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Estimating Country Weights in the ECB's Monetary Policy Setting

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Abstract

We unveil the implicit country weights in the ECB's monetary policy conduct across a sample of 12 Eurozone member-states. Using linear and non-linear Taylor rules, as well as observed and simulated data, we produce counterfactual interest rate paths to assess the differential between observed interest rates and those assumed to have prevailed under autonomy. Then, the estimated weights are compared with the correlation of countries' business cycles and aggregate disturbances overtime. Results show that Germany and Luxembourg persistently receive the biggest weight, while Greece and Ireland secure the smallest. Finally, findings also indicate that countries with a smaller weight are those least correlated with Germany.

Keywords: Taylor rule; Counterfactual Interest Rates; Monetary Weights; Aggregate Supply and Demand Shocks.

1 Introduction

In the second half of the twentieth century, the search for a larger degree of integration in Europe arose as a promise of prosperity and stability. This process culminated, in 1992, in the Maastricht Treaty, which established the institutional framework for the introduction of a common currency, the Euro. However, the economic and monetary union's gathering of momentum was not unchallenged. Some feared that sacrificing monetary autonomy would prevent adjustment to country-specific shocks (Bayoumi and Eichengreen, 1992), with a single monetary policy being unable to address countries' idiosyncratic disturbances. Others questioned how independent the European Central Bank would be from political institutions (Alesina and Grilli, 1991). This debate grew larger in the light of the 2008's financial crisis and the 2010's sovereign debt crisis, which affected member-states differently, hence suggesting different policy responses, and gave rise to Eurosceptic behaviour, placing pressure on European institutions. More recently, Stiglitz, 2016, even argued that, in the presence of an adverse shock, «stronger countries gained at the expense of the weaker», supporting the idea that different member-states facing asymmetric conditions ultimately promotes strong imbalances within the EMU.

Given this setting, we propose a novel approach to assess the implicit weights attributed to each member-state by the ECB, based on a macroeconomic counterfactual, which represents how national monetary authorities were likely to have behaved under autonomy, thus allowing for the measurement of the departure from each member's reference interest rate. Then, we establish a comparison between these weights and each country's degree of economic integration with Germany during the course of the EMU, to understand if the obtained weights can be a result of a higher correlation given that «the Bundesbank provided the role model for the European Central Bank» (Beyer et al., 2008). This analysis is of utmost importance as it provides quantitative evidence to the ongoing debate on the asymmetric consideration of member-states, while substantiating policy discussions around the Eurozone reform.

Counterfactual rates are produced using the monetary policy rules prevailing in a set of Eurozone countries under independent monetary policy, as evidence shows that monetary authorities follow an implicit rule. For this purpose, linear and non-linear procedures, namely a Markov-switching model, are used, as well as observed and simulated data. Then, to measure economic integration, we use both the correlation of countries' output gaps, and of their supply and demand shocks overtime, obtained from a Blanchard and Quah decomposition.

First, we find that neither economic nor population size are correlated with the weight attributed to each member-state. Second, Germany, Luxembourg, Belgium and the Netherlands are, across the five different considered specifications, the countries with a bigger weight, whereas Greece, Ireland, Portugal and Italy exhibit the smallest. Third, we find that the correlation of countries' output gaps and supply shocks with Germany follows the pattern observed by the implicit weights, i.e countries which display a higher symmetry of shocks with Germany have a larger weight *vis-à-vis* those less correlated or even asymmetric.

2 Related Literature

In order to analyse the ECB's decision-making regarding interest rates, following its mandate to ensure price stability, one needs to understand how monetary policy decisions are conducted. Hence, we first review some of the existing literature on monetary policy rules and, secondly, on measures of integration, as our aim is to establish a comparison between country-weights and economic convergence overtime.

From the decade of 1960, what is known as the rational-expectations revolution contributed to the emergence of a vast range of literature on monetary policy rules (some seminal examples are Friedman, 1960, Kydland and Prescott, 1977, and Barro and Gordon, 1983), most arguing in favour of the usage of policy rules versus discretion. That influence extends to the present, with most modern central banks deciding on monetary policy «by adjusting the short-term nominal interest rate in response to various disturbances» (Romer, 2012).

Regarding specific policy rules, Taylor, 1993, is one of the most influential references, as the author presents what is currently known as the Taylor rule, in which the short-term interest rate rises if inflation increases above a given target or if real GDP rises above trend. Given the remarkable fit of the rule to actual policy performance in the United States between 1987 and 1992, it became a benchmark for monetary policy analyses. Another significant contribution is one by Clarida, Galí, and Gertler, 1998, where monetary policy reaction functions for 6 countries are estimated, namely Germany, Japan, the US, the UK, France and Italy. Among different specifications, the authors consider a forward-looking Taylor rule by using expected rather than contemporaneous inflation, and they introduce an interest rate smoothing parameter to represent the notion that central banks tend to smooth changes in interest rates. These two features became a standard practice in the estimation of monetary policy rules. Regarding findings, they conclude that, while the first three countries had been pursuing an «implicit form of inflation targeting», the remaining «were heavily influenced by German monetary policy».

Several other empirical studies attempted to assess how monetary policy reacted to changes in inflation, the output gap and other variables using the aforementioned rule, since there may be other policy objectives (Clarida et al., 1998, Taylor, 2001 and Muscatelli et al., 2002, among others). The same authors, Clarida et al., 2000, also estimate monetary policy reaction functions for the U.S. pre- and post-1979, using a simple linear forward-looking smoothed rule. Gerlach and Schnabel, 1999, estimate linear Taylor rules using average interest rates, GDP-weighted average output gaps and inflation in EMU countries for the period of 1990 to 1998, and conclude that, if there were an institution such as the ECB which conducted monetary policy using a Taylor rule for that period, the aggregate behaviour of interest rates would not differ significantly from the observed. Eleftheriou, Gerdesmeier, and Roffia, 2006, estimate monetary policy reaction functions for 11 EMU countries in the post-Maastricht period until 1998, using not only inflation and the output gap, but also the exchange rate, money stock, the German interest rate – in the case of Germany, the Federal Funds rate is used –, and time dummies to capture «extraordinary events». The authors find that the augmented specification unambiguously improves the rule's fit for all countries, and that rules differ substantially across member-states.

Due to the plausibility of non-linearities in the impact of both inflation and the output gap on nominal interest rates, mostly because of their asymmetric adjustment to the business cycle[1], a significant volume of the relevant literature focuses on non-linear approaches. Hamilton, 1989, and Garcia and Perron, 1995, consider, respectively, a two-state and a three-state Markov-switching model for the U.S. interest rate and find evidence of regime switches in both the mean and variance of the series, thus providing further support for the usage of non-linear approaches. Wesche, 2003, also considers a Markov-switching model for for France, Germany, Italy, the UK and the US, and concludes that the two-states estimated can be classified as either restrictive or accommodative, using data from 1973 until the beginning of the EMU. Castro, 2011, estimates an augmented linear Taylor rule for the Eurozone, the UK and the US, as well as an augmented smooth transition regression model, with both models including a financial conditions' index. Among other findings, the ECB and the BoE's behaviour are best described by a non-linear specification, and the ECB only reacts actively to expected inflation when it is above a target of 2.5% and to the output gap when inflation is stabilised below its target. Murray et al., 2015, characterise the Fed's behaviour for the period from 1965 to 2007 using a Taylor rule with endogenous Markov-switching coefficients and variance, and conclude that the regime-shift between states in the model occurs when «the Fed does and does not try to stabilize inflation by following the Taylor principle[2]».

