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The Regional Effects of Monetary Policy in the Euro Area: Does One Size Fit All or None?

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Abstract

We estimate a Structural Dynamic Factor Model for 165 NUTS 2 regions across 11 euro area countries over 2000–2023, decomposing regional GDP growth into common euro area, country-specific, and regional components. This is the first structural shock decomposition at the regional level for the euro area, suitable to evaluate optimum currency area (OCA) properties along both shock-similarity and monetary policy transmission dimensions. Four findings emerge. First, the relative importance of common euro area shocks has increased steadily at both the country and union levels, indicating improving OCA properties, while country-specific components - most pronounced in peripheral economies - have declined, pointing to a gradual erosion of *the border effect*. Second, aggregate business cycle synchronization conceals substantial within-country heterogeneity, implying that the costs of relinquishing monetary policy autonomy are distributed unevenly across regions and countries. Third, euro area regional dynamics are driven predominantly by endogenous OCA convergence rather than specialization-induced divergence; regions with atypical sectoral compositions do face greater exposure to idiosyncratic shocks, but this reflects structural or geographic distinctiveness rather than integration-driven specialization. Fourth, monetary policy shocks generate smaller and more homogeneous regional output responses than demand or supply shocks, and transmission heterogeneity - while modestly increasing over the sample - reflects within-country regional divergence rather than cross-country fragmentation. Taken together, OCA properties at the regional and country levels are broadly comparable, and heterogeneous monetary transmission does not constitute a major threat to policy effectiveness.

JEL codes: E32, E52, F45
Keywords: Regional divergence, Regional heterogeneity, Monetary policy, SDFM

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1 Introduction

The study of business cycles in the euro area has long been conducted primarily at the country level. Yet the euro area is not a uniform economic space, but a mosaic of *regional* economies with different structural characteristics, sectoral compositions, and exposure to common euro area, country-specific, and idiosyncratic disturbances. The regional perspective therefore offers more than a simple zoom-in on country aggregates: it reveals forms of heterogeneity and adjustment that are invisible at higher levels of aggregation, but directly relevant for the functioning of economic and monetary union (de Groot et al., 2020; Iammarino et al., 2019). Regional divergence is economically and politically consequential in its own right, especially when it is perceived as being at least partly driven by unequal effects of common monetary policy, as regions left behind may generate social discontent, erode institutional trust, and weaken support for common institutions.[1]

In OCA theory, sufficiently aligned business cycles are a necessary condition for a monetary union to operate efficiently (Mundell, 1961). Although classical OCA criteria were formulated around geographic areas rather than states, the empirical literature has largely operationalised them at the country level (Alesina and Barro, 2002; Bayoumi and Eichengreen, 1992; Kunovac et al., 2026; Mongelli, 2002; Peersman, 2011). But assessed at that level, this condition may be misleading, because aggregate synchronisation can conceal substantial within-country regional heterogeneity. In that case, a common monetary policy may *fit all* countries on average while fitting almost none of their constituent regions in practice. A relatively high importance of symmetric shocks at the country level may arise in very different regional constellations: when all regions of a country are well aligned with the euro area cycle; when a small number of regions are exceptionally well aligned while the majority are not; or when regions move closely together within national borders while remaining collectively misaligned with the common cycle. This paper moves the analysis to the regional level precisely to distinguish among these cases.

These constellations imply very different costs of foregoing an independent monetary policy, yet they are difficult to distinguish in aggregate country-level data alone. When all regions are well synchronised with the euro area aggregate, the common policy is generally well suited to stabilise them and the costs of monetary union are low. By contrast, when within-country heterogeneity is large, no single policy stance can stabilise all regions simultaneously, the costs fall unevenly across the national territory, and the country-level aggregate may serve as a misleading policy benchmark. In the final case, when regions are internally coherent but collectively misaligned with the euro area, the country bears the cost of a policy calibrated elsewhere, although the burden is at least shared more uniformly within it.

Importantly, business cycle correlation alone does not guarantee the appropriateness of a common monetary policy - what also matters is whether the common policy produces symmetric stabilisation outcomes. These two dimensions can diverge. Regions may be well synchronised in their business cycles - facing few asymmetric shocks - yet still experience very different impacts from a given policy stance, if the monetary transmission mechanism operates unevenly across them.[2]

[1]Regional divergence has been linked to social unrest driven by perceptions of geographic neglect and to the rise of regionalist and populist movements; see, for example, Rodríguez-Pose (2018). As de Grauwe (1996) argues, when a common monetary policy imposes systematically unequal costs across member regions, pressures for exit or renegotiation may intensify.

[2]Dornbusch et al. (1998) made this argument most explicitly at the country level suggesting that heterogeneous monetary

To assess both dimensions - *shock similarity* and *monetary policy transmission* - one needs an empirical framework that can identify the relative importance of common, country-specific, and local forces at the regional level and trace the regional propagation of identified macroeconomic shocks. In this paper, we provide, for the first time, a unified framework that delivers a structural shock decomposition of regional GDP fluctuations across regions in 11 euro area countries and allows us to study how individual regions respond to a common monetary policy.

Our framework allows us to address the main questions that arise once the OCA problem is examined at the regional level. The first concerns the drivers of regional business cycles: whether fluctuations are shaped predominantly by common euro area shocks or by country-specific and idiosyncratic disturbances, and how the relative importance of these forces evolves over time. This is ultimately a classical question of *convergence* versus *divergence*: are regional cycles becoming more coherent as integration deepens, as the OCA endogeneity hypothesis would suggest (Frankel and Rose, 1998), or more dissimilar as greater specialisation makes regions more exposed to idiosyncratic disturbances, as implied by the Krugman specialisation hypothesis (Krugman, 1993)? The second question concerns heterogeneity in monetary transmission: even if shocks are, or are becoming, more similar, a common monetary policy may still be inefficient if its transmission differs substantially across regions (Forni and Reichlin, 2001).

The existing literature addresses important pieces of this picture, yet no unified framework or clear answer has emerged. At the core of OCA theory lies a straightforward logic: a common monetary policy can effectively stabilise member economies only when they are predominantly driven by *symmetric shocks* that affect them similarly and thus align business cycles. In the empirical literature, this criterion has been operationalised predominantly at the country level. At the regional level, however, this logic has not been operationalised with the same degree of structural detail. A large regional business-cycle literature studies cyclical synchronisation using simple correlations of extracted cycles and generally documents a national border effect together with mixed evidence on convergence (Bandrés et al., 2017; Barrios and de Lucio, 2003; de Haan and Acedo Montoya, 2008; Fatàs, 1997). These analyses are mostly conducted on pre-euro (1999) or even pre-Maastricht (1992) data and therefore predate the Global Financial Crisis, the European sovereign debt crisis, and the COVID-19 pandemic - events that may have substantially reshaped cyclical co-movement across regions. More recent work by Beck and Okhrimenko (2025) provides the only updated evidence on this question, though its finding that border effects are stronger in core than in peripheral economies stand in tension with both the macroeconomic record and standard priors, and may reflect a methodology that conflates episodic crisis dynamics with structural trends.

A similar limitation applies to the monetary-policy transmission literature. Evidence on heterogeneous transmission is largely confined to the country level and the few regional studies that exist (Carlino and DeFina, 1998; de Groot et al., 2020) do not embed transmission estimates within a framework that simultaneously accounts for the shock structure driving regional cycles. The two strands have never been brought together - and without that, a proper regional evaluation of OCA properties remains largely out of reach. For that reason, in this paper we estimate a Structural Dynamic Factor Model (SDFM) for re-

transmission is itself an OCA problem, not merely a consequence of asymmetric shocks. Although they focus on member states, the same logic applies at a more granular level.

gional real GDP growth across 165 NUTS 2 regions in 11 euro area countries over 2000–2023, providing a unified framework to study regional OCA properties from multiple angles.

Regional OCA features. We conduct, for the first time, a proper structural shock-accounting exercise for each individual region. This directly addresses a key limitation of the earlier regional synchronisation literature, which largely relies on correlations of extracted cycles and therefore cannot distinguish whether changes in co-movement reflect common euro area, country-specific, or regional forces. It also allows us to revisit the recent evidence of Beck and Okhrimenko (2025), who document broad-based divergence of regional cycles from the common European factor. By contrast, we find strong evidence of increasing synchronisation and improving OCA properties of the union as a whole over time, although with important heterogeneity across countries and regions. Richer regions tend to display a higher relative importance of common euro area shocks, while poorer regions are more exposed to country-specific fluctuations; however, this pattern largely reflects the concentration of poorer regions in peripheral economies rather than a pure development gradient.

Border effect. We identify a strong country-specific component in regional GDP growth - our model's interpretation of the border effect - particularly in peripheral countries such as Greece, Spain, Portugal, Ireland, and, to a lesser extent, Italy. Our analysis also suggests that this component loses importance over the sample, suggesting improving OCA properties across all countries, although it remains relatively important in peripheral economies and intensifies during the sovereign debt crisis.

Within-country heterogeneity. We also document substantial within-country heterogeneity in the configuration of common euro area, country-specific, and idiosyncratic shocks. Existing regional studies do not explicitly decompose cross-regional differences into their between-country and within-country components - a distinction that is central to assessing where the binding constraint on monetary union efficiency actually lies. Our framework allows us to uncover these internal configurations directly. The heterogeneity we uncover does not take the same form everywhere. It is especially visible in Germany and Italy, where our results uncover cyclical fault lines along traditionally recognised regional divides - east versus west in Germany and the *Mezzogiorno* divide in Italy. These divides are well documented in the literature on regional income inequality and real convergence (Boltho et al., 2018), but we show that they extend to the cyclical dimension as well, manifesting as systematic differences in exposure to common euro area shocks rather than merely in levels of income or productivity. By contrast, countries such as Spain and Greece appear less integrated with the common euro area cycle in aggregate but relatively homogeneous within national borders. This confirms that similar aggregate OCA profiles may imply different regional distributions of the costs of common monetary policy.

Economic structure of European regions and OCA properties. Our results also speak directly to the literature linking synchronisation to sectoral specialisation (Barrios and de Lucio, 2003; Beck and Okhrimenko, 2025; Belke and Heine, 2006) and to the broader theoretical tension between the Krugman (1993) specialisation hypothesis and the OCA endogeneity mechanism (Frankel and Rose, 1998). On average, over the whole sample, our results seem to be consistent with the *implications* of Krugman: regions with more atypical sectoral compositions tend to display a larger role for idiosyncratic regional shocks. This is particularly visible in geographically distinct or structurally unusual regions, as well as in some capital cities and resource-based mainland regions. But we also show that the relationship between specialisation and synchronisation depends on the nature of shocks and on the sectoral and cross-country linkages through which they propagate, as already recognized by Imbs (2004); Kalemli-Ozcan et al. (1999, 2001). Our decomposition clearly shows that specialisation in itself does not imply weak exposure to the common cycle. Regions specialised in globally integrated tradeable activities - those in western Germany or northern Italy - are strongly synchronised with euro area-wide fluctuations despite being structurally distinctive. Dynamically, however, the evidence points in a different direction. While sectoral structures change little over time, common shocks become more important, suggesting that euro area regional dynamics are shaped more by endogenous OCA convergence than by specialization-driven divergence.

Regional effects of monetary policy. Finally, we study regional responses to common monetary-policy shocks within the same framework. This allows us to speak directly to the still limited regional literature on heterogeneous monetary transmission in the euro area, an exception being de Groot et al. (2020). We find that the importance of monetary-policy shocks for regional output fluctuations is modest relative to demand and supply shocks and largely unrelated to regional economic structure. Although some heterogeneity in transmission exists, it is limited and driven primarily by within-country rather than cross-country variation. This pattern, however, differs between core and peripheral economies: in the core, dispersion in monetary-policy responses is driven mainly by within-country regional differences, whereas in peripheral economies a larger share of variation reflects country-level deviations from the euro area average. Total variability in monetary-policy exposure has nonetheless increased modestly over the sample period, mainly because of within-country regional factors. Overall, heterogeneity in monetary transmission does not appear to pose a major challenge for policy effectiveness, since monetary-policy shocks are less important for regional business cycle fluctuations than demand and supply shocks and heterogeneity in their transmission remains limited.

2 Relation to the literature

Regional business cycle synchronisation in the euro area has received considerable attention in the literature,[3] although empirical studies at the regional level remain relatively scarce compared with country-level analyses.

To evaluate cyclical coherence, most regional business cycle studies such as Barrios and de Lucio (2003); Belke and Heine (2006); Clark and van Wincoop (2001); de Haan and Acedo Montoya (2008); Fatàs (1997) rely on simple correlations between regional cycles, typically extracted using the Hodrick-Prescott filter. These analyses yield mixed and inconclusive evidence on the direction of cyclical convergence over time: Bandrés et al. (2017); Barrios and de Lucio (2003); Fatàs (1997) provide evidence of increased regional similarity, while Belke and Heine (2006) support the hypothesis of business cycle

[3] Regional business cycle analyses outside the euro area provide important methodological comparators. For the United States, Carlino and DeFina (1998) document heterogeneous regional responses to monetary policy shocks using structural VAR models for US states. Hamilton and Owyang (2012) develop a Markov-switching panel framework to study recession propagation across US states, finding that differences are largely a matter of timing rather than depth. Leiva-Leon (2017) uses a regime-switching interdependence framework to document increasing synchronisation among US states since the early 1990s. Ductor and Leiva-Leon (2016) adopt a social network analysis approach to characterise global business cycle interdependence at the country level.

divergence. Several studies also document a *national border effect*, suggesting that business cycle correlation may be significantly stronger within national borders than across them (see, for example, Barrios and de Lucio (2003); Clark and van Wincoop (2001); de Haan and Acedo Montoya (2008); Fatàs (1997)), although its quantitative importance remains unclear.

Importantly, however, most of this literature remains primarily based on co-movement measures and therefore does not distinguish whether changing synchronisation reflects common euro area forces, country-specific dynamics, or genuinely local regional shocks. This limitation is especially relevant because much of the earlier work was conducted on relatively early samples; see Bandrés et al. (2017) for an extensive review of the regional business-cycle literature. As a result, it does not fully reflect the sequence of major shocks that may have altered the pattern of regional synchronisation.

A different strand of the literature moves closer to the empirical logic of OCA assessment by focusing on the *similarity of shocks* as a catch-all criterion, typically assessed by decomposing output fluctuations into common and idiosyncratic components (Alesina and Barro, 2002; Bayoumi and Eichengreen, 1992; Mongelli, 2002). The same principle is followed at the regional level by Forni and Reichlin (2001) and Marino (2013), who quantify the relative importance of common, country-specific, and regional shocks driving regional GDP dynamics using dynamic factor models and point to a large importance of the common European component in explaining regional cycles. More recently, however, Beck and Okhrimenko (2025) reach different conclusions. Using a Bayesian dynamic factor model estimated on 59 euroarea regions over 1992-2020, they find broad-based divergence from the common European cycle, with 46 out of 59 regions recording a declining share of variance explained by the common European factor when comparing the pre- and post-2006 sub-periods. Importantly, they find an almost non-existent idiosyncratic regional component, implying that the declining common factor share is absorbed entirely by a rising country-specific component. In other words, their findings point to increasingly important border effects, which they find to be more important in the core countries (Netherlands, Belgium, or Austria) than in the peripheral countries (Greece, Portugal, or Spain), which are usually considered to follow more idiosyncratic cycles. These results are obtained by computing variance shares over sub-periods and rolling windows, an approach that may conflate genuine structural decoupling with the episodic dominance of country-specific shocks during the sovereign debt crisis.

Another strand links cyclical synchronisation to regional economic structure, following the argument that trade integration may foster sectoral specialization and increase the likelihood of asymmetric regional dynamics as suggested by Krugman (1993)[4]; see, for example, Barrios and de Lucio (2003) and Belke and Heine (2006). Beck and Okhrimenko (2025) suggest that divergence in regional business cycles is associated with a modest increase in regional sectoral specialisation.

Beyond shock similarity, what matters equally for the efficient conduct of common monetary policy is the degree to which regions respond uniformly to monetary policy shocks. Where such homogeneity exists, countercyclical measures by a common central bank are more likely to deliver similar stabilisation outcomes across member regions. While heterogeneity at the country level has been investigated exten-

[4] Krugman (1993) argues that deeper economic integration may lead to increased regional specialisation, as regions concentrate in activities where they have a comparative advantage. This specialisation, in turn, raises the likelihood of asymmetric shocks, since regions become more exposed to sector-specific disturbances and less exposed to the broad-based fluctuations that drive the common euro area cycle.

sively (Ciccarelli et al., 2013; Dornbusch et al., 1998; Georgiadis, 2015; Mandler et al., 2022; Peersman and Smets, 2005), the regional dimension in the euro area has received far less attention. An important exception is de Groot et al. (2020), who use local projections on NUTS 3-level data to document heterogeneity in monetary policy transmission across European regions, finding stronger responses in poorer regions. However, they do not integrate monetary policy transmission into a broader framework of regional business cycle synchronisation.

Against this background, our paper provides fresh evidence on regional business cycles in the euro area within a unified structural framework. While the standard approach in the multi-level dynamic factor literature (Jackson et al., 2018; Kose et al., 2003, 2008; Otrok and Whiteman, 1998) tracks common versus country-specific dynamics through variance shares, our structurally identified setup goes further by decomposing regional fluctuations into identified supply, demand, and monetary-policy shocks and tracing their regional propagation through impulse responses and historical decompositions.[5] We rely primarily on historical decompositions because they track the time-varying contribution of each shock to regional output rather than averaging over the full sample. This is especially important in a sample marked by very different crisis episodes, where the relative importance of shocks changes substantially over time, (Deskar-Škrbić et al., 2020; Kunovac et al., 2026), and where a unified structural framework is needed to study shock similarity, border effects, within-country heterogeneity, and the regional transmission of common monetary policy.

3 Methodology

3.1 Data

Our dataset comprises regional real GDP data for 11 Euro Area (EA) countries - Germany, France, Italy, Spain, Portugal, the Netherlands, Belgium, Austria, Finland, Ireland, and Greece - along with seasonally adjusted EA HICP and EA interest rates. Quarterly regional real GDP series for 165 NUTS 2 region covering the period 2000-2023 were constructed from country-level seasonally adjusted real GDP.[6] A complete list of all regions is provided in Appendix A.1. The interest rate employed is the Shadow Short Rate (SSR) of Krippner (2013). Regional real GDP and EA HICP enter the model in log-differences and interest rate in first difference. All variables are standardized prior to estimation.

3.2 Structural Dynamic Factor Model for Euro Area Regions

For each country i, let X_t^i be an $N_i \times 1$ vector of regional GDP growth and let Y_t denote the common 2×1 vector of observable EA variables. We assume that the dynamics of X_t^i can be explained by two

[5] A similar structural setup is used by Bäurle et al. (2021) for disaggregated prices in Switzerland.

[6] We interpolate annual regional GDP to quarterly frequency using the Chow-Lin method with country-level seasonally adjusted real GDP as the reference series, which is, in our application, preferable to working with annual data directly - the latter would average over multiple policy rate decisions within a year and substantially blur the timing of structural policy shocks. The policy meeting is normally held by the European central bank (ECB) once in a six weeks. While the Chow-Lin method uses a common indicator series, it does so via region-specific GLS regressions, so regional series are not simply rescaled copies of the national aggregate - their quarterly profiles reflect each region's own historical co-movement with the indicator (Chow and Lin, 1971). Nevertheless, to verify that this choice does not distort the relative synchronisation of regions within countries or countries within the euro area, we re-estimate the model on annual data as a robustness check (see Appendix A.2).

latent factors - an EA-wide common factor F_t^{EA} and a country-specific factor F_t^i - together with the two observable factors contained in Y_t (EA HICP and the interest rate):

$$X_t^i = \Lambda^{1,i} Y_t + \Lambda^{2,i} F_t^{EA} + \Lambda^{3,i} F_t^i + \nu_t^i, \tag{3.1}$$

where $\nu_t^i \sim N(0, R_i)$ is the idiosyncratic component and R_i is diagonal. The combination of observable and latent factors in equation (3.1) follows the structure of the observation equation in the FAVAR model of Bernanke et al. (2005), but with additional parameter restrictions. These restrictions provide a partial structural interpretation of the latent factors: the common EA factor captures the co-movement of regional GDP conditional on the observable EA variables, while the country factors absorb residual country-level GDP dynamics. Defining $X_t = [X_t^{1\prime} \dots X_t^{11\prime}]'$ and $\nu_t = [\nu_t^{1\prime} \dots \nu_t^{11\prime}]'$, we can rewrite (3.1) in stacked form as

$$\begin{bmatrix} X_t \\ Y_t \end{bmatrix} = \begin{bmatrix} \Lambda^{1,1} & \Lambda^{2,1} & \Lambda^{3,1} & \dots & \mathbf{0} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \Lambda^{1,11} & \Lambda^{2,11} & \mathbf{0} & \dots & \Lambda^{3,11} \\ I_2 & \mathbf{0} & \mathbf{0} & \dots & \mathbf{0} \end{bmatrix} \begin{bmatrix} Y_t \\ F_t^{EA} \\ F_t^1 \\ \vdots \\ F_t^{11} \end{bmatrix} + \begin{bmatrix} \nu_t \\ \mathbf{0} \end{bmatrix}, \tag{3.2}$$

where $\nu_t \sim N(0, R)$ and R is block-diagonal with matrices R_i on its main diagonal. The restrictions imposed on the elements of Λ in (3.2) are analogous to those in Kose et al. (2003), Belviso and Milani (2006), and Jackson et al. (2018). The diagonality of R implies that all cross-sectional correlation among the elements of X_t is channelled through the common factors. The dynamics of the common factors is assumed to follow a structural vector autoregression (VAR):

$$A_0 \begin{bmatrix} Y_t \\ F_t^{EA} \end{bmatrix} = A(L) \begin{bmatrix} Y_{t-1} \\ F_{t-1}^{EA} \end{bmatrix} + \varepsilon_t, \tag{3.3}$$

where $\varepsilon_t = \begin{bmatrix} \varepsilon_t^1 & \varepsilon_t^2 & \varepsilon_t^3 \end{bmatrix}'$ are structural shocks with zero mean and a unit covariance matrix. Country-specific factors F_t^i are modelled as univariate autoregressive processes, following Kose et al. (2003). Pre-multiplying the structural VAR (3.3) by A_0^{-1}, the joint dynamics of all factors - common euro area and country-specific - can be written as:

$$\begin{bmatrix} Y_t \\ F_t^{EA} \\ F_t^1 \\ \vdots \\ F_t^{11} \end{bmatrix} = \begin{bmatrix} B(L) & \mathbf{0} & \dots & \mathbf{0} \\ \mathbf{0} & b_1(L) & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \mathbf{0} & 0 & \dots & b_{11}(L) \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ F_{t-1}^{EA} \\ F_{t-1}^1 \\ \vdots \\ F_{t-1}^{11} \end{bmatrix} + u_t, \tag{3.4}$$

where $B(L) = A_0^{-1}A(L)$ and $u_t = \begin{bmatrix} u_t^1 & u_t^2 & u_t^3 & \dots & u_t^{14} \end{bmatrix}'$ are reduced-form shocks with zero mean and a block-diagonal covariance matrix with leading 3×3 block $(A_0' A_0)^{-1}$. Remaining blocks are scalars σ_i^2, where σ_i is the residual standard deviation from the autoregression for country factors F_t^i. We further assume that u_t and ν_t in (3.2) are mutually independent.

Together, equations (3.2) and (3.4) constitute a state-space model that is estimated within a Bayesian framework via Gibbs sampling, which iterates between two blocks:

1. **Draw parameters conditional on factors.** This block consists of three sub-steps:

   (a) *Loadings and idiosyncratic variances*: draw $\Lambda^{1,i}$, $\Lambda^{2,i}$, $\Lambda^{3,i}$ and R_i from their conditional posteriors. This reduces to a set of independent Bayesian linear regressions, one per region (Koop et al., 2007).

   (b) *Reduced-form VAR and country AR parameters*: draw $A(L)$ in equation (3.3) and the autoregressive coefficients $b_i(L)$ for the country factors, following standard Bayesian VAR procedures (Kilian and Lütkepohl, 2017; Koop et al., 2007).

   (c) *Structural identification*: given the reduced-form VAR draw, recover the structural impact matrix A_0 by applying the sign-restriction algorithm of Rubio-Ramírez et al. (2010) subject to the restrictions in Table 1.

2. **Draw factors conditional on parameters.** Draw the full paths of F^{EA} and F^i using the Carter-Kohn algorithm (Carter and Kohn, 1994) with the modifications of Kim and Nelson (1999) to handle the singular state equation covariance matrix when the VAR lag order exceeds one.

The model employs two distinct identification strategies: one to identify factors and one to recover structural shocks in (3.3) from reduced form regressions. To identify the EA common factor from the dynamics of 165 regional GDP series, we impose an informative prior on the corresponding factor loadings ($\Lambda^{2,i}$ in equation (3.1)), setting the prior mean to one for each region, following Bäurle et al. (2021).[7] Country-specific factors are identified by normalising the loading of a selected region to one (one element of $\Lambda^{3,i}$ in equation (3.1), corresponding to capital region within each country), which uniquely identifies the country factors (Bai and Wang, 2012).

The second component of our identification strategy concerns structural shocks. To identify a parsimonious set of economically relevant EA shocks, we employ the approach of Rubio-Ramírez et al. (2010) and impose sign restrictions on impact impulse responses. These restrictions are theory-consistent and uncontroversial (see Table 1): prices and economic activity (as measured by the common factor) should

[7] The prior variance is, however, set to be relatively large: in that case, if the data is informative about the loadings, this will be reflected in the posterior distribution, as argued by Bäurle et al. (2021). The posterior draws of the coefficients $\Lambda^{2,i}$ are reported in Figure 6 in Appendix B.1; it is evident that some of these loadings differ importantly from one. All remaining loadings have zero prior means with unit prior variances. The prior on idiosyncratic and country factor variances is uninformative (improper inverse-gamma with zero degrees of freedom and zero scale), leaving these parameters determined entirely by the data. VAR coefficients are assigned a Minnesota-type prior with a prior mean of 0.5 on own first lags and loose shrinkage on contemporaneous and cross-variable coefficients ($\lambda_1 = \lambda_2 = 100$). The VAR covariance matrix is assigned an inverse-Wishart prior with degrees of freedom $\alpha = N_{var} + 1$, where N_{var} is the number of endogenous variables in the VAR - the minimum value guaranteeing a proper posterior - and a diagonal scale matrix proportional to the OLS residual variances of each equation, making this a loose prior on Σ. Country factor autoregressive coefficients have zero prior means with identity prior covariance. The Gibbs sampler runs for 10000 iterations with a burn-in of 1000.

move in the same direction following a demand shock and in opposite directions following a supply shock; additionally, we assume that the ECB raises the policy rate in response to an expansionary demand shock, see for example Canova and De Nicoló (2002) and Peersman (2005). An expansionary monetary policy shock is identified as one that simultaneously increases both economic activity and inflation. The effects of the identified structural shocks are transmitted to regional variables through the observation equation (3.1): shocks are driving common factors that are, in the end, related to regional growth via regression parameters.

Table 1. Sign restrictions for the identification of common structural shocks

Shock	**Interest rate**	**Prices**	**Common factor**
Demand (AD)	+	+	+
Monetary policy (MP)	−	+	+
Supply (AS)	?	−	+

Notes: (+) positive; (−) negative; (?) unrestricted response. All shocks are normalised as expansionary; all restrictions imposed at impact. Impulse responses from the structural VAR are shown in Figure 7 in Appendix B.2.

In addition to the three common structural shocks, we analyse the contribution of country-specific shocks - defined as the residuals from the autoregressive equations in the state equation (3.4) - and idiosyncratic shocks, which correspond to the residuals of the observation equation (3.1). This decomposition allows us to attribute the dynamics of regional GDPs to five sources: three common (EA-wide) structural shocks, a country-specific shock, and an idiosyncratic disturbance. The framework thereby enables standard VAR-based analyses, including impulse response functions, forecast error variance decompositions, and historical decompositions.

3.3 Propagation of Shocks to Regional Variables: Impulse Responses, Variance and Historical Decomposition

Since the model is estimated by Bayesian Gibbs sampling, all impulse response functions, forecast error variance decompositions, and historical decompositions are computed for *each posterior draw* of the model parameters and factors. This yields full posterior distributions over these objects, which naturally quantify estimation uncertainty. Related regional business cycle literature based on Kose et al. (2003); Otrok and Whiteman (1998) typically does not consider structural shocks and instead decomposes the total variance of regional GDP directly from the observation equation (3.1) into common, country, and idiosyncratic components. Our approach is more demanding in that it further identifies structural EA-wide shocks and traces their propagation to the regional level. This additional structure, however, allows for a richer and more policy-relevant evaluation of the forces driving regional economic fluctuations.

To derive the response of regional variables to structural shocks, we use the Wold MA(∞) representation of the factor dynamics (Kilian and Lütkepohl, 2017). From the state equation (3.4), the common factors follow the moving-average representation:

$$\begin{bmatrix} Y_t \\ F_t^{EA} \end{bmatrix} = \sum_{k=0}^{\infty} \Psi_k \, \varepsilon_{t-k}, \qquad F_t^i = \sum_{k=0}^{\infty} \phi_k^i \, u_{t-k}^{3+i}, \tag{3.5}$$

where Ψ_k collects the moving-average coefficients for the common block and ϕ_k^i those for the i-th country factor. Substituting into the observation equation (3.1) gives the h-step-ahead forecast error for region r of country i:

$$X_{r,t+h}^i - E_t(X_{r,t+h}^i) = \sum_{k=0}^{h-1} \tilde{\Psi}_k^i \, \varepsilon_{t+h-k} + \sum_{k=0}^{h-1} \tilde{\Phi}_k^i \, u_{t+h-k}^{3+i} + \nu_{r,t+h}, \tag{3.6}$$

where the impulse response matrices are defined as

$$\tilde{\Psi}_k^i = \begin{bmatrix} \Lambda^{1,i} & \Lambda^{2,i} \end{bmatrix} \cdot \Psi_k, \qquad \tilde{\Phi}_k^i = \Lambda^{3,i} \cdot \phi_k^i. \tag{3.7}$$

Three types of error terms appear in (3.6): the common structural shocks $\varepsilon_t = [\varepsilon_t^1 \; \varepsilon_t^2 \; \varepsilon_t^3]'$ with $E[\varepsilon_t \varepsilon_t'] = I$, the country-specific shocks u_t^{3+i} with $\mathrm{Var}(u_t^{3+i}) = \sigma_i^2$, and the idiosyncratic errors $\nu_{r,t}^i$ with $\mathrm{Var}(\nu_{r,t}^i) = R_i^{rr}$, where R_i^{rr} is the r-th diagonal element of R_i. All three error terms are mutually independent by assumption.

