response was almost always higher in the case of the expected inflation rate than its lagged value and accordingly the fit of such forward-looking model was better. The pronounced instability of the intercept across different rule specifications for a single country as well as across different countries confirm the need to employ more advanced econometric methods that allow for its time-variance (note that the intercept is composed of a real equilibrium interest rate and an inflation objective that may both vary) and urge us not to interpret its values. The previous results have not been in general sensitive to alternative measures of short-term interest rate (overnight) and the output gap (derived from the industrial production index).

[23] This finding is not surprising given limited autonomy of the domestic monetary policy of these countries due to de facto exchange rate peg to the German Mark via ERM. The recent theoretic literature on monetary policy rules claim that a policy rule consisting in credible interest rate peg constitute means of exchange rate fixing (Benigno *et al*., 2007). On the other hand, the economic developments of most countries was also rather close to German one, therefore the response to German interest rate may actually mean indirect response to own economic fundamentals.

[24] Although the monetary policy of these countries was also conditioned by the participation in ERM (except Sweden), the developments of their economies were rather different, which explains the additional consideration for domestic variables.

The correlation between the actual interest rate and the target interest rate (the fitted value from the specification with the highest explanatory power) has been very decent in all cases. Nevertheless, in some countries we have found short periods of significant deviation of these two series, which can be an indication of *monetary policy shock*.[25] In Figure 1, we plot the series of the actual interest rate and the interest rate target (the fitted value). First, we find deviation of the actual interest rate from the target value during the ERM crisis in 1993 for several ERM participants (Belgium, Denmark, Finland, France, Spain) while countries that did not participate (Austria, Sweden) were unaffected. Second, some deviations can be related to country specific event like the departure from the target in Greece in 1994. The Central bank of Greece had to fight the market expectations about the drachma depreciation, which resulted in a significant decrease of the actual interest rate and its deviation from the rule-implied target. Similarly, the deviation of the actual rate from the target in Portugal, between 1993 and 1995, is likely related with the escudo devaluation that occurred in this period. Finally, some deviations seem to be rather related to worse fit of the model for some countries (Ireland).

[25] In fact this holds only when the model is well-specified and the residuals do not represent omitted variables.

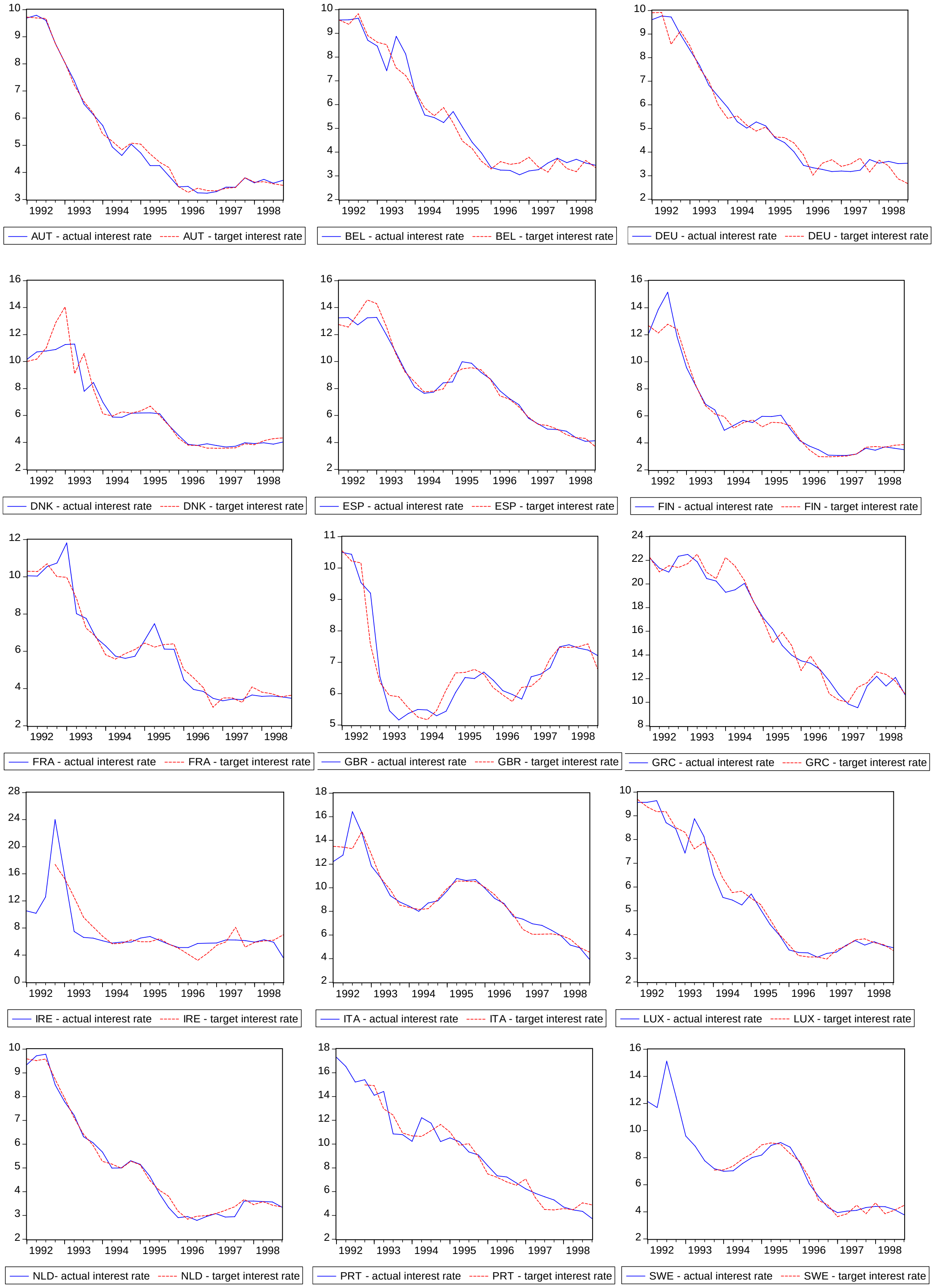

Figure 1. Target interest rate implied from the best rule and the actual interest rate for EU-15 (1992-1998)

5. Monetary policy rules during the EMU period (1999-2006)

5.1 Monetary policy rules outside the Euro area

The launch of the euro and the EMU may have represented a structural change in monetary policy setting even in countries that did not adopt the common currency, notably in Denmark and Sweden. We have confirmed that in these countries the German interest rate had significant impact in the pre-EMU period policy rule. The structural stability of the estimated policy rule for Denmark, Sweden and the UK over year 1999 has been rejected by the Chow breakpoint test (see Table 4) and on this account we have estimated policy rules separately for each period. The rules with the best adjustment for each country during the EMU period are presented in Table 5.[26]

Table 4. Chow breakpoint test of structural stability of the pre-EMU monetary policy rule with the highest explanatory power for non-EMU countries (1992-2006, break in 1999)

DNK		GBR		SWE	
F-stat.	P-value	F-stat.	P-value	F-stat.	P-value
1.99	0.09	7.76	0.00	9.28	0.00

Table 5. GMM estimates of the monetary policy rule specification with the highest explanatory power for non-EMU countries (1999-2006)

Country	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_t)	R^2	LB	J-stat.
DNK 1	**0.55** (0.12)	0.58 (0.50)	**0.39** (0.17)	**0.35** (0.14)			0.92	0.05	0.75
DNK 2		**-0.60** (0.08)	-0.02 (0.04)	**-0.10** (0.02)	**1.25** (0.02)		0.98	0.37	0.62
GBR (LTIR)	**0.63** (0.06)	-1.46 (1.27)	**0.42** (0.15)	**0.55** (0.16)		**0.54** (0.20)	0.89	0.32	0.65
SWE (LTIR)	**0.60** (0.05)	**-0.46** (0.13)	**0.12*** (0.04)	**0.18** (0.03)		**0.33** (0.05)	0.97	0.	0.54

Notes: Standard errors in parenthesis. Coefficients statistically significant at 5% in bold LB is p-value of Ljung-Box test for 1. order serial correlation in residuals. J-stat is p-value of Sargan-Hansen over-identification test. Additional variable *x*: LTIR – long-term interest rate.