Examples are scarce regarding counterfactual interest rate exercises. Wyplosz, 1999, uses the specification proposed by Clarida et al., 1998, to estimate the Taylor rules in several European countries. Then, he replaces as inputs, in the estimated rule for Germany, the average economic conditions in Europe, as to obtain a counterfactual of what would have been the ECB's policy prior to the EMU, given that «the Bundesbank is known to have worked as the *de facto* leader

[1]During upswings, monetary policy tends to be more 'hawkish', and during downturns more 'dovish', as argued by Hamilton, 1989, Garcia and Perron, 1995, and Castro, 2011.

[2]The Taylor Principle is commonly described as a policy rule having a stabilising inflation coefficient, i.e. bigger than 1.

in Europe». He concludes that, if the Bundesbank were to set interest rates at a wider level, monetary policy would have been looser. Hayo, 2007, estimates linear Taylor rules for 11 EMU countries, and then simulates a counterfactual interest rate path until 2004, and concludes that Germany was the only country which realised higher interest rates than warranted by its pre-EMU trajectory.

Concerning measures of integration, literature is quite extensive. Mundell's, 1961, seminal contribution, later extended by McKinnon, 1963, and others, regarding optimum currency areas argues that factor mobility and symmetry of shocks are crucial to ensure the proper functioning of common currencies. Thus, assessing labour and capital mobility pose as important empirical research avenues, as analysed by Arpaia et al., 2014, who conclude that, regarding labour, «the response of migration to shocks has been growing over time, becoming almost twice as important after EMU completion». Another method of evaluating economic integration is assessing the symmetry of country-specific shocks, as performed by Bayoumi and Eichengreen, 1992 and 2018, or, in a similar logic, the symmetry of business cycles (Canova et al., 2007). Others focus on the integration of sovereign debt markets through yield co-movement (Ehrmann et al., 2007), on the real convergence between income levels and productivity (Franks et al., 2018), and on the synchronisation of financial cycles, which have received a great deal of attention since the crisis. Given the abundance of contributions regarding integration, we conclude with Gros's, 2018, assertion that, since the financial crisis, there has been divergence between the Eurozone's northern and southern countries, particularly regarding real wages, investment and consumption, which is deeply connected with the motivation for the present analysis.

3 Empirical Strategy

In this section, we describe our empirical strategy, which can be divided in three subsections: the estimation of monetary policy rules, the assessment of implicit weights, and the identification of aggregate supply and demand disturbances.

3.1 Monetary policy rules

To assess the weight attributed to each country concerning the setting of the short-term interest rate, we depart from the assumption that, without monetary unification, countries would have continued responding to deviations in certain relevant variables as they did prior to the EMU. Thus, to produce counterfactual interest rate paths for each member-state, we estimate five different rules, using two sets of models: (i) a baseline linear rule, (ii) an augmented linear rule, (iii) a baseline non-linear rule, (iv) an augmented non-linear rule, and, finally, (v) a baseline linear rule, using simulated data for both inflation and the output gap. Here, our aim is to obtain a robust characterisation of monetary policy conduct to then estimate implicit weights.

Regarding linear rules, we begin by using the specification proposed by Clarida et al., 1998[3], in which the target interest rate responds to deviations in inflation and output from their targets, as in (1). i_t^* is the target short-term nominal interest rate, $\bar{i}$ is the long-term equilibrium nominal rate, π_{t+n} is the inflation rate between periods t and $t+n$, π^* is the inflation target, y_t is output and y_t^* is potential output, with the difference between the latter two being the output gap.

$$i_t^* = \bar{i} + \beta(\pi_{t+n} - \pi^*) - \gamma(y_t - y_t^*) + \epsilon_t \tag{1}$$

Additionally, as proposed by the authors, we incorporate an interest rate smoothing mechanism, as to model the partial adjustment undertaken by central banks given the implications of sudden policy changes. Thus, the contemporaneous interest rate is a combination of the target and last period's rate, as presented in (2).

$$i_t = \rho i_{t-1} + (1-\rho) i_t^* + v_t, \rho \in [0,1] \tag{2}$$

Combining equations (1) and (2), along with $\alpha = \bar{r} - \beta\pi^*$ to facilitate estimation, we obtain our final baseline specification as in (3), with x_t being the output gap and $D1$ a dummy variable to account for structural breaks in some countries' series.

$$i_t = \rho i_{t-1} + (1-\rho)(\alpha + \beta\pi_{t+n} + \gamma x_t + \delta_1 D_1) + v_t \tag{3}$$

For the augmented linear specification, presented in (4), we include the Federal Funds rate, fed_t , the long-term interest rate on 10-year government bonds, i_t^{lt}, and a national share prices' index, sp_t. The idea is that, besides responding to deviations in inflation and the output gap, the linkage posed by financial and trade integration with the United States and market sentiment

[3]Unlike the authors, we do not consider expected inflation nor the output gap as we do not have data on forecasts of these variables for all countries throughout the sample.

may impact the decision regarding short-term interest rates, as rules serve as guidelines and some judgement may be recommended (Taylor, 1993). Thus, these variables may represent a broader economic outlook being considered.

$$i_t = \rho i_{t-1} + (1-\rho)(\alpha + \beta\pi_{t+n} + \gamma x_t + \lambda_1 fed_t + \lambda_2 i_t^{lt} + \lambda_3 sp_t + \delta_1 D_1) + v_t \tag{4}$$

As mentioned in the previous section, the Taylor rule may be subject to some parameter instability, particularly in different phases of the business cycle or according to distinct policy stances (Ghysels and Marcellino, 2018). Therefore, we estimate non-linear rules using a two-state Markov-switching procedure, given that we do not observe the discrete binary state variable, S_t, which we will assume follows a Markov chain. This allows for the regime shift to occur with a certain probability rather than deterministically. We consider time-varying parameters for inflation and the output gap, while also allowing for switching in the variance of the error term, thus deterring the possibility that periods of shifts in volatility are confounded with regime switches (Sims and Zha, 2006). Hence, equation (5) presents the baseline non-linear specification, and equation (6) the augmented non-linear one.

$$i_t = \rho i_{t-1} + (1-\rho)(\alpha + \beta_{S_t}\pi_{t+n} + \gamma_{S_t} x_t + \delta_1 D_1) + u_t \tag{5}$$

$$i_t = \rho i_{t-1} + (1-\rho)(\alpha + \beta_{S_t}\pi_{t+n} + \gamma_{S_t} x_t + \lambda_1 fed_t + \lambda_2 i_t^{lt} + \lambda_3 sp_t + \delta_1 D_1) + u_t \tag{6}$$

$$\beta_{S_t} \in \{\beta_1, \beta_2\}, \gamma_{S_t} \in \{\gamma_1, \gamma_2\}$$

$$u_t \sim N(0, \sigma_{S_t}),\ \ \sigma_{S_t} \in \{\sigma_1, \sigma_2\} \tag{7}$$

Finally, the last specification considered uses simulated rather than actual data. As our aim is to evaluate what would have been the short-term interest rates chosen by individual monetary authorities under autonomy, we simulate the inflation rate and output gap series for each country, based on their trajectory prior to the EMU, using a Monte Carlo simulation, which generates data for these two variables based on two distinct AR(2) processes, as in (8) and (9).

$$x_t = a_0 + a_1 x_{t-1} + a_2 x_{t-2} + e_{1t} \tag{8}$$

$$\pi_t = b_0 + b_1 \pi_{t-1} + b_2 \pi_{t-2} + e_{2t} \tag{9}$$

The Monte Carlo simulation performed consists of the following steps: first, equations (8) and (9) are estimated to obtain the coefficients, a_i and b_i, and the standard deviation of the error term. Second, data is generated to reproduce a normally distributed random process for the sequences $\{e_{1t}\}$ and $\{e_{2t}\}$, which will then be used in the simulation as the error terms. Third, according to the estimates from the first step, the randomly-generated errors and the last two observations of both the inflation and output gap series, we construct the $\{x_t\}$ and $\{\pi_t\}$ sequences. As each generated sequence of the stochastic component can be interpreted as a scenario among several possible outcomes, we generate 10 repetitions for both inflation and the output gap. Afterwards, we estimate the baseline linear rule using the generated sequences for all repetitions, and then compute the implicit weight for each one of those series. Finally, we perform a standard geometric average of the weights per country.