Squaring and taking expectations of (3.6), and exploiting the mutual independence of the three error terms, the *forecast error variance decomposition* (FEVD) for region r of country i, h periods ahead, is:

$$E\left[\left(X_{r,t+h}^i - E_t(X_{r,t+h}^i)\right)^2\right] = \sum_{k=0}^{h-1} \tilde{\Psi}_k^{i,r} \tilde{\Psi}_k^{i,r\prime} + \sigma_i^2 \sum_{k=0}^{h-1} \left(\tilde{\Phi}_k^{i,r}\right)^2 + R_i^{rr}, \tag{3.8}$$

where $\tilde{\Psi}_k^{i,r}$ denotes the row of $\tilde{\Psi}_k^i$ corresponding to region r. Stacking over all regions of country i, the FEVD in matrix form is:

$$E\left[\left(X_{t+h}^i - E_t(X_{t+h}^i)\right)^2\right] = \sum_{k=0}^{h-1} \mathrm{diag}\left(\tilde{\Psi}_k^i \tilde{\Psi}_k^{i\prime}\right) + \sigma_i^2 \sum_{k=0}^{h-1} \tilde{\Phi}_k^i \tilde{\Phi}_k^{i\prime} + \mathrm{diag}(R_i), \tag{3.9}$$

where $\mathrm{diag}(\cdot)$ extracts the diagonal elements of a matrix into a column vector. The three terms on the right-hand side correspond to the contributions of the common structural shocks, the country-specific shock, and the idiosyncratic component, respectively.

The matrices $\tilde{\Psi}_k^i$ and $\tilde{\Phi}_k^i$ defined in (3.7) also give the *impulse response functions* of regional variables to structural shocks directly. Specifically, $\tilde{\Psi}_h^i$ represents the response of the regional GDP of country i to the three common structural shocks h periods after impact, and $\tilde{\Phi}_h^i$ gives the corresponding response to the country-specific shock.[8]

While the FEVD summarises the average contribution of different shocks over a given horizon, the historical decomposition tracks the cumulative impact of actual shocks at each point in time. Formally, the historical decomposition attributes the dynamics of regional variables to five shock-related components (the contributions of the three common structural shocks, the country factor shock, and the idiosyncratic shock) and two components related to initial conditions (arising from the VAR and the country factor autoregression). Since our focus is on the shock-related contributions, let $X_t^{i,s}$ denote the

[8]The (i, j)-th element of Ψ_h represents the average response of variable i to shock j after h periods.

contribution of structural shock s ($s = 1, 2, 3$) to the regional GDP of country i at time t:

$$X_t^{i,s} = \sum_{h=0}^{t-1} \tilde{\Psi}_h^{i,s} \cdot \varepsilon_{t-h}^s, \tag{3.10}$$

where $\tilde{\Psi}_h^{i,s}$ denotes column s of $\tilde{\Psi}_h^i$. Similarly, the contribution of the country factor shock is

$$X_t^{i,4} = \sum_{h=0}^{t-1} \tilde{\Phi}_h^i \cdot u_{t-h}^{3+i}, \tag{3.11}$$

[9]

and the idiosyncratic component is simply

$$X_t^{i,5} = \nu_t^i. \tag{3.12}$$

3.3.1 Measures of Relative Importance of Shocks: Forecast Error Variance Decomposition vs. Historical Shock Decomposition

Although FEVD and historical decomposition are derived from the same underlying structural model, they differ in the way they aggregate information over time.

While forecast error variance decomposition (FEVD) provides a useful steady-state characterisation of the average contribution of different shocks to regional business cycle dynamics, it is inherently static and therefore less informative when the importance of shocks varies over time. By contrast, historical decomposition is history-dependent and allows the contribution of different shocks to be traced across episodes. This distinction is particularly relevant in the euro area, where the sources of fluctuations vary across crisis episodes. For example, the Global Financial Crisis was driven by common global shocks, but European debt crisis was driven by developments in a small number of European countries (Kunovac et al., 2026). A steady state measure like FEVD fails to represent the importance of each shock over these very distinct episodes. For these reasons, we rely primarily on historical decompositions and, building on them, construct a simple measure of the relative importance of different types of shocks, distinguishing between common euro area shocks (aggregate demand, aggregate supply and monetary policy), country-specific shocks and regional shocks.

The implications of using different decomposition measures are illustrated in Figure 1 for the region of Galicia (ES11).[10] Based on the FEVD, almost half of overall regional GDP variability is attributed to country-specific shocks (Figure 1 (a)). Historical decomposition in Figure 1 (b), however, reveals that the relative importance of shocks changes quite strongly over time. For that reason, we follow Kunovac et al. (2026) and also construct measures of the relative importance ($RelImp$) of shock s ($s = 1, \ldots, 5$) for region r of country i as:

$$RelImp_t^{ir,s} = \frac{\left| X_t^{ir,s} \right|}{\sum_{l=1}^{5} \left| X_t^{ir,l} \right|}, \tag{3.13}$$

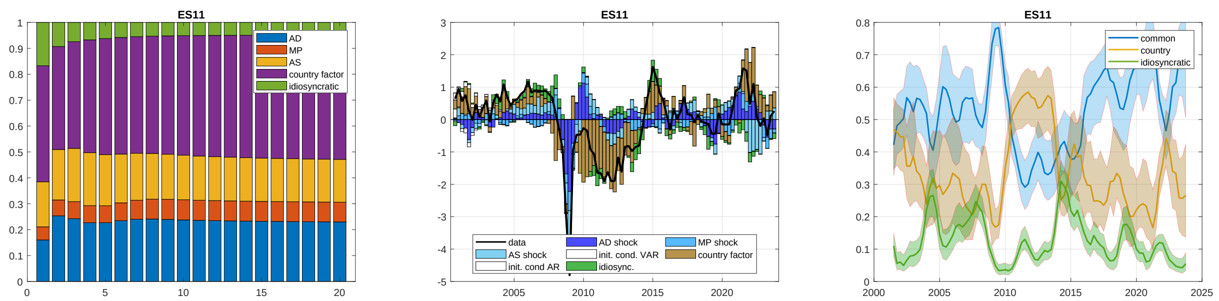
[9] Shocks u_t^1, u_t^2, and u_t^3 are the reduced-form shocks from the VAR.

[10] While Galicia (ES11) serves here as a representative illustration, many other regions across the euro area exhibit a similarly pronounced divergence between the static picture conveyed by the FEVD and the richer time-varying pattern revealed by the historical decomposition.

where $X_t^{ir,s}$ denotes the element of $X_t^{i,s}$ corresponding to region r, see Figure 1 (c). This measure confirms the importance of country-level dynamics, while revealing substantial variation over time. Based on the FEVD, the common and country-specific components appear roughly equally important for Galicia - yet this masks pronounced heterogeneity across distinct episodes. Prior to the global financial crisis, common and country-specific shocks contributed similarly to regional fluctuations. During the sovereign debt crisis (2010-2012), the country-specific component became dominant, reflecting developments specific to Spain. In the post-crisis period, however, common euro area shocks emerged as the primary driver of regional business cycle dynamics, a pattern visible in Figure 1 (c). Relying on the FEVD alone would therefore obscure this post-crisis convergence, during which Galicia has been predominantly driven by common euro area shocks. The choice of representation thus depends on the research question at hand: whether the focus is on the average importance of a shock across the full sample, or on how its contribution evolves across distinct episodes over time - a distinction that is central to our paper, given the episodic nature of the shocks that have shaped euro area regional dynamics over our sample.

Figure 1: An illustrative example - Different decompositions for Galicia (ES11)

(a) Forecast error variance decomposition (b) Historical shock decomposition (c) Relative importance of shocks ($RelImp$)



Note: Figure (a) is based on formula (3.8), Figure (b) on (3.10) - (3.12) and Figure (c) is based on (3.13).

4 Results

We begin by examining the estimated common euro area and country-specific factors, and then analyse the sources of business cycle fluctuations at the euro area, country, and regional levels.[11] Next, we study how the relevance of idiosyncratic shocks relates to regional economic structure, both across regions and over time. Finally, we discuss the role of monetary policy and the heterogeneity of its transmission across regions.

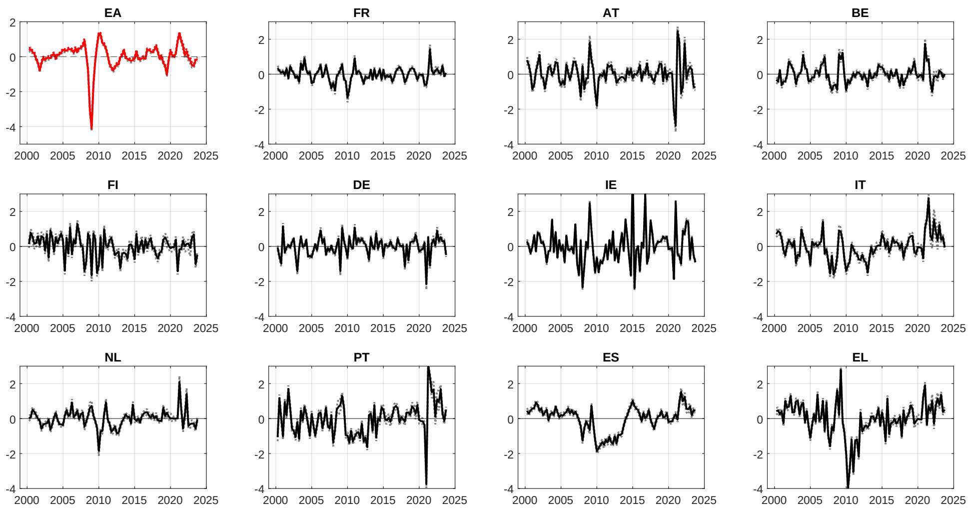
4.1 Estimated Common Factors

Figure 2 compares the estimated common euro area factor with the country-specific factors for euro area members under analysis. The common factor closely tracks the well-documented dynamics of euro area GDP growth over the period we analyse, suggesting that the model successfully isolates the business cycle component shared across member states. The factor captures the global recession during the Global

[11]The full set of region-level impulse responses, historical decompositions, and forecast error variance decompositions is reported in Appendix B.4.

Financial Crisis and, to a lesser extent, the euro area contraction during the sovereign debt crisis. The pandemic period is treated separately: we include region-specific dummy variables for the COVID-19 quarters to prevent the exceptionally large volatility of that episode from distorting the estimated factor dynamics and the underlying co-movement structure of regional GDP series.[12] Consistent with the existing literature, country-level variation is limited in magnitude and largely transitory in core euro area countries. In contrast, some countries, most prominently Greece and Spain, and to a lesser extent Portugal, Ireland, and Italy, display sizable and occasionally persistent country-specific dynamics, particularly during the euro area sovereign debt crisis. Relatively strong country-specific idiosyncratic component underlying business cycles in peripheral members is well elaborated in related literature, see Lehwald (2013) and Belke et al. (2017) for example.

Figure 2: Common euro area (EA) factor and country factors



Note: All factors are normalised and shown on the same scale.

4.2 Relative Importance of Common, Country-Specific and Regional Shocks: Aggregated Results

4.2.1 Euro Area as a Total

We begin by examining the shock decomposition at the euro area level - the most policy-relevant aggregation and the most directly comparable with existing literature. Figure 3 presents historical decomposition results, obtained by aggregating regional estimates using average regional nominal GDP as weights.[13]

As the historical decomposition makes clear, the relative contributions of common, country-specific, and regional shocks fluctuate substantially over time. At the beginning of the sample, in the early 2000s,

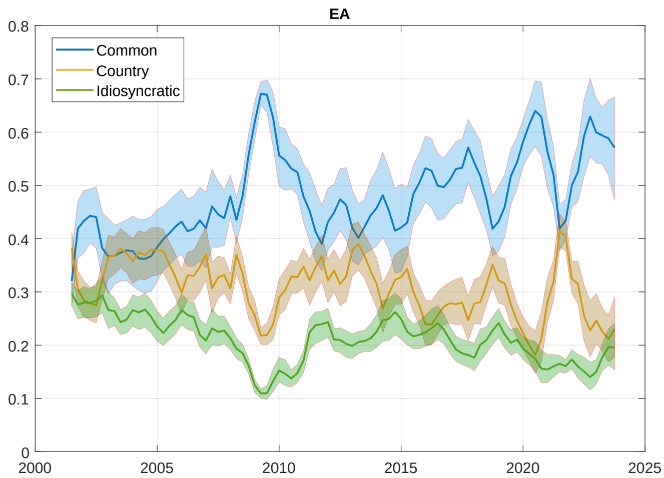
[12] While alternative approaches to handling pandemic-related shocks have been proposed in the literature - most notably in VAR (Lenza and Primiceri, 2020) and factor-model settings (Ng, 2021) - our approach to dummy-out COVID period from each of the series in a pre-treatment stage is simple to implement, with the trade-off that the COVID period is excluded from inference.

[13] Aggregate forecast error variance decomposition (FEVD) results are reported in Appendix B.3, Figure 11 and aggregate impulse responses are reported in Figure 8 in Appendix B.2.

common euro area, country-specific and regional shocks contribute roughly equally to aggregate fluctuations. Over time, however, the relative importance of common euro area shocks increases steadily, and by the end of the sample they account for the largest share of aggregate variation. This pattern is particularly pronounced during global downturns - most notably the global financial crisis - while country-specific shocks gain prominence during the euro area sovereign debt crisis.

These aggregate results may nonetheless conceal substantial heterogeneity across countries and regions, so a rising importance of common euro area shocks at the aggregate level does not by itself imply that a common monetary policy is equally appropriate across the monetary union; persistent asymmetries in shock exposure may still generate tensions within EMU, as elaborated in de Grauwe (1996); Kunovac et al. (2026); Orphanides (2020).

Figure 3: Relative importance of shocks for the euro area based on the historical decomposition



4.2.2 Business Cycles and Regional Development

Beyond the standard country-level aggregation usually employed in literature, several alternative regroupings of regions offer additional insight into the sources of business cycle heterogeneity. Among these, we exploit the income dimension by comparing the relative importance of common, country-specific and regional shocks across groups of regions ranked by their average GDP per capita over the sample period.[14]

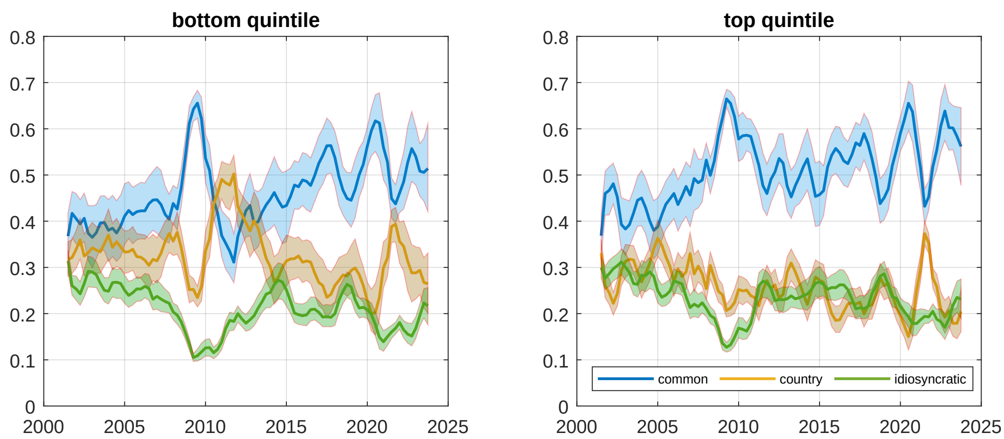
Figure 4 reveals a clear pattern. In poorer regions, country-specific shocks account for a disproportionately large share of business cycle fluctuations, whereas richer regions assign greater relative importance to both common euro area and regional shocks. The divergence is not a structural feature of the full sample period, but is driven largely by the sovereign debt crisis, during which country-level disturbances became dominant in lower-income regions. This suggests that poorer regions are particularly vulnerable to country-level stress events, while richer regions remain more closely tied to the euro area business cycle throughout the sample.

These findings should nonetheless be interpreted cautiously, as they do not reveal whether the ob-

[14] Impulse responses by regional income quintile are reported in Figure 9 in Appendix B.2.

served patterns reflect a genuine development gradient or simply the border effect. A more granular look at our results points to the latter: twelve of the sixteen regions in the lowest development decile are located in Greece (9) and Portugal (3). This interpretation also has implications for the broader literature: analyses that document heterogeneous regional effects along the income distribution - such as de Groot et al. (2020) for monetary policy - may similarly be conflating border effects with a genuine development gradient. More broadly, this suggests that empirical analyses of regional heterogeneity should account for both the regional and country-level dimensions simultaneously, as failure to do so risks attributing to a development gradient what is in fact a border effect - a confusion that the two-dimensional structure of our framework allows us to detect and separate.

Figure 4: Relative importance of common, country-specific and regional shocks: bottom and top income quintiles



4.3 Country-Level Analysis

Figure 5 compares relative importance of shocks across countries.[15] Two well-known groups of countries emerge: peripheral economies (Greece, Spain, Portugal and Ireland) are characterised by a relatively larger role of country-specific shocks - that is, shocks that operate at the national level and are best interpreted as border effects - while core countries (Germany, France, Belgium and the Netherlands, as well as Austria, Finland and Italy) are predominantly driven by common euro area shocks.

In contrast to some earlier analyses, our results place Italy within the core rather than the periphery group, reflecting its relatively high share of common euro area shocks and comparatively limited role for country- and region-specific disturbances. Although Italy is often grouped with the periphery on fiscal and structural grounds,[16] our results are consistent with a growing body of evidence showing that, in terms of business cycle synchronisation, it aligns more closely with the core (Belke et al., 2017;

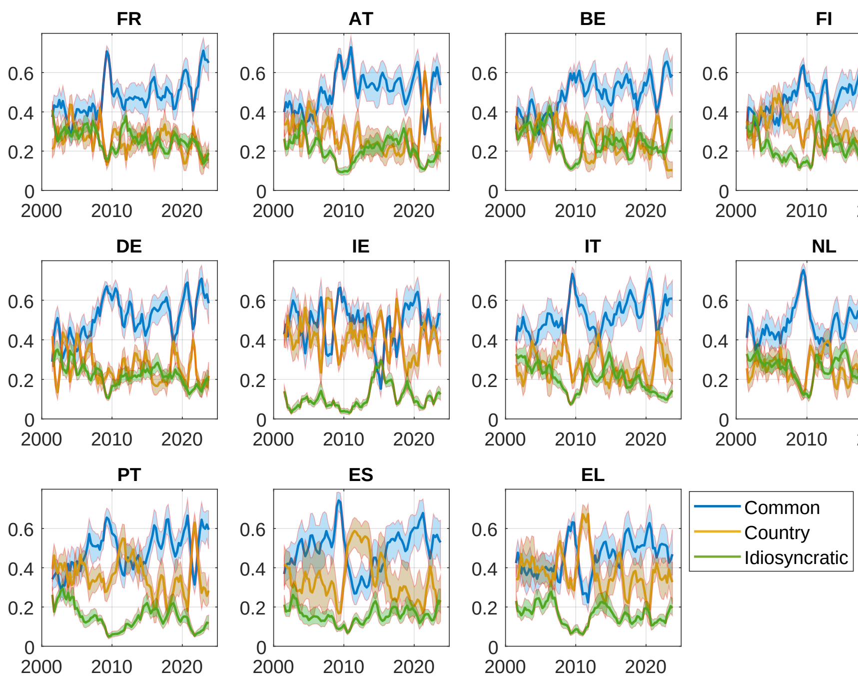
[15] Country-level impulse responses to aggregate demand, aggregate supply and monetary policy shocks are reported in Figure 10 in B.2 and FEVD at country level is given in Figure 13.

[16] Given its persistently high public debt, sluggish productivity growth, and vulnerability to sovereign-bank feedback loops, Italy shares a number of characteristics commonly associated with peripheral economies (Bugamelli et al., 2018; European Commission, 2024). From this perspective, grouping Italy with the periphery may seem natural. However, when the focus shifts to business cycle synchronisation and the relative importance of common versus idiosyncratic shocks - the dimension this paper examines - Italy aligns more closely with the core. Its trade structure, productive capacity, and cyclical co-movement with the rest of the euro area place it among economies predominantly driven by common euro area shocks.

Ferroni and Klaus, 2015; Kunovac et al., 2026). This distinction between fiscal vulnerability and cyclical synchronisation is important: the two need not coincide, and keeping them distinct is essential for a precise assessment of monetary union costs.

Importantly, the prominence of country-specific border effects across the periphery does not appear to be a constant feature of these economies. As in the aggregate euro area results, the country-specific component has been declining over the sample period, with the contribution of common euro area shocks rising correspondingly - suggesting ongoing cyclical convergence rather than persistent national idiosyncrasies. In contrast, regional shocks constitute an important source of variation across core euro area economies, often comparable in magnitude to country-specific shocks. Most importantly, however, over the more recent part of the sample the contribution of common shocks rises and becomes dominant across all countries, while both border effects and regional dynamics lose importance on average at the country level.

Figure 5: Relative importance of common, country specific and regional shocks at country level



Notes: Relative importance for each country is GDP-weighted and calculated based on 3.13.

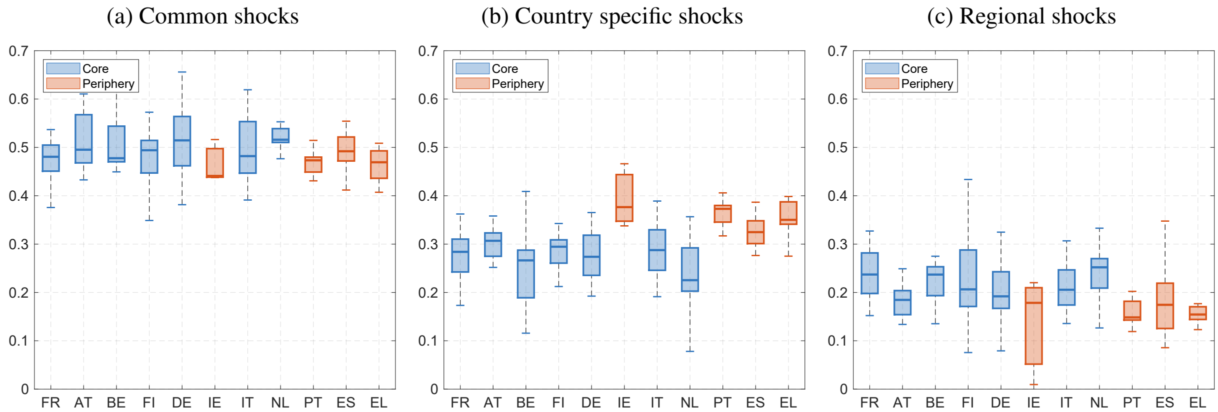
4.4 Regional heterogeneity

4.4.1 Shock-Accounting: Relative Importance of Shocks

Figure 6 presents box plots of the relative importance of each shock type, grouping regions by country, and is therefore informative about both the average level of shock exposure and the degree of within-country dispersion. Consistent with the country-level results, cross-country differences in average exposure remain visible. More importantly, however, the figure reveals substantial within-country heterogeneity that does not map neatly onto the core - periphery divide. Italy and Germany, followed closely by

Austria, display the largest internal dispersions in the sample, whereas countries such as Spain, Portugal, and Greece appear considerably more homogeneous within national borders. The figure therefore points to an additional layer of heterogeneity that is obscured by country averages alone.

Figure 6: Relative importance of shocks across regions by country



Notes: For each country, the boxplot summarizes the unweighted distribution of the median posterior estimate of relative importance of shocks (based on 3.13) across its constituent NUTS 2 regions, averaged over the full sample (2000-2023).

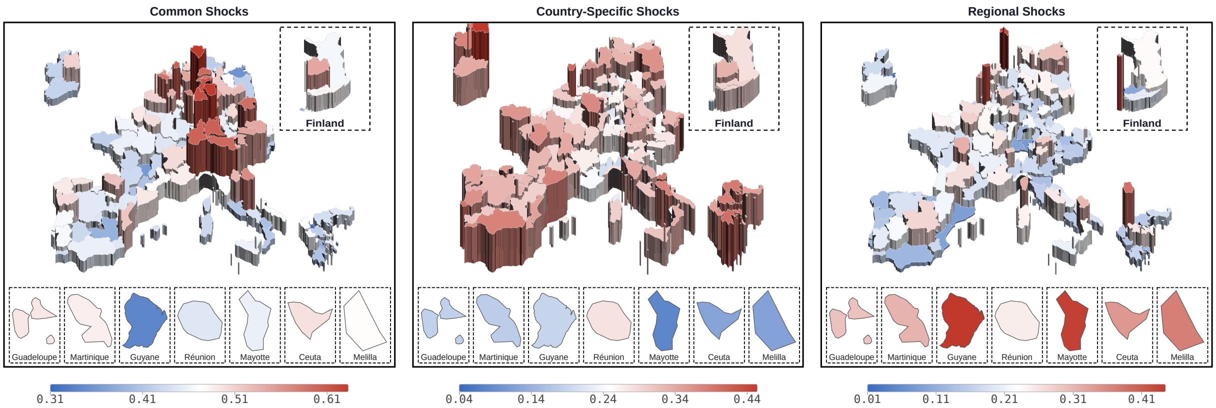
To allow the relative importance of each shock type to be compared directly across regions, Panel (a) of Figure 7 presents disaggregated results on a colour-coded map, with red indicating high incidence and blue low incidence of a shock. The three-dimensional representation adds another layer, making differences in shock exposure across regions even more apparent. Panel (b) of Figure 7 illustrates how these shares evolve over the sample period for each region individually.

The importance of common shocks displays substantial variation both across and within countries, and the patterns map closely onto well-known structural divides. Germany and Italy exhibit the largest within-country spreads in the sample, yet the structural fault lines run in different directions. In Italy, the divide follows the classic Mezzogiorno pattern: on average, northern industrial regions record substantially higher common shock exposure than the south - Lombardia (ITC4, with a relative importance of 0.62), Piemonte (ITC1, 0.62), and Emilia-Romagna (ITH5, 0.61) are among the most common-shock-exposed in the entire sample, while southern regions such as Basilicata (ITF2, 0.39), Calabria (ITF5, 0.42), and Campania (ITF6, 0.43) sit well below the Italian mean, reflecting their more fragmented, domestically oriented economies. In Germany, the fault line runs east - west rather than north - south: on average, western manufacturing regions record considerably higher values than eastern states - the Baden-Württemberg manufacturing corridor - Arnsberg (DEA5, with a relative importance of 0.66), Tübingen (DE14, 0.65), and Freiburg (DE13, 0.64) - records the highest values, while post-reunification eastern states such as Mecklenburg-Vorpommern (DE80, 0.38) and Dresden (DED2, 0.42) remain structurally less integrated with the western industrial core.

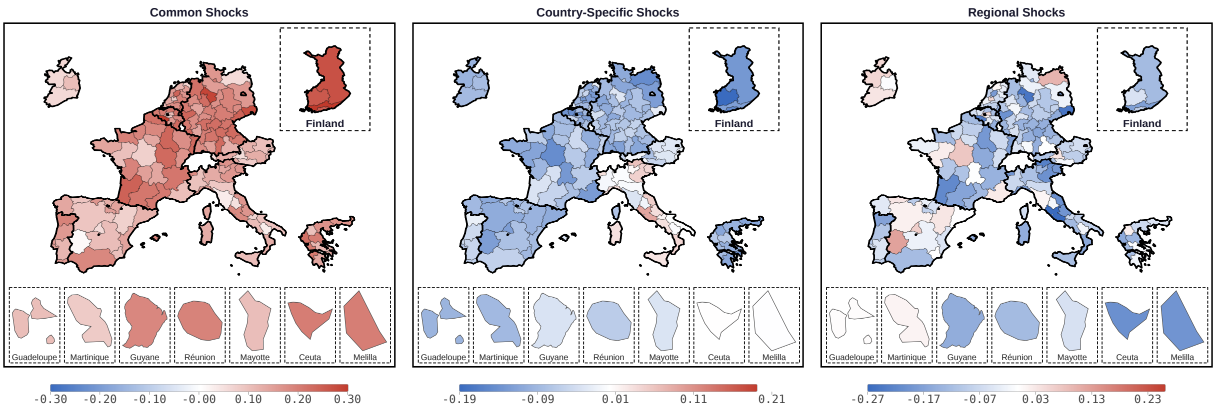
France has the lowest national average among the large economies (0.47), and unlike Germany and Italy lacks a dramatic structural fault line, with most metropolitan regions clustering in a narrow band; within-country dispersion is therefore limited.

Figure 7: Relative importance of shocks in NUTS 2 regions: sample average and change over the sample period

(a) Average 2000 - 2023



(b) Difference: last five years minus first five years



Notes: Finland is not to scale (shown in dashed rectangle). The five French overseas regions (Guadeloupe, Martinique, French Guiana, Réunion, and Mayotte) and the two Spanish autonomous cities in Africa (Ceuta and Melilla) are displayed as separate insets in the bottom of each panel. Relative importance is calculated based on 3.13. Panel (b) shows the difference in the relative importance of shocks between the last and first five years of the sample.

Spain presents a sharp contrast: its national average (0.50) is close to Italy's, yet within-country dispersion is less than half as large, suggesting that its regions move together in a more coordinated fashion despite similar average exposure. Portugal is even more compressed, effectively functioning as a single homogeneous block. Among the smaller economies, Austria stands out with a pronounced west-to-east gradient - Salzburg (AT31, with a relative importance of 0.61) against Burgenland (AT11, 0.43) - reflecting the stronger integration of its western alpine regions with the German industrial core. The remaining smaller economies show more limited internal variation: Belgium, the Netherlands, and Ireland all display relatively compressed distributions, while Greece records both the lowest national average in the sample (0.46) and relatively small within-country dispersion, suggesting its regions are uniformly weakly integrated with the euro area cycle over the whole sample.