The response to the inflation rate is lower than unity in the long-term in the three countries. However, in case of Sweden and the UK there is additionally strong response to the long-term interest that may contain the inflation expectations. The response to the output gap is significant and relatively strong in all cases. For Denmark we have found good fit for two specifications (with and without the euro interest rate). This country would likely be the least affected by the adoption of common monetary policy as its short-term interest rate development has been very similar to the Euro area.[27] During this period we have not found

[26]

[27] While Denmark participated in the ERM before 1999 and in the ERM II since then, Sweden and the UK has maintained during the whole estimation period managed, respectively free floating.

significant deviation of the actual short-term interest rate from the rule implied target (Figure 2).

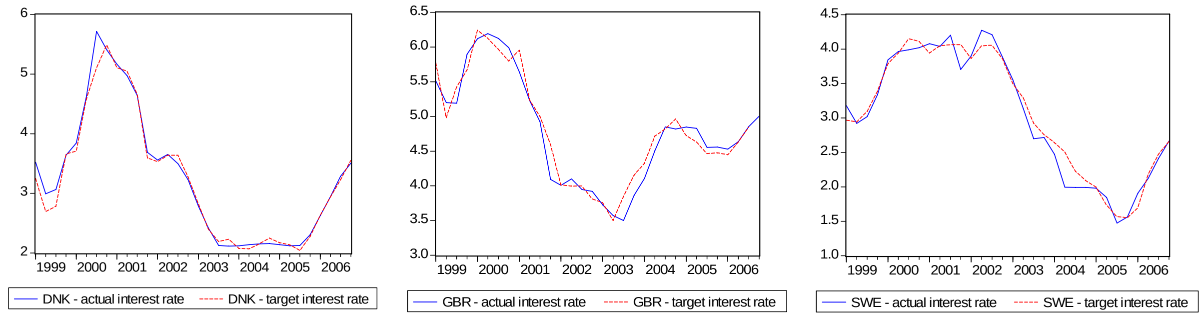

Figure 2. Target interest rate implied from the best rule and the actual interest rate for the non-EMU countries (1999-2006)

5.2 Monetary policy rule of the ECB

First, we have used the same estimation framework as for individual countries and estimated the ECB policy rule from *aggregated data* of the Euro area.[28] Table 6. illustrates the results of different alternatives of the forward-looking specification that has in general better fit than backward-looking one.

Table 6. GMM estimates of ECB forward-looking policy rule based on EMU aggregated data

Specification	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t+1})	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1}, x_t*)	R^2	LB	J-stat.
ECB	**1.40** (0.17)	0.86 (1.25)	-0.92 (0.59)	**-0.58** (0.17)			0.83	0.06	0.37
ECB	**0.91** (0.08)	**1.39** (0.66)	-0.70 (0.36)	-0.04 (0.09)	**0.13** (0.02)		0.94	0.45	0.86
ECB (NER)	**0.86** (0.05)	**0.70** (0.55)	-0.33 (0.23)	-0.01 (0.05)	**0.13** (0.04)	0.00 (0.01)	0.96	0.39	0.73
ECB (REER)	**0.85** (0.04)	0.79 (0.51)	-0.33 (0.22)	0.01 (0.04)	**0.12** (0.04)	0.01 (0.01)	0.96	0.38	0.75
ECB (SHI)	**1.04** (0.06)	-0.34 (0.34)	0.04 (0.14)	0.04 (0.07)	0.03 (0.03)	**0.01*** (0.00)	0.94	0.98	0.86
ECB (MA)	**0.75** (0.05)	**1.54** (0.24)	-0.31 (0.15)	**0.14** (0.05)	**0.16** (0.01)	**-0.09*** (0.01)	0.98	0.99	0.57
ECB (LTIR)	**0.60** (0.10)	0.15 (0.51)	-0.23 (0.22)	0.10 (0.08)	**0.15** (0.01)	**0.23*** (0.04)	0.97	0.28	0.84
ECB (LTIR+ VAR)	**0.43** (0.10)	-0.40 (0.22)	-0.16 (0.11)	0.12 (0.07)	**0.16** (0.01)	**0.36*** (0.04) **0.34*** (0.12)	0.98	0.94	0.94

Notes: Standard errors in parenthesis. Coefficients statistically significant at 5% in bold. LB is p-value of Ljung-Box test for 1. order serial correlation in residuals. J-stat is p-value of Sargan-Hansen over-identification test. Additional variables *x*: NER – nominal exchange rate EUR/USD, REER - real effective exchange rate, SHI – asset prices, MA – monetary growth, LTIR – long-term interest rate, VAR – inflation variance across 12 EMU members.

The main feature is the statistical insignificance of the inflation coefficient β, which is a finding that is very contra-intuitive. Yet, it is robust even if we estimate a backward-looking specification or a forward-looking specification with different inflation leads. On the other hand, we have found a significant response to the long-term interest rate that can be understood as a response to inflation expectation. The instability of the smoothing parameter ρ (including an estimate exceeding unity) is another unusual feature, as compared to different

[28] We have assumed that Greece joined the EMU in 1999 instead of 2001.

specification that were estimated for each of the 15 countries in pre-EMU period.[29] Only the coefficient of the US interest rate is consistently significant. While the euro exchange rate did not seem to be taken into account, there is a significant but very small response to the asset prices and a significant but negative response to M3 growth. Finally, the most interesting finding is that when we include the inflation variance across the EMU countries as an additional variable, it has a significant and very elevated coefficient. This seems to be an indication that the cross-section dimension representing the national developments was relevant for policy decisions. Figure 3 shows that the short-term interest rate of the Euro area moves very closely with the inflation variance across the EMU members.

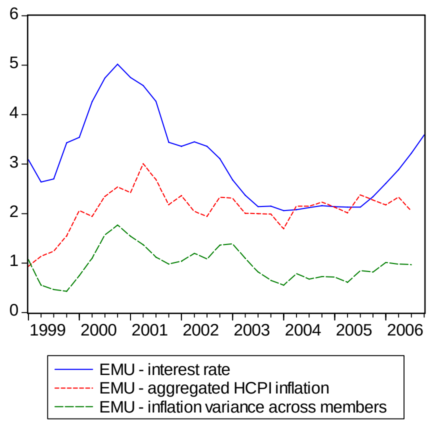

Figure 3. The short-term interest rate, the overall HCPI inflation rate and inflation variance across countries in the Euro area (1999-2006)

Moreover, as we have discussed above the use of aggregated series can have some empirical shortcuts. First, an aggregation bias seems to apply in our case, because the aggregated series features significantly lower variability than the individual ones.[30] Second, the multicollinearity can be a real problem since some regressors are strongly correlated.[31] Given the relevance of the cross-section dimension as well as the econometric deficiencies of single-equation estimation, we pursue the quasi-panel analysis proposed above with pooled series of the 12 EMU countries. This focus may even better correspond to the two-pillar monetary strategy of the ECB asserting that a large set of diverse variables is considered for monetary policy decisions. We have used the panel specification (8) and a 2-step Arellano and Bover

[29] These results are not sensitive when we have used the overnight interest rate (EONIA) instead of 3 month interest rate (EURIBOR) as a dependent variable and the industrial production index instead of the GDP for the construction of the output gap.
[30] The standard deviation of the HCPI series for the Euro area in our sample (1999-2006) is 0.4 while for the individual series it is around 0.8. The same holds for the output gap (0.8 versus 1.1).

(1995) GMM estimator (forward orthogonal deviations transformation of the model) accompanied with untransformed instruments (in levels). 4 lags of endogenous and exogenous variables of each specification have been used as instruments.[32] The results of forward-looking specification that has in general higher explanatory power than backward-looking specification are presented in Table 7.