3.2 Implicit weights

After estimating the monetary policy rules for each country using the aforementioned specifications, dynamic forecasting is used to produce counterfactual interest rates for each estimated rule. Hence, using both the actual and counterfactual rates, we assess the weight attributed to each country using the inverse of a simple root mean square error (RMSE), as presented in (10), which typically is employed as a measure of accuracy (e.g. to evaluate the difference between predicted and observed values). Then, we consider the relative frequency of weights for each country in order to have our desired measure as a share of the total, thus summing up to 1. The concept of monetary weight draws from that of monetary stress, initially proposed by Clarida et al.,1998, and further developed by Sturm and Wollmershäuser, 2008.

$$w_c = \frac{1}{\sqrt{\sum_{t=0}^{T}(i_{c,t} - \hat{i}_{c,t})^2}}, \ c \in [1,12] \tag{10}$$

3.3 Aggregate supply and demand shocks

One of the much-discussed aspects of monetary unification is the synchronisation of underlying economic shocks. Hence, our aim is to understand if the estimated implicit weights can be a result of a larger symmetry between EMU countries and the Eurozone's anchor, Germany. Thus, following Bayoumi and Eichengreen, 1992 and 2018, we investigate the correlation between each member-state's underlying aggregate supply and demand shocks with Germany. A novelty is that we divide the assessment in different periods, as to understand the evolution of the synchronisation of shocks before the EMU, before the crisis, and during and after the crisis.

The identification of aggregate supply and demand disturbances is achieved using a Blanchard and Quah decomposition, 1989, which allows for the distinction between permanent and temporary shocks. For this purpose, using the standard AD-AS framework, a rise in aggregate supply (i.e. a supply shock) permanently increases output and decreases prices. On the other hand, a positive shock in aggregate demand has only a temporary effect on output, which rises in the short-run, and a permanent increase in prices. Given that this is a recognised procedure, further detailing can be found in Appendix 1.

4 Data

As previously mentioned, our assessment focuses on the monetary policy rules prevailing in a set of Eurozone countries under autonomy, as to subsequently produce a macroeconomic counterfactual. Hence, we use data for 12 countries, namely Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain. The remaining Eurozone countries were excluded from the analysis given their late entry in the EMU, thus restraining any comparison until their *de facto* adoption of the Euro.

For most countries and specifications, quarterly data is used from the first quarter of 1980 to the second quarter of 2018, however, the span of data availability depends on the series considered, as some have later starting periods.

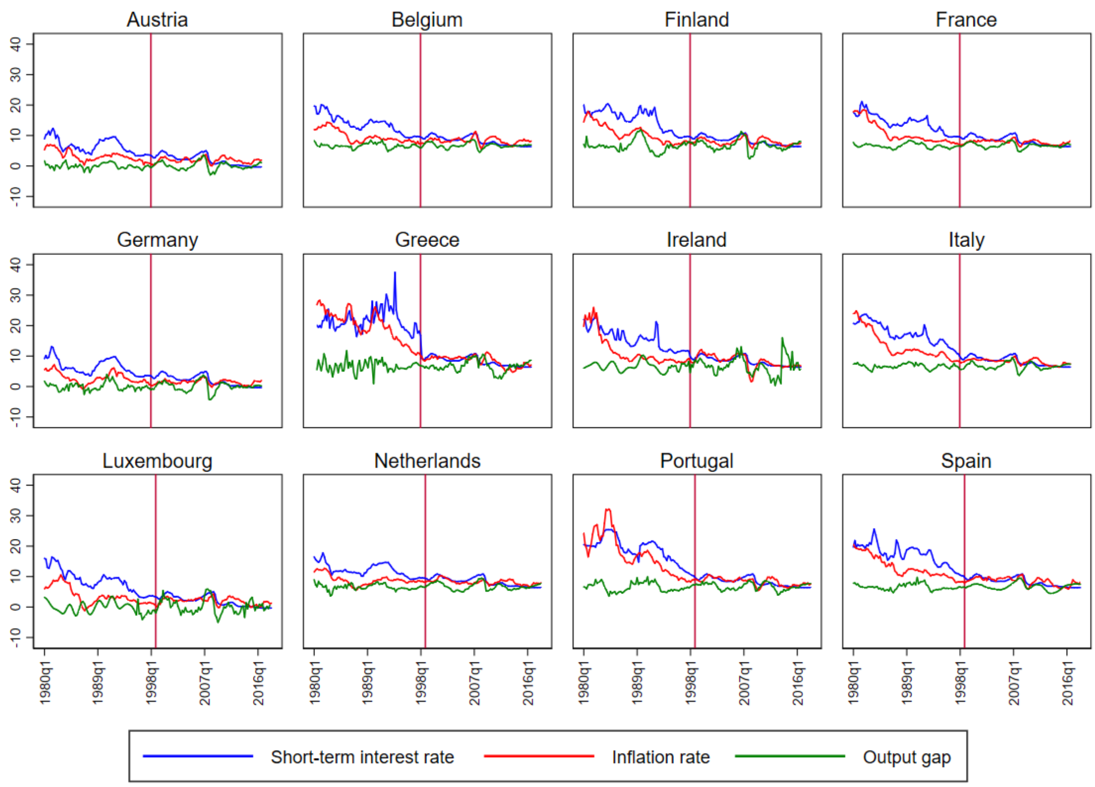
Following most of the literature, the short-term interest rate is measured using the 3-month money market interest rate. This series was combined from the Eurostat and the OECD, since the two have earlier starting periods for different countries. The inflation rate was collected from the OECD's annual growth rate of the Consumer Price Index. The output measure was obtained from the OECD's Quarterly National Accounts' GDP, using an expenditure approach, in millions of U.S. dollars, referenced in 2010 and seasonally adjusted. The output gap was constructed using a Hodrick-Prescott filter[4] on the logarithm-transformed output series, and then multiplied by 100, as to obtain more intelligible estimates. The Federal Funds rate was

[4]The smoothing parameter considered was $\lambda = 1600$, following the literature and as is standard practice when using quarterly data.

retrieved from the Federal Reserve of St. Louis' database, and then converted from monthly to quarterly data. The long-term interest rate was also combined from the Eurostat's EMU criterion convergence bond yields and the OECD's long-term interest rate, for the same reason as regarding short-term interest rates, with both considering 10-year government bonds. Lastly, as prices of shares are assumed to reflect market sentiment, a national index of share prices for each country was extracted from the OECD.