Country-specific shocks follow a clear core - periphery gradient. Peripheral economies - Ireland, Portugal, and Greece - record the highest average exposure (means of 0.39, 0.37, and 0.36, respectively), reflecting the outsized role that national-level developments - sovereign stress, domestic policy shifts, or sector-specific crises - play in driving regional cycles in most of their regions. Spain (0.31) also sits above the core average, though its country-specific component is somewhat lower than in the other peripheral economies. Core countries show substantially lower average country-specific components, consistent with deeper integration into euro area-wide fluctuations, but also greater heterogeneity across regions within countries. This pattern broadly mirrors the fiscal and financial vulnerabilities exposed during the euro area crisis, and peripheral countries therefore display business cycles that remain more nationally idiosyncratic even over the full 2000 - 2023 sample period. It should be noted, however, that the average country-specific component for peripheral economies is elevated by the sovereign debt crisis of 2010 - 12, which generated a sharp but localised spike in national idiosyncratic dynamics rather than a permanent structural feature.

Regional shocks are on average the smallest of the three components, yet the map in Figure 7 (a) reveals a number of regions where idiosyncratic local dynamics is clearly dominant. These tend to be geographically or structurally exceptional regional economies that sit outside the mainstream of both their national and euro area cycles. The most prominent examples are the French and Spanish overseas territories - French Guiana, Guadeloupe, Martinique, Réunion, Mayotte, Ceuta, and Melilla - whose remote location and structurally distinct economies naturally insulate them from common and country-specific fluctuations alike. Among continental regions, Basilicata (ITF2) and Groningen (NL11) stand out, both characterised by economies dominated by natural resources rather than broader industrial or service-sector dynamics. The elevated regional component in these cases is not incidental - it reflects deep structural features of these economies, and we return to this relationship between economic structure and the incidence of idiosyncratic shocks in the next section.

Turning to changes over time, Figure 7 (b) maps the difference in the relative importance of each shock type between the first (2001 - 2005)[17] and last (2019 - 2023) five years of the sample, with red indicating an increase and blue a decrease. The pattern is consistent across regions and countries. The common-shocks panel is almost uniformly red, indicating a broad-based increase in the importance of euro area-wide fluctuations. The country-specific panel shows the opposite pattern: national-level dynamics decline in most regions, with the partial exception of Italy, where several regions - particularly in the south and centre - display a modest increase over time.

This adds an important regional dimension to the country-level results: the shift toward common shock exposure is visible across virtually all regions, suggesting that the strengthening of common euro-area forces reflects a broadly shared process of deeper integration rather than a change confined to a small set of countries or regions.

[17]The initial five-year window is intended to capture the early phase of EMU and the implementation of the common monetary policy, rather than a particular cyclical benchmark. The comparison is therefore not designed to hinge on a specific starting year or pre-crisis reference point, but to contrast the early institutional phase of monetary union with the most recent part of the sample.

4.4.2 Regional economic structure and idiosyncratic shocks: Krugman specialization, OCA endogeneity or something else?

We examine how regional economic structure is related to the incidence of idiosyncratic shocks across regions. The previous section showed that some regions have highly idiosyncratic business cycles - largely unrelated to common euro area or country-specific developments - and indicated that this may reflect their specific economic structure. In this section, we investigate this more formally using the Krugman specialisation index (KSI, Krugman, 1991) that measures how far a region's sectoral composition deviates from the euro area average. In our analysis we examine how this index correlates with the estimated incidence of regional shocks across regions.

It is important to note that the incidence of regional shocks is not an automatic consequence of having a non-typical sectoral mix. What matters is how synchronised individual sectors are, both across countries and within them: in a hypothetical setting where all sectors were equally synchronised across countries and equally correlated with one another within countries, the sectoral composition of a region would be less relevant for the relative importance of common and regional shocks. It is therefore the specific pattern of sectoral synchronisation - which sectors co-move strongly across borders and which do not - that ultimately determines whether a structurally distinctive region is also cyclically distinctive.

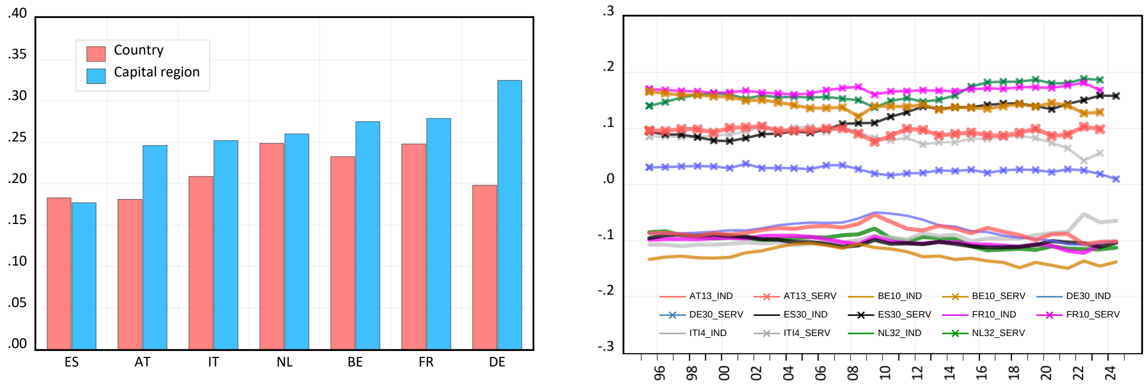
Tables 3 and 4 in Appendix A.3 compare how different sectors are correlated within and between member states and show that this hypothetical setting does not hold - there are important differences in synchronisation both across sectors and across countries. Market services emerge as the most robustly synchronised sector, both in terms of cross-country co-movement and in terms of correlation with other sectors within countries.[18] Since we have established that different sectors display different correlation patterns, a possible shift in the sectoral composition of regions - whether already underway or emerging - may affect the degree of business cycle synchronisation and ultimately the efficacy of a common monetary policy. For this reason, we proceed in two steps. We first examine how differences in regional economic structure correlate with the estimated importance of regional shocks across regions. We then investigate the dynamic dimension along the lines suggested by the Krugman specialisation hypothesis - the idea that economic integration tends to increase sectoral specialisation as regions concentrate in their comparative advantage activities - asking whether there is any meaningful change in sectoral compositions that is, or may in the future become, a source of diverging business cycles across euro area regions.

Figure 8 highlights a distinctive group of regions that illustrates the link between regional sectoral mix and the incidence of local shocks: capital areas in large countries. We plot the share of idiosyncratic shocks for capital regions against their respective country averages, and then look at their sectoral composition. Capital regions tend to be heavily concentrated in market services and public administration, with a relatively low share of industry, reflecting a degree of sectoral specialisation that diverges from the national average - and this is associated with a higher share of idiosyncratic shocks relative to their

[18] Excluding the COVID-19 period, as in our analysis, market services record the highest cross-country correlation, followed by industry, while agriculture and construction display the weakest synchronisation. When the full sample including COVID-19 is considered, non-market services dominate - a result driven by the highly synchronised and unusually large fiscal policy responses across euro area countries during the pandemic rather than by underlying structural integration. This stands in contrast with the conventional finding in the literature that industry is the primary driver of business cycle synchronisation.

Figure 8: Capital regions: importance of regional shocks and economic structure

(a) Regional shocks: country vs. capital region (b) Share of industry and market services



Notes: Panel (a) compares the average importance of regional shocks in each capital region with the corresponding country average. Panel (b) reports the shares of industry and market services in gross value added for the same capital regions (difference to total euro area share).

respective country averages, see Figure 8 (b). The pattern is most pronounced in large countries - Berlin (DE30, 0.325 vs. country average 0.199), Île-de-France (FR10, 0.284 vs. 0.251), Brussels (BE10, 0.275 vs. 0.234), Lazio (ITI4, 0.256 vs. 0.210), and Noord-Holland (NL32, 0.263 vs. 0.249) - where the capital is economically distinct enough from the rest of the country to generate its own idiosyncratic dynamics. Wien (AT13, 0.249 vs. 0.182) also sits notably above the Austrian average. Madrid (ES30, 0.175 vs. 0.185) is the only large country capital that sits marginally below its national average, which likely reflects the relatively homogeneous regional dynamics observed across Spanish regions more broadly. In smaller euro area members the pattern reverses, with capital regions tending to sit below their national averages. This likely reflects the fact that, in smaller member states, the capital region itself accounts for a large share of the national aggregate and therefore also absorbs a substantial part of the country-specific component[19]. The evidence from large capital regions is consistent with the implications of the Krugman specialisation hypothesis: service-sector concentration generates idiosyncratic dynamics that diverge from the national average. In smaller member states, however, the pattern reverses not because specialisation matters less, but because the capital dominates the national aggregate to such a degree that its cycle is largely indistinguishable from the country factor rather than the regional one.

To provide more formal evidence, we study how the incidence of idiosyncratic shocks correlates with the Krugman specialisation index, constructed based on five sectors, as defined in Table 2 in Appendix A.3, and the aggregate economy. For each region i, the index is defined as:

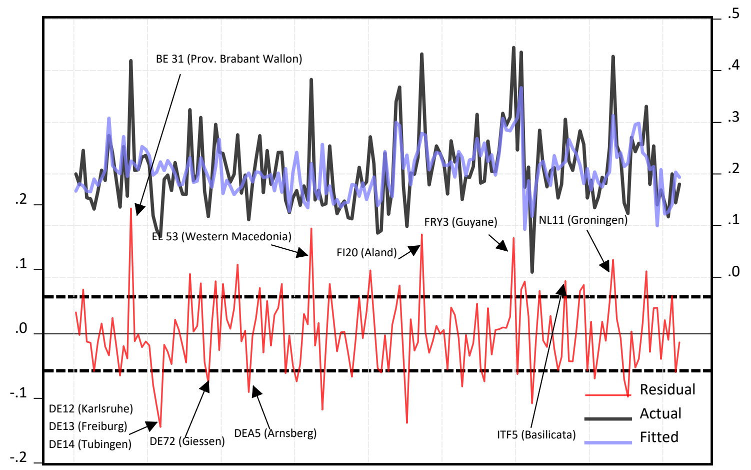
$$\mathrm{KSI}_i = \sum_{s=1}^{5} \left| \frac{x_{is}}{x_i} - \frac{x_s}{x} \right| \tag{4.1}$$

where x_{is} denotes gross value added of sector s in region i, x_i is total gross value added of region i, x_s is total gross value added of sector s in all euro area regions, and x is total euro area gross value added.The

[19]Dublin (IE06) accounts for over half of Irish GVA, Attiki (EL30) for around 51% of Greek GVA, and Lisboa (PT17) for around 36% of Portuguese GVA.

index thus measures the deviation of a region's sectoral composition from the euro area average, taking a value of zero when the region's sectoral mix perfectly mirrors the aggregate and reaching a theoretical maximum of two in the extreme case of complete sectoral concentration, with higher values indicating a more atypical structure.

Figure 9: Regional shock share and the Krugman specialisation index



Notes: Fitted values are obtained from a regression of the regional shock share on the Krugman specialisation index (KSI) with country fixed effects.

Figure 9 compares the estimated shares of regional shocks and the OLS prediction based on KSI and country fixed effects. The relationship is positive, though with notable outliers on both sides of the fitted line - some regions exhibit far more idiosyncratic dynamics than their sectoral mix would predict, while others are significantly more synchronised with the common euro area cycle than expected.

The regression results in Table 5 in Appendix A.3 confirm that the KSI is a highly significant and robust determinant of the regional shock share across all specifications.[20] In the baseline, the KSI, after controlling for country fixed effects, explains around 40% of the cross-regional variability in the incidence of regional shocks. In order to test to what extent the results are affected by the large outliers identified above, we additionally include dummy variables for the 10 regions with the largest positive residuals and the 10 with the largest negative residuals. Importantly, the results show that the KSI coefficient remains stable and precisely estimated, with the t-statistic actually increasing as the exceptional cases are controlled for, while the explanatory power rises sharply to around 80%, with both outlier dummies highly significant. This stability suggests that the positive relationship between sectoral specialisation and the incidence of idiosyncratic shocks is genuine and pervasive - it holds not just on average but consistently across the full distribution of regions, and is not driven by the outliers at either end.

Moreover, OLS regression results for all shock types confirm that the KSI enters with the expected sign across all dependent variables: a higher degree of specialisation is associated with a larger share of regional shocks, a smaller share of country-specific shocks, and a smaller share of common euro

[20] Given that the dependent variables are bounded between zero and one, we also estimate beta regressions as a robustness check; the results, available upon request, are qualitatively similar, with minor differences reflecting the non-linear nature of the beta specification at the tails of the distribution.

area shocks, with all three effects statistically significant. Country fixed effects alone explain a modest share of the cross-regional variability in regional shock incidence, and the KSI more than doubles the explanatory power, confirming that regional economic structure captures variation that country-level factors cannot. Overall, the results are consistent with the *implications* of the Krugman specialisation hypothesis: regions with a more atypical sectoral mix tend to be less exposed to common and country-specific fluctuations and more driven by local dynamics.

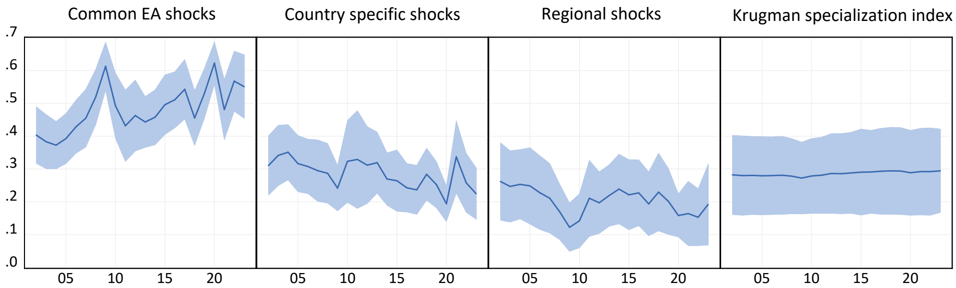
The largest positive residuals - regions where the model most substantially underpredicts the incidence of regional shocks - broadly correspond to those already identified as structurally exceptional. This does not imply that these regions are at odds with the Krugman hypothesis; rather, their structural divergence from the euro area average is so extreme that the KSI, while correctly signed, cannot fully capture the magnitude of their idiosyncrasy. The French overseas territories - French Guiana (FRY3) in South America, Mayotte (FRY5) off the coast of Africa, and Martinique (FRY2) in the Caribbean - the Mediterranean island of Corsica (FRM0), the Spanish autonomous cities of Ceuta (ES63) and Melilla (ES64) in North Africa, and the Swedish-speaking Åland Islands (FI20), an autonomous Finnish island region in the Baltic Sea, are characterised by a very low share of industry and market services and a dominant presence of non-market services, reflecting their remote location, dependence on public transfers, and structural disconnection from the European economic mainstream (see Figures 4 and 5 in Appendix A.4). Among continental regions, Groningen (NL11) is a major onshore gas extraction hub whose regional cycle is dominated by energy sector dynamics rather than broader economic forces - a manifestation of what the literature has termed the *Dutch disease*, associated with the large onshore gas field discovered in 1959. Basilicata (ITF5) hosts Europe's largest onshore oil and gas reserves and exhibits a similarly resource-driven cycle. Limousin (FRI2) and Epirus (EL53) reflect a different form of structural peripherality - sparsely populated and weakly integrated with the broader industrial and services base of their respective national economies. Walloon Brabant (BE31) is the principal exception to the structural interpretation: despite having a sectoral mix broadly in line with the euro area average, it displays a highly idiosyncratic cycle driven by exceptional productivity dynamics rather than by sectoral concentration.[21]

The most prominent negative outliers - regions that are significantly more synchronised than their specialisation would predict - are a cluster of western German manufacturing regions: Tübingen (DE14), Freiburg (DE13), Karlsruhe (DE12), Gießen (DE72), and Arnsberg (DEA5), a major steel and metalworking hub in the Ruhr area, as well as Emilia-Romagna (ITH5) in northern Italy, home to Ferrari, Lamborghini, and advanced packaging machinery. This points to a fundamental limitation of the specialisation hypothesis as standardly applied: the KSI captures the degree of deviation from the average sectoral mix, but does not distinguish between specialisation in locally oriented activities, which generates idiosyncratic dynamics, and specialisation in globally integrated, tradeable sectors, which may actually reinforce synchronisation with the common cycle. The literature has long recognised this tension, though primarily in the context of cross-country comparisons rather than within-country regional

[21] Bisciari (2024) documents that Walloon Brabant was the fastest-growing NUTS2 region between 1996 and 2019, with GDP per capita well above the EU15 median, driven by suburbanisation from Brussels, the development of the university town Louvain-la-Neuve, and high-performing firms, including a major pharmaceutical subsidiary.

analysis. Imbs (2004) shows, using country-level data, that the relationship between specialisation and synchronisation is not monotonic and depends critically on the nature of inter-sectoral and inter-country linkages, while Kalemli-Ozcan et al. (1999, 2001) demonstrate, again at the country level, that specialisation increases shock asymmetry when shocks are predominantly sector-specific and locally driven - a condition that clearly does not hold when the dominant shocks are global demand shocks transmitted through tightly integrated trade and value chains, as is the case for these regions. While this tension between types of specialisation has been recognised in the literature on cross-country synchronisation, our framework allows us to document it directly at the level of individual euro area regions - a granularity at which structural and cyclical heterogeneity interact in ways that aggregate analyses cannot capture.

Figure 10: Regional shock importance and the Krugman specialisation index over time



Notes: The figure compares the time variation in the relative importance of common, country-specific, and regional shocks with the evolution of the Krugman specialisation index; average across all regions surrounded by one standard deviation.

Shocks vs. Structure? While regional economic structure is an important source of cross-sectional heterogeneity, an open question is whether ongoing structural change leads to increasing regional divergence over time - as the Krugman hypothesis actually predicts. Figure 10 shows that temporal variation in the incidence of regional shocks is hardly related to changes in the Krugman specialisation index, which remains largely stable over time, both in aggregate and across its sectoral components (see Appendix A.4, Figure 3) - suggesting that structural change has not been a meaningful driver of regional divergence. The increase in the relative importance of common shocks over time instead is consistent with a deepening of economic integration within the euro area - as trade, financial, and production linkages tightened, regional business cycles became increasingly exposed to the same euro area-wide fluctuations, resulting in a higher share of common shocks across virtually all regions. Since it is the shocks themselves that became more correlated rather than the structures that became more similar, the Krugman dynamic mechanism does not appear to operate over our sample period. Taken together, the cross-sectional evidence is consistent with the implications of the Krugman specialisation hypothesis - regions with a more atypical sectoral mix tend to exhibit more idiosyncratic dynamics - but the dynamic evidence points in a different direction. The Krugman hypothesis is ultimately a claim about how integration reshapes economic structures over time; on that dimension, we find little supporting evidence. Instead, the dynamic pattern is better described by the OCA endogeneity mechanism, with common shocks rising over time as integration deepened rather than as a consequence of structural divergence (Kunovac et al., 2026). At the same time, the nature of specialisation matters: regions concentrated in globally integrated tradeable sectors appear to become more, not less, synchronised with the common cycle. Our results therefore suggest that the euro area business cycle is shaped by an interplay of forces that resist simple classification - and that the question of whether integration ultimately fosters convergence or divergence remains, as the debate initiated by Kalemli-Ozcan et al. (1999) makes clear, an empirical one.

4.5 Heterogeneity in Regional Responses to Common Monetary Policy Shocks

Having examined the sources of business cycle fluctuations from an OCA perspective, we now turn to regional responses to common monetary policy shocks and assess whether heterogeneity in their transmission is quantitatively important relative to other common euro-area shocks, and whether it is large enough to generate uneven stabilisation outcomes under a common policy stance.

Figure 11 (upper panel) shows the distribution of regional output responses to each of the three identified common shocks four quarters after impact, summarised separately for each country. The impulse responses, measuring the output effect of a one-standard-deviation shock, reveal a clear ranking across shock types. Aggregate demand shocks generate the largest output effects, with the mean of country means equal to 0.71 percentage points, followed by aggregate supply shocks at 0.66 - though the difference between the two is modest. Monetary policy shocks, by contrast, elicit substantially weaker output responses: the mean of country means stands at 0.30 percentage points, less than half the magnitude of the demand shock response, with country medians ranging from 0.15 in Ireland to 0.46 in Austria. Within-country dispersion, as captured by the interquartile range of each box plot, is present for all three shocks but remains moderate and does not reveal a systematic pattern linking regional heterogeneity in monetary policy responses to any particular country or group of countries.

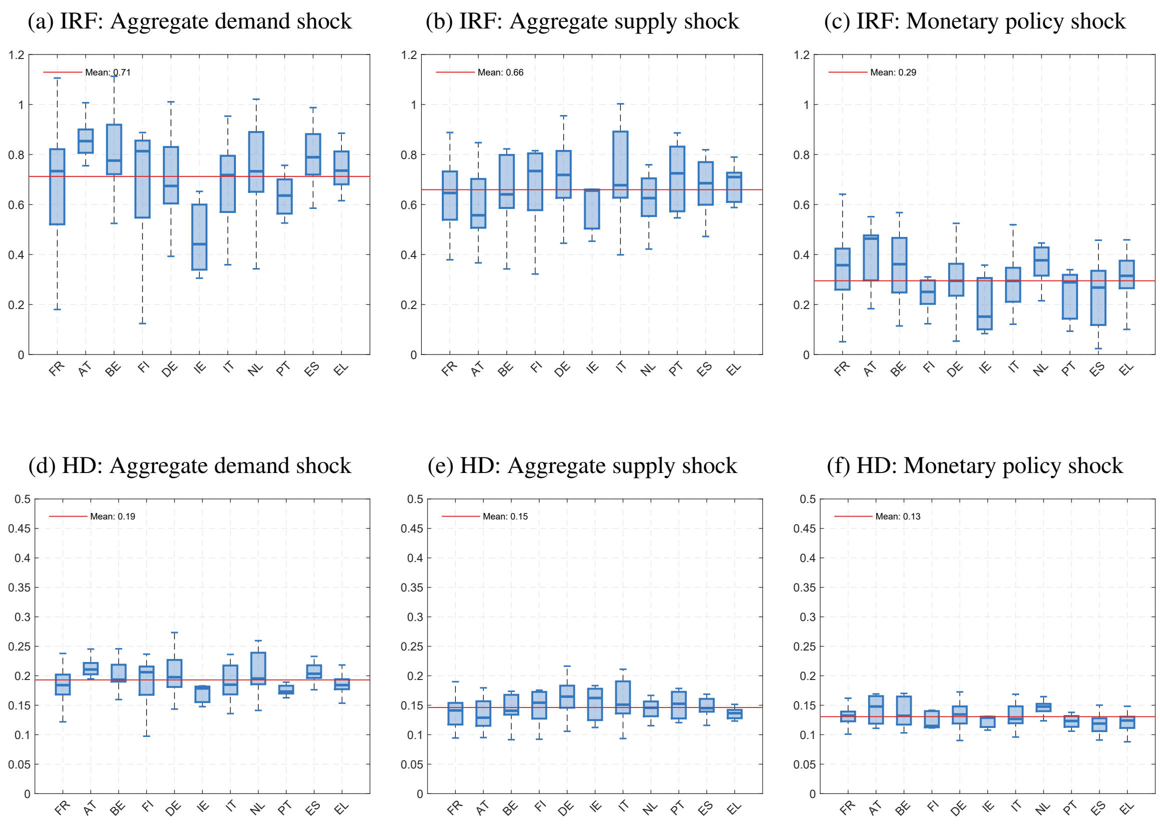
To the extent that regional economic structure explains cross-regional variation in output responses, the relationship is most evident for aggregate demand and supply shocks, where bivariate OLS regressions confirm that the shares of non-market services, industry, and agriculture are negatively associated with the magnitude of regional output responses; for monetary policy shocks, by contrast, sectoral composition has no meaningful explanatory power, and overall explanatory power remains limited even after controlling for country fixed effects.[22]

The lower panel of Figure 11 reports the average relative importance of each common shock in accounting for regional output fluctuations, as measured by the historical decomposition. These are averages over the full sample period; as already documented, there is important time variation in these shares, which we study further below. The ranking of shocks mirrors that of the impulse responses. Aggregate demand shocks account for the largest share of regional output variation, with a mean of country means of 19%, followed by aggregate supply shocks at 15%. The contribution of monetary policy shocks is the smallest, averaging 13% across countries - confirming that, beyond generating weaker output responses, monetary policy shocks also explain a comparatively modest share of regional business cycle fluctuations. Notably, the non-negligible share of supply shocks is consistent with Kunovac

[22] The absolute KSI measures the magnitude of sectoral deviation from the euro area average, $|s_i - s_{\text{EA}}|$, while the sign-sensitive index $s_i - s_{\text{EA}}$ preserves the direction of the deviation; the two need not yield the same results. The sign-sensitive regressions confirm a negative association between above-average shares of agriculture, construction, and non-market services and the magnitude of output responses to demand and supply shocks. For monetary policy shocks, a partial exception emerges: regions with above-average shares of agriculture and construction tend to exhibit smaller output responses, while regions more specialised in market services exhibit larger responses, though overall explanatory power remains low. Full results are reported in Appendix A.3, Tables 6 and 7.

et al. (2026), who find that a substantial part of the symmetric shocks driving euro area business cycles are supply-side in nature - a composition that complicates the conduct of monetary policy, as central banks may not always be in a position to react to supply shocks without creating additional distortions (Beaudry et al., 2022; Tenreyro et al., 2023). Peripheral economies (Greece, Ireland, Portugal, Spain) tend to exhibit somewhat lower within-country dispersion in the monetary policy shock contribution relative to core countries, suggesting that regions within peripheral economies are more homogeneous in their exposure to common monetary policy. The historical decomposition regressions largely confirm the impulse response findings: the aggregate Krugman specialisation index is negatively associated with the demand and supply shock shares but carries no explanatory power for the monetary policy share. Decomposing the KSI into its sectoral components yields the same pattern, with agriculture and market services being the most consistently significant regressors for the supply shock share. For the monetary policy share, only the agriculture component enters significantly in the sign-sensitive specification - with regions having a below-average agricultural share exhibiting stronger monetary policy responses, consistent with agriculture being the sector least exposed to interest rate and credit channel effects - while overall explanatory power remains low across all specifications; see Table 5 in Appendix A.3.

Figure 11: Impulse response function (upper panel) and historical shock decomposition (lower panel): cross-country and regional dispersion



Note: The figure reports the distribution of regional output responses four quarters after the identified common shock. For each country, box plots summarise the cross-regional distribution of impulse responses.

While regional output responses to common shocks are to some extent heterogeneous, monetary policy shocks generate weaker output responses and account for a smaller share of regional output fluctuations than aggregate demand or supply shocks, and the cross-regional differences in monetary policy sensitivity bear no systematic relationship to sectoral economic structure. Since these conclusions are based on sample averages, we next examine how this heterogeneity evolves over time.

4.5.1 Quantifying Regional Heterogeneity: Within- and Between-Country Variation

Cross-country and cross-regional heterogeneity in business cycle fluctuations lies at the heart of the optimal currency area debate. When countries or regions within a monetary union experience different cyclical conditions, a common monetary policy cannot be simultaneously appropriate for all of them - generating tensions and distributional costs that can undermine the sustainability of the union. These tensions operate at two distinct levels. At the cross-country level, divergent national business cycles expose the well-known one-size-fits-all problem. Within countries, however, regions exposed to a common national policy stance may face cyclical conditions that diverge not only from the euro area average but also from their own national context - creating an equally important, if less visible, layer of misalignment. Both dimensions therefore matter for assessing the costs of monetary union. Understanding which one dominates, and for which countries, is a question of direct policy relevance.

To address this, we employ a decomposable measure of total variance in the relative importance of each structural shock for regional output fluctuations. The deviation of each region's shock share from the euro area average is decomposed into a between-country component - capturing how much country-level averages deviate from the euro area mean - and a within-country component, capturing how much individual regions deviate from their own national average.

Let x_r^c denote a measure of the relative importance of a given shock for region r in country $c \in \{1, \ldots, N\}$, and let w_r^c be the corresponding regional GDP weight. The weighted country mean is

$$\bar{x}^c = \frac{\sum_r w_r^c \, x_r^c}{\sum_r w_r^c}, \tag{4.2}$$

and the weighted euro-area mean and weighted sample variance of x around the euro area mean are, respectively,

$$\bar{x}_{\text{EA}} = \frac{\sum_{c,r} w_r^c \, x_r^c}{\sum_{c,r} w_r^c}, \qquad \hat{\sigma}^2_{\text{EA}} = \frac{\sum_{c,r} w_r^c \, (x_r^c - \bar{x}_{\text{EA}})^2}{\sum_{c,r} w_r^c}. \tag{4.3}$$

The total weighted sum of squares in the numerator of (4.3) can be split by adding and subtracting the respective country mean $\bar{x}^c$:

$$\sum_{c,r} w_r^c \, (x_r^c - \bar{x}_{\text{EA}})^2 = \sum_{c,r} w_r^c \left[(x_r^c - \bar{x}^c) + (\bar{x}^c - \bar{x}_{\text{EA}}) \right]^2. \tag{4.4}$$

Expanding the square, the cross-term vanishes,[23] and the total variance decomposes as

$$\hat{\sigma}^2_{\text{EA}} = \underbrace{\frac{\sum_{c,r} w^c_r \, (x^c_r - \bar{x}^c)^2}{\sum_{c,r} w^c_r}}_{\text{Within}} + \underbrace{\frac{\sum_{c,r} w^c_r \, (\bar{x}^c - \bar{x}_{\text{EA}})^2}{\sum_{c,r} w^c_r}}_{\text{Between}}. \tag{4.5}$$

Because both components in (4.5) are additive across countries, the total variance can equivalently be written as a sum of country-level contributions:

$$\hat{\sigma}^2_{\text{EA}} = \sum_c \Big(\underbrace{\frac{\sum_r w^c_r \, (x^c_r - \bar{x}^c)^2}{\sum_{c,r} w^c_r}}_{\text{Within}_c} + \underbrace{\frac{\sum_r w^c_r \, (\bar{x}^c - \bar{x}_{\text{EA}})^2}{\sum_{c,r} w^c_r}}_{\text{Between}_c} \Big), \tag{4.6}$$

where Within_c is country c's contribution to the within-country variance and Between_c is its contribution to the between-country variance, both already weighted by country c's GDP share. This representation allows one to assess, country by country, whether, and to what extent, deviations from the EA aggregate are driven by heterogeneity *among* the country's own regions (Within_c) or by the country as a whole differing from the EA mean (Between_c). The within component captures the weighted dispersion of regions around their own national mean. A large within-country term indicates that region-specific characteristics - beyond those shared with the rest of the country - drive the deviation from the EA benchmark. The between component captures how much country-level averages themselves differ from the EA mean; a dominant between term implies that the region's deviation is largely inherited from national-level factors. Because the decomposition rests on a sum of (weighted) squares, it is fully additive and the relative contribution of each component can be reported as a share of total variance.

