DO ALL FIT ONE SIZE?
AN EVALUATION OF THE ECB POLICY RESPONSE TO CHANGING ECONOMIC CONDITIONS IN EURO AREA MEMBER STATES

By

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Abstract

This paper empirically investigates the extent to which the European Central Bank has responded to evolving economic conditions in its member states as opposed to the euro area as a whole. Based on a forward-looking Taylor rule-type policy reaction function, we conduct counterfactual exercises that compare the monetary policy behavior of the ECB with two alternative hypothetical scenarios: (1) were the euro member states to make individual policy decisions, and (2) were the ECB to respond to the economic conditions of individual members. The results reflect the extent of heterogeneity among the national economies in the monetary union and indicate that the ECB's monetary policy rates have been particularly close to the "counterfactual" interest rates of its largest euro members, as well as of countries with similar economic conditions, which includes Germany, Austria, Belgium and France.

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1. Introduction

In 1999, all but four members of the European Union (EU) participated in the third stage of the Economic and Monetary Union (EMU) process by adopting the euro as their national currency and transferring responsibility for monetary policy to the European Central Bank (ECB)—the hub institution of the eurosystem. The official policy stance of the ECB is that monetary policy decisions reflect changing economic conditions of the entire euro area; they do not take into account any diversity among the national economies within the region (Duisenberg, 2001). While the establishment of the ECB was necessary for monetary union between EU member states, its "one size fits all" monetary policy has faced criticisms on many fronts, and indeed it is now largely accepted that "all will not fit one size" in most circumstances.

The efficacy of a single monetary policy for all euro area members is akin to the issue of whether the member states participating in the euro area constitute an optimum currency area. Above all, the significant amount of diversity that remains among euro area members today constitutes a challenge to the implementation of a single currency or monetary policy. A growing volume of literature (e.g., Faust *et al*, 2001; Carstensen, 2006; Arestis and Chortareas, 2006; Fendel and Frenkel, 2006; Sturm and Wollmershäuser, 2008) has attempted to evaluate ECB performance in managing the aggregate economy of the euro area. For instance, Faust *et al* (2001) rely on the behavior of Germany's Bundesbank in the pre-euro period as a benchmark to assess ECB policy. Many of these studies are, however, hampered by the short history of EMU; consequently, the results of these earlier studies appear to be fragile and/or anecdotal.

This paper aims is to evaluate the performance of the ECB's monetary policy by comparing its historical policy behavior against the hypothetical monetary policies of its members. More specifically, we ask two related questions: (1) What would the policy interest rates have been if the ECB were to make policy decisions based on the economic conditions of individual euro area member states instead of the euro area as a whole? And (2) What would the interest rates of euro area member states have been if their central banks were given the power to make individual policy decisions? The two questions are addressed using counterfactual exercises with a popular Taylor rule-type policy reaction function. Based on these exercises, we can construct aggregate "stress" measures, which indicate how economic conditions diverge within the euro area.

In addition to the counterfactual analysis—an approach different from the traditional regression-based methods in earlier studies—our work contributes to the existing monetary policy literature in three aspects. First, our results benefit from nearly a decade of ECB history as opposed to earlier studies with limited data observations. Second, we implement recursive estimation to accommodate observed instability in feedback coefficients of the reaction functions. This method allows us to model evolving monetary policy conduct, particularly in terms of central banks' changing weights for individual economic variables. Third, we include monetary aggregates in the Taylor rule as a representation of the ECB's "second pillar" of the official ECB monetary policy strategy.

The rest of this paper is organized as follows. The second section discusses the methodology and data. The third section presents the estimation results based on a Taylor rule-type reaction function. The fourth section discusses the results of counterfactual exercises in order to evaluate the monetary policy implications of disparate economic experiences among euro area member states. The fifth section concludes the paper.

2.1 Empirical Methodology

a) The Taylor Rule

We explore central bank behavior using the Taylor rule, which has become the most popular formulation of a monetary policy reaction function.[1] A Taylor rule is a formulation for determining interest rates, and it assumes that interest rates should be related to the rate of inflation and to the output gap (which is calculated as the amount of spare capacity in an economy). As interest rates are not expected to instantaneously adjust to changes in inflation rates and the output gap, a dynamic version of the Taylor rule can be used thereby incorporating "interest rate smoothing," which means that interest rates are adjusted through time to any new developments in inflation and output.

Following Clarida *et al* (1998) and Faust *et al* (2001), among others, the baseline specification of a dynamic version of the Taylor rule for a central bank's policy instrument is expressed as:

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

where ε_t is an i.i.d. error term with a zero mean. The term i_t^* denotes the central bank's "target" interest rate, and the parameter ρ captures the interest-rate smoothing behavior in monetary policy conduct.

According to this forward-looking version of the policy reaction function, the central bank responds to (i) the expected rate of inflation between periods t and $t+n$ that is above its targeted rate, and (ii) the contemporaneous expected value of the output gap, which is the difference between expected output level and the potential output level y_t^*. Price stability and output stabilization are widely considered as the dual objectives of many central banks. From

[1] See Fernandez and Nikolsko-Rzbevskyy (2007) for a recent comparison of different specifications of the Taylor rule.

1999 to 2003 the ECB officially followed a two-pillar strategy (ECB, 2003),[2] putting equal emphasis on targeting both inflation and the money supply, but in recent years the emphasis on the money supply (the "second pillar") has waned, leading to pressure from various quarters to reinstate money supply targeting as an important component of monetary policy.[3] Price stability is the central objective of ECB monetary policy, and this goal is supported by the first pillar of economic analysis of dynamics and shocks (what is traditionally incorporated into a typical Taylor rule), with the second pillar reflecting monetary analysis, that is, developments in monetary growth, particularly in the broad M3 monetary aggregate.[4] Because of this so-called "second pillar" of monetary policy, we augment the conventional Taylor rule with an additional variable, namely the growth rate of a monetary aggregate. From this perspective, the ECB's target rate might be expressed as:

$$i_t^* = \beta_0 + \beta_1(E[\pi_{t+n} \mid \Omega_t] - \pi_t^*) + \beta_2(E[y_t \mid \Omega_t] - y_t^*) + \beta_3(E[m_t \mid \Omega_t] - m_t^*) \quad (2)$$

where m_t denotes money growth, m_t^* its targeted rate, and E is an expectation operator given the information available to the central bank at time t, Ω_t. The expression uses y and π as the standard notations for income and inflation.

To facilitate cross-country comparisons, we follow recent studies (e.g., Clarida et al (1998)) and first estimate the target rate model with a zero targeted inflation rate, i.e., ECB

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[2] In May 2003, the ECB announced its revised monetary policy strategy that no longer explicitly assigned monetary growth a "prominent role" in its policy conduct (Carstensen, 2006).

[3] "The second perspective or pillar—the "monetary analysis"—focuses on a longer-term horizon, exploiting the long-run link between money and changes in the general price level." and "Our two-pillar approach is designed to ensure that no relevant information is lost in the assessment of the risks to price stability and that appropriate attention is paid to different perspectives and the cross-checking of information in order to come to an overall judgment of the risks to price stability." Extracts from speech given by Axel Weber, President of the *Bundesbank* in York, UK, 10th June, 2008

officials (ECB, 1998; 2003) have explicitly defined price stability as an inflation rate below 2 percent over the medium term, but price stability is theoretically a zero inflation rate. Similarly, we consider the expected growth rate of M3 in specifying the reaction function. Although the ECB has announced a reference value of 4.5 percent for annual M3 growth (ECB, 1998), Huchet (2000) asserts that it has never attempted to keep monetary growth at that reference value by changing interest rates. Moreover, various studies (e.g., Favero *et al* 2000; Svensson, 2000) have shown that monetary growth has never played a leading role in the monetary policy practice of the ECB, but other studies (associated with the ECB) have lent credence to the use of the second pillar as a long-term indicator of inflationary pressures (Assenmacher-Wesche and Gerlach, 2007; 2008).

Against this background, we consider the following dynamic version of the Taylor rule:

$$i_t = \rho i_{t-1} + (1-\rho)\{\beta_0 + \beta_1 E[\pi_{t+n} \mid \Omega_t] + \beta_2 (E[y_t \mid \Omega_t] - y_t^*) + \beta_3 E[m_t \mid \Omega_t]\} + \varepsilon_t . \qquad (3)$$

The policy feedback coefficients,β1, β2, β3reflect the central bank's attention to price stability, economic activity and monetary growth, respectively, in making monetary policy decisions. Various studies (e.g., Arestis and Chortereas, 2006; Carstensen, 2006; Fendel and Frenkel, 2006; Hayo and Hofmann, 2006; Huchet, 2000) have used the above Taylor-type reaction function with or without the monetary variable to examine monetary policy for the euro area. Clarida *et al* (1998) finds that this reaction function specification provides a good representation of monetary policy for major central banks, particularly during periods after the early 1980s.