Additionally, as mentioned in previous sections, we also estimate the correlation of member-states' aggregate supply and demand shocks with Germany. For that purpose, we considered the period from 1980 to 2016, for which data on yearly GDP at current prices was collected, as well as on the GDP deflator, referenced in 2010, both from the OECD and using an output approach. Then, real GDP was computed for all countries using the aforementioned series.

FIGURE 1: Short-term nominal interest rate, inflation rate, and the output gap from the log-transformed GDP series multiplied by 100.



Before proceeding, we consider the three main variables of our analysis: the short-term interest rate, the inflation rate and the output gap, calculated as explained above, and presented in Figure 1. The graphical representation of the series highlights the strong differences regarding short-term interest rates and inflation prior to the EMU, suggesting that countries such as Greece – more saliently than the remaining –, Ireland, Italy, Portugal, Spain, and, to a certain extent, Finland, experienced larger and faster reductions in interest rates by adopting the Euro.

5 Estimation

Regarding estimation, both the baseline and the augmented linear rules are estimated for each country using a two-step efficient generalised method of moments (GMM), which derives an optimal weighting matrix with heteroskedastic and autocorrelation consistent (HAC) standard errors, thus providing efficient estimates. The instrument set used includes up to 4 lags of each of the dependent and independent variables, following the literature. Given that we have more instruments than endogenous regressors, we perform the Sargan test of overidentifying restrictions to assess the validity of the instruments included. The test considers a joint null hypothesis that the included instruments are uncorrelated with the error term, thus being valid, which we fail to reject for all of the considered linear rules. For estimation purposes, several inflation specifications were used, ranging from contemporaneous to 6 quarters-ahead, and the specification which maximised the adjusted R^2 was selected.

Concerning the estimation of non-linear rules using a Markov-switching approach, the inflation specification used in each model was chosen according to the Akaike Information Criterion's minimisation. Regarding the variance-covariance matrix, a White-Huber sandwich estimator is used as to create estimates that are robust to potential heteroskedasticity.

As mentioned above, after the estimation of rules, counterfactual monetary policy paths are obtained using dynamic forecasting. Lastly, it is important to note that, following the literature, we assume that the variables are stationary across the period considered (Clarida et al., 1998, Eleftheriou et al., 2006).

6 Results

6.1 Parameter estimates

The estimation results of the different policy rules are presented in Appendix 2. As for the last specification considered, which consists of a baseline linear rule using simulated data, given the extent of rules estimated for each repetition of the Monte Carlo simulation, we refrain from displaying the parameter estimates obtained.

Regarding the baseline linear rules' estimates using equation (3), presented in Table 2, the interest rate smoothing parameter, ρ, is consistent with the literature, ranging from 0.64 to 0.95. This is quite intuitive given that countries which experienced larger changes in interest rates, mostly because of the downward pressure placed by convergence, exhibit a smaller preference for interest rate smoothing (i.e. are less influenced by the last period's rate), as is the case of Greece, Italy and Ireland. The magnitude of the coefficient of inflation, β, is also quite informative as, if $\beta > 1$, monetary policy is considered to be inflation-targeting as it is adjusting to stabilise inflation, and, if the opposite is observed, monetary policy is said to be accommodative (Clarida et al., 1998). As can be observed, Greece, the Netherlands and Portugal are the only countries which display an inflation coefficient of less than unity, with Belgium and Luxembourg being the countries which showcase a more aggressive behaviour towards inflation. Lastly, not all countries are responsive to the output gap, particularly Ireland and Luxembourg, albeit most react in a positive manner, as expected.

Moving to the augmented linear specification, estimated from equation (4), the ajusted R^2, despite already satisfactory, increases for all member-states considered, attaining in some cases almost full explanatory capability (e.g. 99.18% for the Netherlands and 98.74% for Portugal). By also considering the Federal Funds rate, the long-term interest rate and share prices, we observe a reduction in most countries' interest rate smoothing parameters, as well as in their responses to inflation and the output gap. Here, Austria and Germany are the only countries which display an increase in the impact of inflation, with Germany being the most 'hawkish' country of the sample, and with Greece, Ireland, Italy, Portugal and Spain exhibiting an accommodating behaviour.

The results from the baseline and the augmented non-linear rules, namely using a Markov-switching procedure, obtained from equations (5) and (6), can be found in Table 3. Here, as previously mentioned, we observe two-states for inflation and the output gap, with the characterisation of states being quite heterogeneous among countries. In the case of Germany, for example, it is possible to observe a state in which monetary policy is accommodative and responding positively to the output gap, and another in which it is inflation-targeting and responding negatively to the output's cyclical component, thus representing two distinct regimes. In other cases, such as Ireland, Portugal or Spain, we cannot find evidence of the existence of two-states for these variables' impact on interest rates. Concerning the augmented non-linear rule, we also observe a reduction in the degree of interest rate smoothing in comparison to the baseline, as observed in the case of linear rules. Here, the only countries in which different states characterise different monetary policy regimes are Austria and Germany. In the remaining, either both states present different degrees of the same monetary policy regime or, as previously identified, there is no statistically significant evidence of two distinct states.

6.2 Counterfactual interest rate paths

After the estimation of the aforementioned rules, which provide an admirable fit of the pre-EMU short-term interest rate series, we proceed to the forecasting of counterfactual interest rate paths. The results are presented in Figure 2, along with the observed interest rate for the period beginning in 1999.

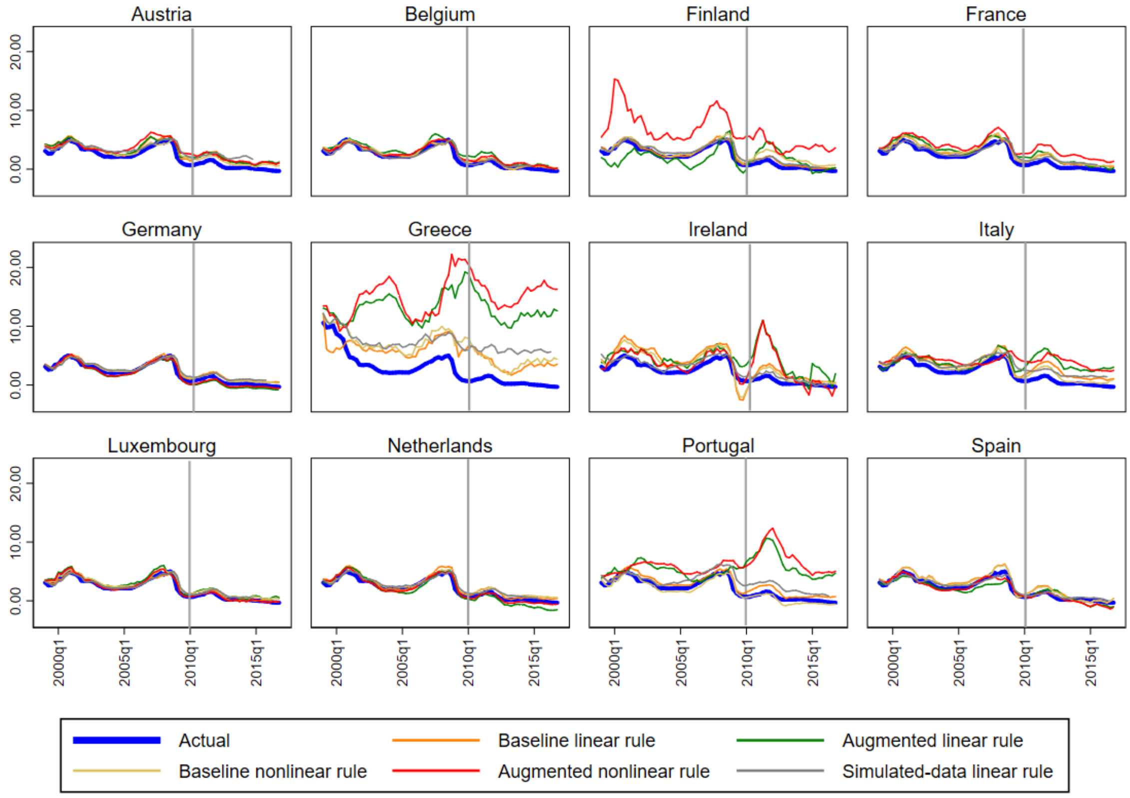
As can be observed, the sample of countries can be approximately divided into two groups: ones which display interest rates similar to what they were practising before monetary unification, and countries whose interest rate setting under autonomy was significantly different that the one observed in the Eurozone.