Figure 12 reports, for the euro area aggregate and for each individual country, the decomposition of total variance in the relative importance of monetary policy shocks into its within-country (regional) and between-country components, together with linear trend lines that capture the evolution over time. At the euro area level, total variability has been broadly increasing over the sample, with the standard deviation rising from around 0.04 in 2005 to about 0.05 in 2017 and ending the sample at a similar level.[24] On average across the sample, regional heterogeneity within countries accounts for around 63% of total dispersion, while country-level deviations from the euro area mean account for the remaining dispersion. The trend lines reveal that within-country variation has been relatively stable and dominant throughout the sample, while between-country variation rose during the sovereign debt crisis of 2011 - 2013, reaching around 40% of total dispersion, before declining again.

Decomposing the source of dispersion reveals a systematic difference between core and peripheral economies. In the core, variation in monetary-policy exposure arises predominantly from differences *within* countries, with the within-country component accounting on average for around 65% of total variance. In the periphery, by contrast, dispersion reflects mainly differences *between* countries, with

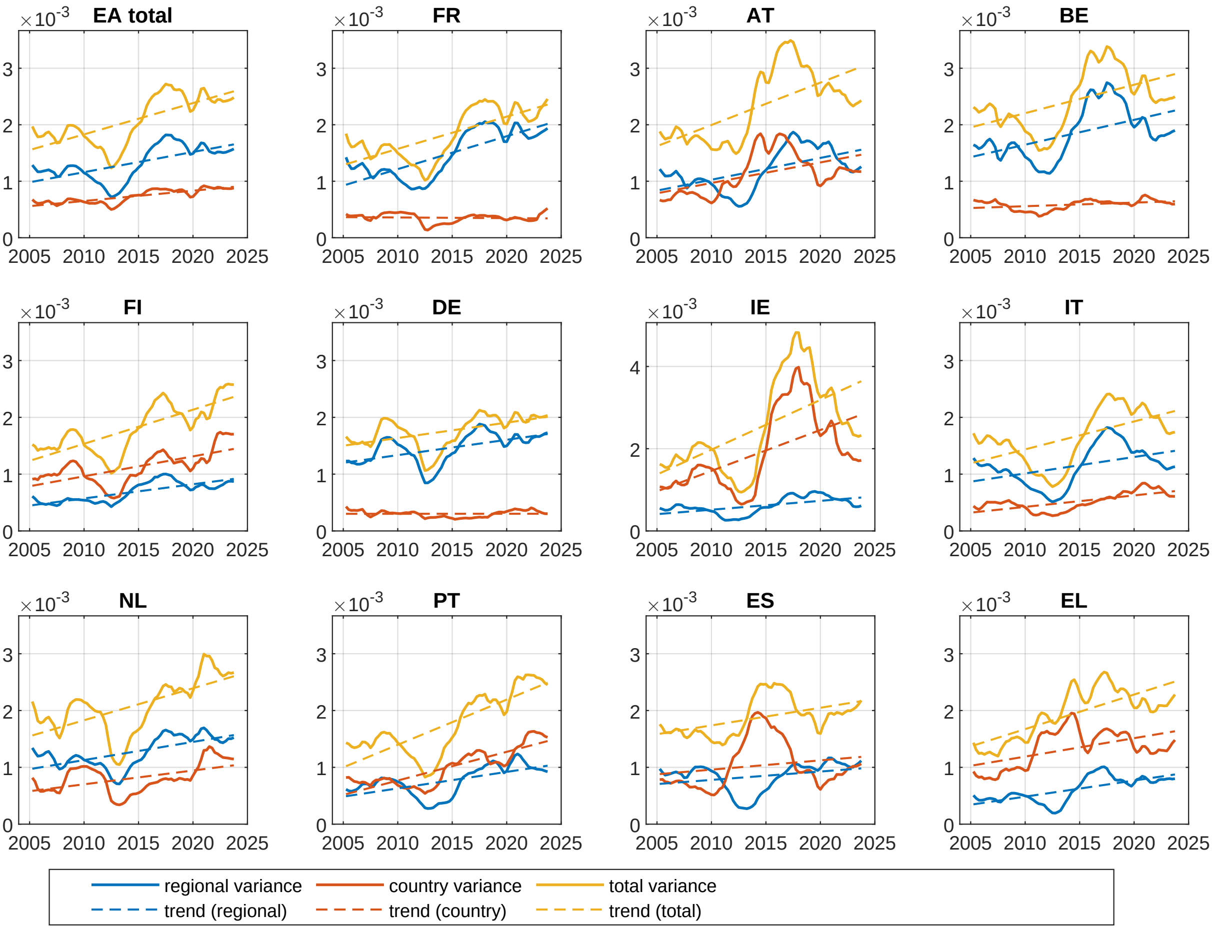
[23] The cross-product in the expansion of (4.4) equals $2\sum_c(\bar{x}^c - \bar{x}_{\text{EA}})\sum_r w^c_r(x^c_r - \bar{x}^c)$. For each country c, the inner sum $\sum_r w^c_r(x^c_r - \bar{x}^c) = \sum_r w^c_r x^c_r - \bar{x}^c \sum_r w^c_r = 0$ by the definition of the weighted country mean (4.2), since $\bar{x}^c \sum_r w^c_r = \sum_r w^c_r x^c_r$. Because the inner sum is zero for every c, the entire cross-term vanishes regardless of the value of $(\bar{x}^c - \bar{x}_{\text{EA}})$.

[24] Throughout this section, variability is reported as the square root of the weighted variance $\hat{\sigma}^2_{\text{EA}}$ defined in equation (4.5), i.e. $\sqrt{\hat{\sigma}^2_{\text{EA}}}$, which has the same units as the underlying shock share and is more readily interpretable.

country-level deviations from the euro area mean contributing about 63% on average. Italy is the main exception, as its regional share reaches 69%, placing it closer to the core pattern. The time profile is consistent with this distinction: in core economies the within-country component is stable or gradually increasing, whereas in peripheral economies the between-country component remains the main source of variation, especially during and after the crisis.

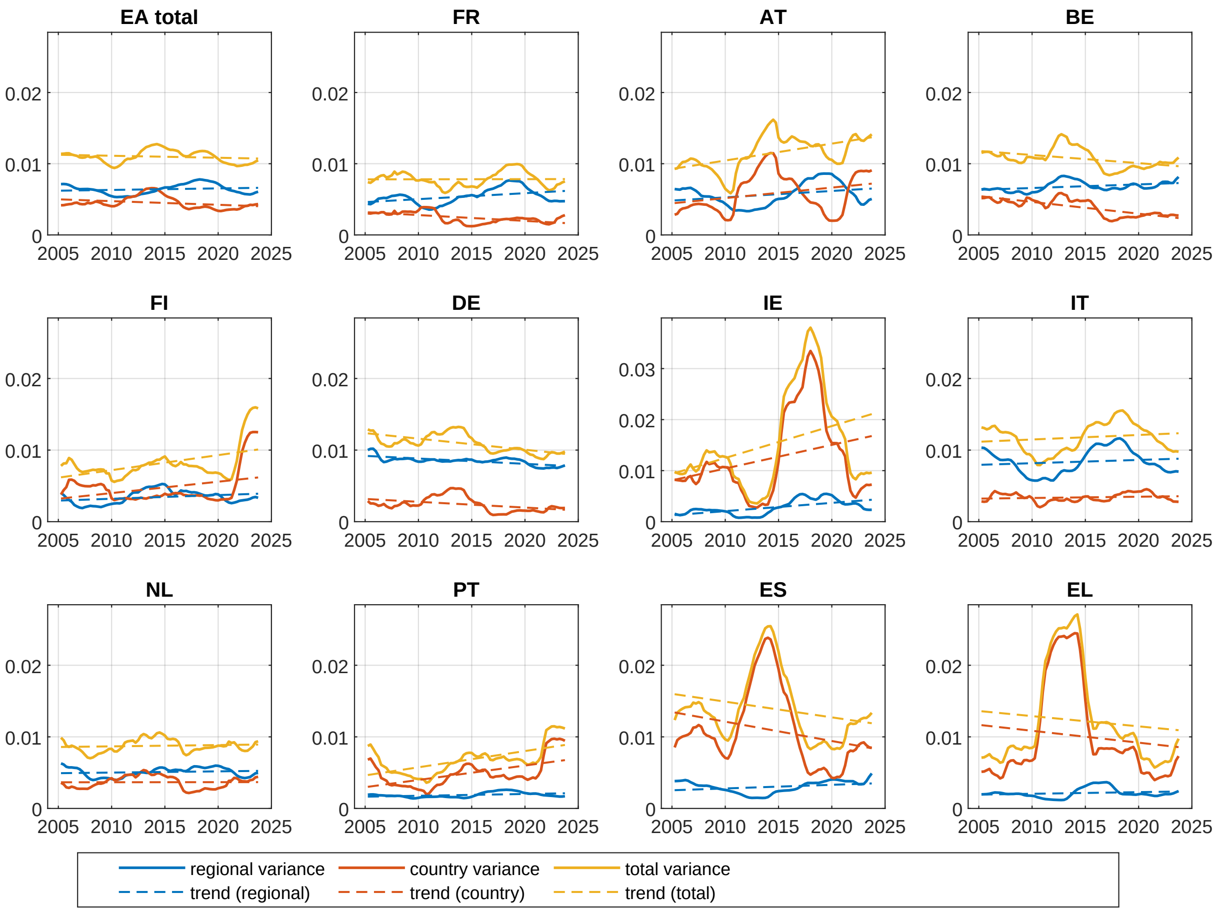
Taken together, these results point to a clear and policy-relevant conclusion: the modest but steady increase in total variability in monetary policy exposure over the sample is driven primarily by rising within-country regional heterogeneity rather than by growing divergence across member states. This implies that the distributional costs of a common monetary policy are becoming increasingly unequal not so much between countries as within them - a dimension that country-level OCA assessments are by construction unable to detect.

Figure 12: Decomposition of total variation of monetary policy shocks for euro area and by countries



When the same decomposition is applied to the combined contribution of all common shocks - aggregate demand, aggregate supply, and monetary policy together - a strikingly different picture emerges, see Figure 13. Total variability is substantially larger, with a standard deviation averaging around 0.10, but it is essentially flat over the sample: the trend line is slightly declining, from 0.11 at the start to 0.10 at the end, with no persistent increase of the kind observed for monetary policy shocks alone. The crisis-period spike visible in the monetary policy decomposition is therefore largely specific to that shock type, while the overall dispersion in common shock importance across regions has remained broadly stable. At the country level, the debt crisis is nonetheless visible in the between-country component for several countries, though with important differences in magnitude: the country-level share of total dispersion rises from around 73% pre-crisis to over 90% during 2011 - 2013 in Greece and from 75% to 90% in Spain, while remaining broadly unchanged in Italy and Ireland. Some core economies also experienced a noticeable increase in the between-country component during the crisis - most notably Austria (from 39% to 70%), the Netherlands (from 39% to 50%), and Germany (from 21% to 33%) - possibly because their cyclical position became more distinct relative to the euro area average during that period, even if this reflected relative resilience rather than crisis-specific weakness. As a result of these combined movements, the between-country component at the euro area level also rose markedly during the crisis, from around 40% pre-crisis to over 50% in 2011 - 2013, reflecting the generalised increase in cross-country divergence across the union.

Figure 13: Decomposition of total variation of all common shocks (AD, AS and MP)



5 Conclusion

Does one size fit all, or (almost) none? This paper has approached that question from a perspective largely absent from the existing literature: the regional level. Using a Structural Dynamic Factor Model for 165 NUTS 2 regions across 11 euro area countries over 2000 - 2023, we decomposed regional GDP growth into common euro area, country-specific, and idiosyncratic components, identified aggregate demand, aggregate supply, and monetary policy shocks, and traced their propagation to individual regions. The result is the first unified structural framework that allows both dimensions of the OCA problem - shock similarity and monetary policy transmission - to be evaluated jointly at the regional level.

Several substantive findings stand out. The euro area has been moving in the right direction: common shocks have steadily gained importance relative to country-specific and regional disturbances, and border effects - while still pronounced in peripheral economies - have weakened over time. This points to genuine OCA convergence, driven by deepening economic integration rather than by structural homogenisation of regional economies. At the same time, the aggregate picture conceals important heterogeneity within countries. Germany and Italy are the clearest examples, where well-documented income divides map onto equally sharp cyclical fault lines: regions in the north and west are tightly integrated with the common euro area cycle, while those in the south and east remain more exposed to national or local dynamics. Countries with similar aggregate OCA scores can therefore imply very different distributions of the costs of monetary union across their territories.

On the specialisation question, our results appear at first glance to support the Krugman hypothesis: regions with more atypical sectoral compositions tend to be more idiosyncratic in their business cycles. The cross-sectional relationship is largely driven, however, by regions that are structurally exceptional for reasons unrelated to economic integration - overseas territories, remote islands, and resource-dominated economies - which were idiosyncratic before integration deepened and are likely to remain so. The dynamic evidence points in the opposite direction to what Krugman predicts: sectoral structures have changed little over the sample, and the regions most specialised in globally integrated tradeable activities have actually become more synchronised with the common cycle. The endogeneity mechanism of OCA theory therefore appears to be the stronger force over our sample period.

Finally, and most directly relevant for policy, monetary policy shocks generate substantially weaker and more homogeneous regional output responses than demand or supply shocks. Heterogeneity in transmission exists but is modest, bears no systematic relationship to regional economic structure, and is driven more by within-country variation than by cross-country fragmentation. The distributional costs of the common monetary policy therefore arise primarily from unequal shock exposure rather than from unequal transmission - and those costs are increasingly concentrated within countries rather than between them.

The regional lens does not overturn the case for a common monetary policy in the euro area, but it sharpens it. Integration is proceeding, OCA properties are improving, and monetary transmission is broadly comparable across regions. What remains is a distribution problem: the benefits and costs of the common policy are not spread evenly across the territory of the union, and that unevenness is becoming more a within-country than a cross-country phenomenon - a distinction that country-level analysis is structurally unable to capture.

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Appendix A Core supplementary material

A.1 NUTS 2 regions

Region	Code	Region	Code	Region	Code
Austria					
Burgenland	AT11	Niederösterreich	AT12	Wien	AT13
Kärnten	AT21	Steiermark	AT22	Oberösterreich	AT31
Salzburg	AT32	Tirol	AT33	Vorarlberg	AT34
Belgium					
Région de Bruxelles-Capitale	BE10	Prov. Antwerpen	BE21	Prov. Limburg (BE)	BE22
Prov. Oost-Vlaanderen	BE23	Prov. Vlaams-Brabant	BE24	Prov. West-Vlaanderen	BE25
Prov. Brabant wallon	BE31	Prov. Hainaut	BE32	Prov. Liège	BE33
Prov. Luxembourg (BE)	BE34	Prov. Namur	BE35		
Finland					
Länsi-Suomi	FI19	Helsinki-Uusimaa	FI1B	Etelä-Suomi	FI1C
Pohjois- ja Itä-Suomi	FI1D	Åland	FI20		
France					
Île-de-France	FR10	Centre - Val de Loire	FRB0	Bourgogne	FRC1
Franche-Comté	FRC2	Basse-Normandie	FRD1	Haute-Normandie	FRD2
Nord-Pas de Calais	FRE1	Picardie	FRE2	Alsace	FRF1
Champagne-Ardenne	FRF2	Lorraine	FRF3	Pays de la Loire	FRG0
Bretagne	FRH0	Aquitaine	FRI1	Limousin	FRI2
Poitou-Charentes	FRI3	Languedoc-Roussillon	FRJ1	Midi-Pyrénées	FRJ2
Auvergne	FRK1	Rhône-Alpes	FRK2	Provence-Alpes-Côte d'Azur	FRL0
Corse	FRM0	Guadeloupe	FRY1	Martinique	FRY2
Guyane	FRY3	La Réunion	FRY4	Mayotte	FRY5
Germany					
Stuttgart	DE11	Karlsruhe	DE12	Freiburg	DE13
Tübingen	DE14	Oberbayern	DE21	Niederbayern	DE22
Oberpfalz	DE23	Oberfranken	DE24	Mittelfranken	DE25
Unterfranken	DE26	Schwaben	DE27	Berlin	DE30
Brandenburg	DE40	Bremen	DE50	Hamburg	DE60
Darmstadt	DE71	Gießen	DE72	Kassel	DE73
Mecklenburg-Vorpommern	DE80	Braunschweig	DE91	Hannover	DE92
Lüneburg	DE93	Weser-Ems	DE94	Düsseldorf	DEA1
Köln	DEA2	Münster	DEA3	Detmold	DEA4
Arnsberg	DEA5	Koblenz	DEB1	Trier	DEB2
Rheinhessen-Pfalz	DEB3	Saarland	DEC0	Dresden	DED2
Chemnitz	DED4	Leipzig	DED5	Sachsen-Anhalt	DEE0
Schleswig-Holstein	DEF0	Thüringen	DEG0		
Greece (Latin transliteration)					
Attiki	EL30	Voreio Aigaio	EL41	Notio Aigaio	EL42
Kriti	EL43	Anatoliki Makedonia, Thraki	EL51	Kentriki Makedonia	EL52
Dytiki Makedonia	EL53	Ipeiros	EL54	Thessalia	EL61
Ionia Nisia	EL62	Dytiki Ellada	EL63	Sterea Ellada	EL64
Peloponnisos	EL65				
Ireland					

Region	Code	Region	Code	Region	Code
Northern and Western	IE04	Southern	IE05	Eastern and Midland	IE06
Italy					
Piemonte	ITC1	Valle d'Aosta/Vallée d'Aoste	ITC2	Liguria	ITC3
Lombardia	ITC4	Abruzzo	ITF1	Molise	ITF2
Campania	ITF3	Puglia	ITF4	Basilicata	ITF5
Calabria	ITF6	Sicilia	ITG1	Sardegna	ITG2
Prov. Aut. Bolzano/Bozen	ITH1	Prov. Aut. Trento	ITH2	Veneto	ITH3
Friuli-Venezia Giulia	ITH4	Emilia-Romagna	ITH5	Toscana	ITI1
Umbria	ITI2	Marche	ITI3	Lazio	ITI4
Netherlands					
Groningen	NL11	Friesland (NL)	NL12	Drenthe	NL13
Overijssel	NL21	Gelderland	NL22	Flevoland	NL23
Utrecht	NL31	Noord-Holland	NL32	Zuid-Holland	NL33
Zeeland	NL34	Noord-Brabant	NL41	Limburg (NL)	NL42
Portugal					
Norte	PT11	Algarve	PT15	Centro (PT)	PT16
Área Metropolitana de Lisboa	PT17	Alentejo	PT18	Região Autónoma dos Açores	PT20
Região Autónoma da Madeira	PT30				
Spain					
Galicia	ES11	Principado de Asturias	ES12	Cantabria	ES13
País Vasco	ES21	Comunidad Foral de Navarra	ES22	La Rioja	ES23
Aragón	ES24	Comunidad de Madrid	ES30	Castilla y León	ES41
Castilla-La Mancha	ES42	Extremadura	ES43	Cataluña	ES51
Comunitat Valenciana	ES52	Illes Balears	ES53	Andalucía	ES61
Región de Murcia	ES62	Ciudad de Ceuta	ES63	Ciudad de Melilla	ES64
Canarias	ES70				

A.2 Temporal disaggregation of regional GDP

Since quarterly regional GDP is obtained by temporally disaggregating annual data using the Chow-Lin procedure with national GDP as the indicator variable, a natural concern is that this step could mechanically corrupt the decomposition of regional business cycles. As noted in Section 3, this concern is mitigated by the fact that the Chow-Lin method relies on region-specific GLS regressions rather than rescaling each region by a common factor, so the quarterly profile of each regional series reflects its own historical co-movement with the national indicator rather than a mechanical copy of national dynamics. Nevertheless, since the indicator series is common to all regions within a country, some degree of artificially induced co-movement cannot be ruled out a priori, and we therefore test for it directly.

Despite this concern, quarterly data are preferred in the baseline analysis, as annual data would severely limit the identification of monetary policy shocks. To assess the robustness of our results, we therefore estimate the model using annual regional GDP data. The results indicate that the quantitative importance of the country component is indeed somewhat smaller at the annual frequency, with the common euro area component correspondingly larger; the regional share remains virtually unchanged across frequencies.[25]

Importantly, the qualitative conclusions are unaffected. The common component remains the dominant source of business cycle fluctuations and exhibits a rising trend over time at country level (see Figures 1 and 2). Countries that display a relatively larger country-specific component in the quarterly specification retain this ranking in the annual specification. Moreover, the regional component continues to play a more prominent role in core economies relative to peripheral ones. These findings suggest that while temporal disaggregation may affect the precise quantitative split between common and country components, it does not generate artificial regional heterogeneity or alter the substantive conclusions of the paper. On the contrary, the annual results further reinforce the evidence of increasing commonality in euro area business cycles.

[25] Results based on annual regional GDP data are available upon request.

Figure 1: Forecast error variance decomposition at country level (annual data)

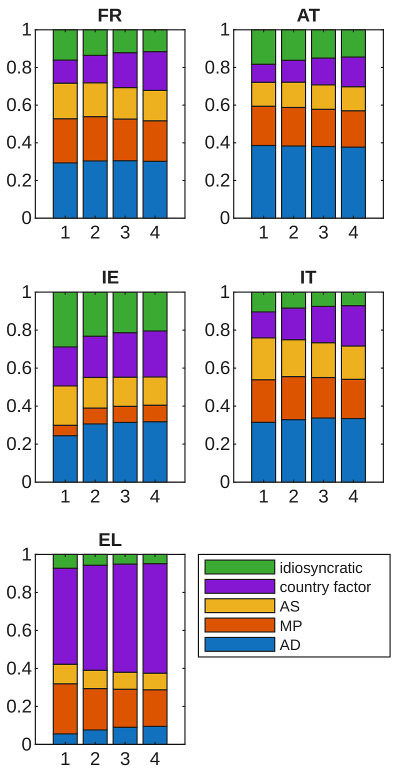
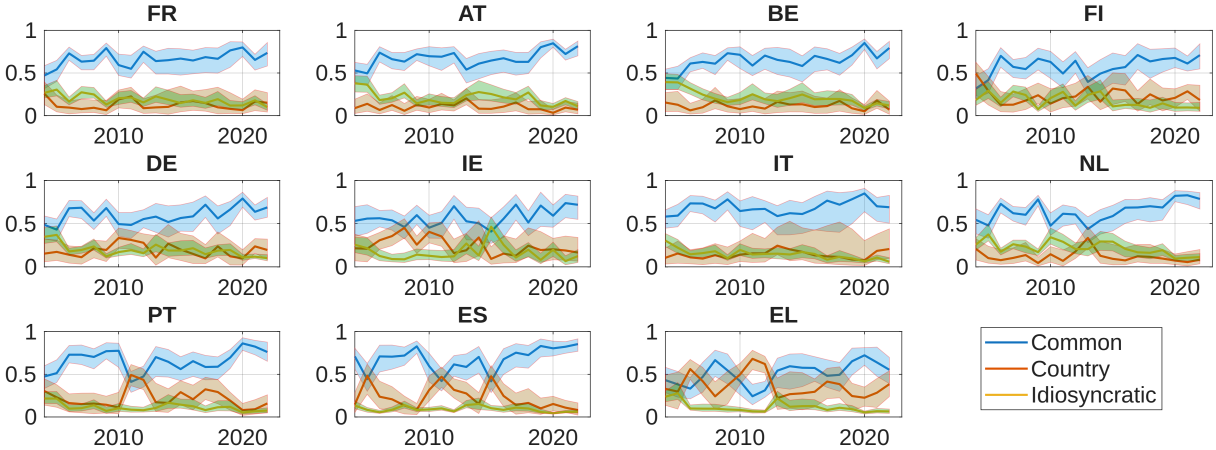


Figure 2: Relative importance of common, country specific and regional shocks at country level (annual data)



A.3 Tables

Table 2. NACE Rev. 2 classification and five-component aggregation

Aggregate	Sec.	Description	NACE
Agriculture	A	Agriculture, forestry and fishing	A
Industry	B	Mining and quarrying	B - E
	C	Manufacturing	
	D	Electricity, gas, steam and air conditioning supply	
	E	Water supply, sewerage, waste management	
Construction	F	Construction	F
Mkt. svc.	G	Wholesale and retail trade; repair of motor vehicles	G - N
	H	Transportation and storage	
	I	Accommodation and food service activities	
	J	Information and communication	
	K	Financial and insurance activities	
	L	Real estate activities	
	M	Professional, scientific and technical activities	
	N	Administrative and support service activities	
Non-mkt. svc.	O	Public administration, defence; social security	O - U
	P	Education	
	Q	Human health and social work activities	
	R	Arts, entertainment and recreation	
	S	Other service activities	
	T	Activities of households as employers	
	U	Extraterritorial organisations and bodies	

Notes: Source: Eurostat, NACE Rev. 2 (Regulation EC No 1893/2006). Mkt. svc. = Market services; Non-mkt. svc. = Non-market services. In Eurostat `nama_10_a10`: Industry = `B−E`; Market services = `G−J` + `K−N`; Non-market services = `O−U`.

Table 3. Cross-country synchronisation

Component	Correlation: Full sample	Correlation: Pre-COVID	Correlation: Excl. 2020 - 22	Rank: Full sample	Rank: Pre-COVID	Rank: Excl. 2020 - 22
Agriculture (A)	0.20	0.21	0.22	5	5	5
Industry (B - E)	0.45	0.53	0.49	3	2	2
Construction (F)	0.24	0.31	0.28	4	4	4
Mkt. svc. (G - N)	0.65	0.56	0.54	2	1	1
Non-mkt. svc. (O - U)	0.81	0.37	0.42	1	3	3

Notes: Average pairwise Pearson correlation across $\binom{11}{2} = 55$ country pairs (EA11: BE, DE, ES, FI, FR, GR, IE, IT, NL, AT, PT). Full sample: 2001 - 2023 ($n = 23$); Pre-COVID: 2001 - 2019 ($n = 19$); Excl. 2020 - 22: dropping 2020 - 2022 ($n = 20$). Mkt./non-mkt. svc. sub-indices summed in levels, then log-differenced. Source: Eurostat `nama_10_a10`, chain-linked volumes, 2010 = 100.

Table 4. Between-component correlations, avg. across EA11 countries

	Agriculture: Full	Agriculture: Pre	Industry: Full	Industry: Pre	Construction: Full	Construction: Pre	Mkt. svc.: Full	Mkt. svc.: Pre	Non-mkt. svc.: Full	Non-mkt. svc.: Pre	Avg: Full	Avg: Pre
Agriculture	-	-	0.11	0.09	0.02	0.02	0.10	0.10	0.07	0.13	0.08	0.09
Industry			-	-	0.39	0.40	0.57	0.56	0.41	0.35	0.37	0.35
Construction					-	-	0.54	0.58	0.30	0.44	0.31	0.36
Mkt. svc.							-	-	0.64	0.46	0.46	0.43
Non-mkt. svc.									-	-	0.36	0.34

Notes: For each of the 11 countries a 5×5 between-sector Pearson correlation matrix is computed; entries are unweighted means across the 11 matrices. Avg: mean of off-diagonal entries. Full = 2001 - 2023; Pre = pre-COVID (2001 - 2019). Mkt. svc. = Market services (G - N); Non-mkt. svc. = Non-market services (O - U).

Table 5. Specialisation and Regional Shock Importance: OLS

		AD	AS	MP	Common	Country	Regional
KSI	Coef.	$-0.05\,(**)$	$-0.05\,(**)$	$0.01\,(\cdot)$	$-0.09\,(**)$	$-0.27\,(***)$	$0.36\,(***)$
	R^2	0.17	0.17	0.16	0.15	0.42	0.40
Agriculture	Coef.	$-0.16\,(\cdot)$	$-0.31\,(**)$	$-0.30\,(***)$	$-0.78\,(***)$	$0.05\,(\cdot)$	$0.72\,(**)$
	R^2	0.15	0.17	0.20	0.17	0.28	0.19
Construction	Coef.	$-0.56\,(\cdot)$	$-0.59\,(*)$	$-0.27\,(\cdot)$	$-1.42\,(**)$	$-0.03\,(\cdot)$	$1.44\,(*)$
	R^2	0.16	0.16	0.16	0.15	0.28	0.19
Market services	Coef.	$-0.09\,(*)$	$-0.14\,(***)$	$-0.01\,(\cdot)$	$-0.23\,(**)$	$-0.13\,(\cdot)$	$0.36\,(***)$
	R^2	0.16	0.20	0.16	0.16	0.29	0.23
Non-mkt services	Coef.	$-0.08\,(\cdot)$	$-0.05\,(\cdot)$	$0.02\,(\cdot)$	$-0.12\,(\cdot)$	$-0.52\,(***)$	$0.63\,(***)$
	R^2	0.16	0.15	0.16	0.14	0.39	0.32
Industry	Coef.	$-0.05\,(\cdot)$	$0.01\,(\cdot)$	$0.06\,(*)$	$0.02\,(\cdot)$	$-0.55\,(***)$	$0.52\,(***)$
	R^2	0.15	0.14	0.17	0.13	0.41	0.28
Baseline: country dummies only							
	R^2	0.14	0.14	0.16	0.13	0.28	0.17

Notes: OLS regressions with country fixed effects. KSI = aggregate Krugman specialisation index; remaining rows are sector-level KSI components, all measured as deviations from the euro area average. Dependent variables are shares of regional output variance attributed to each structural shock and to the common, country-specific, and region-specific components, as measured by the historical decomposition. Baseline uses country dummies only. Significance: $^{(***)}$ p<0.01, $^{(**)}$ p<0.05, $^{(*)}$ p<0.10, $^{(\cdot)}$ not significant.