An earlier version of the Taylor (1993) rule employs only lagged values of the independent variables, implying a backward-looking monetary policy behavior. However,

[4] In 2003 the two pillars were reversed, with economic analysis gaining greater prominence, and monetary analysis having a secondary role, but the ECB continues to defend a separate monetary pillar (see speech by Member of the ECB's Executive Board, Otmar Issing, at *http://www.ecb.int/press/key/date/2005/html/sp050603.en.html*).

Clarida et al (1998), Faust et al (2001), and Fernandez and Nikolsko-Rzbevskyy (2007) find that the forward-looking model specification, as captured by equation (2), better reflects monetary policy conduct of major central banks than do its backward-looking counterparts.

2.2 Estimation Issues

Two issues complicate estimation of the policy reaction function captured by equation 3. Both issues arise from the fact that data for the independent variables are not directly observable at the time that monetary policy decisions are made. First, the forward-looking specification of the Taylor rule assumes that policymakers react to their expectations about future inflation and the output gap, not their past realized values. Second, data for the output gap require information about the potential output level, which is also not directly observable.

For inflation expectations, we consider central banks' policy responses to inflation expectations one-period ahead (n=1). The central banks' published forecasts serve as reasonable measures for the expected inflation and output gap data; however, such forecasts are largely unavailable for countries other than the U.S. and the U.K. Following most studies in the recent literature, including Clarida *et al* (1998) and Muscatelli *et al* (2002), we adopt the errors-in-variables approach that involves the generalized method of moments (GMM) to estimate ex-post data along with a set of instrumental variables. To reflect the policymakers' information set at the time of an interest rate decision, the instruments include four lagged values of the policy interest rate, inflation and output gap series. GMM estimations are carried out using an optimal weighting matrix that accounts for potential heteroskasticity and serial correlation in the error term.

Another estimation issue concerns the data for potential output. A popular method to obtain estimates for potential output is to extract a nonlinear trend from GDP data using the Hodrick-Prescott (HP) filter or a band pass filter. However, Laubach (2003) argues that these univariate filters ignore information from movements in inflation and thus provide a misleading picture of the recent trends for such variables as interest rates and output. These filters are also inappropriate from a conceptual perspective. As Muscatelli *et al* (2002) point out, they are commonly executed using the full sample of estimation data, meaning that policymakers are assumed to possess information about future GDP data that they in fact do not know in real time.

To better model policymakers' decision making process, we obtain a measure of the output gap using a structural approach. Following King *et al* (1995) and Lee (2000), among others, we extract the unobservable trend component of the output series in line of an expectations-augmented Phillips curve model:

$$\pi_t = \sum_{i=1}^{4} \phi_i \pi_{t-i} + \theta(y_t - y_t^*) + \sum_{i=1}^{4} \varphi_i oil_{t-i} + \eta_t \qquad (4)$$

where the variable *oil* controls for the influence of supply shocks and is measured by the first-difference of the logged world crude oil price level. In equation (4), potential output, y_t^*, captures the level of output consistent with stable inflation, ignoring the transitory shocks to aggregate supply. The term y_t^* is an unobservable component that is estimated by a recursive Kalman filter in state-space form that follows a random walk (plus drift)[5]:

$$y_t^* = \delta + y_{t-1}^* + \upsilon_t. \qquad (5)$$

2.3 Data

[5] The Kalman filter recursive updating procedure is executed in a state-space representation, for which equation (4) is the measurement equation and equation (5), the state equation.

We examine quarterly data beginning from 1994, when the forerunner of the ECB—European Monetary Institute—was created. Except for M3, the data are available through the OECD's Main Economic Indicators database,[6] and all variables are collected on a quarterly basis. Today, the euro area consists of 15 member states, including the 11 original "stage-three members" of the EMU, Greece (joining in 2001) and Slovenia (joining in 2007), Cyprus and Malta (both joining in 2008). Because our dataset ends in 2005, the euro area consists of the first 12 member states, excluding Slovenia, Cyprus and Malta.

Inflation is measured by the year-over-year percentage change in the Consumer Price Index. To gain some perspective on the extent of heterogeneity across national economies in the euro area, we plot the inflation data for individual member states in Figure 1 along with the area-wide data. Prior to joining the monetary union, inflation declined noticeably in most member states, especially Greece, Italy and Portugal. In the post-euro period, however, inflation patterns remained quite different among euro area member states.

The output gap is measured by 100 times the log level of real GDP less the log level of potential GDP. Following Clarida et al (1998), among others, the measure of monetary policy instrument is the equivalent of the overnight interbank lending rate. For example, such a rate for Germany before 1999 is its call rate. Interest rate data for the ECB between 1994 and 1998 are taken for all banks included in the calculation of the Euribor. Beginning in 1999, the interest rates for euro area member states are identical to the policy rate of the ECB, as proxied by the 1-month Euribor rate.[7]

[6] Euro area data refer to the evolving composition of the euro area. Data for periods prior to 2001 refer to EU11 (Austria, Belgium, Finland, Germany, Ireland, France, Italy, Luxembourg, the Netherlands, Portugal, and Spain). Data for periods between 2001 and 2005 refer to EU12 (EU11 plus Greece).

[7] Although the European Overnight Index Average (EONIA) is at first pass the best candidate, there are widely reported problems with using this variable as a central bank policy rate because of the ECB use of 4-week reserve averaging, which led to very volatile rates towards the end of averaging periods.

The money growth variable is measured by the year-over-year percentage change in M3. Even though the ECB publishes M3 data for the euro area as a whole, corresponding data for individual member states are not publicly available. To deal with this problem, we use Mehrotra's (2007) estimates for the national contributions to euro area M3. The data are available only for 9 member states (excluding Greece, Ireland and Luxembourg).

3. Estimation Results

3.1 Full Sample Period Results

Table 1 reports GMM estimation results for the euro area, as well as its member states, over the period 1994:1-2005:4. Judging by the standard errors of estimates (SEE) documented in the sixth column of Table 1, the Taylor rule fits the data of Austria and Germany better than other euro area member states as well as the euro area as a whole. It is also noteworthy that all of the reported *J*-statistics (seventh column) for testing over-identifying restrictions indicate that the selected set of instruments in model estimations is relevant. In other words, the statistics support the exogeneity property of the instrumental variables with respect to monetary policy decisions.

For most countries except Greece, the estimated coefficient for the lagged policy rate (ρ) is fairly close to one, implying a great deal of "inertia" in monetary policy.[8] The intercept term (β_0) in the target rate equation represents the equilibrium or long-run target rate. The respective estimates vary remarkably across countries, and some are even negative (Greece, Ireland, Italy, Portugal and Spain).

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[8] Despite possible non-stationarity in the interest rate series, we follow the majority of the existing literature by specifying the interest rate variables in levels in order to compare our results with those in the literature. Alternatively, for interest rates identified with a unit-root (Finland and Ireland), we have followed Judd and Rudebusch (1998) and estimated the Taylor rule with an error-correction approach. The overall results are nevertheless the same as those reported here.

Similarly, the coefficient estimates for the future inflation variable vary widely across member states. The estimate for the euro area as a whole is about 1.4, which differs greatly from those of individual member states. The estimates for Finland, Greece, Ireland, Italy and Spain are relatively higher, suggesting aggressive responses to expected inflation from these member states. On the other hand, the estimates for other member states are statistically insignificant. Unlike the estimates for inflation, the output gap coefficient estimates are mostly positive, except for the case of Portugal.

For the nine member states posting M3 data, the reaction function includes M3 growth in addition to inflation and the output gap. For the euro area, the coefficient estimate for the money growth variable is negative, reflecting the expected relationship between money growth and interest rates.[9] The evidence of such a relationship is, however, much weaker among member states. In the cases of Finland and Portugal, the estimate is even positive.

3.2 Structural Change

Before proceeding further with the estimation results, it makes sense to test first for structural stability in the estimated model parameters. Particularly for euro area member states, handing over monetary policy to the ECB could lead to a change in policy feedback coefficients, and thus parameter instability, in the estimated policy reaction functions.

To explore possible parameter instability, we consider Chow-type tests with *a priori* unknown break points. Specifically, we compute Andrews and Ploberger's (1994) *MeanF* and *SupF*, and Hansen's (1992) L_c statistics for estimating equation (3) as described in the preceding

[9] A negative estimate implies that the liquidity effect dominates the expected inflation effect of an increase in money supply.

section. The Andrews-Ploberger tests are primarily used to detect a sudden break, while the Hansen test can help identify a smooth change.