Regarding the first group, Luxembourg, Germany, the Netherlands, Austria, Belgium and France display counterfactual interest rates quite close to the actual money market rate set by the ECB, despite some small deviations, which will be reflected in the country-specific weights in the next section. Spain, despite belonging to the group of countries known as GIIPS[5], usually used to address the Eurozone members most affected by the financial crisis, showcases very small interest rate differentials in comparison with the actual rate. This can be a reflection of a greater convergence process, as, despite affected by the crisis, its economic recovery was faster than its counterparts. Italy displays some divergence between actual and counterfactual

[5]GIIPS stands for Greece, Italy, Ireland, Portugal, and Spain.

paths beginning at around the time of the financial and sovereign debt crisis, which can perhaps be attributed to significant current account imbalances and other aspects stemming from the experienced slump. In the case of Finland, as only one of the counterfactual series exhibits a large deviation from the observed rate, we do not attribute a large importance to the obtained result. Lastly, the second group of countries mentioned can be easily identified, comprising Greece, Portugal and Ireland. These member-states were among those who observed a larger decline in their inflation and short-term interest rates upon entering the EMU – see Figure 1 –, and were, unambiguously, the most hardly struck by the recession. Additionally, as can be observed, the augmented linear and non-linear rules' paths predict higher rates than those using only inflation and the output gap, meaning the capturing of further dynamics implies a larger divergence.

FIGURE 2: Counterfactual interest rate paths.



6.3 Implicit weight distribution

Using the estimated counterfactual monetary policy paths, the weight measures and their relative frequencies for all member-states were computed. Each of the figures presented hereafter displays the estimated weights, an average of GDP and of population during the period of 1999-

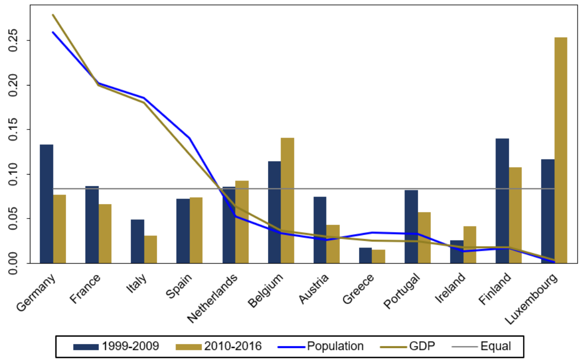
2016 as a share of the total, and an equal size line. The implicit weights are numerically detailed in Appendix 2.

Figure 3 presents the obtained weights using the baseline and augmented linear rules. First, a striking aspect is that economic size, which is very aligned with the size of population, does not seem to be correlated with the weight attributed to each country. According to the baseline linear model, we have that Finland, Germany, Luxembourg and Belgium have the biggest weight, whereas Greece, Ireland, Italy and Spain exhibit the smallest. This paradigm shifts during and after the crisis, namely the period of 2010-2016, in which Luxembourg gains significant weight compared to the remaining countries, with Belgium also becoming heavier. Here, the same member-states as before remain in the bottom, with the exception of Spain. The augmented linear specification reports a somewhat different narrative, as Germany showcases considerable weight, followed by the Netherlands and Luxembourg. Greece, Portugal and Ireland are found to be in the end of the distribution, which does not change when assessing the results after 2010. Nonetheless, after this period, and quite surprisingly, Spain becomes the heaviest member-state, followed by Germany and Luxembourg. In both the baseline and the augmented linear models, we find that more inflation-targeting countries, with Germany being the most obvious example but also comprising Belgium, Luxembourg and the Netherlands, persistently have a bigger weight than the one attributed to southern European countries, such as the ones mentioned above, with the exception of the result obtained for Spain in the latter figure, which appears to be a clear outlier. These results are consistent with the ECB's mandate.

Figure 4 presents the estimated weights using the baseline and the augmented non-linear rules. In the baseline case, we find a much more homogeneous implicit weight distribution across member-states than in the previous cases. Germany exhibits the most significant weight, followed by Luxembourg, Portugal, Belgium and the Netherlands, which all have very similar weights (between 10% and 11%). Greece and Ireland remain the lightest of the sample. However, after 2010, we see that both these countries, along with Belgium, Luxembourg, Portugal and Spain, gain some weight, while the remaining experience the opposite, leaving Belgium as the heaviest member-state and pushing Finland and Italy to the bottom. The augmented non-linear specification presents a larger discrepancy of monetary weights across countries, similarly to the augmented linear case. This a clear result of the fact that the inclusion of more contrasting dynamics, represented by the country-specific long-term interest rates or national share prices, represents more divergent implied interest rates, as mentioned above. Here, Luxembourg, Germany, the Netherlands, Spain and Belgium have the biggest weight, with Greece, Portugal, Ireland and Italy presenting the smallest.

FIGURE 3: Estimated weights using the baseline and the augmented linear Taylor rules.

(A) Baseline specification.



(B) Augmented specification.

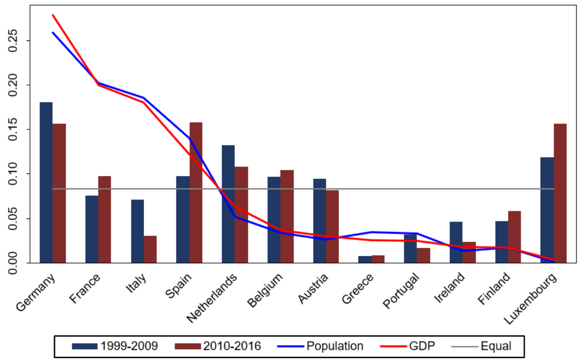
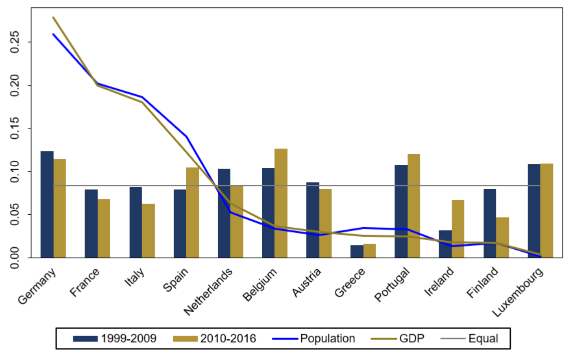
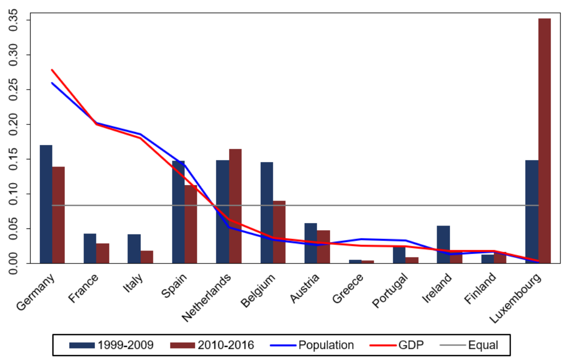


FIGURE 4: Estimated weights using the baseline and the augmented non-linear Taylor rules.