Table 7. GMM panel estimates of ECB forward-looking policy rule

Specification	ρ (i_{t-1})	ψ (time dum.)	$(1\text{-}\rho)\beta$ (π_{t+1})	$(1\text{-}\rho)\gamma$ (y_{t-1})	$(1\text{-}\rho)\delta$ (i_t^{for})	$(1\text{-}\rho)\zeta$ ($x_{t-1,}x_t$*)	R^2	J-stat.
ECB	**0.79** (0.01)		**0.19** (0.02)	**0.10** (0.03)			0.85	0.22
ECB	**0.61** (0.03)	**-0.02** (0.00)	**0.42** (0.02)	0.05 (0.04)			0.80	0.16
ECB	**0.73** (0.02)	**-0.01** (0.00)	**0.35** (0.02)	0.00 (0.01)	**0.11** (0.01)		0.88	0.10
ECB (NER)	**0.64** (0.02)	**-0.01** (0.00)	**0.32** (0.03)	-0.01 (0.03)	**0.07** (0.01)	**-0.01** (0.00)	0.88	0.06
ECB (REER)	**0.68** (0.02)	**-0.01** (0.00)	**0.28** (0.02)	0.00 (0.02)	**0.08** (0.02)	**-0.01** (0.00)	0.90	0.06
ECB (MA)	**0.74** (0.02)	0.00 (0.00)	**0.31** (0.02)	0.00 (0.03)	**0.10** (0.01)	**-0.05*** (0.00)	0.89	0.06
ECB (LTIR)	**0.72** (0.01)	**0.01** (0.00)	**0.11** (0.01)	-0.01 (0.02)	**0.12** (0.00)	**0.30*** (0.00)	0.95	0.06
ECB (LTIR +DUMMY)	**0.73** (0.01)	**0.02** (0.00)	**0.10** (0.01)	0.00 (0.02)	**0.12** (0.01)	**0.30*** (0.01) -0.04* (0.04)	0.95	0.04

Notes: Coefficient α is not estimated as the constant term was removed due to the estimation method. Standard errors in parenthesis. Coefficients statistically significant at 5% in bold. J-stat is p-value of Sargan-Hansen over-identification test. Best rule is in bold. Additional variables x: NER - nominal exchange rate EUR/USD, REER - real effective exchange rate, SHI – asset prices, MA – monetary growth, LTIR – long-term interest rate, dummy – dummy variable = 1 if $\pi_t > 2$.

The difference with the results based on aggregated data is apparent. First of all, the coefficient of the period fixed effect ψ is significant.[33] This approach delivers also significant inflation coefficient β across all specifications and stable size of the smoothing parameter ρ. The implied long-term inflation multiplier is very close to unity. The coefficient β has a lower magnitude in model with the long-term interest rate but the sum of both implied long-term multipliers (of inflation β and long-term interest rate ζ) is above unity. Consequently, our evidence point that the ECB policy had a stabilizing effect in conformity with the Taylor principle. Our results also indicate that the ECB followed the lead of the US FED in setting the interest rates since the coefficient δ is always significant. We have additionally detected a significant but very marginal negative response to the real exchange rate appreciation. On the

[31] The correlation coefficient of aggregate HCPI with the output gap is 0.60, of the output gap with the inflation variance is 0.64 and the lagged interest rate has correlation over 0.70 with the output gap, the inflation variance and the long-term interest rate.

[32] These results of the same estimation with transformed instruments (by the forward orthogonal differences transformation) are noted by higher standard errors. According to Arellano (1989), the estimation with untransformed instruments have some preferable properties. The results with 2-step Arellano and Bond (1991) GMM estimator (consisting in differentiation of the model) with both untransformed (in levels) and transformed (differentiated) instruments does not provide substantially different results.

[33] The period fixed effect is not included in the first specification that is presented for comparison.

other hand, we have not found convincing evidence that the stance of the real economic activity, as measured by the output gap, was taken into account by the ECB for policy decisions.[34] This is surprising given the presence of a subordinated but very specific economic activity goal in the ECB Statute. The measure of monetary growth was found to be significant but has "wrong" negative sign.[35] Therefore, like the previous studies, we failed to find that the monetary growth has a positive impact on the policy decisions. This evidence suggests that "the monetary pillar" of the ECB strategy does not have any practical effect on the policy decisions. Finally, we have included a dummy variable for the inflation rate exceeding the inflation objective of 2% to see whether the expected inflation rate was stronger when the inflation objective was breached. As the corresponding coefficient is not significant, we can claim that the ECB response to inflation is symmetrical.[36]

The estimated parameters of monetary policy rule of the ECB were used for so-called "*counterfactual experiment*". The early studies substituted aggregated data of the actual Euro area into the estimated historic pre-EMU policy rule (of Bundesbank or of the artificial Euro area) to get the implied interest rate path. Its comparison with the actual euro interest rate development gave clear indication the actual ECB interest rate decision is rather close to historic rule of the artificial Euro area than being only extension of the Bundesbank policy as sometimes argued.

The results we have obtained in this study allow us to perform two versions of this experiment. For the first experiment, we have substituted the data of individual EMU members into the estimated ECB rule (the specification from the panel analysis with the foreign interest rate and the long-term interest rate, which has the highest explanatory power) to get the target interest rate based on data of each EMU country. The purpose is to check whether the actual euro interest rate path adjusted better to the rule-implied interest rate from the data of one country compared to another. The results of the first experiment are reported in Figure 4. It is evident that the target interest rate derived from the national series is very similar to the actual euro interest rate. Therefore, it can not be said that the ECB disregarded the developments in any member country at all. This is related to the finding that the ECB

[34] The results are not altered when we have used the industrial production instead of GDP.
[35] The information about monetary growth is available only for the whole Euro area, therefore it is a common regressor that does not vary between cross sections. The stock indices are not available for all countries for the whole period, thus we were unable to asses their effect on the ECB policy.
[36] All specifications have been tested for the presence of residual autocorrelation. For this test, we have regressed by OLS the stacked residuals on their lagged values and checked the statistical significance of the coefficient,

interest rate rule with the best fit is not defined only in terms of the actual inflation rate (that differed across the EMU members) but also long-term interest rates (that have been similar across the EMU).