Test results for the estimated Taylor rule are reported in the last three columns of Table 1. The null hypothesis for all tests is constancy in all estimated parameters. Parameter instability is evident for most member states in the sample and the euro area, even though not all alternative statistics are significant. The L_c statistics overall provide stronger evidence of structural change than the *MeanF* or *SupF* statistics do. In other words, the bulk of euro area member states witnessed a gradual rather than abrupt change in monetary policy reaction over the estimation period.

3.3 Recursive Estimation Results

In light of the evidence of structural instability in the estimated policy reaction function, we follow a procedure similar to Boivin (2006) and allow for evolution in parameters by applying recursive estimations. For each country, we first run GMM estimation of equation (3) using data over the period 1994:1-1999:1. Sequentially, we re-estimate the model by adding data one period at a time until the estimation reaches the end of our observation period in 2005:4. Because Greece did not become part of the eurosystem until 2001, its Taylor rule estimation ends at 2000:4, and the first period for recursive coefficient updating is 2001:1.

Figure 2 illustrates over time recursive estimates of the coefficients on the lagged interest rate (ρ), intercept (β_0), inflation (β_1), the output gap (β_2), and money growth (β_3) for each member state. The time periods shown in the plots refer to the final period of recursive estimation. The solid lines are coefficient estimates, encapsulated by the plus and minus two standard error intervals (shaded bands). To facilitate comparisons, we also superimpose the respective coefficient estimates for the euro area (dotted lines).

The plots for the estimated coefficients on the lagged interest rate reflect very little adjustment in monetary policy behavior in the face of changing economic conditions. For the euro area as a whole, the estimate figures around 0.6 in the first two years of ECB operation before reaching 0.9 in 2004. The overall high degree of interest rate smoothing across member states, particularly Germany, is widely observed in the literature on policy reaction functions, e.g., Clarida *et al* (1998), and Faust *et al* (2001).

The intercept term represents the long-run target interest rate. The estimate for the euro area hovers around two percent, while the corresponding estimates for some member states (Ireland, Italy, Portugal and Spain) are negative during much of the observation period. The declining trends in the long-run target rate measures across member states are associated with their decreasing inflation trends over the observation period.

For the inflation coefficients, the recursive estimate in the case of the euro area is rather stable, at about 1.5 over much of the observation period. Evidence of convergence exists over time between the euro area coefficient estimates and the corresponding estimates for some member states (Germany, Ireland and Luxembourg), but divergence for some others (Greece, Netherlands and Spain). At the end of the observation period, however, a statistically significant discrepancy between the two coefficient estimates is evident for most euro area members, except Portugal.

The fourth column of plots shows the output gap coefficient estimates. The estimate for the euro area is qualitatively indifferent from zero before rising to 1.5 beginning in 2004. The ECB's output coefficient estimates are lower than the corresponding estimates for most member states, except Portugal. The comparative results also highlight the extent of heterogeneity among individual economies within the euro area. As emphasized by ECB officials (Duisenberg, 2001), the ECB responds only to the euro area-wide economic conditions. The estimation results imply that policy might appear to be too tight for some euro area member states while too loose for others. More specifically, the ECB's weights on inflation and the output gap are higher than the corresponding weights for some member states while lower than some others.

A few studies of European monetary policy have focused on comparing the behavior of the ECB with the Bundesbank. For example, Faust *et al* (2001), and Hayo and Hofmann (2006) assert that the ECB, in its early years, placed a higher weight on the output gap relative to the weight on inflation than the *Bundesbank* would have. However, our estimations that allow model coefficients to drift over time suggest the opposite for a much longer observation period.

The last column of plots in Figure 2 shows the coefficient estimates for money growth. For the euro area, the recursive estimates remain negative over the entire observation period, even though they vary noticeably over time. For individual member states, however, the coefficients are positive in the cases of Finland and Portugal. In addition, the estimates are largely indifferent from zero in the cases of Belgium, Germany and Italy. These findings support the hypothesis that the ECB policy rate reflects monetary conditions of the entire euro area, but not necessarily of all its individual member states.

The disparities between the coefficient estimates for the euro area and individual member states highlight the difficulty of managing different economies with a single monetary policy. However, it remains difficult from the individual plots in Figure 2 to judge whether monetary policy might be too tight or too loose at a given period of time. For instance, as argued by Judd (1998), an increase in the coefficient on the output gap may reflect central bank officials' increased emphasis on using developments in the output gap to forecast future inflation. Similarly, monetary growth is widely conceived (e.g. Gerlach and Svensson, 2000) as an indicator of future inflationary pressures.

4. Counterfactual Analysis

4.1. Counterfactual Analysis for Policy Rates

Given the estimation results for the Taylor-type reaction function, we ask the following counterfactual questions:

i) What would the policy rates have been if the ECB made decisions based on the economic data of individual member states instead of the euro area as a whole?

ii) What would interest rates for a euro area member state have been if its central bank were to make its own policy decisions instead of adopting the ECB policy?

To address the first question, we perform a set of exercises as follows. For each country, we calculate the path of its interest rate using the estimated coefficients for the ECB but using its own historical values for the explanatory variables. More specifically, we generate "counterfactual" interest rates for each member state as:

$$\tilde{i}_t = \hat{\rho}^a \tilde{i}_{t-1} + (1 - \hat{\rho}^a)[\hat{\beta}_0^a + \hat{\beta}_1^a \pi_t + \hat{\beta}_2^a (y_t - y_t^*) + \hat{\beta}_3^a m_t] \quad (6)$$

where an "*a*" superscript denotes the corresponding estimate for the euro area, and a coefficient with a hat represents a (time-varying) recursive coefficient estimate obtained from the preceding section. Only coefficient estimates that are statistically significant at the 10 percent level or higher in full-sample estimation (Table 1) are included in generating the counterfactual interest rate paths. In addition, the last term is ignored for member states (Greece, Ireland and Luxembourg) without M3 data. Equation (6) essentially generates the hypothetical interest rate series for the ECB by assuming that it made monetary policy decisions for each member state individually based on its national data.

Alternatively, the second question deals with a hypothetical situation in which central banks in the euro area were to set interest rates individually. We assume that the central banks followed a policy rule established prior to 1999:1, as captured by the same Taylor rule in equation 3 estimated over the period 1994:1-1998:4. In other words, we generate another set of counterfactual policy interest rates by replacing the coefficients in equation (6) with the estimates for the pre-1999 sub-period. Because Greece did not become part of the euro area until 2001, the Taylor rule estimation for this country ends at 2000:4 and the first period of simulation is 2001:1.

Figure 3 shows the results of the counterfactual exercises. The solid lines represent in-sample forecasts of the policy rate using the inflation targeters' own recursive coefficient estimates. The shaded bands correspond to the 95 percent confidence intervals around the in-sample fitted values, and these are used as "baseline" values to assess the appropriateness of ECB monetary policy. For each country, a dotted line is a counterfactual series obtained from fitting equation (6) with the recursive coefficient estimates for the ECB reaction function but the values of the explanatory variables for that member state. A dashed line is a counterfactual series obtained from fitting equation (6) with the fixed coefficient estimates for individual member states over the pre-1999 sub-period instead of using the ECB coefficients.

The majority of counterfactual series implied by the estimated ECB reaction function (dotted lines) mirror the general trend of the fitted interest rates (in-sample fitted values), but they are more volatile. This implies that ECB monetary policy has been more rigid over time than the hypothetical interest rates that responded to the economic conditions of individual euro area member states. In the case of Belgium, Germany, Greece, Luxembourg, the Netherlands and Spain, the two series are overall not qualitatively different from each other over the simulation period, as judged by the 95 percent confidence bands. The two series are the closest for Germany.

In comparison with the first set of counterfactual series, more disparity is evident among the second set of counterfactual series (dashed lines) constructed using the estimated Taylor rules of individual member states over the pre-euro sub-period. Except for Ireland, Portugal and Spain, the counterfactual series tends to follow the same trends as the fitted series. No meaningful discrepancy exists between the counterfactual interest rate and the fitted rate over time in the cases of Belgium, Luxembourg and the Netherlands. Similar to the first set of counterfactual exercises, these counterfactual exercises suggest that if the majority of national central banks in the euro area were to follow their own policy rules established prior to joining the monetary union, then their interest rates would have been meaningfully different from those set by the ECB. In particular, the results show that the economic conditions in Greece, Ireland, Portugal and Spain would have dictated higher interest rates than those set by the ECB.

4.2. Counterfactual Analysis for "Target" Rates

The results in the above counterfactual analyses are largely affected by the substantial amounts of interest rate smoothing in monetary policy conduct. As with Faust *et al* (2001), we alternatively perform counterfactual exercises on the target interest rates instead of the actual policy rates. To gain some perspective on the importance of focusing on the target interest rates, Figure 4 plots the actual interest rates (solid lines) and the fitted target values (dotted lines). For each country, the fitted target rates represent the fitted values using the recursive coefficient estimates in equation (1). These values essentially predict ECB monetary policy rate as a function of the inflation and the output gap variables. In most cases, the fitted target series is less smooth than the actual interest series, and any deviation between the two appears temporary over time.