(A) Baseline specification.



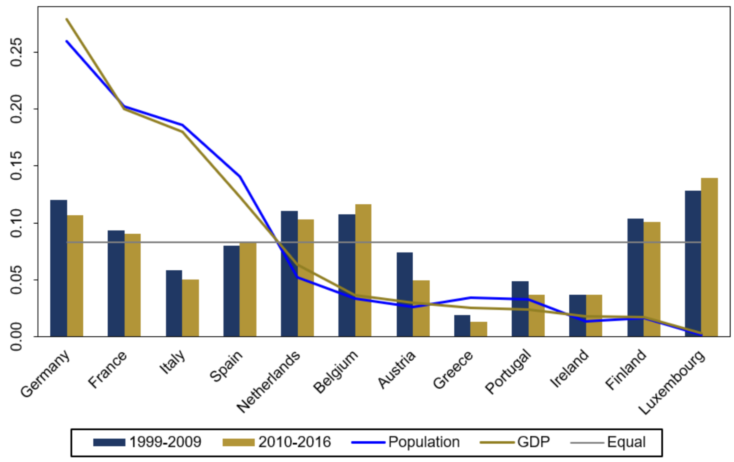
(B) Augmented specification.



Finally, regarding the last specification using a baseline linear rule with the simulated series for inflation and the output gap, we arrive at Figure 5. This exercise is of particular interest given that, while in the previous specifications data that was only observed in the context of the EMU is used, here we use information to estimate the prevailing rule under autonomy that also follows the trajectory running-up to unification, thus further deepening the counterfactual exercise.

Despite not displaying the weight measure for each repetition, we observe two different patterns in the granular data, namely that either Luxembourg or Germany arise as the countries who receive a bigger implicit weight. This is consistent with the results for the four specifications seen thus far, in which either one or the other takes place. Considering a geometric average of each repetitions' weight estimates, from 1999-2009, Luxembourg, Germany and the Netherlands are the countries to which a bigger weight is attributed according to their pre-EMU path. Greece, Ireland and Portugal remain the bottom contenders, presenting relative weight measures ranging from 1.91% to 4.92%. After the financial crisis, we observe that most countries lose weight in relative terms, in favour of Luxembourg, Belgium and Spain. Here, we do not witness significant changes in the ordering of countries, merely a switch in the positioning of heavier member-states.

FIGURE 5: Estimated weights using a baseline linear Taylor rule with simulated data.



Analysing the obtained results, across the different weight measures, we find that some countries persistently place in the upper tail of the distribution, with the same persistence taking place in the bottom. Despite the existence of outliers for some of the specifications, the pattern observed is that Luxembourg and Germany receive a bigger weight, closely followed by Belgium and the Netherlands. Despite Germany's result being quite intuitive, the same cannot be stated regarding Luxembourg. The fact that it receives such an implicit weight can be a result of, prior to the EMU, having short-term interest rates higher than Germany but still significantly low, with rates practised by the ECB being also low but not as much those practised by the Bundesbank under autonomy. Thus, this observed weight by Luxembourg can potentially be a result of a coinciding path as opposed to an active decision.

On the other hand, Greece, Ireland, Portugal and Italy systematically place as the countries that receive a smaller weight. These results can be a consequence of the severity of the crisis for these member-states, while, simultaneously, suggesting the ECB did not respond according to their preferred or usual monetary policy conduct. This supports our initial predictions.

6.4 Output gaps and aggregate shocks

After observing the differences regarding the distribution of implicit weights within the Eurozone, we now turn to assess how the synchronisation of the cyclical component of GDP and shocks within the EMU evolved from 1980 to 2016, as to attempt to understand if the distinct weights are correlated with integration. Thus, we analyse the correlation of output gaps between the countries in the sample and Germany, as well as of their supply and demand shocks. The selection of Germany is mainly due to being one of the member-states to which a bigger weight is attributed, with our aim being to assess up to which extent a bigger or smaller weight may be a reflection of a higher or lower correlation with Germany, following the integration process.

The results obtained can be found in Table 1, presented below. Concerning the output gaps, in the period of 1980-1998, the country with a highest output gap correlation with Germany was the Netherlands (63.7%), closely followed by Austria (61.3%) and Belgium (52.9%). From the period of 1980-1998 to 1999-2009, output gaps of Eurozone countries became significantly more correlated with Germany's, with the exception of Greece. In absolute terms, all showcased a very high correlation, with the smallest after Greece (24.4%) being Ireland (75.2%). However, the pattern suffered a critical shift in the period of 2010-2016, where there was a fall for all countries, more noticeably for Greece, Luxembourg, Ireland, Portugal and Spain.

The results from the correlation of aggregate disturbances demonstrate that, from the period of 1980-1998 to 1999-2009, countries' supply shocks moved much closer with Germany's for the entire sample, being lowest in Ireland (50.5%) and Greece (60.9%). Nonetheless, this correlation changed in the period of the crisis, with these shocks becoming asymmetric for Greece and Ireland, and decreasing for almost all of the remaining countries in a non-significant manner. Regarding the demand shocks, results are much less intuitive. From 1980-1998 to 1999-2009, shocks between Germany and a large segment of the EMU11 become asymmetric, providing evidence against convergence. Notwithstanding, during and after the crisis, Greece becomes the only country whose demand shocks are negatively correlated with Germany's.

Table 1: Correlation of countries' output gaps, and supply and demand disturbances with Germany's.

Countries	Output gaps			Supply shocks			Demand shocks		
	1980-1998	1999-2009	2010-2016	1980-1998	1999-2009	2010-2016	1980-1998	1999-2009	2010-2016
Austria	0.613	0.920	0.896	0.644	0.911	0.930	0.267	0.317	0.563
Belgium	0.529	0.824	0.769	0.675	0.790	0.779	0.458	-0.156	0.028
Finland	-0.006	0.898	0.830	-0.265	0.892	0.963	0.283	0.246	0.311
France	0.365	0.925	0.887	0.394	0.860	0.742	0.420	-0.107	0.718
Greece	0.424	0.244	-0.512	0.363	0.609	-0.085	0.150	0.410	-0.427
Ireland	0.422	0.752	0.082	-0.068	0.505	-0.135	0.382	-0.274	0.240
Italy	0.453	0.940	0.700	0.513	0.889	0.888	0.003	0.287	0.537
Luxembourg	0.419	0.850	0.125	0.445	0.784	0.742	0.186	-0.497	0.211
Netherlands	0.637	0.853	0.679	0.163	0.921	0.753	0.112	-0.211	0.348
Portugal	0.209	0.754	0.092	0.300	0.830	0.731	0.452	0.041	0.217
Spain	0.404	0.845	0.188	0.208	0.774	0.686	0.648	-0.035	0.490

Concluding, assessing the period of 1999-2016 as a whole, we observe that implicit weights[6] move positively with the correlation of output gaps and of supply shocks between member-states and Germany, whereas exhibiting a negative relationship with the correlation of demand shocks, as presented in Figures 6 and 7 in Appendix 2. While the first effect is quite intuitive as a larger weight is expected to be a result of further integration, the latter contradicts our initial reasoning. Nonetheless, we provide two potential explanations for the observed paradigm: first, as argued by Bayoumi and Eichengreen, 1992, demand disturbances are likely to be less informative than supply ones as they include country-specific policies, thus diminishing the importance of these results; second, countries which receive a bigger weight may have a larger discretionary capability regarding these same national policies, whereas members with a smaller weight are more restricted by European institutions, thus by the behaviour deemed fit by Germany, which would explain the higher correlation of demand shocks.