Table 6. Specialisation and IRF (horizon 4): KSI sector components (deviations from euro area average)

		No country FE			*Country FE*		
		AD	AS	MP	AD	AS	MP
KSI	Coef.	$-0.28\,(**)$	$-0.32\,(***)$	$-0.11\,(\cdot)$	$-0.41\,(***)$	$-0.40\,(***)$	$-0.07\,(\cdot)$
	R^2	0.03	0.07	0.01	0.18	0.16	0.15
Agriculture	Coef.	$0.14\,(\cdot)$	$-0.96\,(\cdot)$	$-1.27\,(**)$	$-0.28\,(\cdot)$	$-1.65\,(**)$	$-1.37\,(**)$
	R^2	0.00	0.02	0.04	0.14	0.12	0.17
Construction	Coef.	$0.74\,(\cdot)$	$-1.73\,(\cdot)$	$-1.80\,(*)$	$-3.06\,(\cdot)$	$-2.79\,(*)$	$-0.67\,(\cdot)$
	R^2	0.00	0.01	0.02	0.15	0.10	0.14
Market services	Coef.	$-0.17\,(\cdot)$	$-0.59\,(***)$	$-0.02\,(\cdot)$	$-0.38\,(\cdot)$	$-0.81\,(***)$	$0.12\,(\cdot)$
	R^2	0.00	0.07	0.00	0.14	0.16	0.15
Non-mkt services	Coef.	$-0.84\,(***)$	$-0.63\,(***)$	$-0.30\,(\cdot)$	$-0.85\,(***)$	$-0.62\,(***)$	$-0.37\,(*)$
	R^2	0.05	0.05	0.01	0.18	0.13	0.16
Industry	Coef.	$-0.72\,(**)$	$-0.16\,(\cdot)$	$-0.10\,(\cdot)$	$-0.66\,(**)$	$-0.17\,(\cdot)$	$0.02\,(\cdot)$
	R^2	0.04	0.00	0.00	0.16	0.09	0.14
		Baseline: country dummies only					
	R^2	0.13	0.09	0.14			

Notes: OLS regressions (with and without country fixed effects). KSI = Krugman specialisation index; sector-level components measured as deviations from the euro area average. Dependent variables are impulse response functions of regional output at horizon $h = 4$. Baseline uses country fixed effects only. Significance: $^{(***)}$ p<0.01, $^{(**)}$ p<0.05, $^{(*)}$ p<0.10, $^{(\cdot)}$ not significant.

Table 7. Specialisation and IRF (horizon 4): Sign-sensitive KSI (signed deviations from euro area average)

		No country FE			*Country FE*		
		AD	AS	MP	AD	AS	MP
Agriculture	Coef.	$-0.03\,(\cdot)$	$-0.78\,(*)$	$-0.89\,(**)$	$-0.13\,(\cdot)$	$-1.24\,(**)$	$-1.02\,(**)$
	R^2	0.00	0.02	0.03	0.13	0.11	0.17
Construction	Coef.	$1.02\,(\cdot)$	$-0.79\,(\cdot)$	$-1.10\,(*)$	$-0.43\,(\cdot)$	$-0.83\,(\cdot)$	$-1.23\,(\cdot)$
	R^2	0.01	0.01	0.02	0.14	0.09	0.16
Market services	Coef.	$-0.03\,(\cdot)$	$-0.00\,(\cdot)$	$0.42\,(***)$	$-0.05\,(\cdot)$	$-0.02\,(\cdot)$	$0.40\,(***)$
	R^2	0.00	0.00	0.07	0.14	0.09	0.21
Non-mkt services	Coef.	$-0.51\,(**)$	$-0.58\,(***)$	$-0.24\,(\cdot)$	$-0.57\,(**)$	$-0.66\,(***)$	$-0.35\,(**)$
	R^2	0.03	0.07	0.01	0.17	0.16	0.17
Industry	Coef.	$0.28\,(\cdot)$	$0.43\,(***)$	$-0.14\,(\cdot)$	$0.44\,(**)$	$0.54\,(***)$	$-0.16\,(\cdot)$
	R^2	0.02	0.06	0.01	0.16	0.16	0.15
		Baseline: country dummies only					
	R^2	0.13	0.09	0.14			

Notes: OLS regressions (with and without country fixed effects). KSI = sector-level sign-sensitive Krugman specialisation index components, measured as deviations from the euro area average. Dependent variables are impulse response functions of regional output at horizon $h = 4$. Baseline uses country fixed effects only. Significance: $^{(***)}$ p<0.01, $^{(**)}$ p<0.05, $^{(*)}$ p<0.10, $^{(\cdot)}$ not significant.

A.4 Regional economic structure

Figure 3: Components of the Krugman specialization index

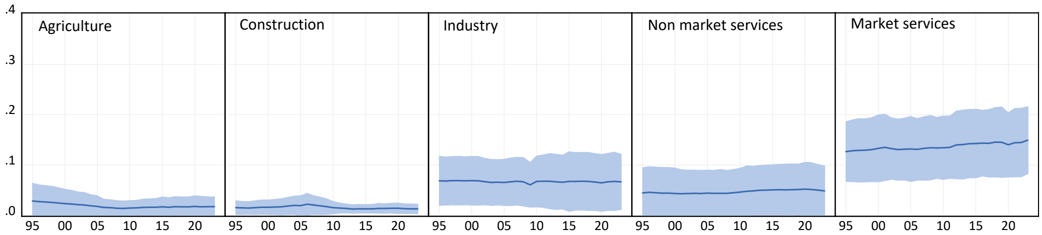


Figure 4: Regions with highest importance of regional shocks: GDP per capita and share of industry

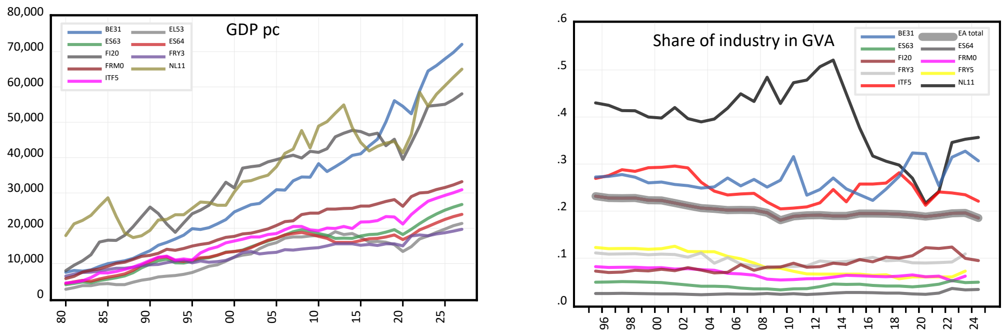
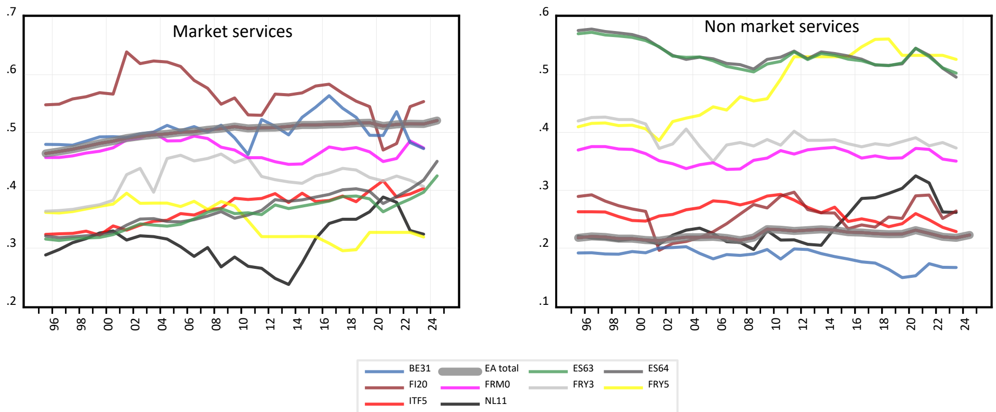


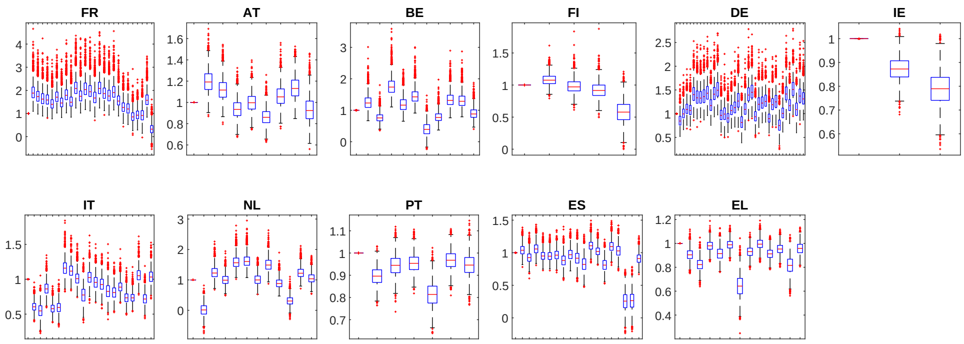
Figure 5: Regions with highest importance of regional shocks: services



Appendix B Additional supplementary material

B.1 Factor identification

Figure 6: Posterior distribution of $\Lambda^{2,i}$ (loadings on common factor)



B.2 Impulse response functions

Figure 7: Impulse responses from the structural VAR block of the SDFM (median and 68% posterior bands)

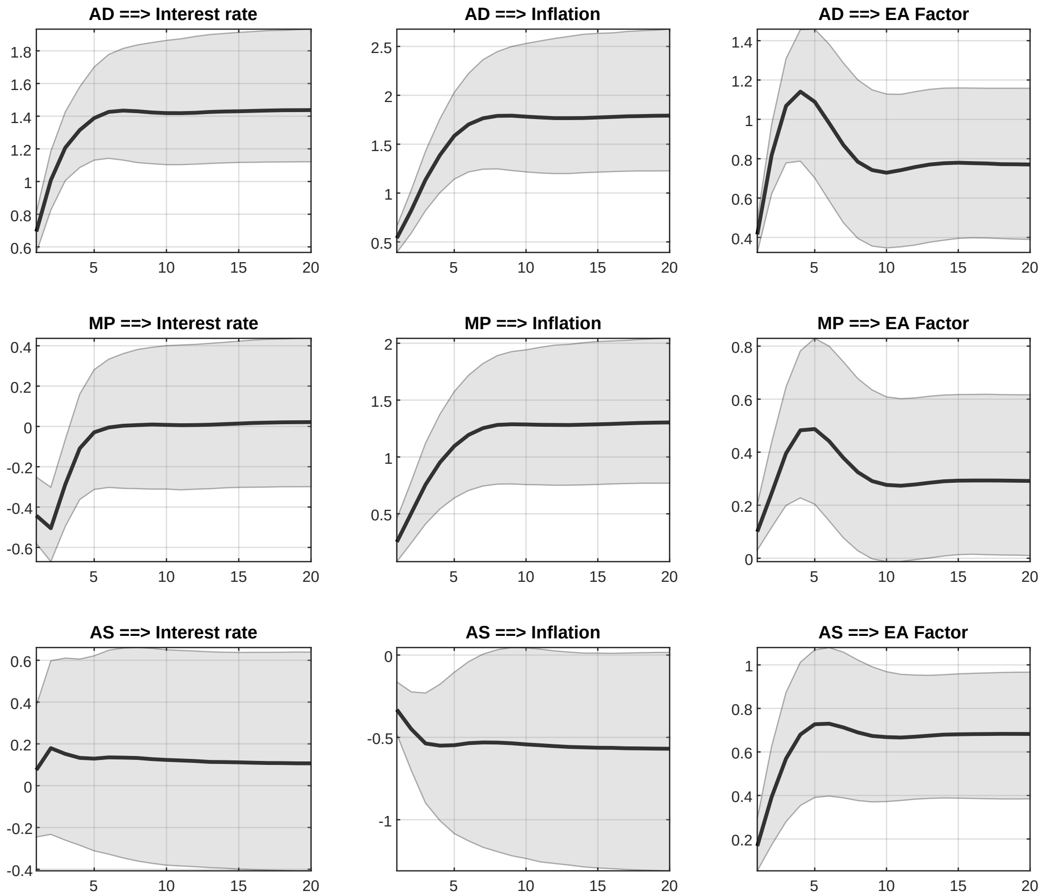


Figure 8: Impulse response functions for euro area (median and 68% posterior bands)

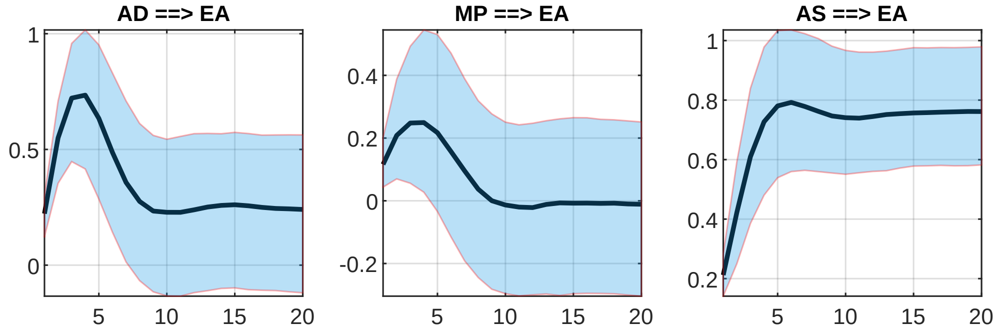


Figure 9: Impulse responses across regional income quintiles (median and 68% posterior bands)

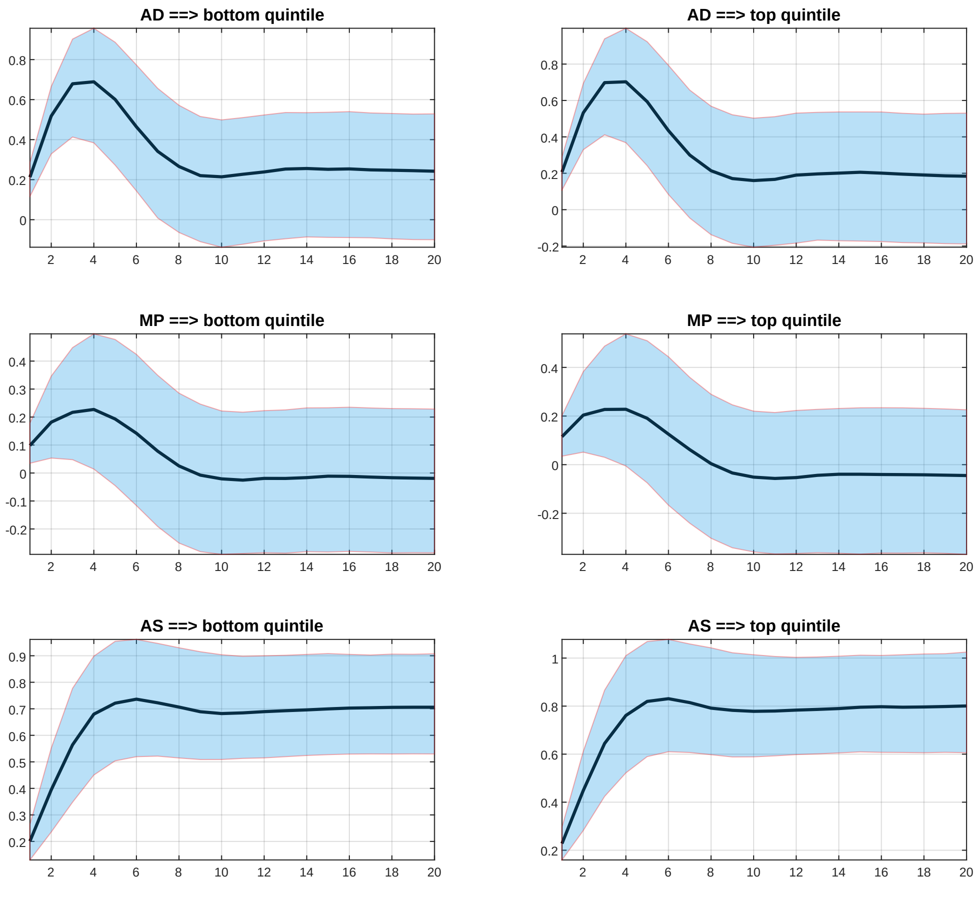
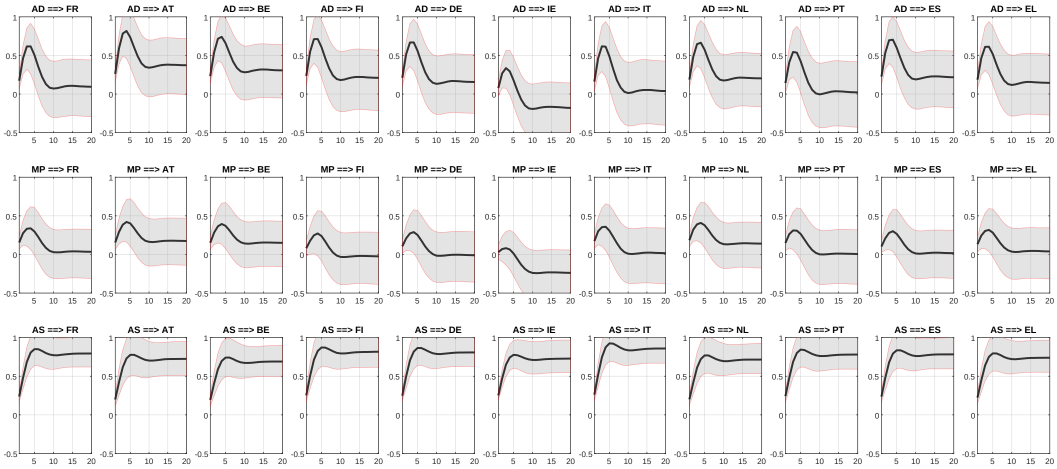


Figure 10: Impulse response functions by country (median and 68% posterior bands)



B.3 Relative importance of shocks

Figure 11: Forecast error variance decomposition for the euro area

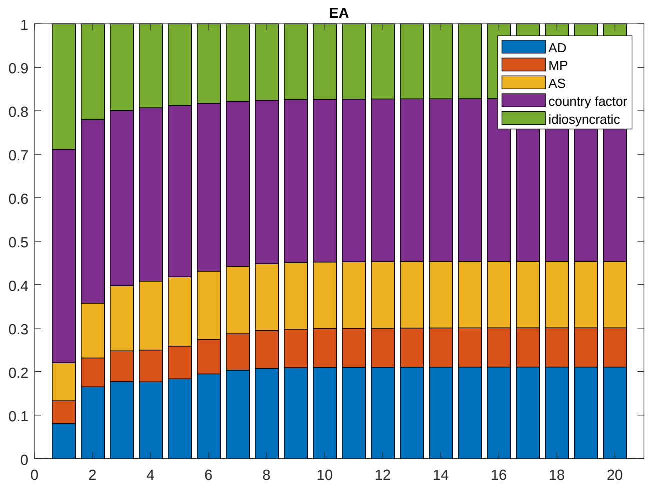
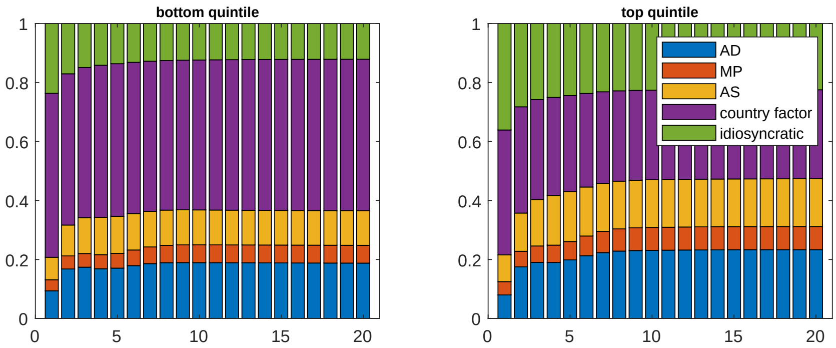
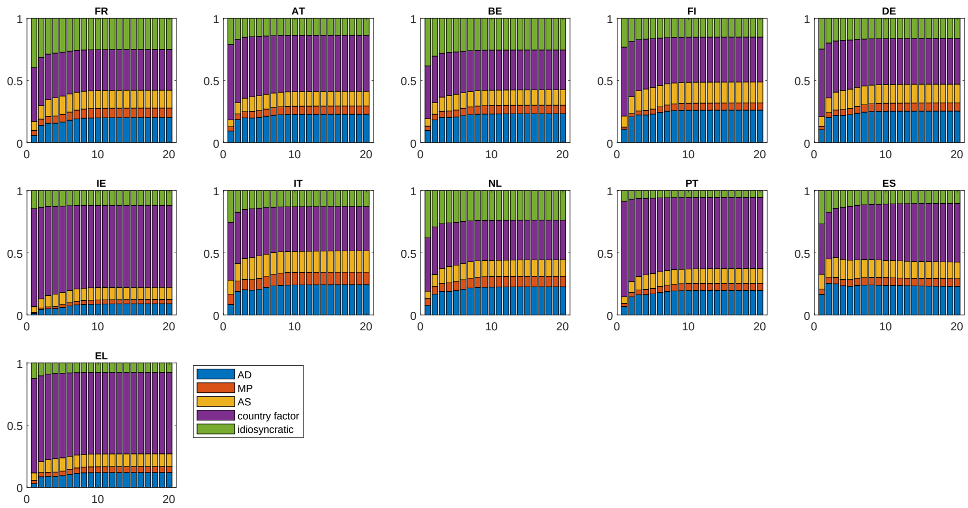


Figure 12: Relative importance of shocks in poor vs. rich regions



Note: Bottom quintile represents poorest 10% of the regions and top quintile is richest 10% measured by regional GDP per capita.

Figure 13: Forecast error variance decomposition at country level



B.4 Appendix: Regional Results by Country

For each country, this appendix reports three sets of results at the regional level. First, impulse response functions (IRFs) showing the output response to each of the three identified common shocks - aggregate demand (AD), aggregate supply (AS), and monetary policy (MP) - at a four-quarter horizon. Second, the relative importance of each shock as derived from the historical decomposition (HD), measuring the contribution of each shock to historical output fluctuations. Third, the share of output forecast error variance attributable to each shock across horizons, as given by the forecast error variance decomposition (FEVD).

B.5 Austria (AT)

Figure 14: Regional impulse response functions: Aggregate demand shock - Austria

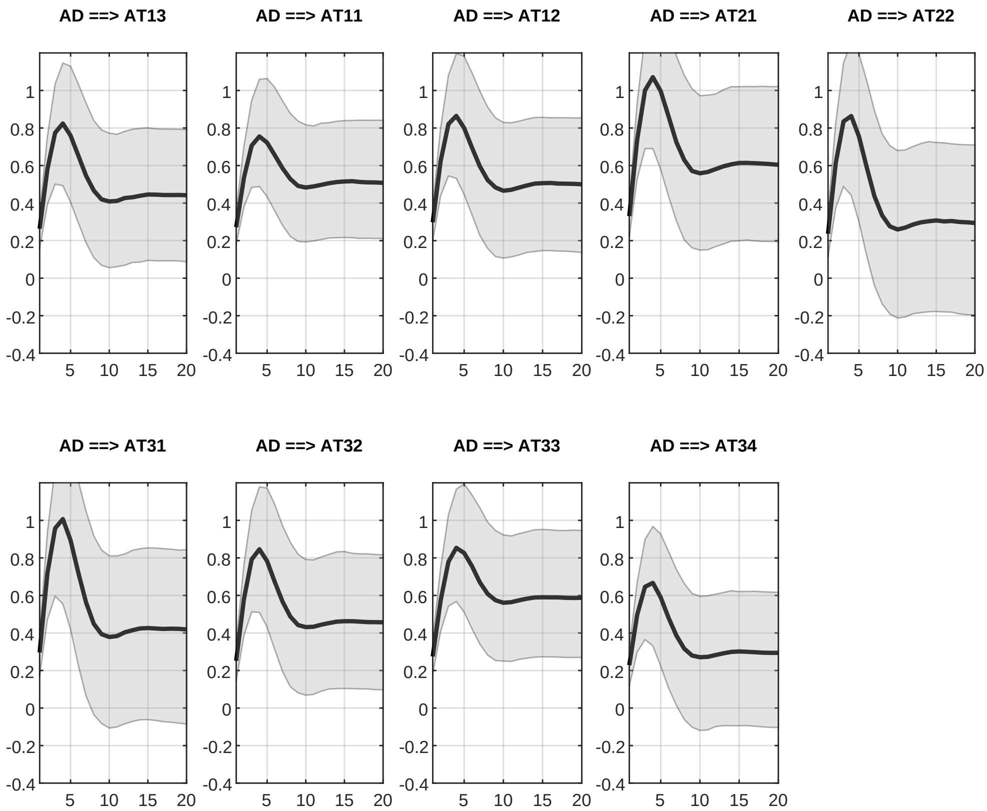


Figure 15: Regional impulse response functions: Aggregate supply shock - Austria

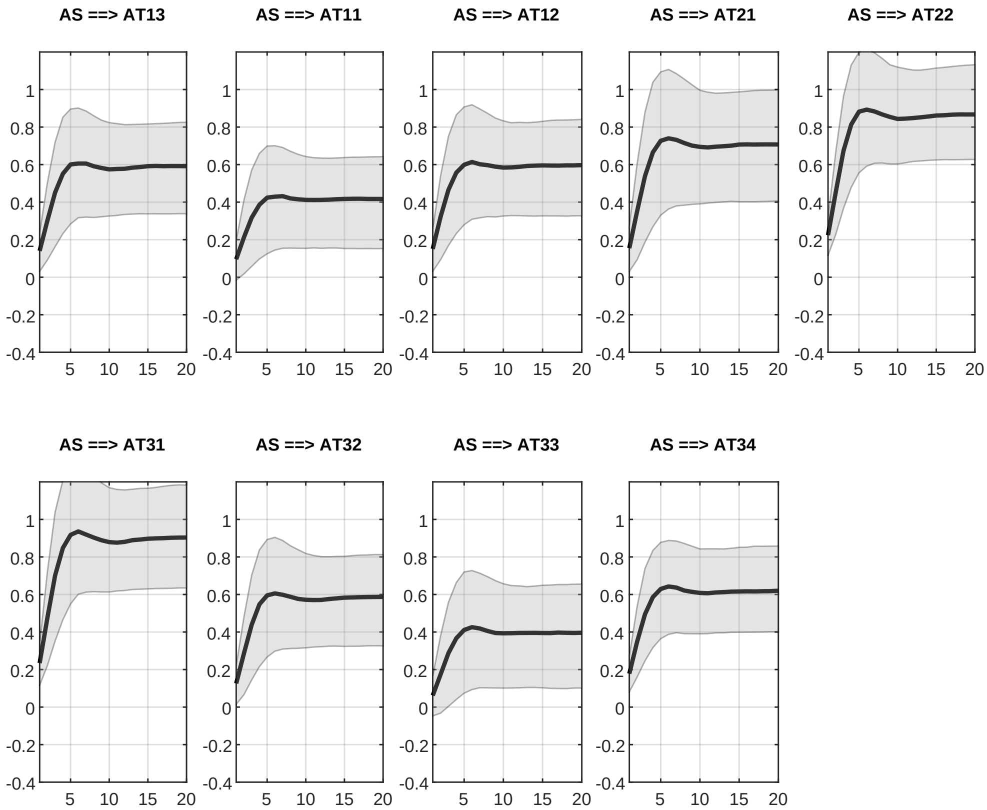


Figure 16: Regional impulse response functions: Monetary policy shock - Austria

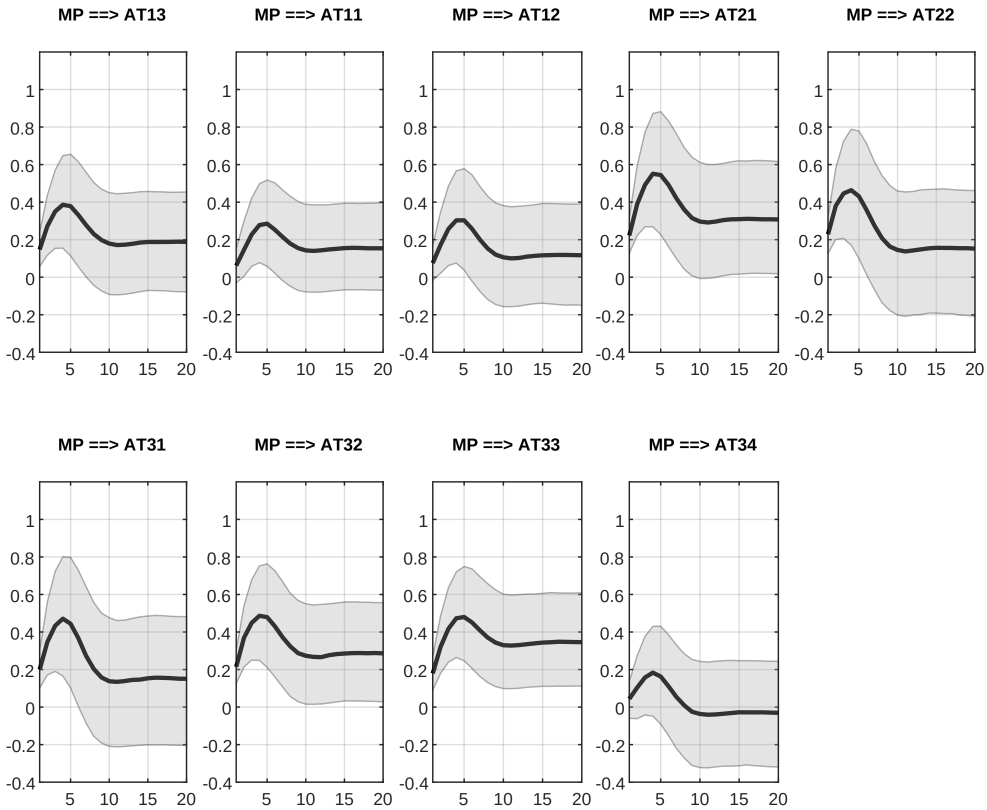
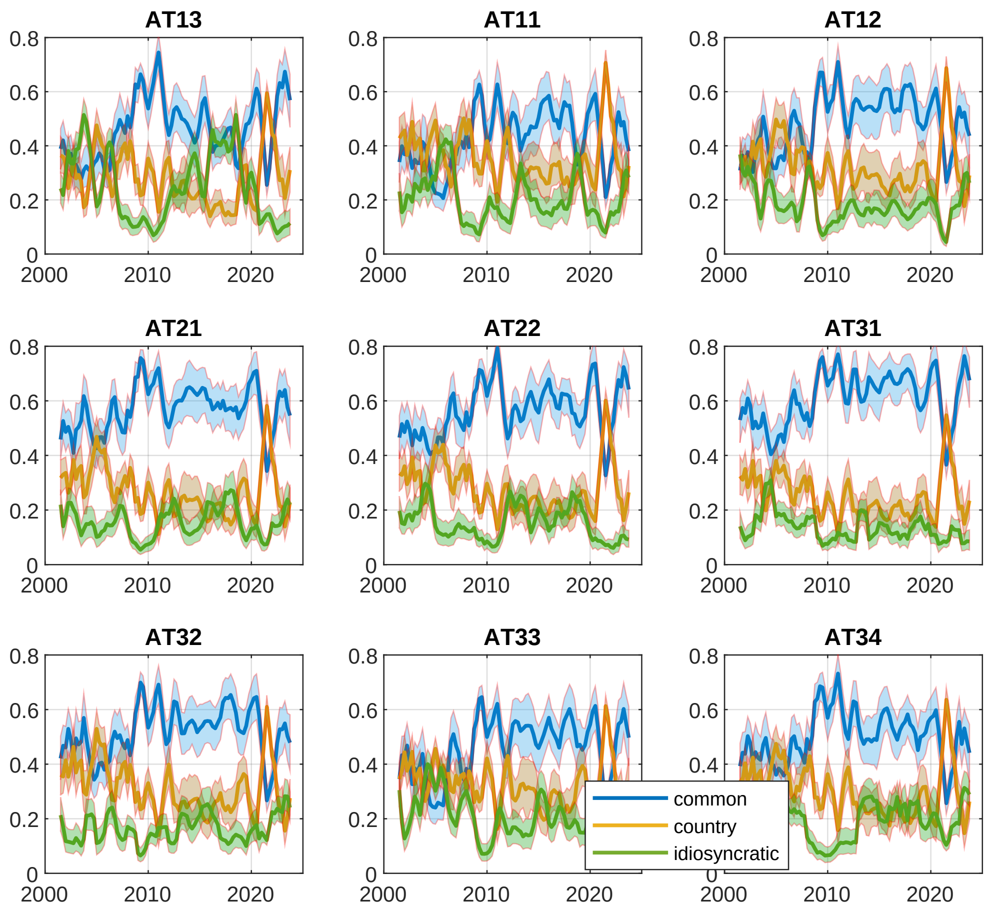
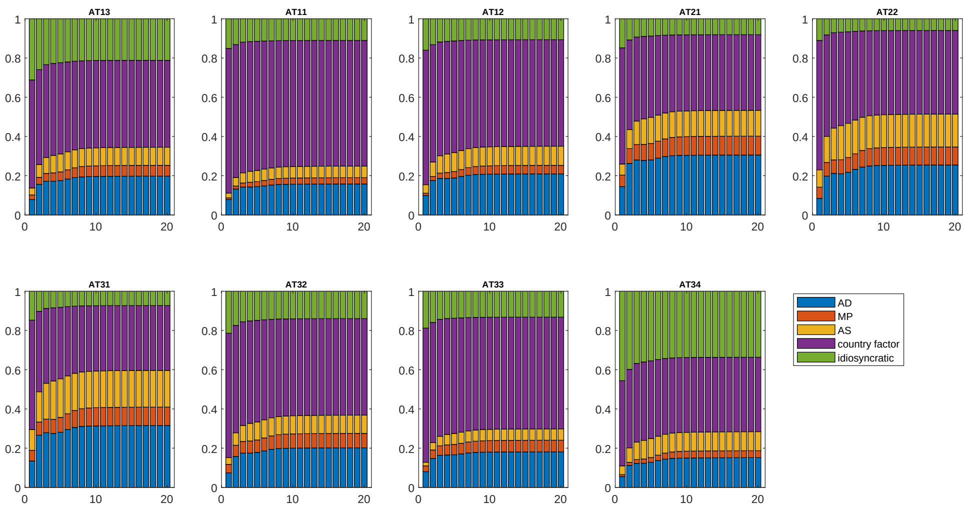