In light of the observed differences between the actual interest rates and the fitted target values, we replicate the counterfactual exercises in the previous subsection for the target rate instead of the actual policy rate. To do so, we generate a counterfactual target rate ($\tilde{i}_t^*$) path for each country using a procedure analogous to that captured by equation (6):

$$\tilde{i}_t^* = \hat{\beta}_0^a + \hat{\beta}_1^a \pi_t + \hat{\beta}_2^a (y_t - y_t^*) + \hat{\beta}_3^a m_t . \tag{7}$$

Analogous to the results for actual policy rates in Figure 4, Figure 5 shows the counterfactual results for the target rates. Again, the solid lines are in-sample forecasts using the member states' own estimated coefficients, the dotted lines are counterfactual series using the ECB's reaction function, and the dashed lines are counterfactual series using the individual member states' pre-euro reaction function.

The overall findings in Figure 5 stand in contrast to those observed in Figure 4. For the counterfactual exercises under the hypothetical scenario that the ECB responded to the economic data of individual member states, some discrepancy exists between the fitted interest rates and the counterfactual path (dotted line) for every country. The counterfactual path follows most closely the fitted target rates in the cases of Greece and Spain. Overall, the two interest rate paths tend to be much closer in the second half of the observation period than the earlier years of ECB history. This trajectory reflects convergence over time of euro member states.

Under the alternative hypothetical scenario that central banks were able to pursue individual monetary policy, the counterfactual target rate path (dashed line) follows the fitted target rates most closely in the case of Germany. In that case, the discrepancy between the two series is virtually nonexistent, implying that the ECB policy conduct is a natural extension of the policy of the *Bundesbank*. Other than Germany, the counterfactual series and fitted target rate series are quite close in the cases of Austria, Belgium, Finland and France, which share similar economic conditions with Germany. On the contrary, the counterfactual target rate paths for Greece, Ireland, Portugal and Spain are persistently higher than their fitted target rates over much of simulation period. This result can be attributed to the fact that those member states had experienced relatively high inflation prior to joining the monetary union.

Overall, the counterfactual results for the target rates clearly reveal that the ECB monetary policy best reflects the economic conditions of the larger members, and most notably Germany. Stated otherwise, the divergence between the fitted ECB target rate and the rate implied by a country's economic conditions is more pronounced for smaller euro area members. The results are supported by Huchet (2000), who finds asymmetric ECB policy effects among euro area members. Moreover, the findings in this subsection, which stand in contrast to the results for the observed policy rates in the preceding subsection, highlight the role of interest rate smoothing behavior in monetary policy conduct.

4.3 Policy Stress

The results of the counterfactual exercises in Figure 5 could be considered a reflection of policy "stress" for a monetary union like the euro area, as emphasized by Clarida *et al* (1998) and as implemented by Sturm and Wallmershäuser (2008) and Flaig (2007). Figure 6 plots the gaps between the fitted target rate series and the counterfactual series constructed using equation (7). In particular, the point estimates in Figure 6 equal the fitted target rates for each country (solid lines in Figure 5) minus the counterfactual target rates using the ECB feedback coefficients (dotted lines in Figure 5). A positive value implies that the ECB target rate was higher than what would be expected by a euro area country using its country-specific data, while a negative value, on the contrary, implies that the ECB policy was more accommodative than expected. The shaded areas represent the 95 percent confidence bands using the bootstrap method with 1,000 replications.

Even though the results in Figure 6 vary markedly across member states, as well as over time, it is apparent that the extent of monetary policy stress overall is not qualitatively significant for Austria, Belgium and Luxembourg. The results for these three member states are consistent with the argument of Sturm and Wallmershäuser (2008) that small euro area members have received more than proportional weights in ECB monetary policy decisions. On the other hand, the ECB target rates beginning 2003 were more accommodative for member states such as Ireland, Portugal, Italy and Germany, than the target rates warranted by economic conditions of these individual member states.

Figure 7 illustrates the extent of policy stress on different member states, as measured alternatively by taking the difference between the fitted target rates (solid lines in Figure 5) minus the counterfactual target rates using the pre-euro coefficients of those member states (dashed lines in Figure 5). For five member states (Austria, Belgium, Finland, France and Germany), the point estimates are not qualitatively different from zero, meaning that the ECB target rates were no different from the target rates implied by their policy rules adopted in the pre-euro period. By contrast, the overall estimates are negative for six member states (Greece, Ireland, Italy, Luxembourg, Portugal and Spain), meaning that the ECB target rates tended to be more accommodative than if these member states were to set their own target rates according to their individual policy rules established before joining the euro area. Taken together, Figures 6 and 7 suggest that the ECB target rates might have been consistent with the rates preferred by some member states, but they have appeared too loose for other members.

To gain some perspective about the "stress" of using a single ECB monetary policy on the national economies within the euro area, Figure 8 plots the weighted sums of the respective policy stress indicators for individual members, where member states' annual GDP data are used to calculate the weights. The absolute value of a member state's policy stress data is used so that an ECB monetary policy decision that is tighter than optimal for an individual member state is treated equally to an ECB target rate that is too loose. The upper panel of Figure 8 corresponds to the counterfactual exercise 1 with the ECB coefficients. The plot reveals that the overall monetary policy stress in the euro area declined gradually during the first two years of ECB operation and hovered around 1.5 percent over the rest of the observation period. The pattern in the early years of the ECB can be interpreted as evidence of convergence among EMU members.

The lower panel of Figure 8 corresponds to counterfactual exercises with the pre-euro coefficients. In contrast to the pattern in the upper panel, this ECB policy stress indicator appears more stable, and its overall size is lower at around 0.5 percent. The noticeable exception to this observation is the nearly zero policy stress in 2001 when most euro area members experienced an economic slowdown. Taken together, the plots in Figure 8 indicate that ECB policy rates deviated, on average, 0.5 percent to 1.5 percent from what would have been optimal for its participating member countries.

4.4 Robustness Check

How robust are our empirical findings? To answer this question, we have replicated the estimation and counterfactual exercises with several modifications. First, instead of the Kalman filter, we have employed the standard HP filter and band pass filter to extract the trend component in the GDP series. In either case, the output gap is measured as the deviation of actual output from a nonlinear low-frequency trend component. Second, instead of recursive estimations, we have performed estimations using a rolling window of five years. Third, we have alternatively estimated the Taylor rule equation using contemporaneous and two-period-ahead data instead of one-period-ahead data for inflation. Overall, these alternative specifications have produced no appreciable qualitative effect on the results presented above.[10]

5. Conclusion

ECB officials claim that monetary policy decisions take into consideration the aggregate economic conditions of the euro area and disregard divergent national developments. Against this background, this paper has investigated the extent to which the ECB has responded to changing economic conditions of individual euro area member states versus the euro area as a whole. To this end, we first estimated a Taylor-type policy reaction function for euro area member states as well as for the euro area as a whole. The estimation results exhibit substantial disparities across member states, reflecting the extent of heterogeneity among the national economies inside the euro area.

We also conducted counterfactual exercises based on the estimated reaction functions to explore two alternative hypothetical scenarios. Under the hypothetical condition that the ECB responded to the economic conditions of individual euro area members, the target interest rates

[10] Detailed results in this subsection are not reported here for brevity, but are available upon request.

for most member states, except Germany, would have been quite different from those predicted by the area-wide data. This implies that the ECB policy rule best fits the economic conditions of certain member states.

Similar results for Germany and other contiguous member states (such as Austria and Belgium) are obtained in counterfactual exercises under an alternative hypothetical scenario that individual euro area member states were able to set their own policy rates. Still, had euro area member states other than these countries followed their own policy rules, their interest rates would have been quite different from those predicted by the ECB policy rule.

The extent of heterogeneity across national economies within the euro area entails a challenge for delegating responsibility for monetary policy to the ECB. Our empirical findings prompt concerns about the efficacy of a single monetary policy given changing economic conditions of individual euro area member states. Because economic conditions of euro area member states have been quite unsynchronized, ECB policy actions, which might be adequate for the euro area as a whole, have arguably been too loose for faster growing member states such as Greece, Portugal and Ireland but too tight for slower growing member states, such as France.