7 Conclusion

The existence of a political and economic union in Europe comprising countries with different characteristics has long steered a large debate regarding the political preferences of European institutions towards specific member-states. Thus, our aim was to provide evidence of the implicit weight the ECB's Governing Council attributed to each Eurozone member from 1999

[6]For illustrative purposes, the implicit weights used are those from the baseline linear rule, however, this behaviour is consistent across the five different specifications.

to 2016, using different approaches based on countries' monetary policy decisions prior to the EMU. Then, the obtained weights were compared to the correlation of output gaps and supply and demand disturbances of each of these countries with Germany, as to establish a comparison between monetary weights and economic integration overtime.

Among our findings, we emphasise that, first, each country's implicit weight is uncorrelated with its economic and population size. Second, across the different weight specifications (i.e. linear, time-varying and simulated-data based), the countries that systematically receive a bigger weight are Luxembourg and Germany, followed by the Netherlands and Belgium. On the other end lay Greece and Ireland, closely followed by Portugal and Italy. Despite some outliers in each specification, these results are those that prevail across distinct methodologies. Lastly, we find that the countries which receive a smaller weight are those that experience a smaller symmetry of output gaps and supply shocks *vis-à-vis* Germany.

Naturally, there are some caveats in the current analysis. First, we depart from the assumption that countries would have behaved in the same manner to deviations in macroeconomic variables as they did prior to unification, also keeping their preferences constant. Additionally, any attempt to predict behaviour based on historical data is subject to the Lucas critique, with policy-makers' decisions varying «systematically with changes in the structure of series» (Lucas, 1976).

Nonetheless, our analysis does present sensible results, aligned with the observed during and in the aftermath of the crisis, thus signalling some policy implications. Given the beheld disparities, policies can be implemented either to increase the symmetry between countries through long-term approaches, or to smooth the response of asymmetric shocks, which can be considered short- and medium-term procedures. Regarding the former, a much debated response are structural reforms, which can increase countries' resilience to shocks (Draghi, 2017) and have the potential of boosting integration. Concerning the second, risk-sharing and fiscal insurance mechanisms at the Eurozone level have been proposed, as to promote income stabilisation when certain members face asymmetric disturbances.

Further research should focus on assessing member-states' optimal interest rate setting according to fundamentals and identifying the specific sources of asymmetry within the EMU, as to provide evidence for Eurozone reforms that can improve shared prosperity.

In conclusion, the common currency constituted a different narrative for each member-state, with the rate practised by ECB having a distint meaning across countries. Nonetheless, it is important to recognise that any positive assessment has a limited impact as reforming the Eurozone remains primarily a normative issue, with any policy proposal requiring political support.

Appendices

Appendix 1 – Identification of aggregate shocks

We consider a bivariate VAR(2) representation for the first difference of the logarithm series of real GDP, y_t, and the GDP deflator, p_t, defined as

$$x_t = Ax_{t-1} + B\epsilon_t, \text{ with } x_t = \begin{bmatrix} \triangle y_t \\ \triangle p_t \end{bmatrix} \text{ and } \epsilon_t = \begin{bmatrix} \epsilon_{dt} \\ \epsilon_{st} \end{bmatrix} \tag{11}$$

where ϵ_t are the structural shocks and $B = P^{-1}$, with P being the triangular matrix that is used to obtain the structural shocks from the reduced-form residuals e_t such that $\epsilon_t = Pe_t$. The corresponding moving average representation is

$$x_t = (I - AL)^{-1} B\epsilon_t \tag{12}$$

with the cumulative long-run response of output and prices to structural shocks being

$$(I - AL)^{-1} B = \begin{bmatrix} \pi_{11} & \pi_{12} \\ \pi_{21} & \pi_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} d_{11} & d_{12} \\ d_{21} & d_{22} \end{bmatrix} \tag{13}$$

As previously stated, the considered framework implies that that supply shocks have permanent effects on both output and prices, whilst demand shocks have a temporary effect on output and a permanent one on prices. Thus, for identification, we impose that $\pi_{11}b_{11} + \pi_{12}b_{21} = d_{11} = 0$, i.e. the demand shock ϵ_{dt} has no long-run impact on output. This restriction, along with the other three imposed on the variance-covariance matrix $\sum_\epsilon$ – namely the normalisation of the variances of ϵ_{dt} and ϵ_{st}, and the imposing of orthogonality between the structural shocks –, allows for exact identification of the matrix B and, subsequently, of supply and demand shocks.

Appendix 2 – Estimates and figures

Table 2: Estimates of the baseline and augmented linear Taylor rule specifications.

Countries	n	ρ	β	γ	α	λ_1	λ_2	λ_3	δ_1	Adjusted R^2
Austria	6	0.75***	1.37***	1.52***	2.73***	–	–	–	–	0.9591
	6	0.74***	1.67***	1.07***	-0.35	0.09**	-0.04	0.53***	–	0.9675
Belgium	6	0.93***	3.29***	1.47**	-1.47	–	–	–	–	0.9451
	4	0.81***	1.53***	0.20	-42.73***	-1.01***	2.52***	9.00***	–	0.9674
Finland	3	0.90***	1.50**	1.02***	2.51	–	–	–	–	0.9314
	0	0.43***	1.02***	0.64***	20.21***	-0.66***	0.19	-4.36***	–	0.9542
France	3	0.83***	1.83***	1.78***	3.11***	–	–	–	–	0.9255
	4	0.70***	1.02***	0.86***	-17.93***	-0.65***	1.65***	3.92***	–	0.9387
Germany	6	0.79***	1.49***	0.63***	2.27***	–	–	–	–	0.9613
	6	0.98***	3.26***	0.15	-95.31***	5.72***	1.16	14.32***	–	0.9743
Greece	0	0.64***	0.49***	1.12**	10.06***	–	–	–	58.96***	0.6347
	2	0.33***	0.78***	0.79***	12.86***	-2.00***	–	1.38**	25.09***	0.8292
Ireland	0	0.69***	2.20***	-0.06	2.22	–	–	–	–	0.7060
	2	0.35***	0.13***	0.40***	-6.61***	-0.48***	1.52***	1.39***	–	0.8829
Italy	0	0.66***	1.35***	0.91***	3.38***	–	–	–	–	0.9000
	2	0.63***	-0.23***	0.52***	14.88***	0.33***	0.68***	-3.29***	–	0.9721
Luxembourg	6	0.95***	3.66***	0.24	-3.24	–	–	–	–	0.9376
	6	0.79***	1.83***	0.15*	-3.57	0.01***	0.79***	–	–	0.9639
Netherlands	4	0.89***	0.84*	2.91***	4.16**	–	–	–	–	0.9603
	2	0.88***	1.07***	1.42***	-51.69***	-0.62***	3.74***	8.41***	–	0.9918
Portugal	0	0.79***	0.95***	0.79***	3.26	–	–	–	–	0.9422
	4	0.28***	0.61***	0.25***	5.47***	-0.80***	0.79***	-0.50**	–	0.9874
Spain	0	0.77***	1.86***	0.62***	0.44	–	–	–	–	0.8940
	6	0.59***	0.22**	0.00	2.14	0.15**	1.05***	-1.35***	–	0.9272

Note: ***, ** and * mean statistically significant at 1%, 5% and 10% significance levels, respectively. The column n denotes the number of quarters-ahead considered for inflation, as in π_{t+n}.