Figure 17: Regional relative importance of common shocks: historical decomposition - Austria



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 18: Regional relative importance of common shocks: forecast error variance decomposition - Austria



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.6 Belgium (BE)

Figure 19: Regional impulse response functions: Aggregate demand shock - Belgium

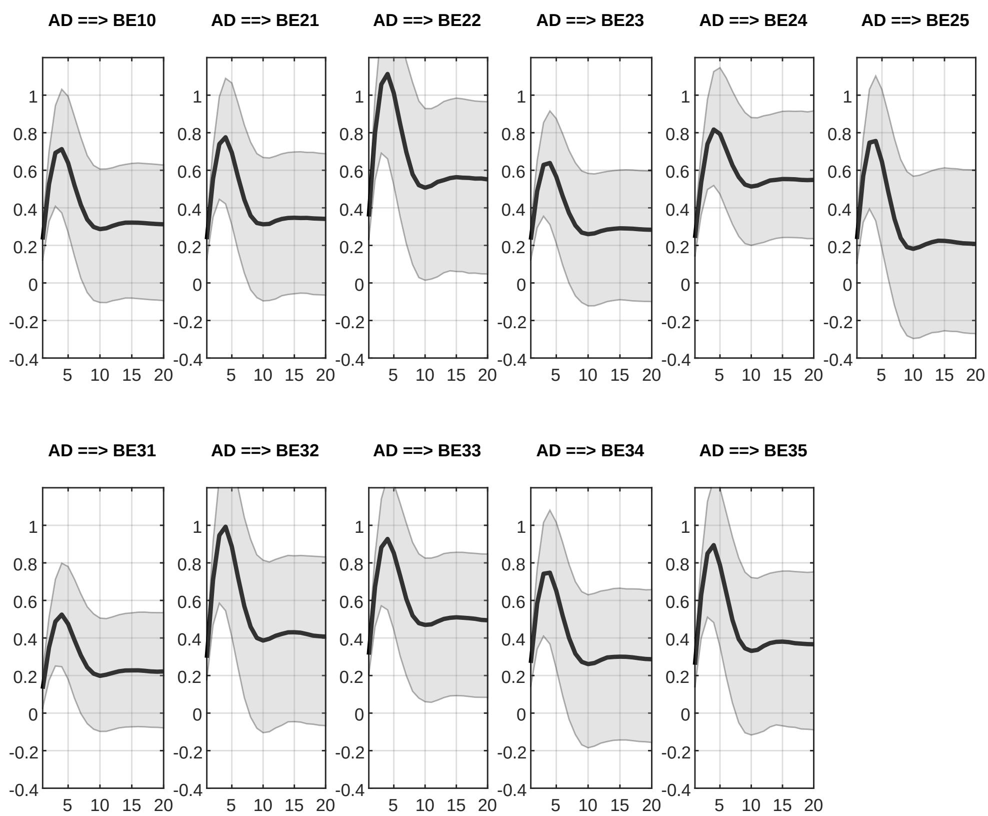


Figure 20: Regional impulse response functions: Aggregate supply shock - Belgium

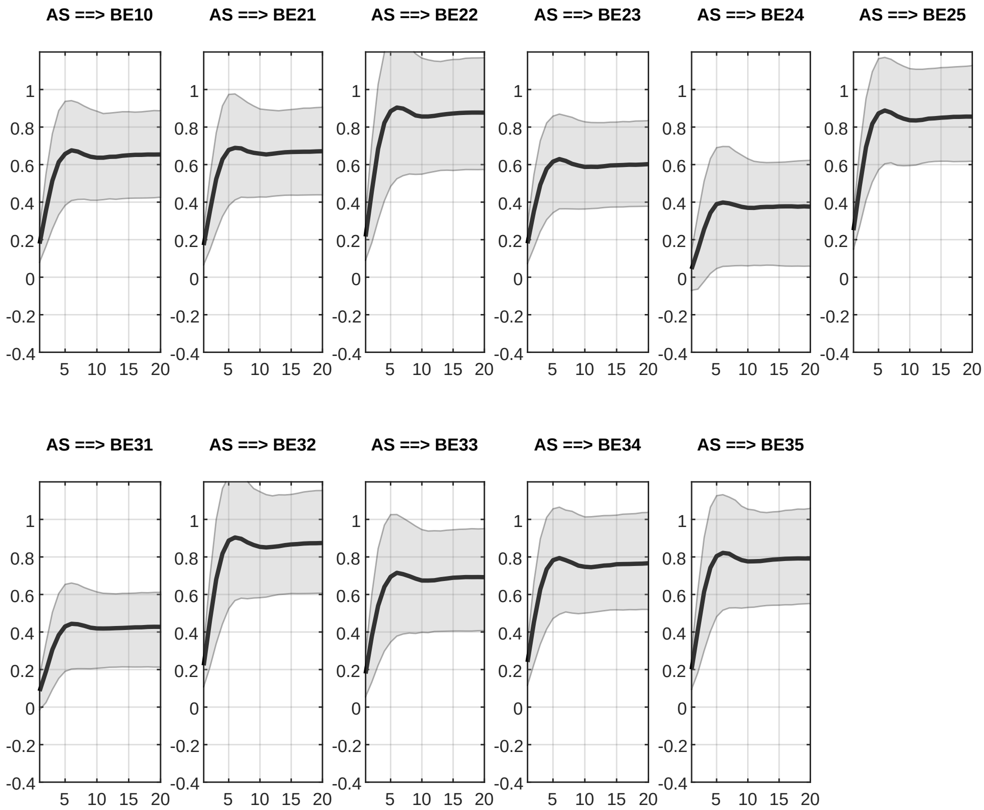


Figure 21: Regional impulse response functions: Monetary policy shock - Belgium

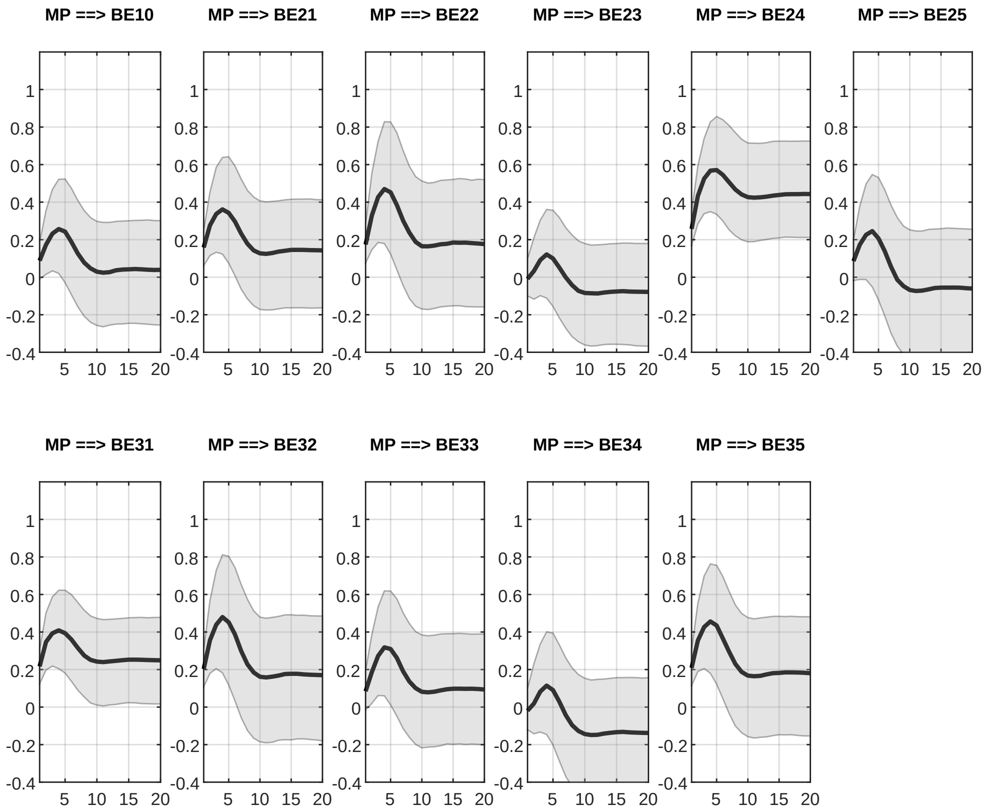
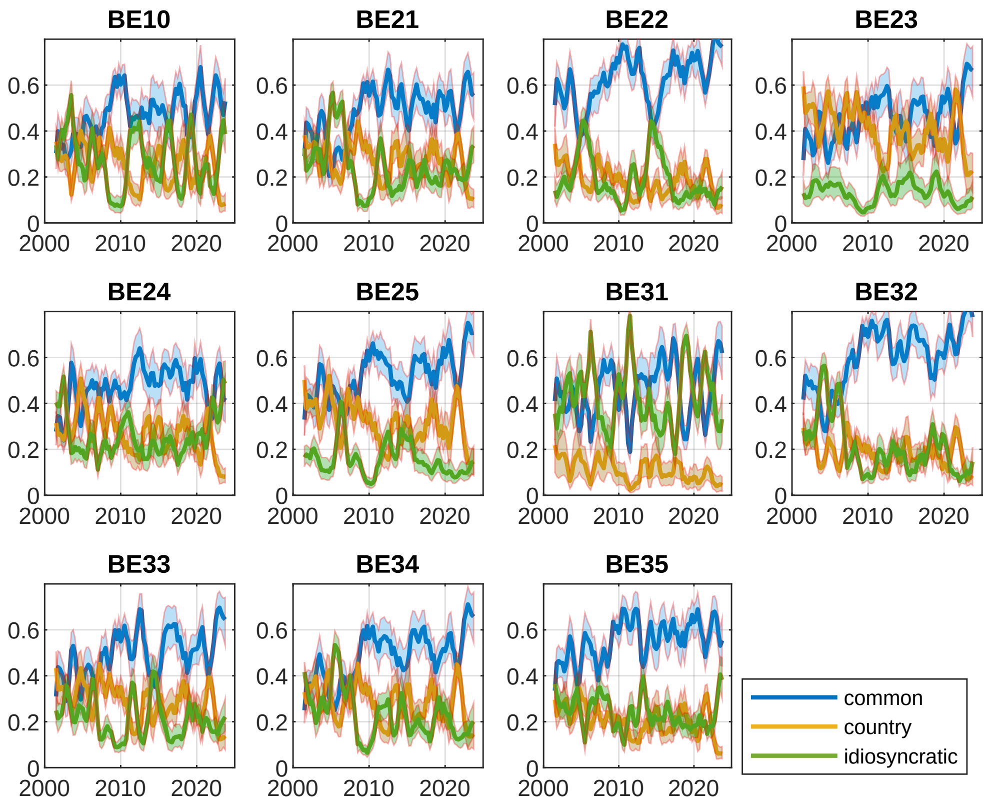
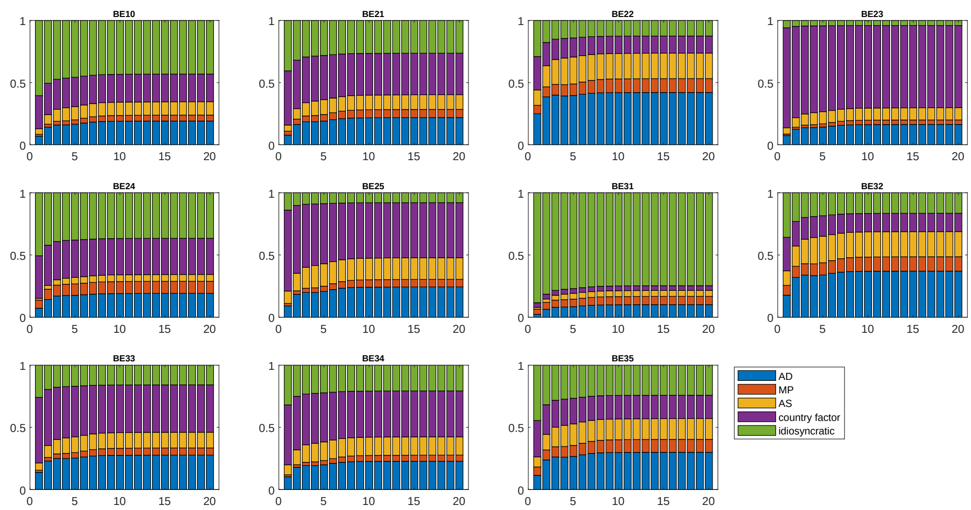


Figure 22: Regional relative importance of common shocks: historical decomposition - Belgium



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 23: Regional relative importance of common shocks: forecast error variance decomposition - Belgium



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.7 Germany (DE)

Figure 24: Regional impulse response functions: Aggregate demand shock - Germany

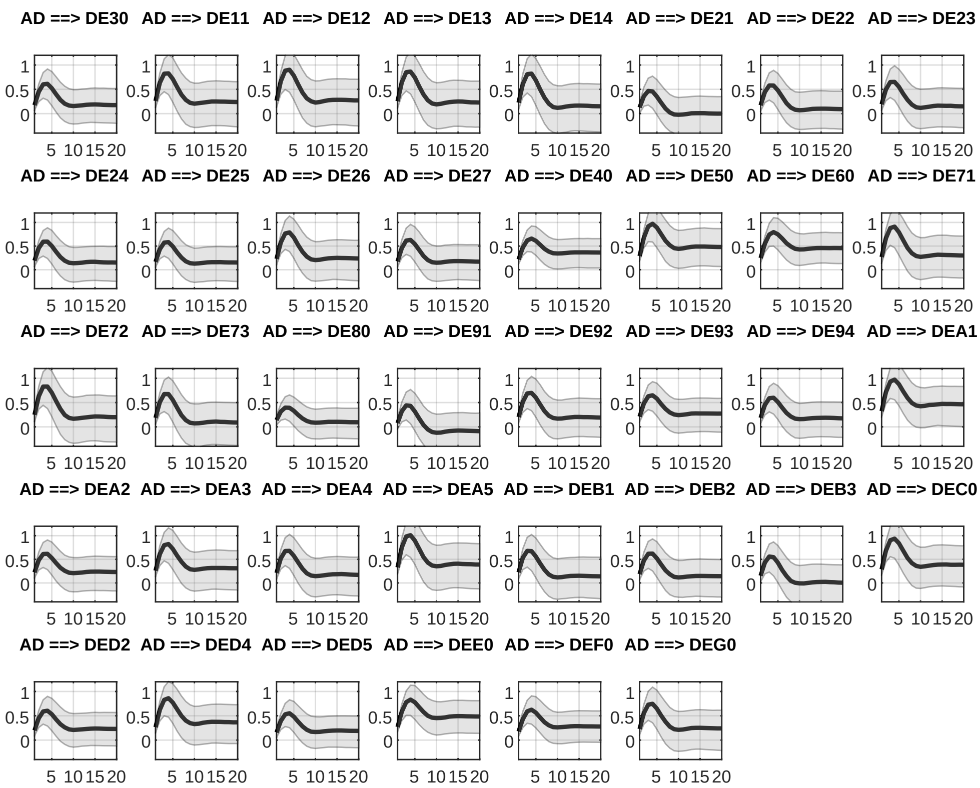


Figure 25: Regional impulse response functions: Aggregate supply shock - Germany

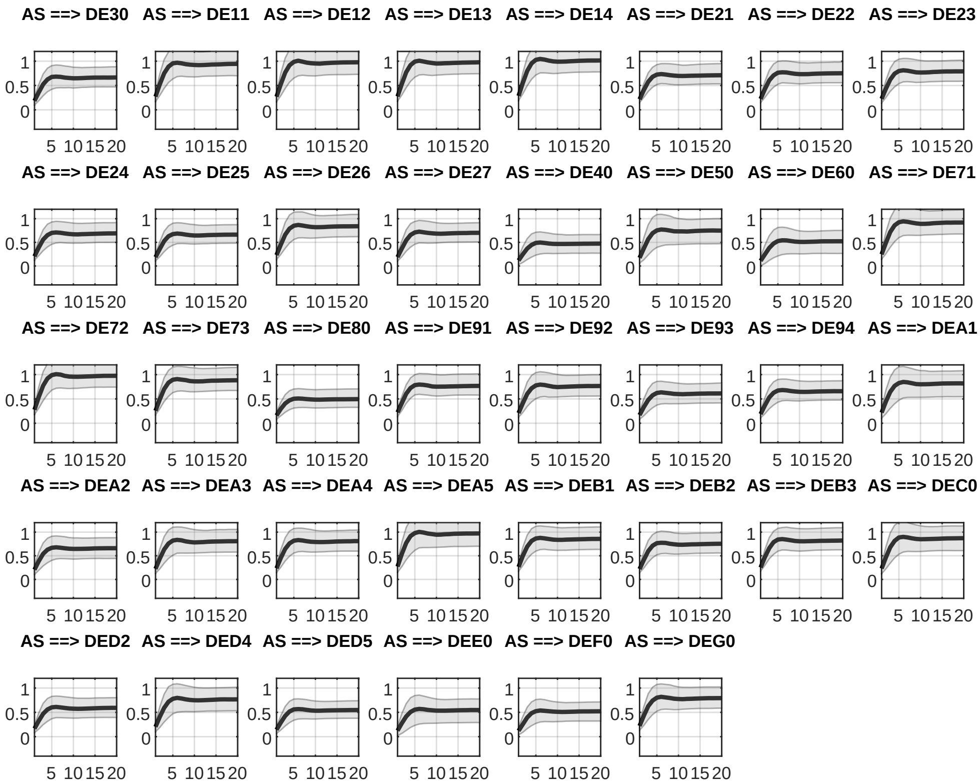


Figure 26: Regional impulse response functions: Monetary policy shock - Germany

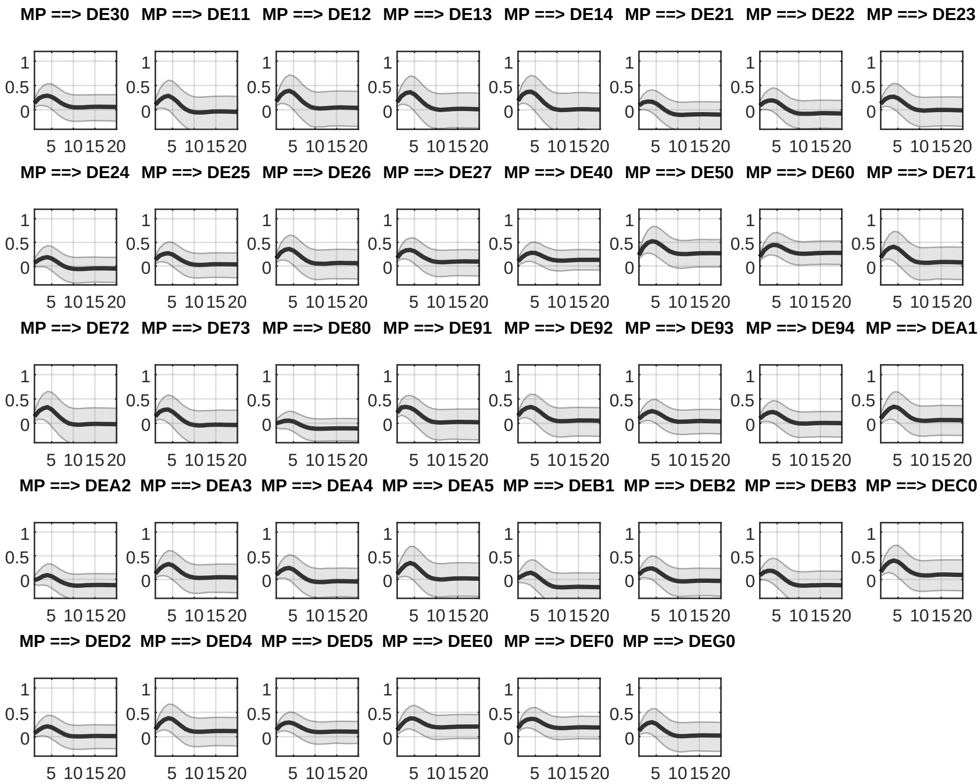
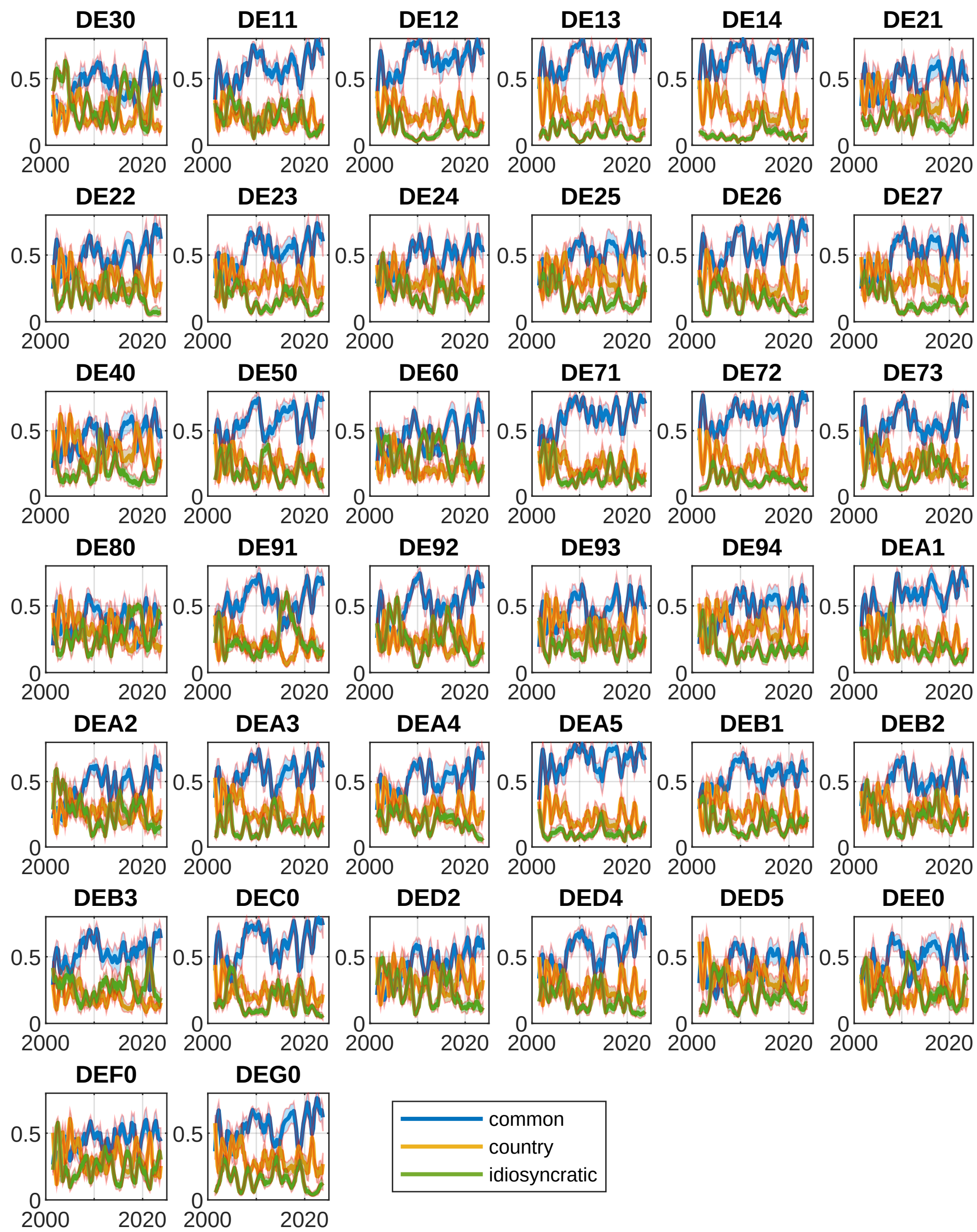
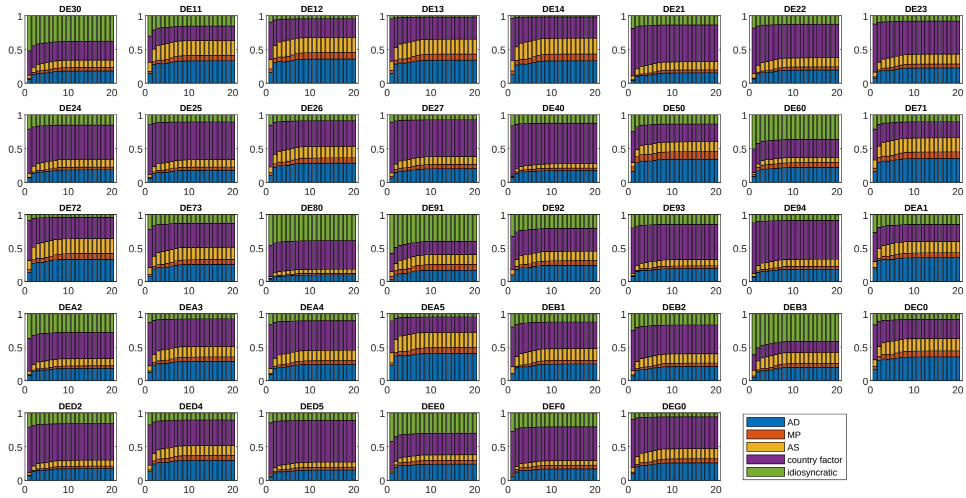


Figure 27: Regional relative importance of common shocks: historical decomposition - Germany



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 28: Regional relative importance of common shocks: forecast error variance decomposition - Germany



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.8 Greece (EL)