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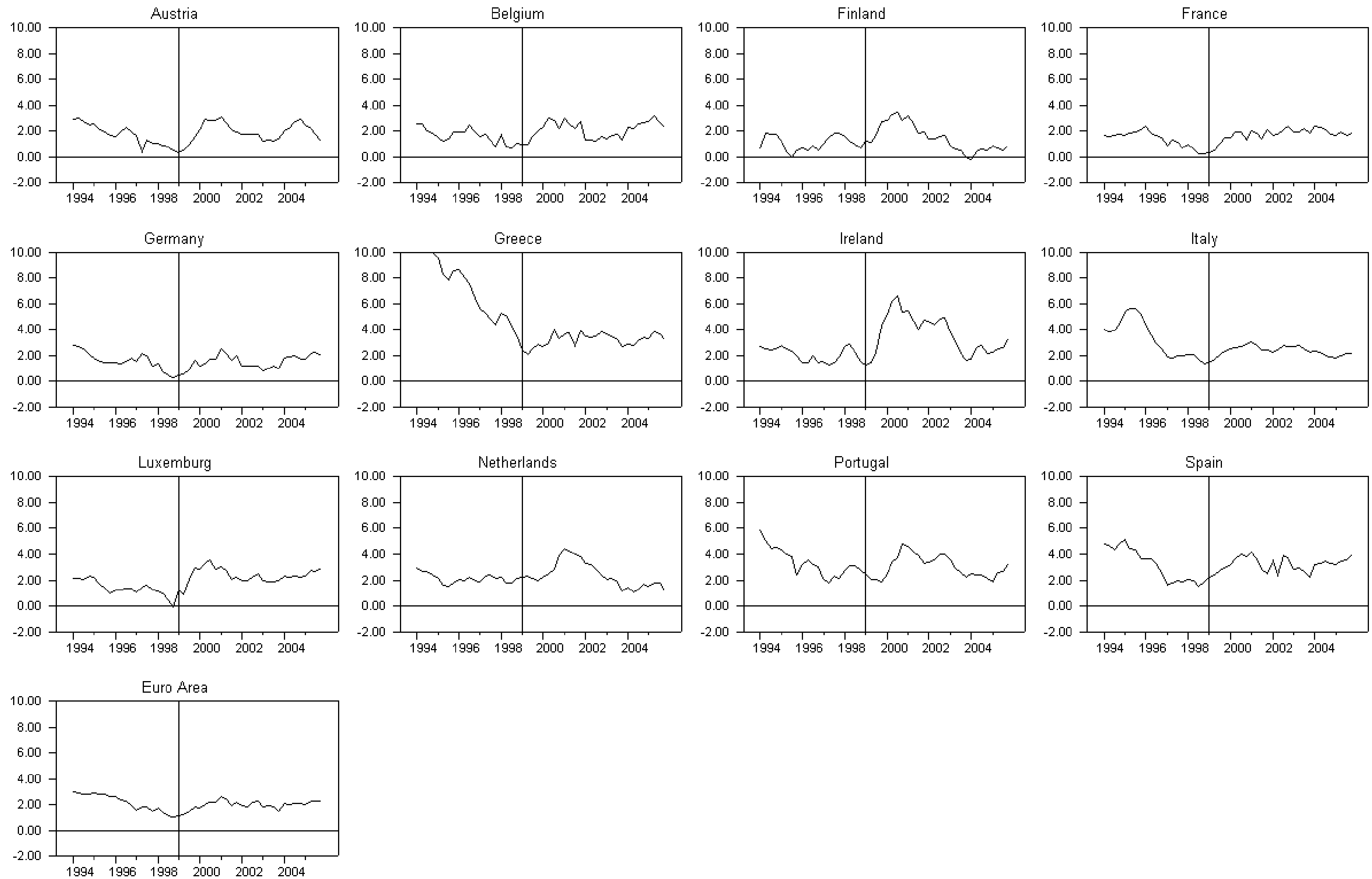
Table 1: GMM Estimation and Test Results, 1994-2005

	Explanatory Variables									
	Lagged Interest	Intercept	Inflation	Output Gap	M3	SEE	*J*	*MeanF*	*SupF*	L_c
Austria	0.90 ***	4.25 ***	0.28	3.21 ***	-0.32 ***	0.24	7.72	4.49 *	11.51	1.61 **
	(48.56)	(5.61)	(0.80)	(8.14)	(3.77)					
Belgium	0.81 ***	3.49 ***	-0.20	2.54 ***	-0.06 *	0.29	7.02	4.87 **	14.21 *	2.37 ***
	(30.14)	(5.04)	(0.77)	(8.44)	(1.68)					
Finland	0.95 ***	-4.61 ***	2.61 *	1.31 **	0.22 *	0.26	6.24	6.03 **	15.15 *	2.23 **
	(44.41)	(2.71)	(3.42)	(2.22)	(1.73)					
France	0.84 ***	6.52 ***	-1.15	5.53 ***	-0.35 ***	0.41	7.32	3.37	10.43	1.26 *
	(37.09)	(7.09)	(1.49)	(9.83)	(4.54)					
Germany	0.79 ***	2.24 ***	0.43 *	2.38 ***	-0.02	0.25	7.73	3.29 *	10.31	0.82
	(42.37)	(4.47)	(1.80)	(6.09)	(0.66)					
Greece	0.84 ***	-6.58 ***	2.76 ***	1.79 *		1.27	5.59	2.98	8.31	1.66 **
	(25.50)	(4.00)	(4.42)	(1.74)						
Ireland	0.94 ***	-12.54 ***	5.01 ***	-4.70 ***		0.62	6.74	4.59 *	11.82	1.83 *
	(34.67)	(2.67)	(3.54)	(4.44)						
Italy	0.89 ***	-3.03 ***	2.62 ***	2.67 ***	-0.06	0.37	8.43	5.79 **	15.21 *	1.01
	(52.25)	(4.32)	(6.61)	(5.31)	(0.91)					
Luxembourg	0.79 ***	2.93 ***	0.50 **	0.86 **		0.36	7.92	7.24 ***	18.39 **	2.70 ***
	(17.41)	(2.89)	(1.98)	(2.12)						
Netherlands	0.97 ***	10.94 **	-1.17	16.52 ***	-0.51 **	0.48	5.86	3.63	12.21	1.74 **
	(29.19)	(2.47)	(1.13)	(6.41)	(2.23)					
Portugal	0.80 ***	-2.64 ***	0.97 ***	-1.79 ***	0.60 ***	0.49	7.35	2.36	7.42	1.01 *
	(25.47)	(4.07)	(3.78)	(3.86)	(5.55)					
Spain	0.92 ***	-5.45 **	4.32 ***	2.00 **	-0.72 ***	0.40	8.37	2.93 **	9.65 *	1.42 **
	(36.87)	(2.36)	(4.88)	(2.08)	(4.25)					
Euro Area	0.85 ***	2.98 **	1.39 **	1.38 **	-0.50 ***	0.33	7.21	2.51	7.72 **	1.39 *
	(21.93)	(3.03)	(2.27)	(2.38)	(3.21)					

Note: Absolute *t*-statistics are in parentheses; *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Figure 1: Inflation Rates



Note: Vertical gridlines indicate the formation of the ECB.