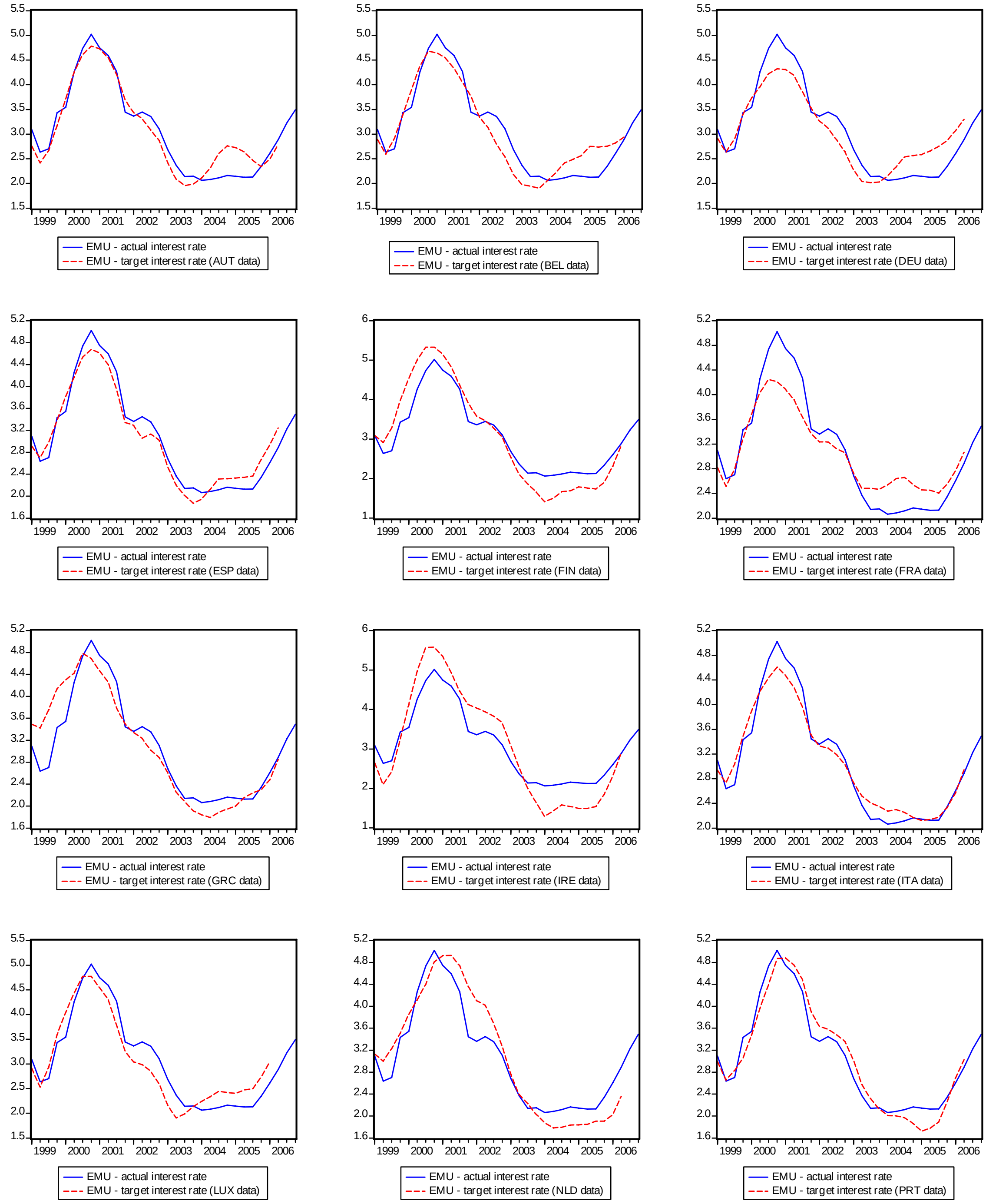

Figure 4. Counterfactual experiment I - Target interest rate implied from the best rule for EMU (using national data) and the actual euro interest rate (1999-2006)

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which is simpler procedure than the test proposed by Arellano and Bond (1991) for dynamic panels. The long-term interest rate is a decisive variable in order to avoid the residual autocorrelation.

According to Figure 4 there is also no indication of the monetary policy shocks since the EMU launch. In particular, there is no period when the actual euro interest rate would significantly deviate from the target interest rate for most countries in the same direction.

For the second counterfactual experiment we have carried out an out-of-sample forecast for the EMU period (1999-2006) from individual pre-EMU (1992-1998) policy rules of each country. In this case we are interested in the difference between the interest rate target for each country (if it had not joined the EMU and maintained its pre-EMU policy rule) and the actual interest rate in the country as an EMU member. This can give some clues to how each country was affected by the adoption of a common monetary policy. The results are reported in Figure 5. We observe for most countries that if they had not joined the EMU and kept its pre-EMU monetary policy setting they would have had actually higher short-term interest rates than they did as EMU members. A straightforward interpretation of this finding can be that the pre-EMU policy rules of most EMU countries were more conservative in the sense that the response to the domestic inflation rate was stronger than the one of the ECB. However, this procedure is not appropriate for countries whose interest-rate setting in the pre-EMU period depended crucially on the German interest rate decision. As there is not specific German short-term interest rate since 1999 we have to use the euro short-term interest rate instead. Therefore, e.g. for Ireland we obtain a very high interest rate target, which is related to the fact that the estimated coefficient of German interest rate in the pre-EMU policy rules was almost two.

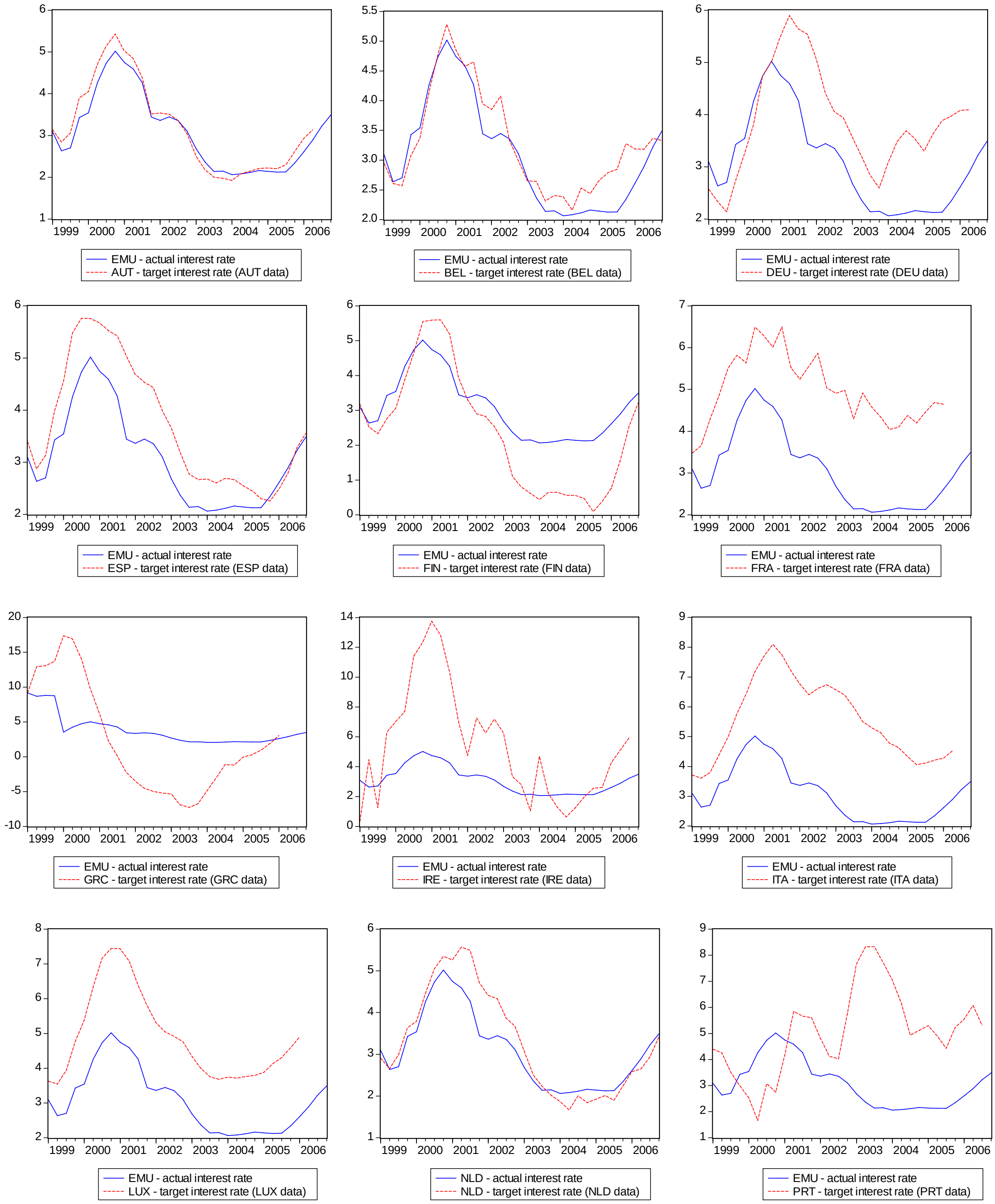

Figure 5. Counterfactual experiment II - Target interest rate implied from the best pre-EMU rule (of each EMU country) and the actual euro interest rate (1999-2006)

6. Conclusions

The objective of this study was to identify empirically the logic behind the interest-rate setting pursued in 15 EU countries before and after the launch of the EMU. We were able to reveal (by means of estimation of the augmented version of the TR) well-specified interest rate rules for all countries. However, the specification with the highest explanatory power generally differs from the form proposed by Taylor (1993).