Figure 29: Regional impulse response functions: Aggregate demand shock - Greece

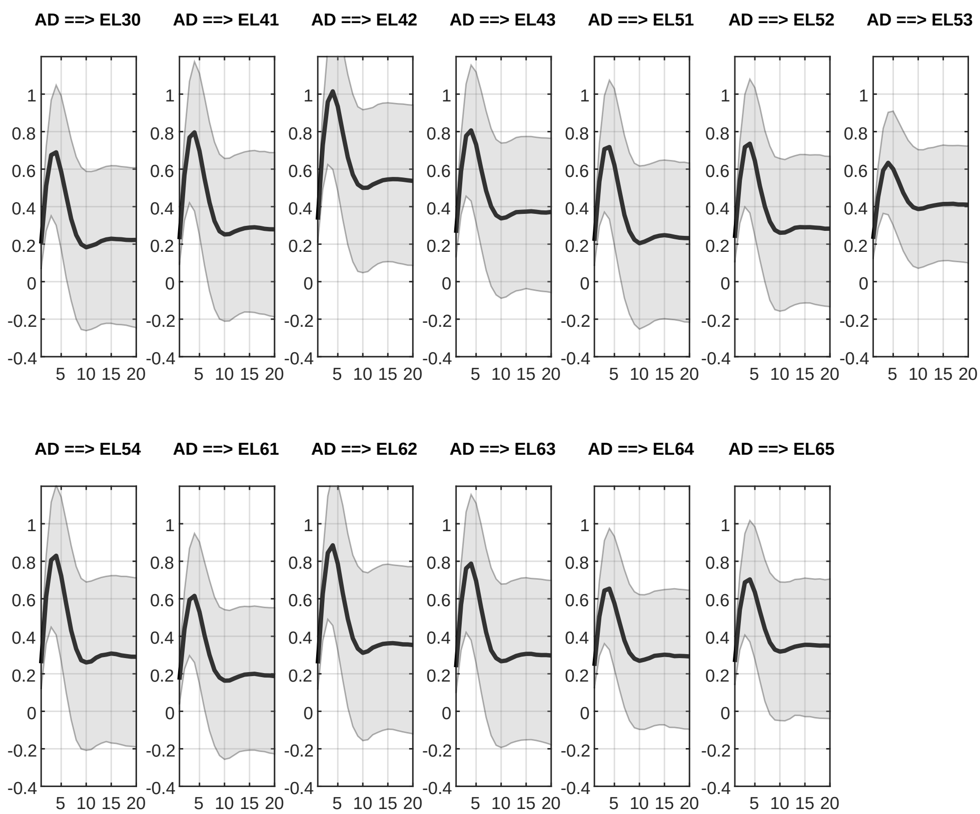


Figure 30: Regional impulse response functions: Aggregate supply shock - Greece

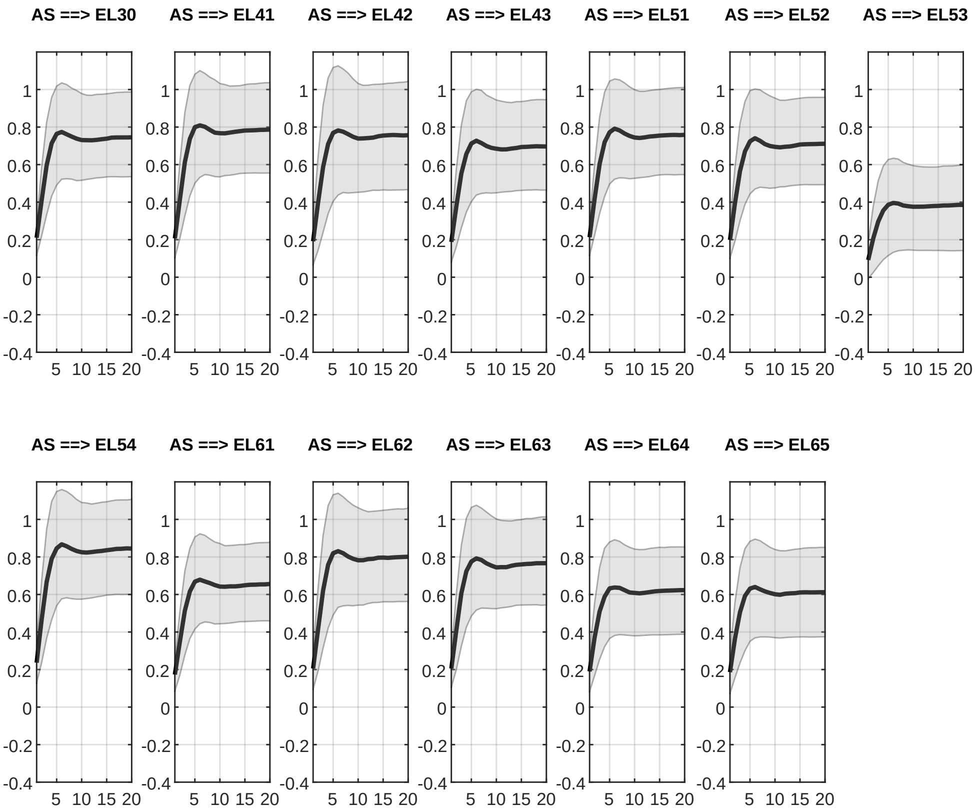


Figure 31: Regional impulse response functions: Monetary policy shock - Greece

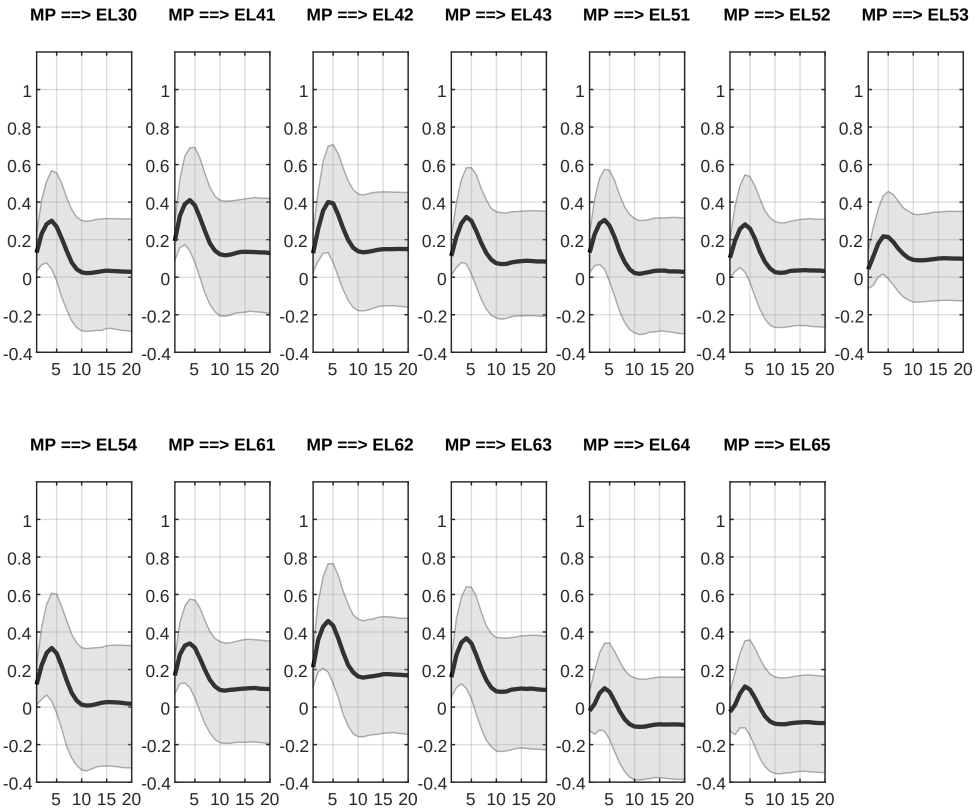
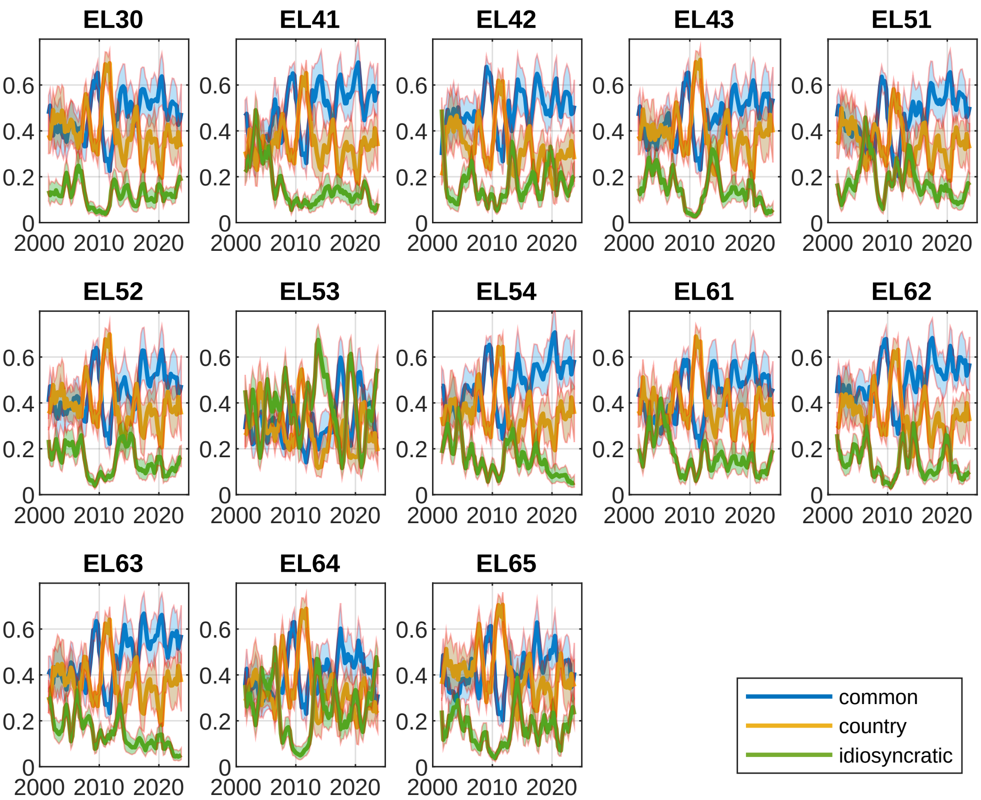
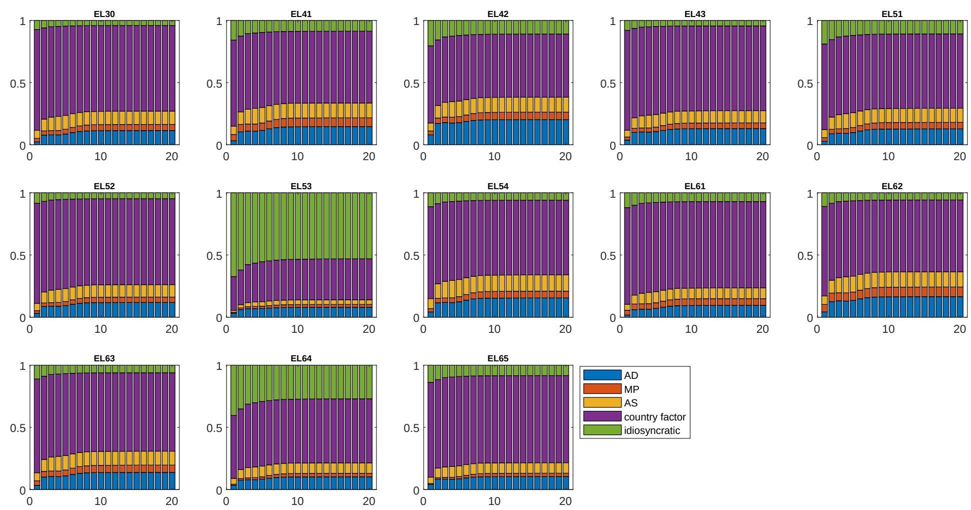


Figure 32: Regional relative importance of common shocks: historical decomposition - Greece



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 33: Regional relative importance of common shocks: forecast error variance decomposition - Greece



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.9 Spain (ES)

Figure 34: Regional impulse response functions: Aggregate demand shock - Spain

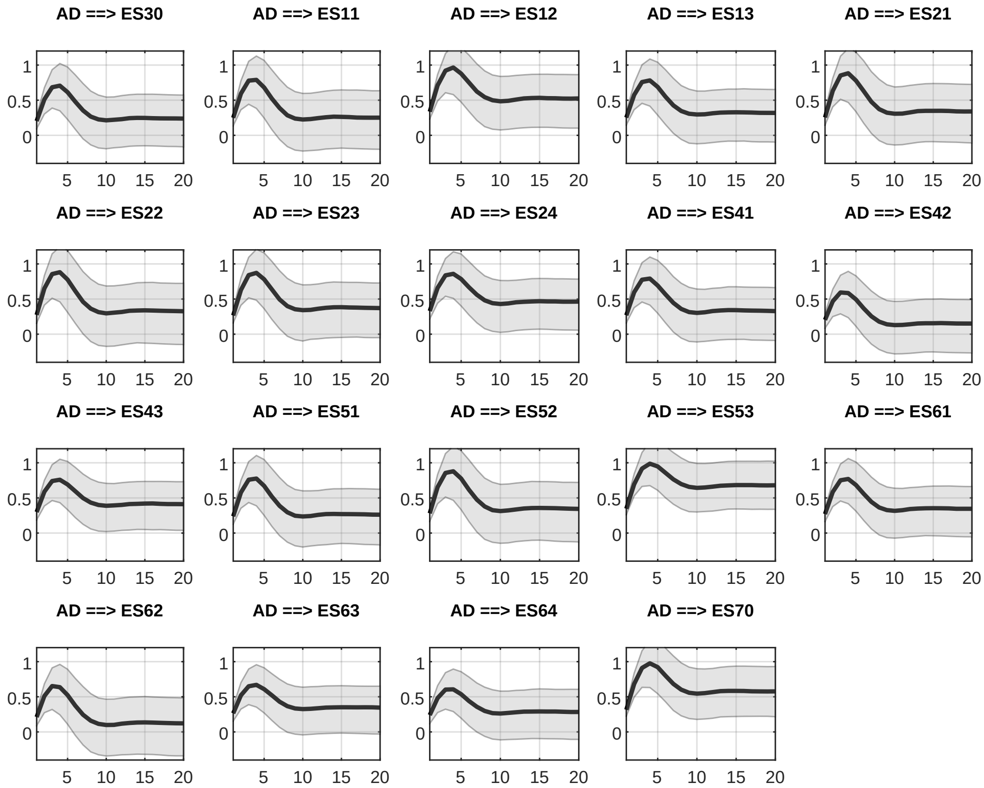


Figure 35: Regional impulse response functions: Aggregate supply shock - Spain

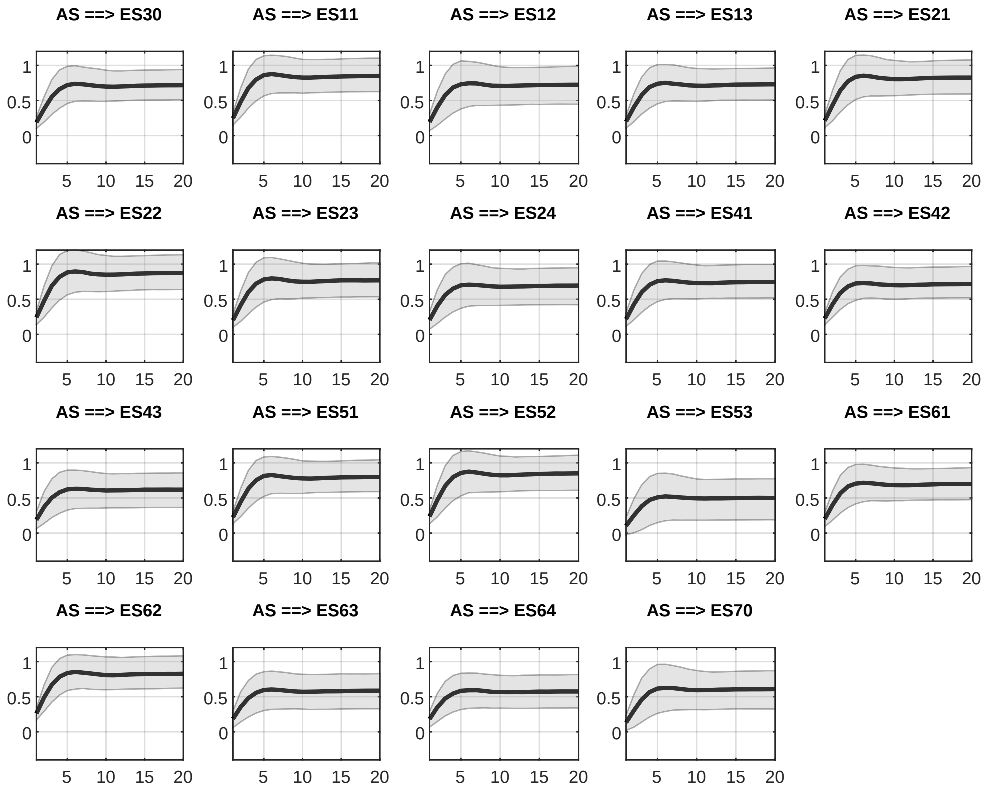


Figure 36: Regional impulse response functions: Monetary policy shock - Spain

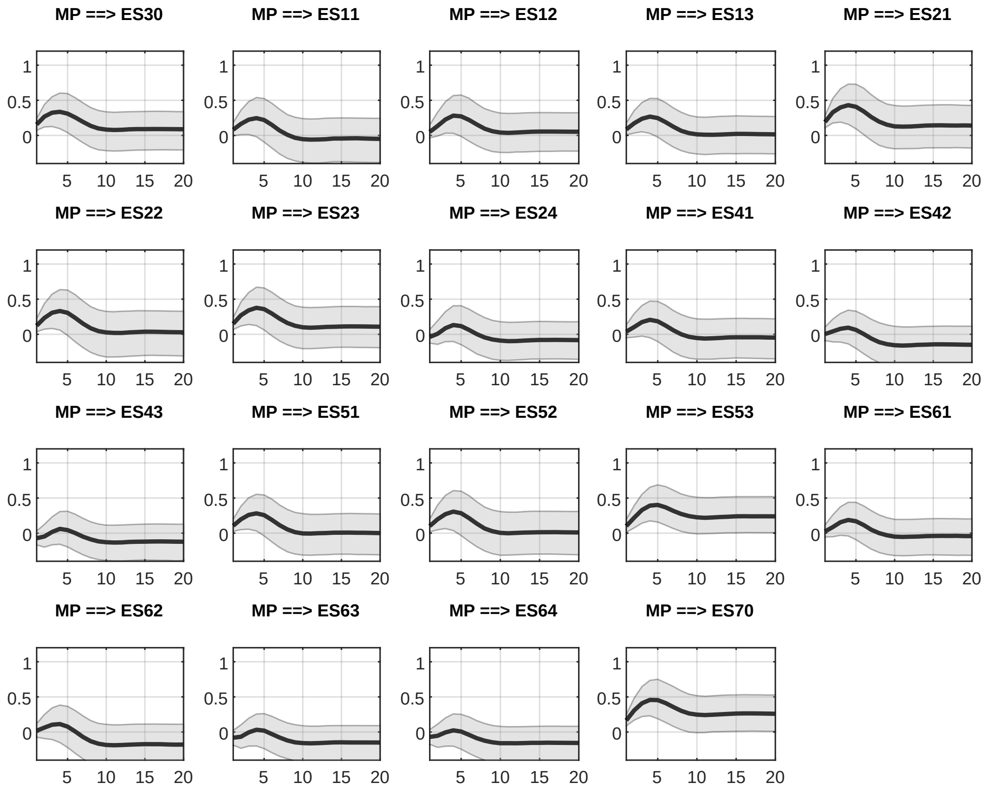
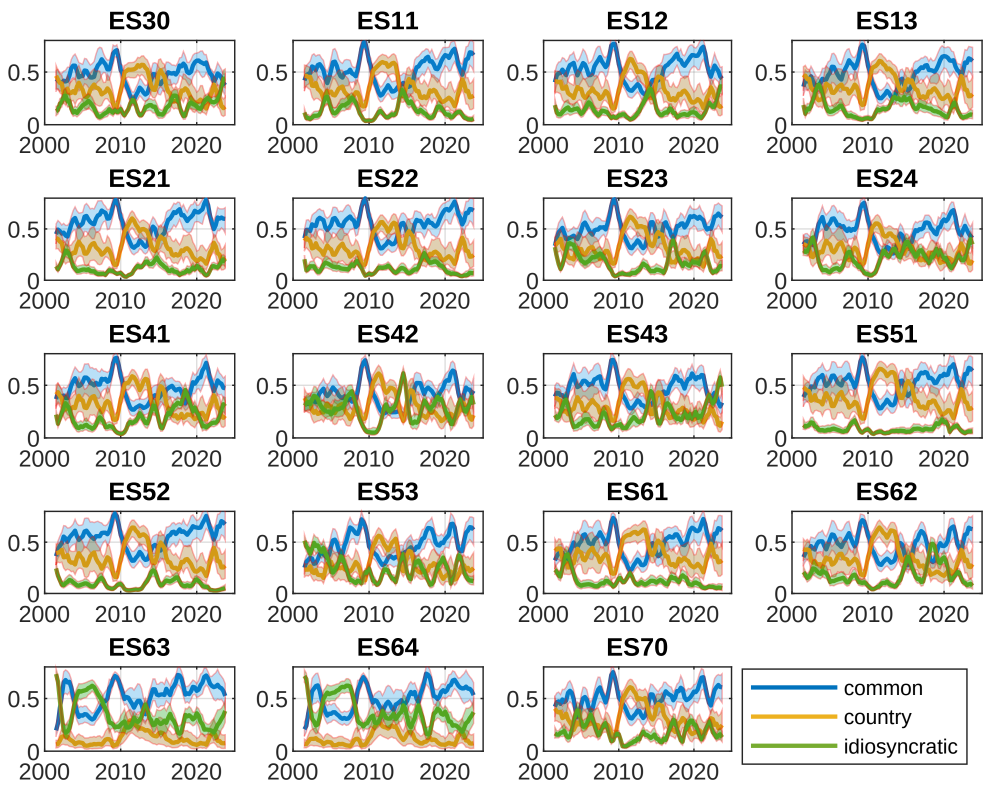
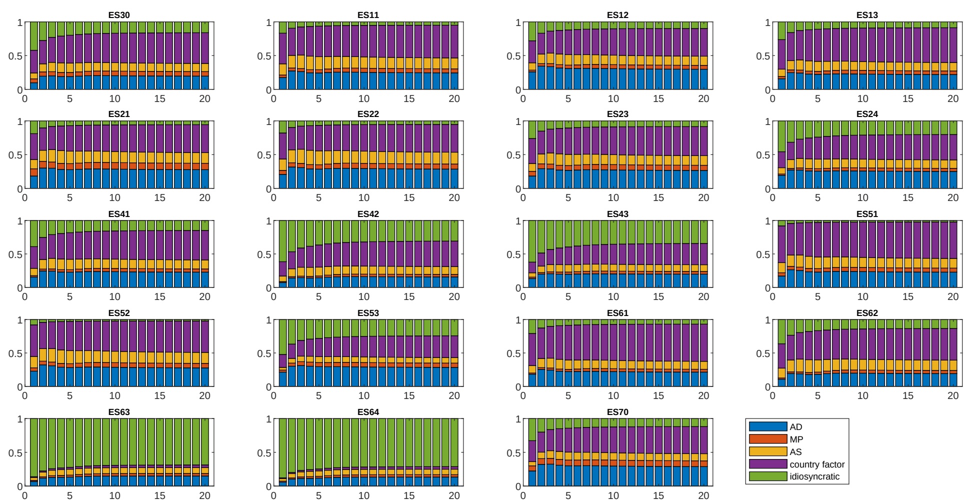


Figure 37: Regional relative importance of common shocks: historical decomposition - Spain



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 38: Regional relative importance of common shocks: forecast error variance decomposition - Spain



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.10 Finland (FI)