Figure 2: Recursive Coefficient Estimates

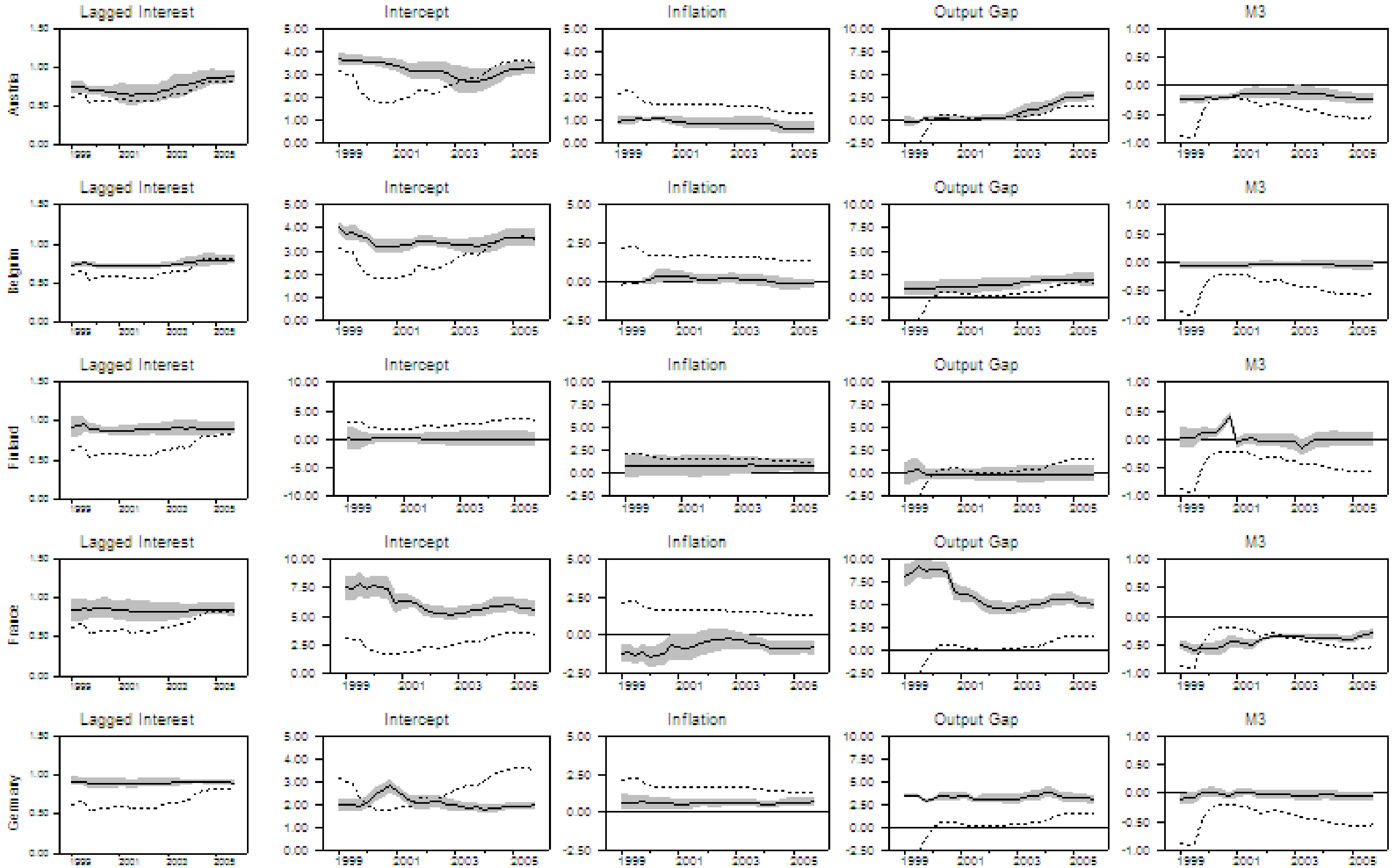


Figure 2 (continued)

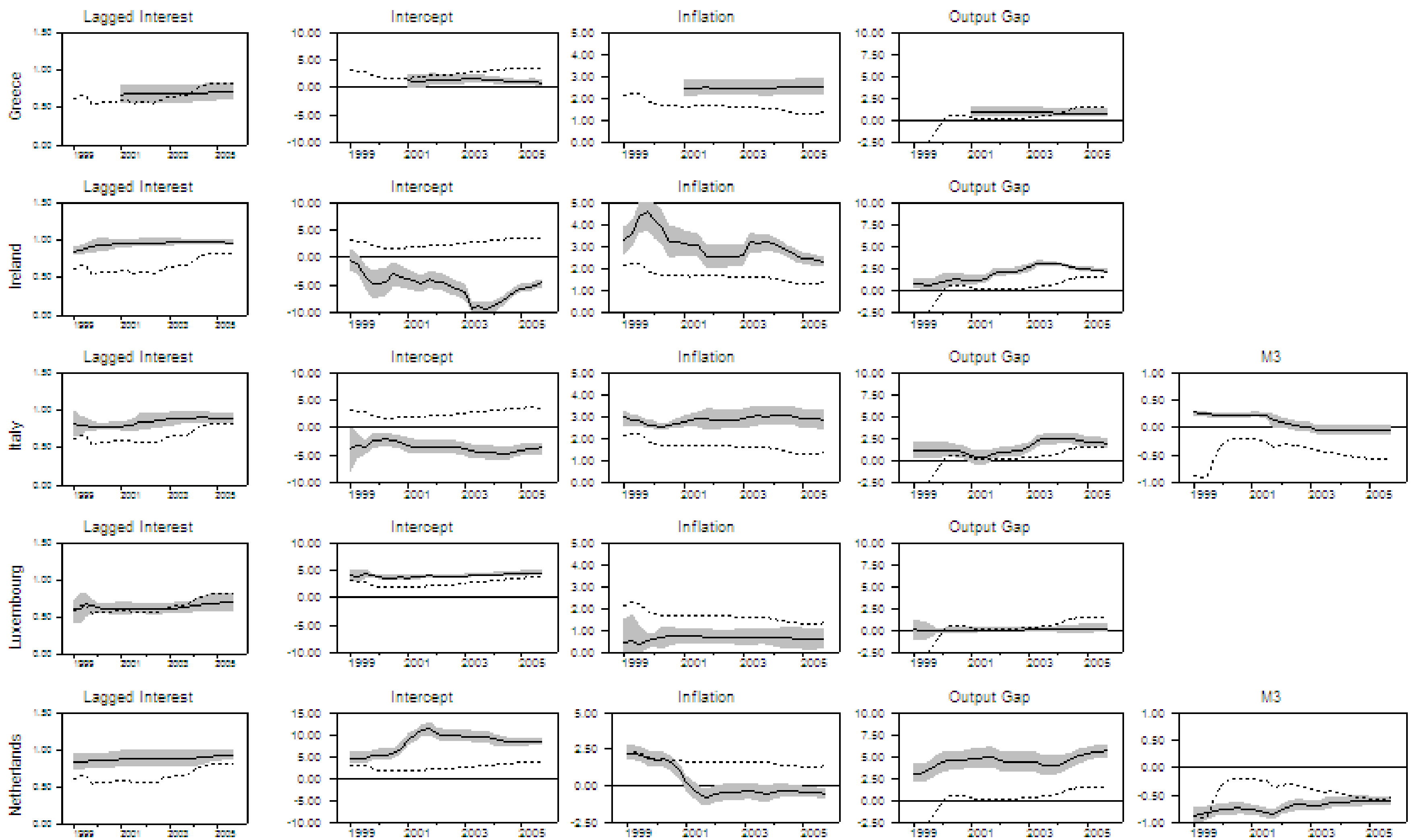
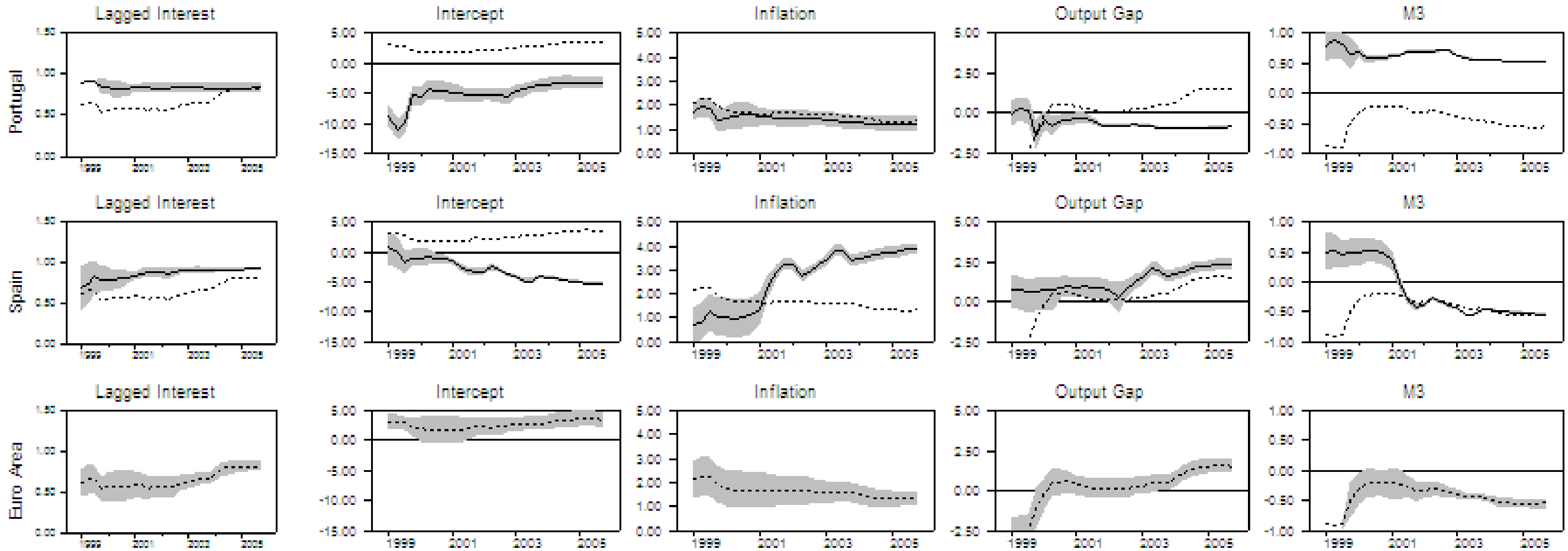
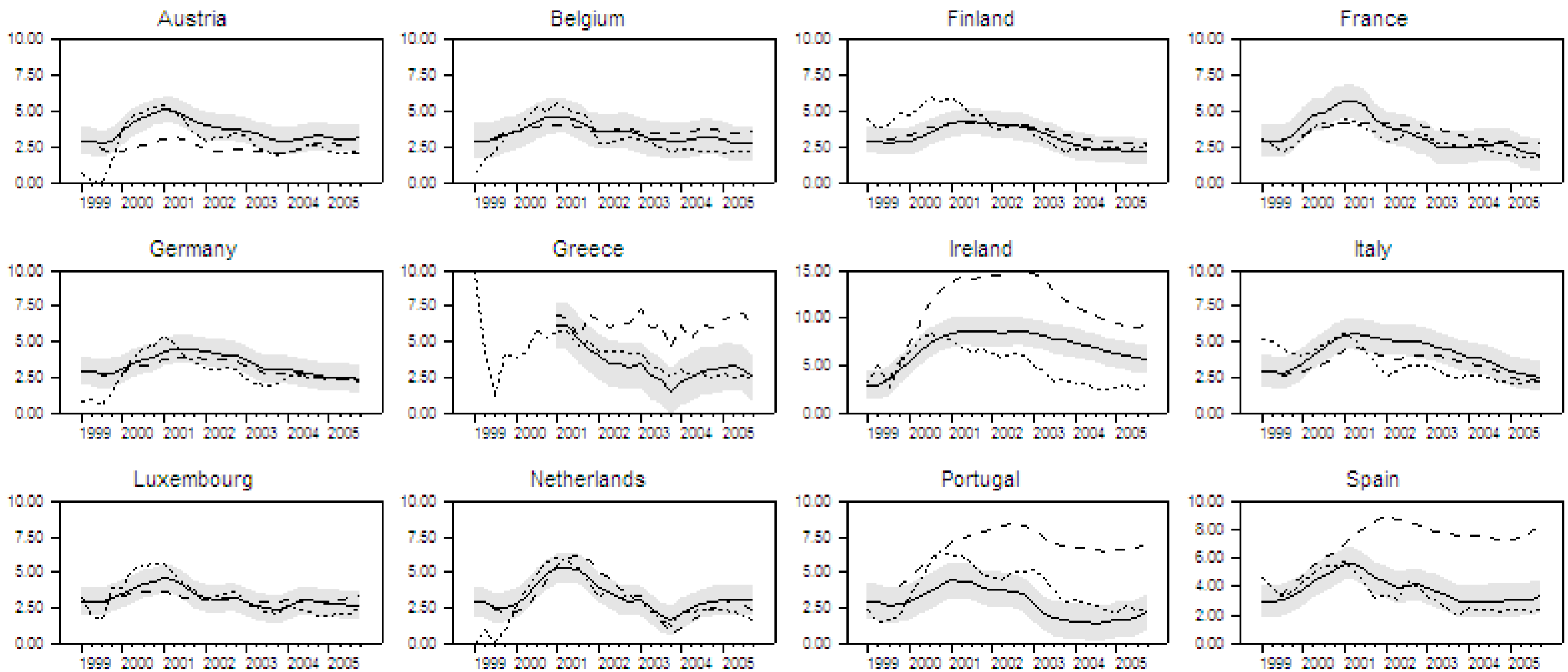