In the pre-EMU period we have found four classes of rules according to the degree of a country's dependence on the German monetary policy. The Taylor principle (proposing more than a unit increase of the nominal short-term interest rate as a response to the inflation increase) applied only in large economies and economies with elevated inflation rates. Nevertheless, the price stability of small economies was assured by the response of domestic interest rates to additional variables not considered by Taylor (1993), in particular the foreign interest rate.

The estimated policy rules of the three non-EMU countries show sign of structural change in 1999. While Sweden and the UK were still concerned mostly with their domestic variables (the inflation rate, the output gap), the Danish interest rate setting seems to have followed the ECB. Denmark has – unlike Sweden and the UK - participated in ERM II.

Results of the analysis on the ECB policy rule based on aggregated data of the Euro area are affected by econometric problems. The main finding of this approach is that the ECB pays attention to the national developments as demonstrated by positive and significant coefficient of the inflation dispersion (variance) across the EMU countries. Consequently, we have used quasi-panel analysis based on pooled series of individual EMU members. These results affirm that the ECB increased the interest rate one by one with the expected inflation in the Euro area, yet with consideration of its dispersion across countries. The ECB also follows the lead of the US FED in interest rate setting.

The overall results enables us to draw some general conclusions on the nature of short-term interest rate setting. First, the forward-looking behaviour is very pronounced. Valuable information on inflation expectation is contained in the long-term interest rate. Second, it is not possible to understand fully the interest rate setting without consideration of other variables like the foreign short-term interest rate. Finally, neither the monetary developments nor the evolution of asset prices appear be of interest to monetary authorities.

The present study is open to extensions in various directions; concerning the data used (monthly frequency, longer estimation periods, other sensitivity checks), the model specification (consideration of additional non-linearities), and the estimation method applied (consideration of cross-section dependencies in the panel analysis and of time variance of some parameters).

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Appendix I: Monetary policy inertia

The monetary policy inertia that is represented usually by the partial adjustment mechanism (Clarida *et al.*, 1998). There are some reasons for smoothing of policy decision over time like the effect on financial markets (Goodfriend, 1991). In addition, some theoretic studies like McCallum (1999) and Rotemberg and Woodford (1999) claim that the interest-rate smoothing is desirable for the inflation stabilization. The empirical analysis revealed a very significant parameter of the lagged policy variable for many countries, which point to very slow adjustment of the policy instrument. This slow adjustment should imply predictability of interest rates, which is rejected by the analysis of the term structure of interest rates. Rudebusch (2002) shows that in an empirical study it is difficult to distinguish between a slow partial adjustment with no serial correlation (due to instrument smoothing) and an immediate adjustment with serial correlation of residuals (due to omission of relevant variables). We can write both cases in a nested form like:

$$i_t = \rho_1 i_{t-1} + (1 - \rho_1 + \rho_2)(g_\pi \pi_t + g_y y_t) - \rho_2 (g_\pi \pi_{t-1} + g_y y_{t-1}) + \omega_t \tag{10}$$

If we impose restriction $\rho_1 \neq 0$ and $\rho_2 = 0$, we get a rule with partial adjustment:

$$i_t = \rho_1 i_{t-1} + (1 - \rho_1)(g_\pi \pi_t + g_y y_t) + \omega_t \tag{11}$$

On the other hand by imposing restriction $\rho_1 = \rho_2 \neq 0$, we obtain a rule with autoregressive disturbance:

$$i_t = g_\pi \pi_t + g_y y_t + \rho_1 (i_{t-1} - g_\pi \pi_{t-1} - g_y y_{t-1}) + \omega_t \tag{12}$$

which can be finally written like:

$$i_t = g_\pi \pi_t + g_y y_t + \xi_t \tag{13}$$

where the disturbance follows autoregressive process AR (1): $\xi_t = \rho_1 \xi_{t-1} + \omega_t$.

Appendix II: GMM estimates of the policy rules for EU-15 (1992-1998)

Austria	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		1.39 (1.26)	**1.57** (0.39)	**1.62** (0.46)			0.76	0.01	0.28
FL + SMT	**0.68** (0.07)	**1.06** (0.20)	**0.28*** (0.13)	**0.54** (0.12)			0.98	0.01	0.55
FL + SMT + FIR	**-0.55** (0.25)	-0.10 (0.29)	**-0.28*** (0.13)	-0.08 (0.12)	**1.69** (0.31)		0.98	0.09	0.45
FL + FIR		**0.59** (0.09)	**-0.26*** (0.12)	**0.17** (0.05)	**1.01** (0.06)		0.99	0.02	0.83
FL + FIR + REER		**0.24** (0.09)	0.00 (0.05)	**0.14** (0.06)	**0.96** (0.03)	**-0.06*** (0.01)	0.99	0.14	0.59
FL + FIR + SHI		**0.25** (0.11)	-0.12* (0.10)	0.04 (0.05)	**1.00** (0.06)	**-0.01*** (0.00)	0.99	0.20	0.69
FL + FIR + MA		0.31 (0.17)	**-0.47*** (0.08)	**0.15** (0.06)	**1.05** (0.04)	**0.13*** (0.05)	0.99	0.36	0.71
FL + FIR + LTIR		-0.98 (0.52)	**-0.39*** (0.10)	**0.04** (0.07)	**1.02** (0.04)	**0.27** (0.09)	0.99	0.60	0.84

Notes: Standard errors in parenthesis. The coefficients statistically significant at 5% in bold LB is p-value of Ljung-Box test for 1. order serial correlation in residuals. J-stat is p-value of Sargan-Hansen over-identification test. Best rule is in bold. BL – backward-looking rule, FL – forward-looking rule, SMT – interest rate smoothing, REER – yearly change in the real effective exchange rate, SHI - annualized quarterly change in share index of the local stock exchange, MA – yearly change in the M3 aggregate, LTIR – 10 year government bond yield

Belgium	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**-4.51** (1.51)	**5.01** (0.67)	**1.31** (0.20)			0.32	0.07	0.66
BL + SMT	**0.87** (0.04)	-0.25 (0.37)	0.42 (0.23)	**0.25** (0.12)			0.94	0.95	0.73
BL + SMT + FIR	**0.59** (0.14)	-0.10 (0.41)	0.38 (0.28)	**0.39** (0.18)	0.27 (0.15)		0.93	0.82	0.71
BL + FIR		**-0.52** (0.18)	**0.46** (0.15)	**-0.21** (0.08)	**0.95** (0.05)		0.95	0.49	0.82
BL + FIR + REER		-0.54 (0.33)	**0.83** (0.28)	-0.04 (0.08)	**0.83** (0.06)	0.03* (0.02)	0.95	0.40	0.93
BL + FIR + SHI		-0.77 (0.38)	**0.42** (0.16)	**-0.20** (0.07)	**0.98** (0.06)	0.01* (0.01)	0.96	0.42	0.91
BL + FIR + MA		-0.28 (0.19)	**0.62** (0.15)	-0.12 (0.06)	**0.88** (0.03)	**-0.02*** (0.01)	0.95	0.28	0.90
BL + FIR + LTIR		-0.11 (0.31)	**0.70** (0.14)	-0.10 (0.05)	**0.95** (0.07)	-0.12 (0.10)	0.95	0.55	0.95