Table 3: Estimates of the baseline and augmented non-linear Taylor rule specifications.

Countries	n	ρ	β_1	γ_1	β_2	γ_2	α	λ_1	λ_2	λ_3	δ_1
Austria	6	0.83***	1.68***	1.86***	2.70***	-1.60**	0.99	–	–	–	–
	6	0.69***	0.54**	0.31	1.41***	-0.15	-2.92***	0.16*	0.49***	0.05***	–
Belgium	6	0.91***	1.85**	3.28***	3.28***	0.45	0.19	–	–	–	–
	2	0.66***	-0.57**	0.16	0.87**	-0.09	-5.79***	-0.10	1.28***	0.06***	–
Finland	0	0.71***	1.03***	0.17	2.19***	-0.51	2.08***	–	–	–	–
	6	0.61***	0.57***	-0.69***	0.72***	0.57***	-11.75***	-1.34***	2.25***	0.21***	–
France	2	0.80***	1.44***	1.45***	1.94***	1.42**	3.12***	–	–	–	–
	2	0.62***	0.67***	1.19***	0.96***	1.29***	0.49	-0.74***	1.04*	0.03	–
Germany	6	0.87***	0.73***	1.61***	1.73**	-3.64*	3.09***	–	–	–	–
	6	0.95***	0.96***	-2.08***	2.10***	1.96*	-21.52***	2.88***	0.13	0.12***	–

Greece	2	0.60***	0.30***	0.04	0.59***	1.81***	10.75*	–	–	–	47.81***
	6	0.27***	0.67***	0.36**	0.83***	1.39***	23.00***	-2.29***	–	0.00	24.27***
Ireland	0	0.76***	2.23**	0.41	2.17	-0.14	1.95	–	–	–	–
	0	0.28***	-0.15	0.38***	0.84***	0.18*	-3.84**	-0.39**	1.48***	0.01	–
Italy	2	0.76***	1.70***	0.96***	1.70***	0.82	1.72	–	–	–	–
	4	0.33***	-0.27**	0.24*	0.28***	-0.63***	-3.87	-0.12	0.72***	-0.01**	–
Luxembourg	2	0.90***	1.83***	0.74***	1.15**	0.63	3.20***	–	–	–	–
	2	0.84***	1.28**	0.72*	0.83	0.63*	-2.08	0.80**	0.27	–	–
Netherlands	4	0.86***	-0.82	1.17	1.39***	0.69	5.47***	–	–	–	–
	6	0.87***	0.21***	0.21***	0.88***	1.60***	-6.82***	0.61***	0.92***	0.03***	–
Portugal	6	0.99***	8.85	26.96	29.80	249.96	-175.84***	–	–	–	–
	0	0.23*	0.09	-0.66	0.49*	0.07	2.19*	-0.68*	0.82***	0.02	–
Spain	0	0.81***	1.68**	1.40***	2.14	-0.66	0.54	–	–	–	–
	6	0.70***	0.31	-0.04	0.52*	-0.30	-7.75***	0.61**	1.07***	0.03	–

Note: ***, ** and * mean statistically significant at 1%, 5% and 10% significance levels, respectively. The column n denotes the number of quarters-ahead considered for inflation, as in π_{t+n}.

TABLE 4: Estimated weights for all considered specifications for the period of 1999 to 2016.

Countries	(i) Baseline linear	(ii) Augmented linear	(iii) Baseline non-linear	(iv) Augmented non-linear	(v) Simulated data
Austria	6.20%	9.13%	8.59%	5.91%	6.39%
Belgium	12.85%	10.46%	11.44%	12.80%	11.13%
Finland	13.47%	5.40%	6.10%	1.52%	10.26%
France	8.31%	8.83%	7.57%	3.97%	9.24%
Germany	11.06%	17.48%	12.22%	17.31%	11.48%
Greece	1.77%	0.81%	1.57%	0.53%	1.66%
Ireland	3.07%	3.12%	3.96%	2.84%	3.68%
Italy	4.31%	4.12%	7.38%	2.91%	5.51%
Luxembourg	14.31%	13.94%	11.13%	19.36%	13.29%
Netherlands	9.34%	12.34%	9.57%	16.86%	10.76%
Portugal	7.55%	2.16%	11.55%	1.44%	4.42%
Spain	7.77%	12.23%	8.92%	14.55%	8.08%

FIGURE 6: Implicit weights using the baseline linear rule and correlation of output gaps with Germany in 1999-2016.

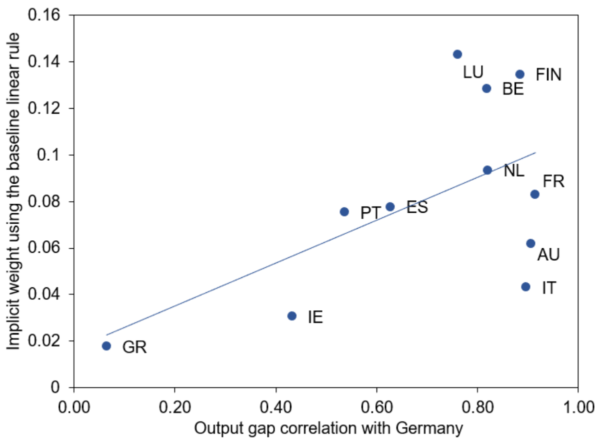
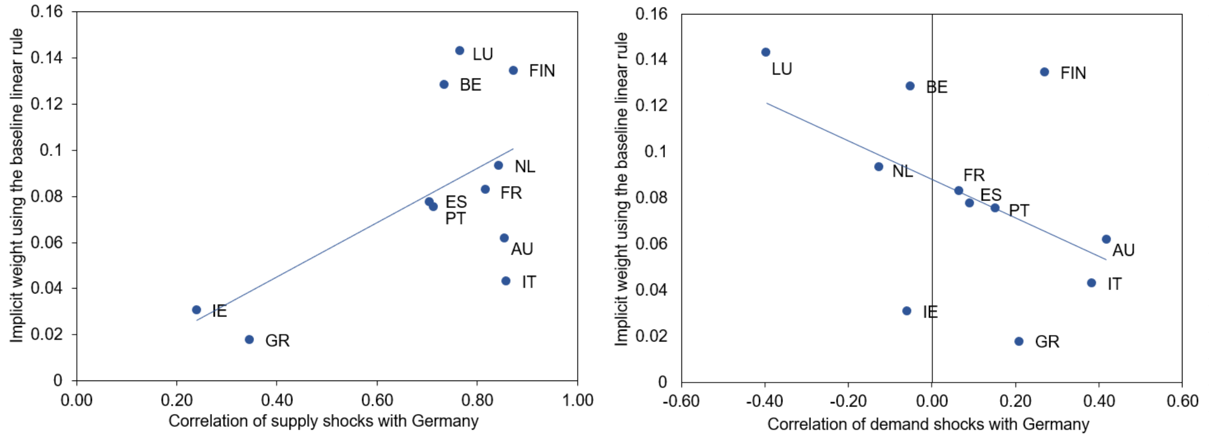


Figure 7: Implicit weights using the baseline linear rule and correlation of supply and demand shocks with Germany in 1999-2016.



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