Figure 2 (continued)



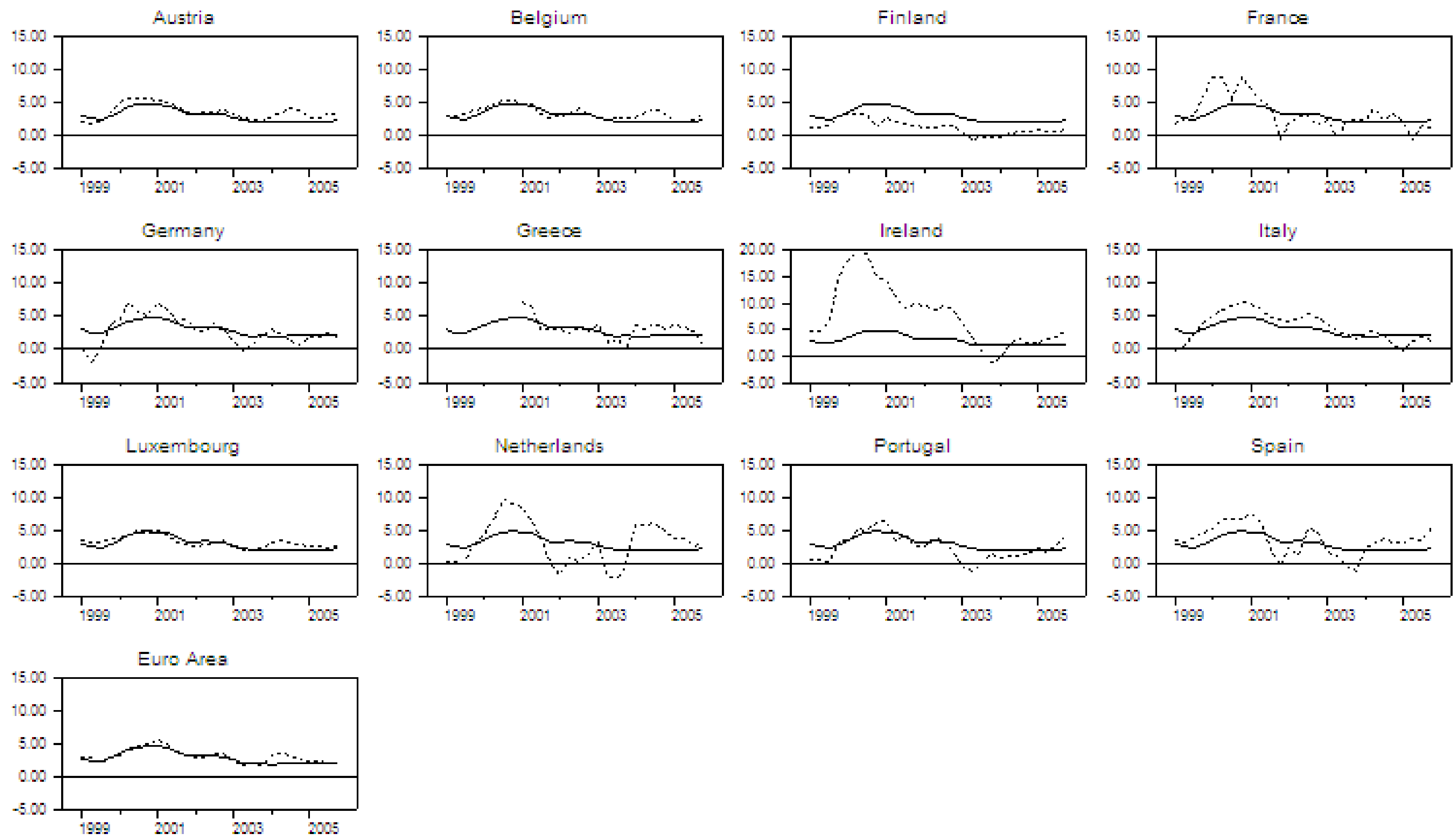
Note: Dashed lines represent estimates for the euro area. Shaded areas are ± two standard error intervals around point estimates.

Figure 3: Counterfactual Results for Fitted Policy Rates



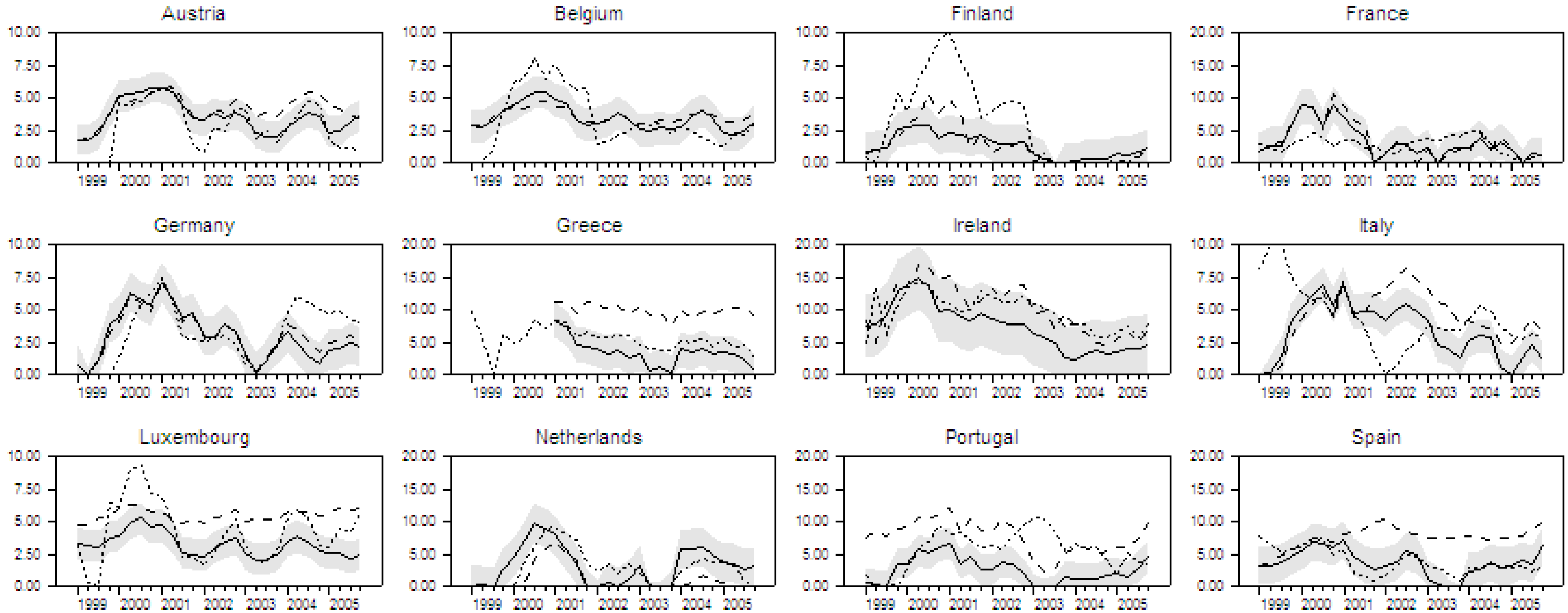
Note: Solid lines represent fitted policy rates, encapsulated within 95% confidence bands (shaded areas). Dotted lines represent counterfactual series projected by using the estimated Taylor rule for the ECB but data of individual euro area members. Dashed lines represent counterfactual series projected by using the estimated Taylor rules for the pre-euro sample but historical data for explanatory variables.