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Denmark	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**24.57** (8.44)	**-8.67** (3.71)	1.53 (1.00)			-0.29	0.39	0.82
BL + SMT	**1.13** (0.04)	-1.37 (2.38)	0.30 (1.17)	**0.78** (0.36)			0.86	0.12	0.43
BL + SMT + FIR	**0.58** (0.09)	-1.08 (0.71)	0.49 (0.36)	0.11 (0.17)	**0.50** (0.09)		0.86	0.10	0.78
BL + FIR		1.21 (2.09)	-1.10 (1.04)	0.72 (0.41)	**1.42** (0.11)		0.87	0.05	0.51
BL + SMT + FIR + REER	**0.42** (0.10)	-0.71 (0.89)	0.43 (0.46)	-0.30 (0.28)	**0.63** (0.09)	0.08* (0.04)	0.89	0.15	0.78
BL + SMT + FIR + SHI	**0.52** (0.07)	-0.95 (0.66)	**0.56** (0.27)	0.17 (0.18)	**0.52** (0.09)	-0.01* (0.03)	0.88	0.42	0.81
BL + SMT + FIR + MA	**0.55** (0.09)	-1.71 (0.68)	0.00 (0.09)	**0.32** (0.14)	**0.92** (0.08)	0.03* (0.03)	0.96	0.43	0.91
BL + SMT + FIR + LTIR	**0.59** (0.13)	-0.72 (0.54)	**0.62** (0.27)	0.16 (0.13)	**0.52** (0.09)	-0.12 (0.10)	0.89	0.08	0.72

Notes: See table for Austria

Germany	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**1.19** (0.20)	**1.50** (0.07)	**0.72** (0.16)			0.89	0.02	0.35
FL + SMT	**0.55** (0.11)	**0.82** (0.32)	**0.60*** (0.17)	**0.43** (0.13)			0.97	0.60	0.75
FL + SMT + FIR	**0.72** (0.13)	-0.20 (1.20)	**0.38*** (0.15)	0.11 (0.15)	0.11 (0.15)		0.98	0.16	0.59
FL + FIR		**10.73** (0.94)	**0.70*** (0.10)	**1.39** (0.20)	**-1.41** (0.16)		0.89	0.45	0.35
FL + SMT + REER	**0.89** (0.09)	-0.18 (0.25)	0.24* (0.12)	**0.36** (0.08)		**-0.05*** (0.02)	0.98	0.35	0.58
FL + SMT + SHI	**0.57** (0.14)	**0.78** (0.37)	**0.52*** (0.21)	**0.35** (0.10)		**0.04** (0.01)	0.96	0.03	0.81
FL + SMT + MA	**0.62** (0.08)	**0.74** (0.22)	**0.50*** (0.11)	**0.30** (0.11)		-0.01* (0.01)	0.97	0.52	0.81
FL + SMT + LTIR	**0.90** (0.06)	**1.85** (0.78)	**0.29*** (0.12)	**0.28** (0.16)		**-0.33** (0.14)	0.98	0.32	0.92

Notes: See table for Austria

Finland	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		0.86 (1.65)	**2.62** (1.14)	-0.45 (0.38)			0.61	0.00	0.88
BL + SMT	**0.99** (0.05)	-0.20 (0.18)	0.15 (0.21)	**0.25** (0.09)			0.92	0.82	0.87
BL + SMT + FIR	**0.52** (0.17)	**-1.05** (0.47)	**-0.32** (0.13)	**0.41** (0.10)	**0.86** (0.29)		0.96	0.42	0.62
BL + FIR		**-2.54** (0.92)	-0.16 (0.51)	**0.53** (0.23)	**1.73** (0.32)		0.94	0.78	0.80
BL + SMT + FIR + REER	**0.48** (0.10)	-0.06 (0.26)	0.13 (0.12)	-0.02 (0.11)	**0.53** (0.16)	**0.04** (0.01)	0.92	0.20	0.97
BL + SMT + FIR + SHI	**0.59** (0.07)	-0.42 (0.49)	0.04 (0.16)	0.24 (0.13)	**0.60** (0.17)	**-0.04*** (0.02)	0.97	0.67	0.93
BL + SMT + FIR + MA	**0.75** (0.19)	0.44 (0.43)	**0.48** (0.15)	-0.13 (0.09)	-0.05 (0.36)	**0.05** (0.01)	0.91	0.06	0.94
BL + SMT + FIR + LTIR	**0.48** (0.11)	-1.47 (0.54)	-0.05 (0.11)	**0.34** (0.09)	**0.61** (0.20)	**0.19** (0.05)	0.95	0.33	0.96

Notes: See table for Austria

France	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		2.26 (1.54)	**2.51** (0.87)	**1.76** (0.55)			0.69	0.65	0.86
BL + SMT	**0.67** (0.06)	**1.19** (0.34)	0.54 (0.29)	**0.80** (0.16)			0.91	2.18	0.48
BL + SMT + FIR	**0.61** (0.07)	**1.05** (0.31)	0.34 (0.25)	**0.70** (0.09)	0.15 (0.12)		0.93	2.46	0.58
FL + FIR		**0.78** (0.29)	**0.73** (0.19)	**0.98** (0.14)	**0.85** (0.05)		0.93	1.39	0.80
FL + FIR + REER		0.25 (0.16)	**1.18** (0.13)	0.00 (0.10)	**0.78** (0.05)	**0.13*** (0.02)	0.95	0.68	0.56
FL + FIR + SHI		**1.21** (0.27)	**1.17** (0.22)	**0.68** (0.14)	**0.60** (0.06)	0.00* (0.01)	0.93	0.06	0.85
FL + FIR + MA		0.10 (0.27)	**1.02** (0.11)	-0.02 (0.16)	**0.79** (0.03)	**0.09*** (0.02)	0.95	0.93	0.77
FL + FIR + LTIR		**1.92** (0.79)	**1.17** (0.23)	**0.64** (0.15)	**0.75** (0.04)	-0.25 (0.18)	0.92	0.04	0.76

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Greece	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		1.95 (1.27)	**1.35** (0.11)	**-1.61** (0.42)			0.70	0.27	0.54
FL + SMT	**0.78** (0.08)	0.48 (0.89)	**0.29*** (0.08)	**-0.23** (0.09)			0.97	0.15	0.75
FL + SMT + FIR	**0.66** (0.16)	1.33 (1.12)	-0.11* (0.19)	**-0.33** (0.15)	**0.82** (0.30)		0.96	0.30	0.81
FL + FIR		**4.82** (0.66)	0.37* (0.37)	**-0.79** (0.33)	**1.37** (0.55)		0.90	0.00	0.52
FL + SMT + REER	**0.76** (0.08)	0.57 (0.75)	**0.34*** (0.08)	-0.16 (0.09)		-0.17 (0.09)	0.98	0.95	0.60
FL + SMT + SHI	**0.81** (0.09)	-2.10 (1.25)	**0.49*** (0.10)	**-0.45** (0.15)		**0.05*** (0.01)	0.95	0.23	0.60
FL + SMT + MA	**0.84** (0.14)	0.45 (1.67)	0.19* (0.13)	-0.25 (0.13)		0.00 (0.05)	0.97	0.41	0.78
FL + SMT + LTIR	**0.96** (0.11)	0.37 (0.55)	0.13* (0.37)	**-0.22** (0.09)		-0.10 (0.23)	0.96	0.93	0.65

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Ireland	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ ($\pi_{t-1},\pi_{t+1}*$)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**5.93** (0.27)	-0.05 (0.18)	-0.14 (0.13)			-0.07	0.38	0.61
BL + SMT	**0.34** (0.12)	**4.25** (1.01)	-0.10 (0.24)	0.04 (0.05)			0.32	0.29	0.20
BL + SMT + FIR	0.16 (0.30)	-1.35 (3.14)	0.89 (1.29)	**1.68** (0.76)	1.63 (0.81)		0.64	0.11	0.81
BL + FIR		-2.26 (2.81)	1.16 (1.15)	**1.76** (0.34)	**1.94** (0.20)		0.65	0.05	0.80
BL + FIR + REER		-0.31 (1.86)	-0.03 (0.92)	**1.33** (0.22)	**1.93** (0.13)	0.11 (0.06)	0.72	0.10	0.89
BL + FIR + SHI		4.69 (4.29)	-1.27 (1.50)	**1.70** (0.17)	**1.77** (0.16)	-0.06* (0.03)	0.72	0.10	0.93
BL + FIR + MA		-3.65 (1.51)	0.58 (0.48)	**1.08** (0.17)	**1.95** (0.16)	**0.10*** (0.03)	0.68	0.18	0.51
BL + FIR + LTIR		**-2.99** (1.30)	-0.43 (1.12)	**1.72** (0.20)	**1.77** (0.23)	0.65 (0.39)	0.68	0.07	0.95

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Italy	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ ($\pi_{t-1},\pi_{t+1}*$)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		6.09 (4.60)	0.87 (0.97)	1.13 (1.13)			0.61	0.00	0.98
FL + SMT	**0.59** (0.07	**2.26** (0.53)	**0.40*** (0.12)	**0.49** (0.15)			0.87	0.04	0.57
FL + SMT + FIR	**0.47** (0.08	**2.41** (0.62)	**0.22*** (0.10)	**0.72** (0.16)	**0.32** (0.10)		0.89	0.15	0.81
FL + FIR		-1.23 (2.68)	**1.59*** (0.53)	**0.76** (0.36)	**0.74** (0.18)		0.58	0.00	0.74
FL + SMT + FIR + REER	**0.54** (0.06)	0.05 (0.38)	**0.69*** (0.15)	**0.32** (0.11)	**0.28** (0.07)	**0.04** (0.01)	0.91	0.89	0.90
FL + SMT + FIR + SHI	- -	- -	- -	- -	- -	- -	-	-	-
FL + SMT + FIR + MA	- -	- -	- -	- -	- -	- -	-	-	-
FL + SMT + FIR + LTIR	**0.60** (0.03)	0.05 (0.36)	0.07* (0.08)	**0.46** (0.11)	**0.24** (0.06)	**0.20*** (0.06)	0.93	0.94	0.87

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Luxembourg	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ ($\pi_{t-1},\pi_{t+1}*$)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		0.64 (0.83)	**2.44** (0.30)	0.15 (0.18)			0.79	0.02	0.86
FL + SMT	**0.59** (0.16)	**1.11** (0.37)	0.57* (0.33)	**0.18** (0.06)			0.95	0.51	0.81
FL + SMT + FIR	**0.49** (0.11)	**0.83** (0.21)	0.32* (0.19)	**0.18** (0.05)	**0.27** (0.09)		0.96	0.72	0.80
FL + FIR		**0.61** (0.18)	0.16* (0.32)	**0.13** (0.04)	**0.86** (0.13)		0.96	0.08	0.90
FL + SMT + FIR + REER	**0.62** (0.05)	**0.55** (0.12)	0.14* (0.19)	**0.16** (0.03)	**0.25** (0.05)	**-0.05*** (0.02)	0.97	0.83	0.85
FL + SMT + FIR + SHI	- -	- -	- -	- -	- -	- -	-	-	-
FL + SMT + FIR + MA	- -	- -	- -	- -	- -	- -	-	-	-
FL + SMT + FIR + LTIR	0.41 (0.06)	**0.82** (0.15)	**0.24*** (0.07)	**0.06** (0.02)	**0.50** (0.06)	**-0.11** (0.04)	0.97	0.40	0.69

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Netherlands	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ ($\pi_{t-1},\pi_{t+1}*$)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		-4.42 (5.33)	3.72 1.99	-0.25 (1.14)			0.49	0.01	0.82
BL + SMT	**0.80** (0.05)	0.00 (0.46)	0.39 0.27	**0.23** (0.09)			0.99	0.64	0.29
BL + SMT + FIR	0.22 (0.20)	-0.22 (0.38)	0.32 0.16	0.14 (0.08)	**0.65** (0.21)		1.00	0.14	0.80
BL + FIR		-0.23 (0.38)	**0.38** 0.14	**0.24** (0.10)	**0.84** (0.02)		0.99	0.43	0.90
BL + FIR + REER		-0.06 (0.28)	**0.35** 0.10	**0.31** (0.09)	**0.83** (0.02)	-0.02* (0.01)	0.99	0.60	0.95
BL + FIR + SHI		-0.30 (0.25)	**0.45** 0.11	**0.19** (0.07)	**0.83** (0.02)	0.00* (0.00)	0.99	0.29	0.93
BL + FIR + MA		**0.74** (0.33)	-0.13 0.13	**0.23** (0.07)	**0.95** (0.02)	**-0.04*** (0.01)	0.99	0.84	0.74
BL + FIR + LTIR		-0.37 (0.25)	**0.29** 0.09	**0.23** (0.06)	**0.83** (0.02)	0.07 (0.04)	0.99	0.88	0.93

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Portugal	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**2.90** (0.93)	**1.32** (0.13)	-0.07 (0.30)			0.84	0.01	0.58
BL + SMT	**0.82** (0.09)	**-0.40** (0.17)	**0.36*** (0.17)	**-0.24*** (0.08)			0.94	0.16	0.79
BL + SMT + FIR	**0.96** (0.05)	-1.33 (0.71)	-0.21* (0.49)	-0.12* (0.22)	0.49 (0.57)		0.90	0.80	0.57
BL + FIR		1.58 (1.71)	**2.16*** (1.09)	-0.64* (0.51)	-0.47 (1.10)		0.76	0.02	0.79
BL + SMT + REER	**0.41** (0.15)	0.38 (0.41)	**0.90*** (0.27)	**-0.84*** (0.27)		**0.21** (0.07)	0.94	0.55	1.00
BL + SMT + SHI	**1.17** (0.20)	**-2.86** (1.04)	0.29* (0.24)	0.26* (0.32)		**0.02*** (0.01)	0.96	0.32	0.59
BL + SMT + MA	**0.73** (0.09)	**-0.50** (0.20)	**0.44*** (0.15)	**-0.31*** (0.09)		**0.07** (0.02)	0.94	0.07	0.81
BL + SMT + LTIR	**0.58** (0.22)	-0.53 (0.43)	**0.53*** (0.21)	**-0.26*** (0.06)		0.16 (0.16)	0.94	0.22	0.72

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

Spain	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		1.57 (1.16)	**1.70** (0.26)	**0.72** (0.17)			0.78	0.70	0.92
BL + SMT	**0.63** (0.22)	0.53 (0.69)	0.59 (0.36)	**0.38** (0.11)			0.94	1.00	0.65
BL + SMT + FIR	**0.74** (0.12)	0.27 (0.40)	0.33 (0.23)	**0.42** (0.10)	0.07* (0.08)		0.96	1.14	0.78
BL + FIR		1.54 (1.35)	**1.55** (0.45)	**0.65** (0.25)	0.10* (0.34)		0.74	0.65	0.81
BL + SMT + FIR + REER	**0.65** (0.05)	-0.71 (0.37)	**0.51** (0.14)	-0.08 (0.13)	0.26 (0.13)	**0.08** (0.03)	0.97	0.06	0.90
BL + SMT + FIR + SHI	**0.63** (0.04)	**1.90** (0.37)	0.12 (0.10)	**0.23** (0.04)	**0.21** (0.05)	**-0.02** (0.00)	0.98	0.32	0.99
BL + SMT + FIR + MA	**0.94** (0.06)	-0.05 (0.39)	**0.53** (0.21)	**0.47** (0.10)	-0.09* (0.09)	**-0.20*** (0.06)	0.95	0.13	0.69
BL + SMT + FIR + LTIR	**0.38** (0.09)	**-0.97** (0.41)	0.05 (0.21)	**0.32** (0.06)	**0.35*** (0.10)	**0.44** (0.13)	0.98	0.06	0.93