Figure 4: Policy Rates and Fitted "Target" Rates



Note: Solid lines represent actual policy rates. Dotted lines represent fitted "target" rates.

Figure 5: Counterfactual Results for Fitted "Target" Rates



Note: Solid lines represent fitted "target" rates, encapsulated within 95% confidence bands. Dotted lines represent counterfactual series projected by using the estimated Taylor rule for the ECB but data of individual euro area members. Dashed lines represent counterfactual series projected by using the estimated Taylor rules for the pre-euro sample but historical data for explanatory variables.

Figure 6: Difference between Fitted "Target" Rate Series and Counterfactual Series with ECB Coefficients (Exercise 1)

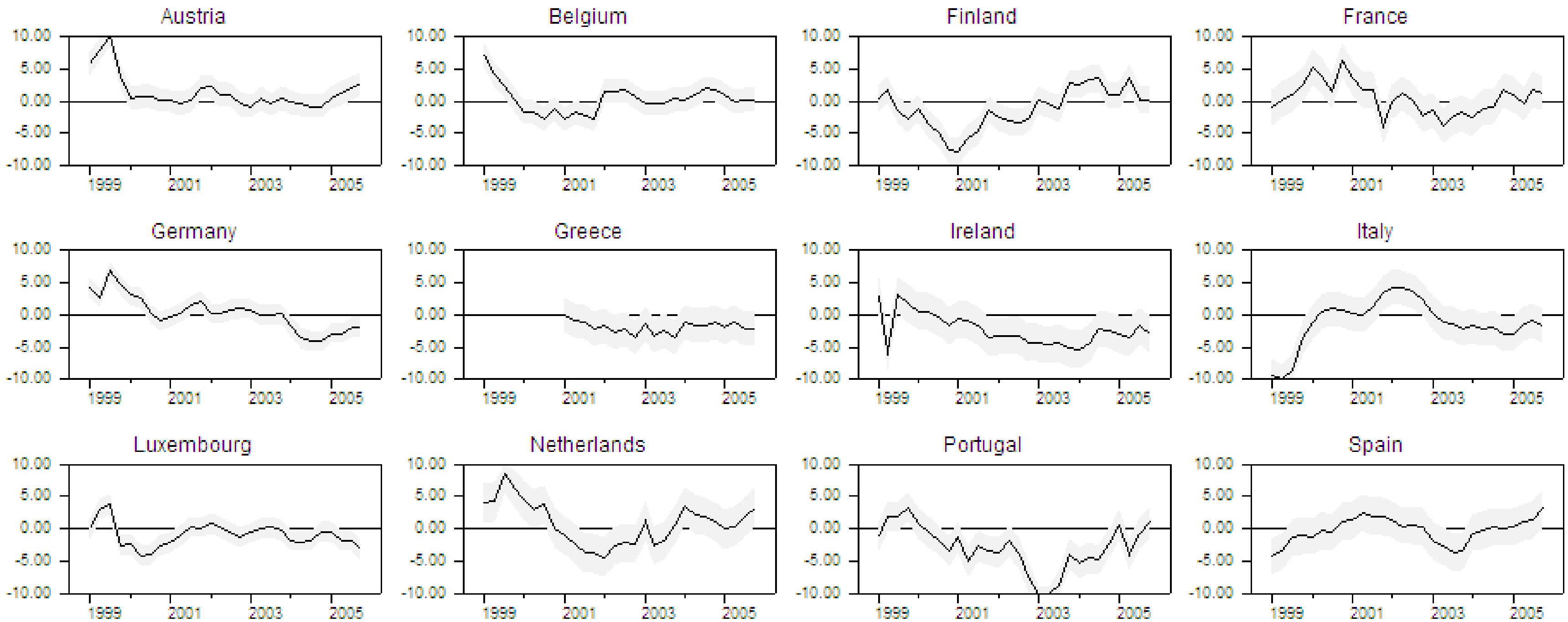


Figure 7: Difference between Fitted "Target" Rate Series and Counterfactual Series with Pre-Euro Coefficients (Exercise 2)

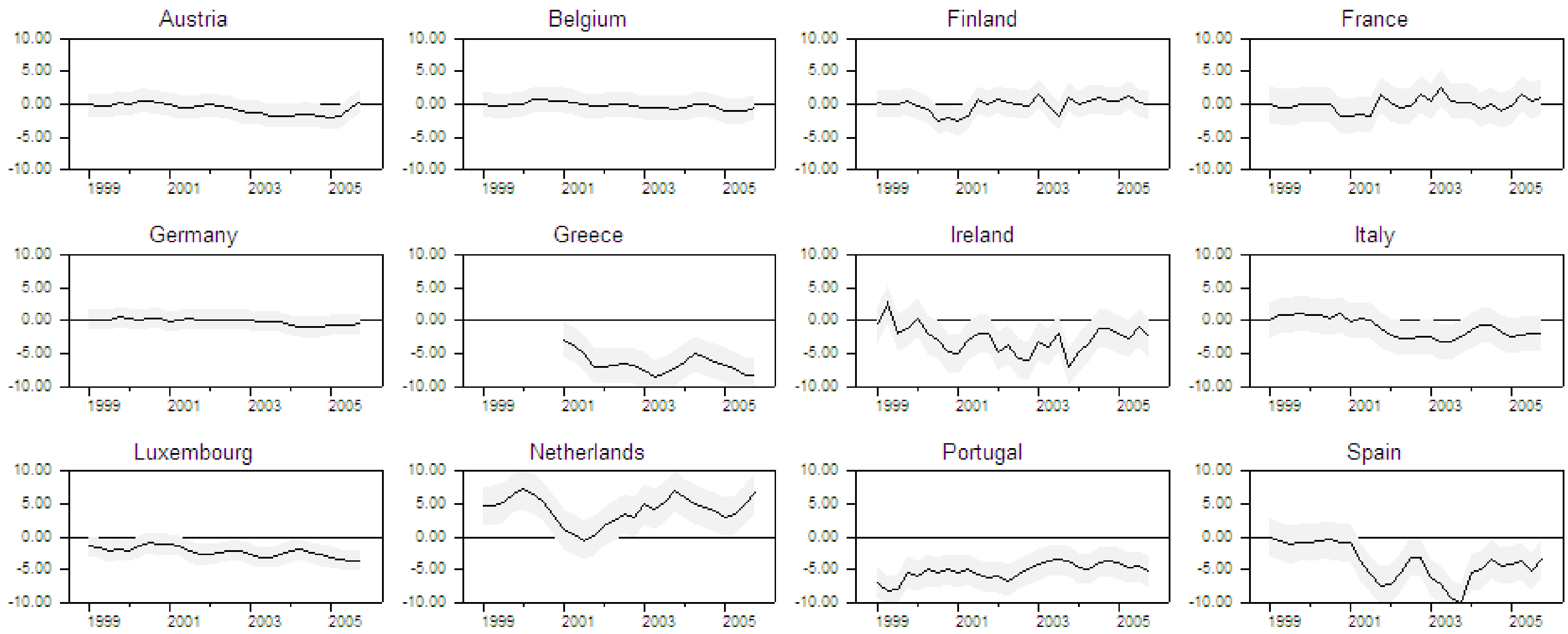


Figure 8: Area-Wide Policy Stress Measures