Notes: See table for Austria

Sweden	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**5.61** (0.60)	0.61 (0.32)	**1.52** (0.52)			0.82	0.01	0.86
FL + SMT	**0.49** (0.09)	**2.31** (0.51)	**0.73*** (0.11)	**0.59*** (0.14)			0.95	0.30	0.92
FL + SMT + FIR	0.28 (0.31)	**2.16** (0.80)	0.17* (0.53)	1.17* (0.68)	0.55* (0.55)		0.97	0.82	0.93
FL + FIR		**4.06** (0.23)	**0.31*** (0.09)	**1.51*** (0.07)	**0.48** (0.07)		0.96	0.62	0.60
FL + FIR + REER		**3.64** (0.38)	**0.49*** (0.15)	**1.35*** (0.11)	**0.55** (0.11)	**0.04** (0.01)	0.96	0.79	0.94
FL + FIR + SHI		**4.58** (0.35)	**0.59*** (0.12)	**1.44*** (0.11)	**0.20** (0.10)	**0.01** (0.00)	0.94	0.75	0.58
FL + FIR + MA		**3.59** (0.28)	0.16* (0.08)	**1.47*** (0.08)	**0.59** (0.08)	0.02 (0.01)	0.95	0.86	0.61
FL + FIR + LTIR		**3.21** (0.90)	**0.36*** (0.09)	**1.37*** (0.14)	**0.48** (0.06)	0.10 (0.10)	0.96	0.83	0.79

Notes: See table for Austria besides SHI - yearly change in share index of the local stock exchange

United Kingdom	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_{t-1},x_t*)	R^2	LB	J-stat.
BL		**5.63** (0.91)	0.60 (0.38)	0.00 (0.61)			0.42	0.00	0.78
BL + SMT	**0.77** (0.08)	**1.18** (0.39)	**0.18** (0.09)	**0.40** (0.08)			0.88	0.39	0.80
BL + SMT + FIR	**1.13** (0.31)	7.47 (6.37)	0.05 (0.19)	2.56 (2.07)	-1.59 (1.49)		0.70	0.04	0.97
BL + FIR		-3.39 (3.60)	**0.77** (0.16)	-1.66 (0.94)	**1.61** (0.71)		0.67	0.01	0.90
BL + SMT + REER	**0.78** (0.04)	**0.69** (0.22)	**0.27** (0.04)	**0.15** (0.07)		**0.04** (0.01)	0.87	0.95	0.68
BL + SMT + SHI	**0.73** (0.08)	**0.87** (0.35)	**0.28** (0.08)	**0.42** (0.08)		0.02 (0.01)	0.89	0.30	0.71
BL + SMT + MA	**0.80** (0.08)	**1.24** (0.31)	**0.17** (0.07)	**0.41** (0.08)		-0.04* (0.03)	0.89	0.60	0.65
BL + SMT + LTIR	**0.79** (0.10)	1.02 (1.18)	0.16 (0.16)	**0.43** (0.10)		0.01 (0.12)	0.88	0.44	0.98

Notes: See table for Austria

Appendix III: GMM estimates of the policy rules for non-EMU members (1999-2006)

Denmark	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_t)	R^2	LB	J-stat.
BL		**3.03** (0.50)	0.10 (0.24)	**1.05** (0.17)			0.73	0.04	0.81
BL + SMT	**0.55** (0.12)	0.58 (0.50)	**0.39** (0.17)	**0.35** (0.14)			0.92	0.05	0.75
BL + SMT + FIR	**0.28** (0.08)	-0.07 (0.32)	-0.02 (0.14)	0.04 (0.13)	**0.78** (0.27)		0.97	0.04	0.54
BL + FIR		**-0.60** (0.08)	-0.02 (0.04)	**-0.10** (0.02)	**1.25** (0.02)		0.98	0.39	0.62
BL + FIR + REER		**-0.79** (0.11)	0.00 (0.03)	**-0.18** (0.03)	**1.32** (0.05)	**-0.02** (0.01)	0.98	0.67	0.77
BL + FIR + SHI		**-0.78** (0.08)	0.00 (0.03)	**-0.13** (0.02)	**1.30** (0.04)	**0.00*** (0.00)	0.98	0.77	0.67
BL + FIR + MA		**-0.61** (0.09)	-0.01 (0.04)	**-0.10** (0.03)	**1.25** (0.03)	0.00* (0.00)	0.98	0.38	0.67
BL + FIR + LTIR		**-0.45** (0.11)	-0.01 (0.02)	0.04 (0.04)	**1.09** (0.04)	0.08 (0.02)	0.98	0.27	0.62

Notes: See table for Austria

Sweden	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_t)	R^2	LB	J-stat.
BL		**2.69** (0.34)	0.41 (0.23)	**0.60** (0.17)			0.48	0.00	0.98
BL + SMT	**0.83** (0.03)	**0.34** (0.08)	**0.07** (0.03)	**0.22*** (0.02)			0.95	0.17	0.47
BL + SMT + FIR	**0.73** (0.09)	0.26 (0.32)	0.07 (0.05)	0.12* (0.15)	0.14 (0.19)		0.95	0.04	0.63
BL + FIR		-2.98 (1.49)	-0.01 (0.26)	-1.12* (0.52)	**2.04** (0.58)		0.65	0.01	0.95
BL + SMT + REER	**0.81** (0.03)	**0.38** (0.09)	**0.08** (0.03)	**0.22*** (0.03)		0.00 (0.01)	0.94	1.30	0.61
BL + SMT + SHI	**0.84** (0.02)	**0.28** (0.07)	**0.11** (0.04)	**0.29*** (0.03)		**0.01** (0.00)	0.95	1.73	0.43
BL + SMT + MA	**0.77** (0.08)	0.54 (0.32)	**0.10** (0.05)	**0.25*** (0.04)		-0.01 (0.02)	0.94	0.07	0.62
BL + SMT + LTIR	**0.60** (0.05)	**-0.46** (0.13)	**0.12** (0.04)	**0.18*** (0.03)		**0.33** (0.05)	0.97	0.16	0.54

Notes: See table for Austria

United Kingdom	ρ (i_{t-1})	$(1-\rho)\alpha$ (const.)	$(1-\rho)\beta$ (π_{t-1},π_{t+1}*)	$(1-\rho)\gamma$ (y_{t-1})	$(1-\rho)\delta$ (i_t^{for})	$(1-\rho)\zeta$ (x_t)	R^2	LB	J-stat.
BL		**3.95** (1.84)	0.49 (1.19)	**1.10*** (0.44)			0.24	0.00	0.96
BL + SMT	**0.67** (0.07)	**1.28** (0.37)	**0.15** (0.07)	**0.74*** (0.11)			0.92	0.17	0.65
BL + SMT + FIR (EUR)	**0.75** (0.06)	**1.03** (0.22)	**0.13** (0.05)	**0.66*** (0.09)	-0.04 (0.06)		0.92	0.36	0.51
BL + SMT + FIR (USD)	**0.82** (0.09)	0.64 (0.44)	**0.21** (0.10)	**0.64*** (0.11)	-0.03 (0.04)		0.90	0.26	0.45
BL + FIR (EUR)		0.43 (2.48)	1.86 (1.12)	**1.85*** (0.42)	0.56 (0.35)		0.12	0.00	0.96
BL + FIR (USD)		**4.35** (0.22)	-0.49 (0.20)	0.51* (0.29)	**0.29** (0.06)		0.88	0.00	0.76
BL + SMT + REER	**0.70** (0.06)	**1.22** (0.30)	0.10 (0.06)	**0.49*** (0.16)		**0.03*** (0.01)	0.94	0.15	0.67
BL + SMT + SHI	**0.69** (0.07)	**1.49** (0.60)	-0.10 (0.34)	0.51* (0.28)		0.01* (0.01)	0.92	0.44	0.77
BL + SMT + MA	**0.61** (0.05)	**1.76** (0.31)	**0.31** (0.08)	**1.04*** (0.11)		**-0.05*** (0.01)	0.94	0.97	0.64
BL + SMT + LTIR	**0.63** (0.06)	-1.46 (1.27)	**0.42** (0.15)	**0.55*** (0.16)		**0.54*** (0.20)	0.90	0.32	0.65

Notes: See table for Austria

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