Figure 39: Regional impulse response functions: Aggregate demand shock - Finland

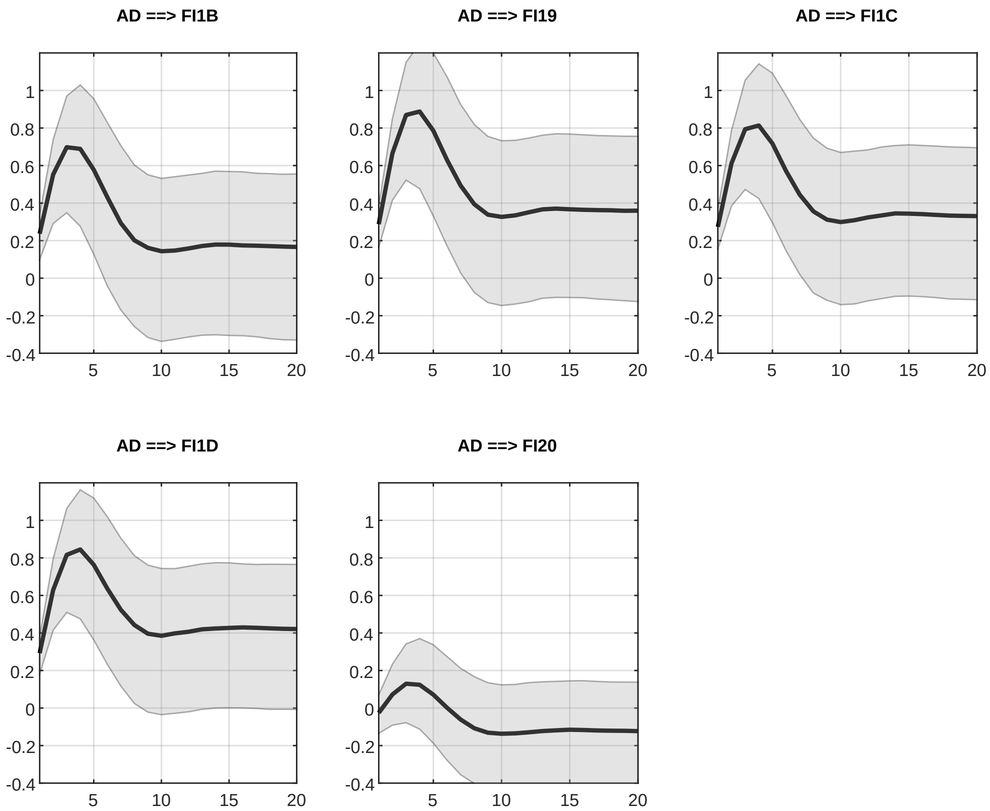


Figure 40: Regional impulse response functions: Aggregate supply shock - Finland

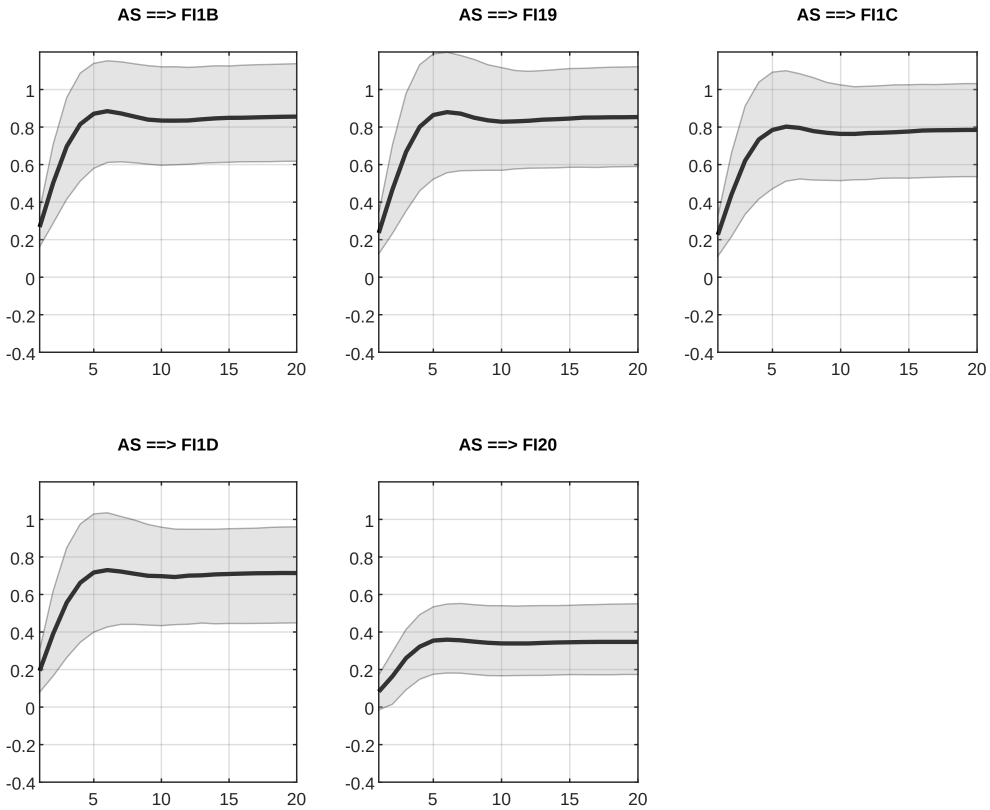


Figure 41: Regional impulse response functions: Monetary policy shock - Finland

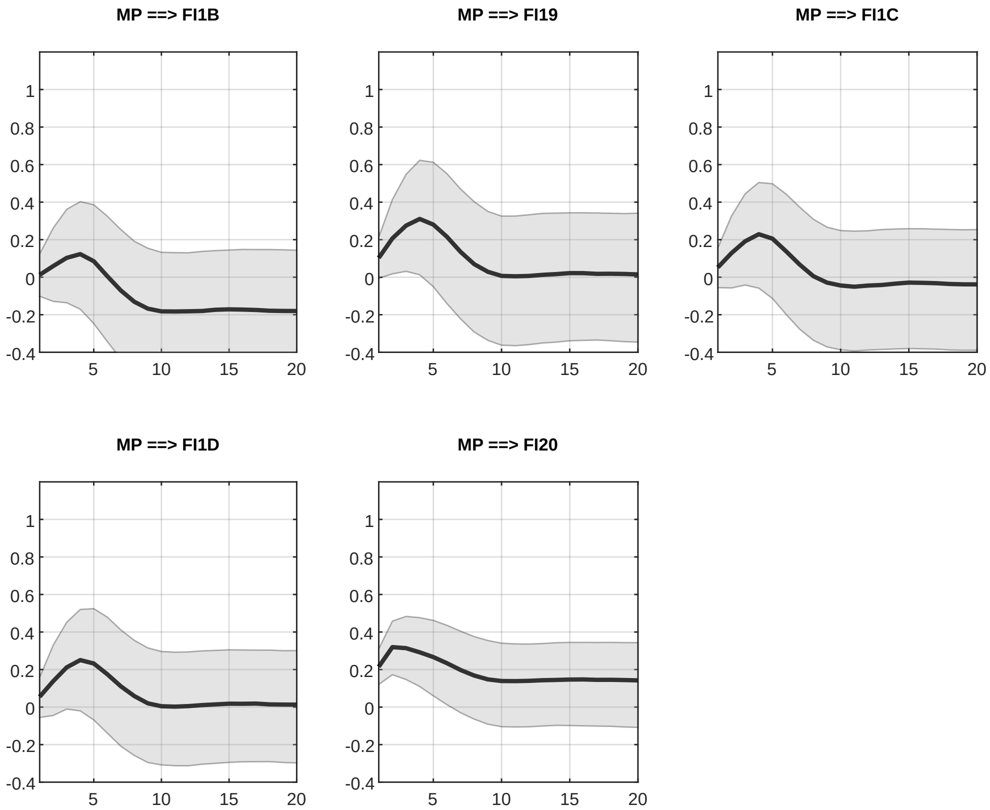
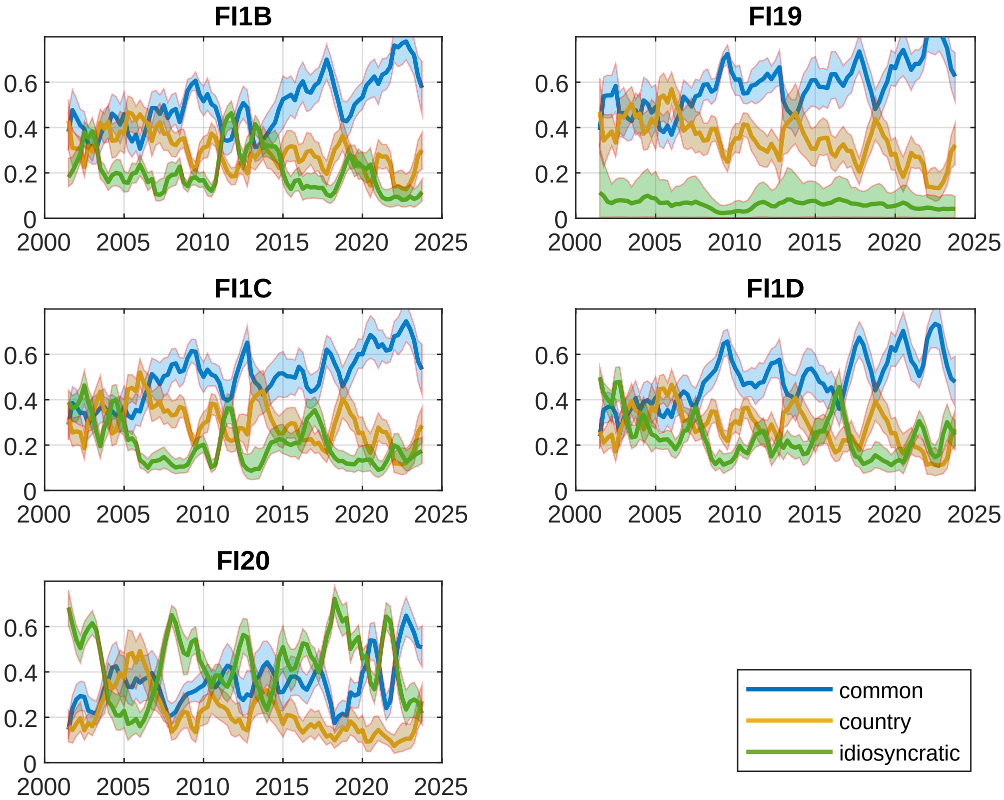
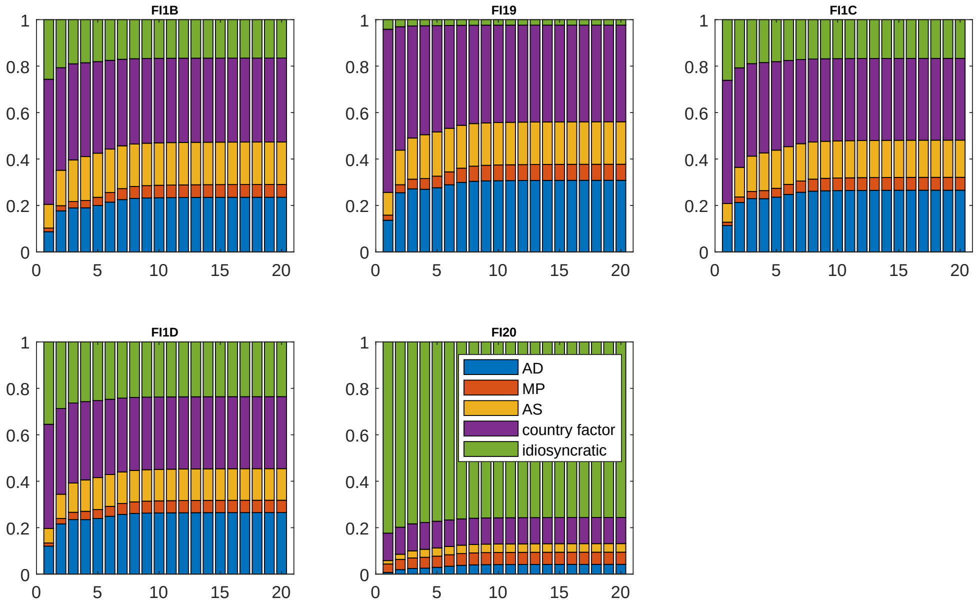


Figure 42: Regional relative importance of common shocks: historical decomposition - Finland



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 43: Regional relative importance of common shocks: forecast error variance decomposition - Finland



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.11 France (FR)

Figure 44: Regional impulse response functions: Aggregate demand shock - France

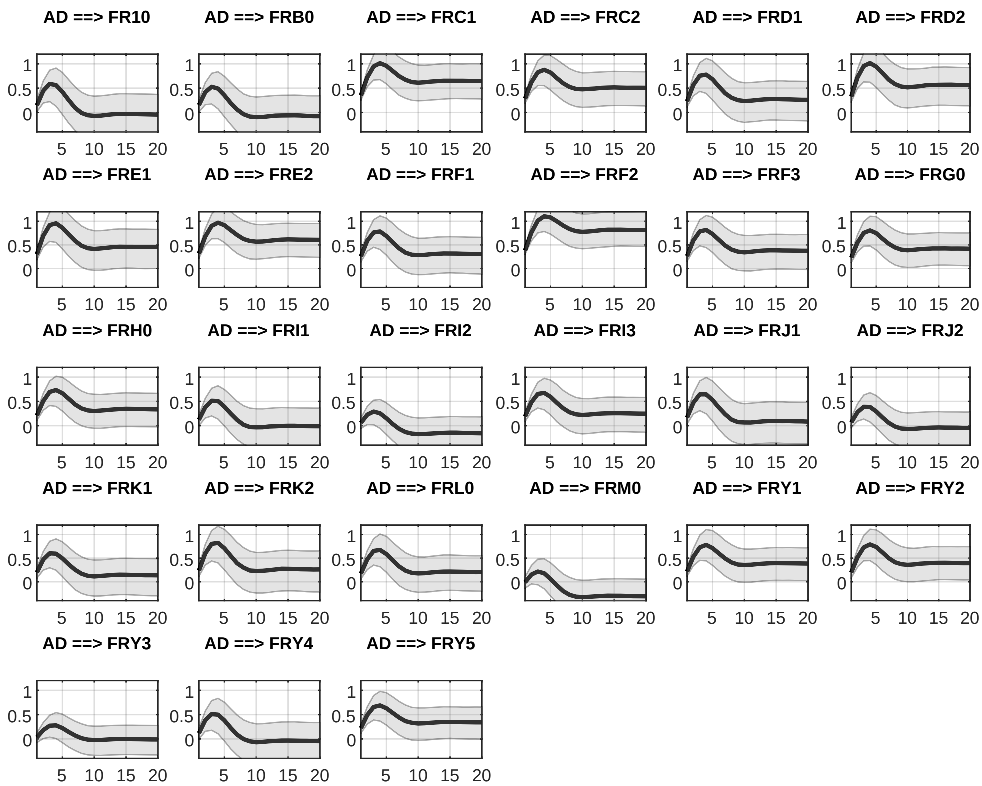


Figure 45: Regional impulse response functions: Aggregate supply shock - France

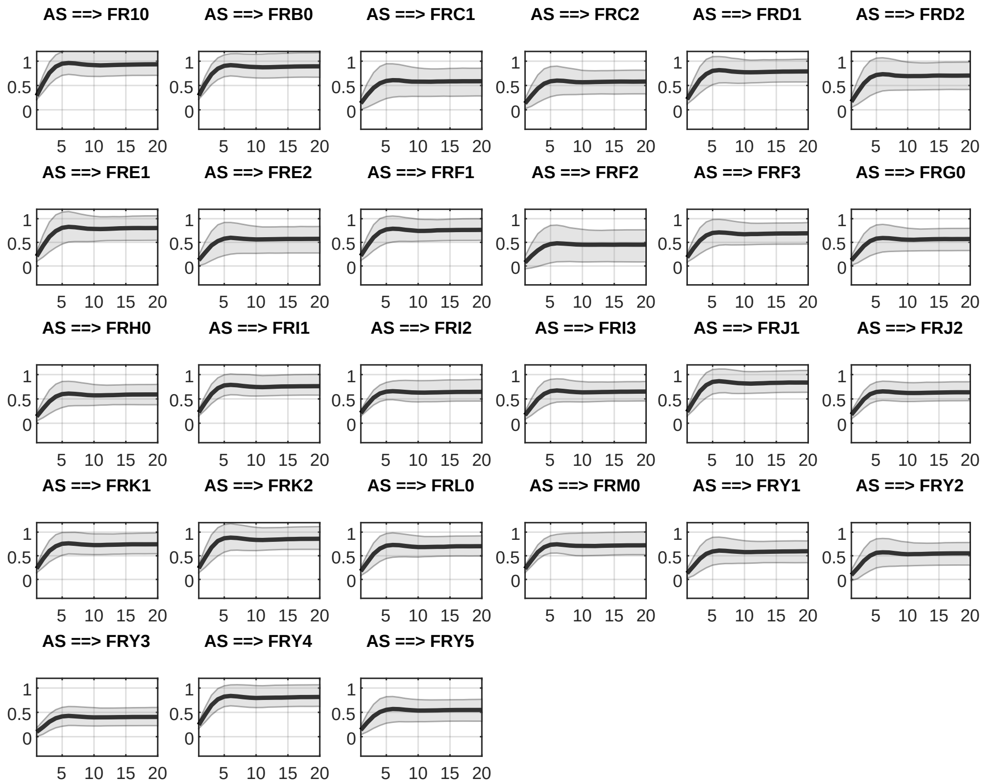


Figure 46: Regional impulse response functions: Monetary policy shock - France

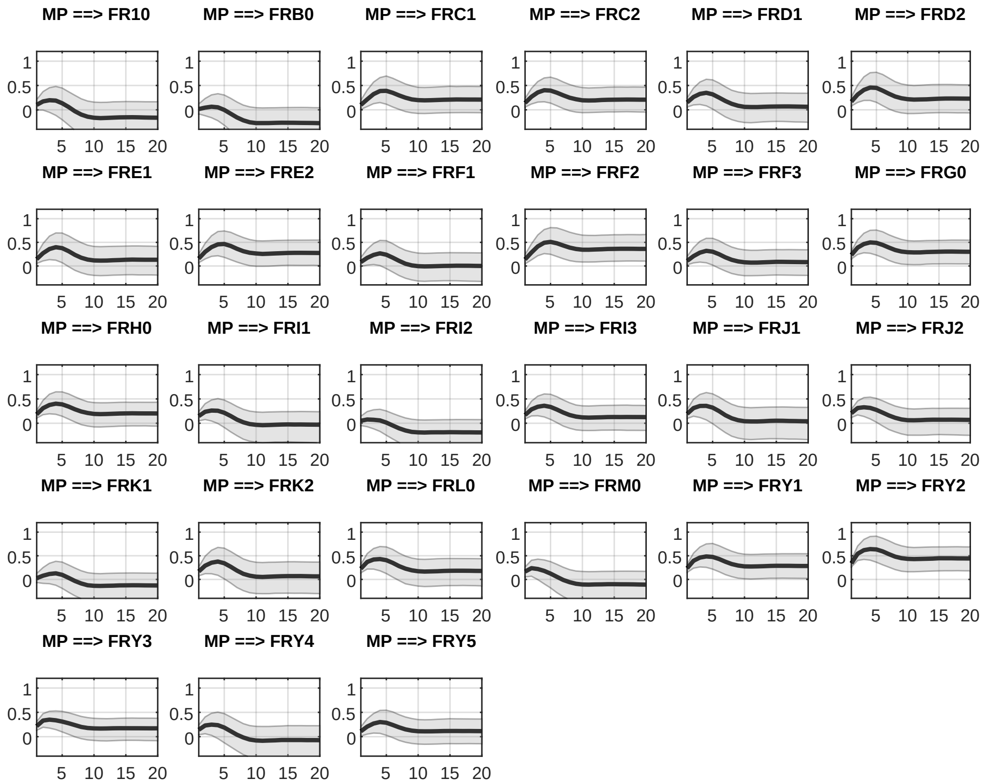
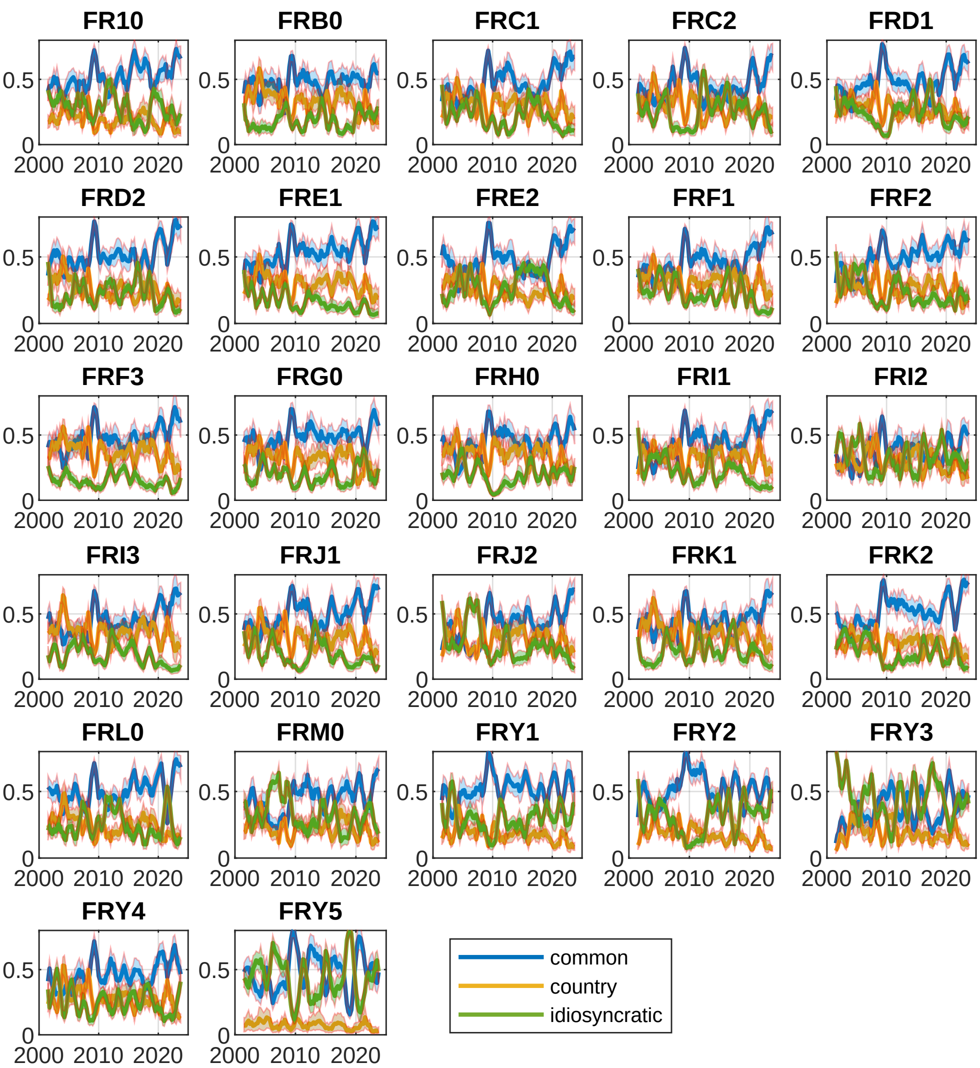
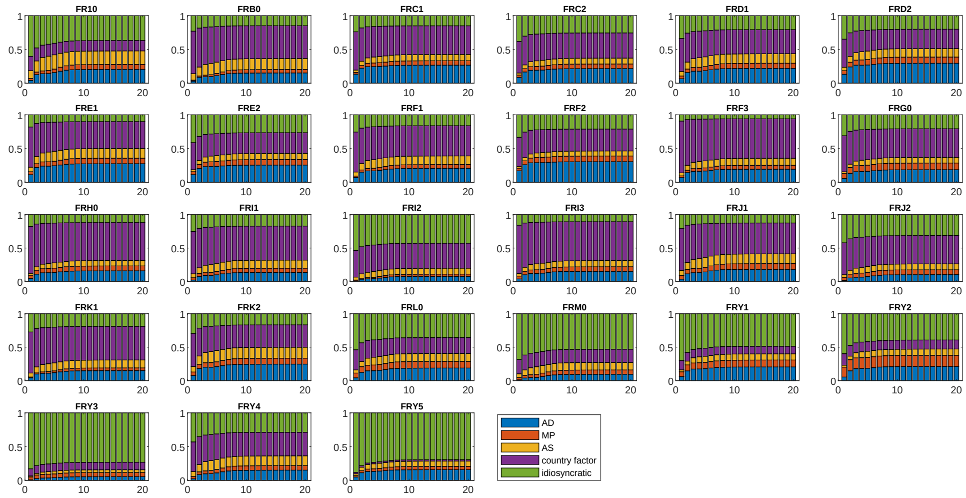


Figure 47: Regional relative importance of common shocks: historical decomposition - France



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 48: Regional relative importance of common shocks: forecast error variance decomposition - France



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.12 Ireland (IE)

Figure 49: Regional impulse response functions: Aggregate demand shock - Ireland

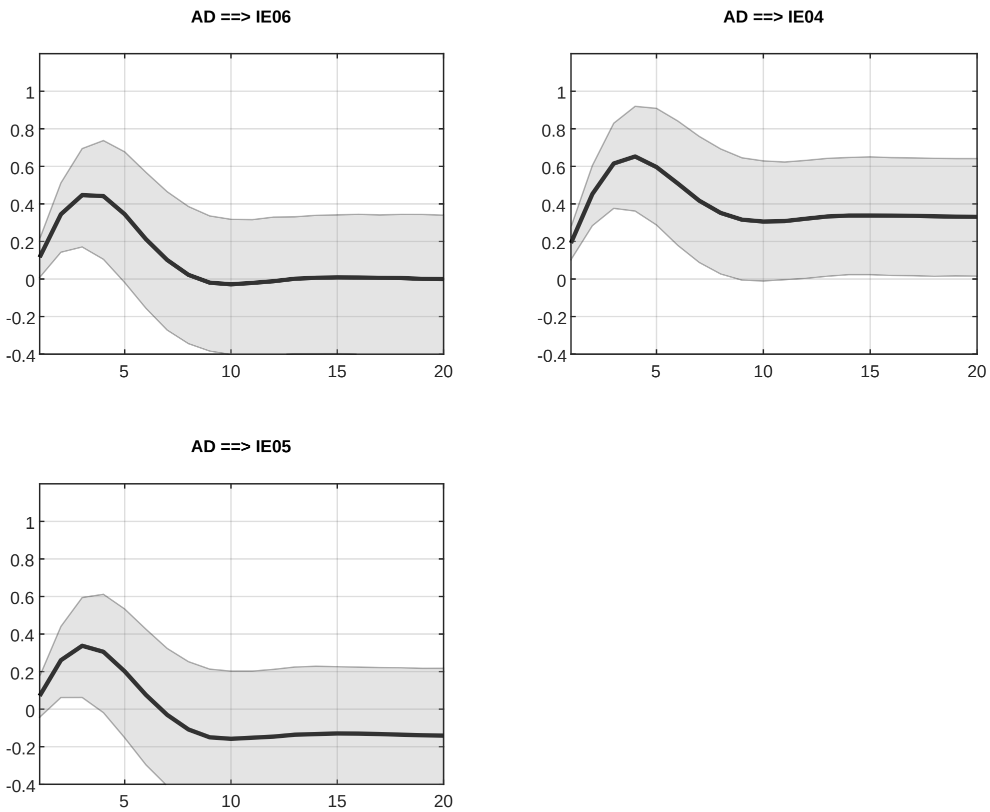


Figure 50: Regional impulse response functions: Aggregate supply shock - Ireland

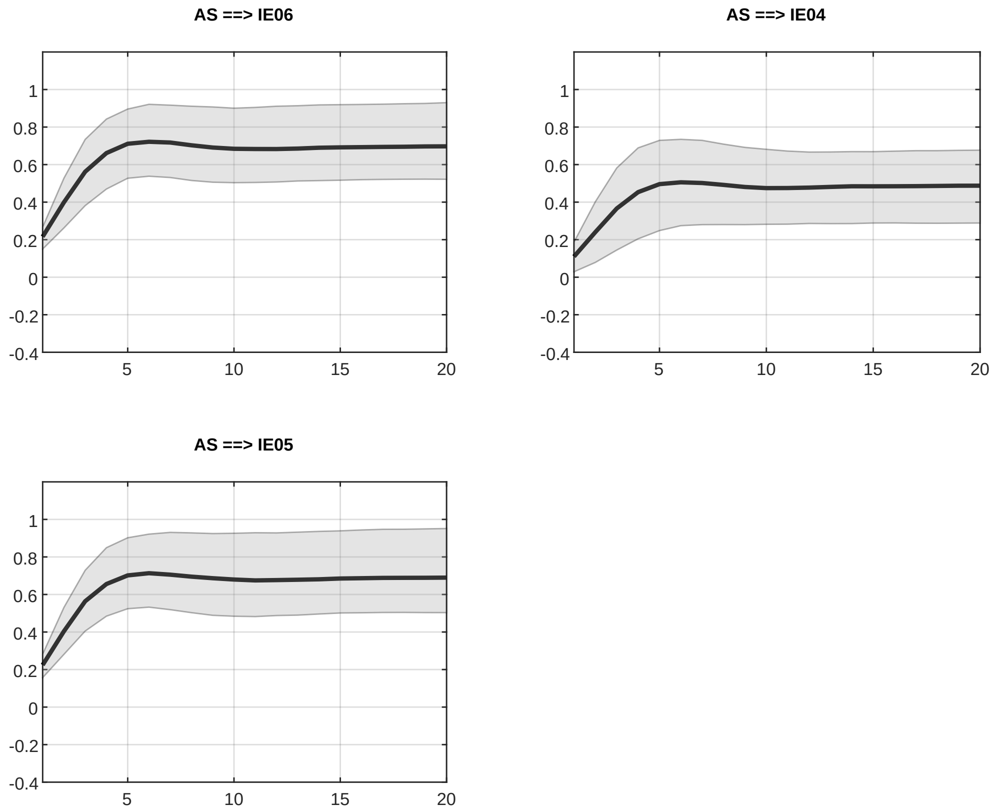


Figure 51: Regional impulse response functions: Monetary policy shock - Ireland

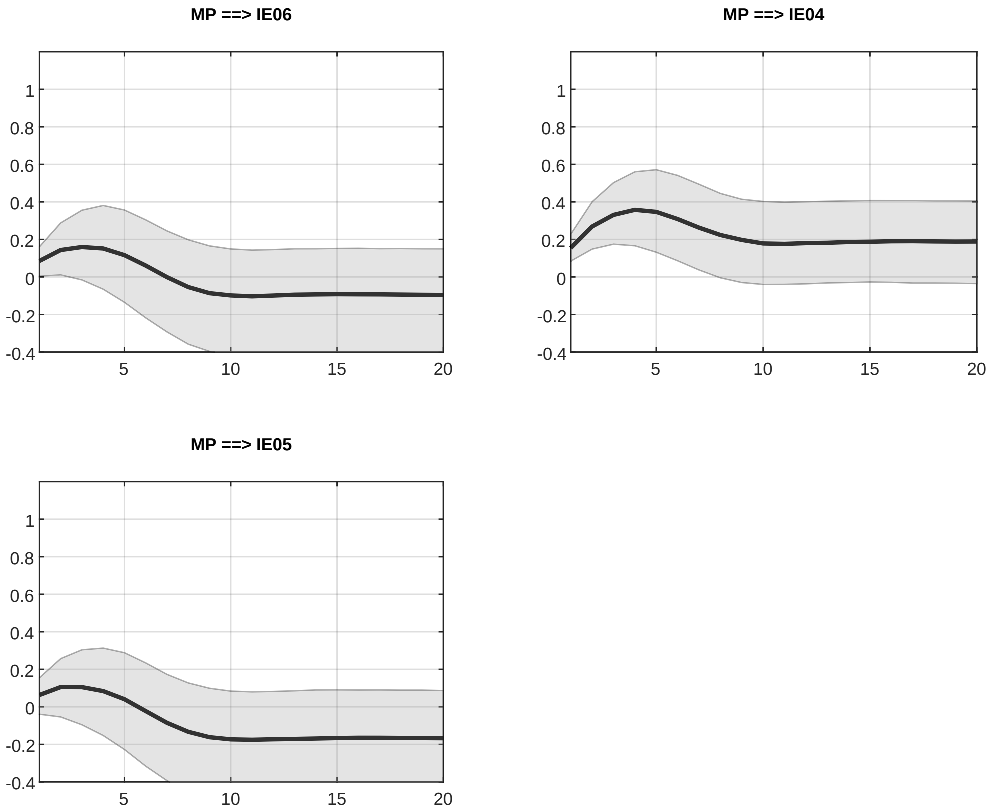
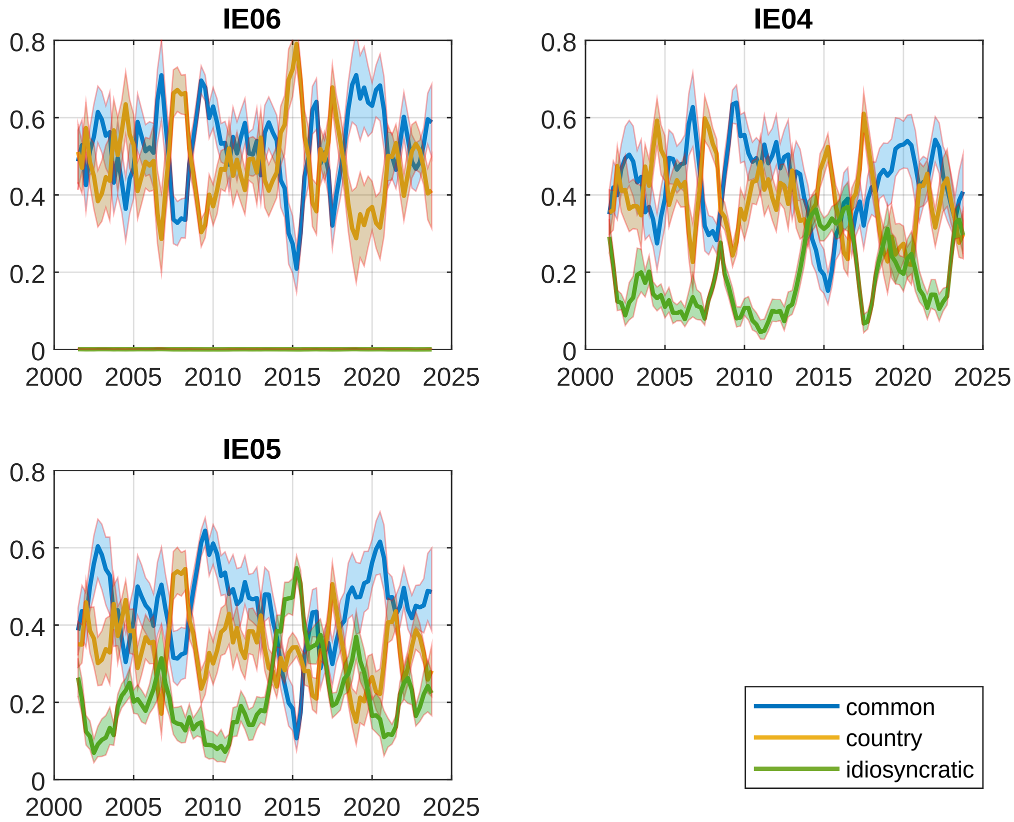
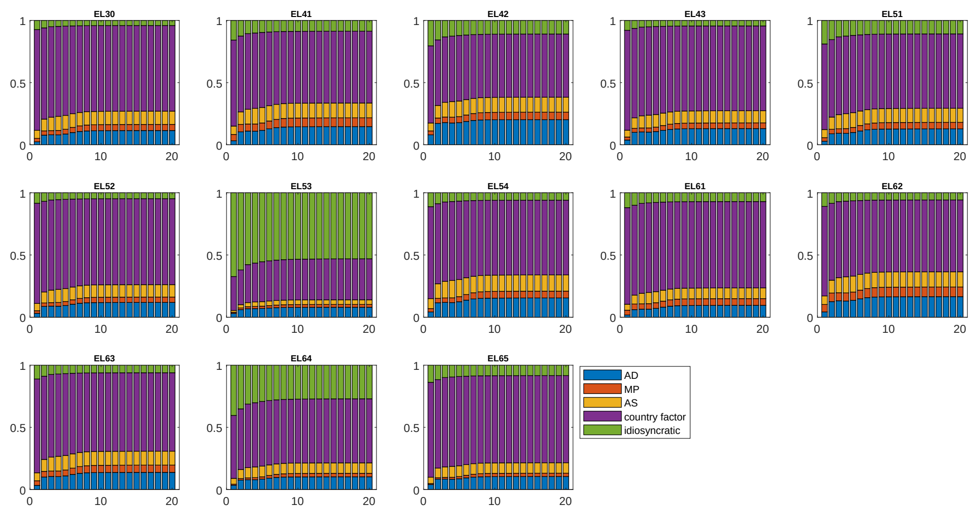


Figure 52: Regional relative importance of common shocks: historical decomposition - Ireland



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 53: Regional relative importance of common shocks: forecast error variance decomposition - Ireland



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.13 Italy (IT)

Figure 54: Regional impulse response functions: Aggregate demand shock - Italy

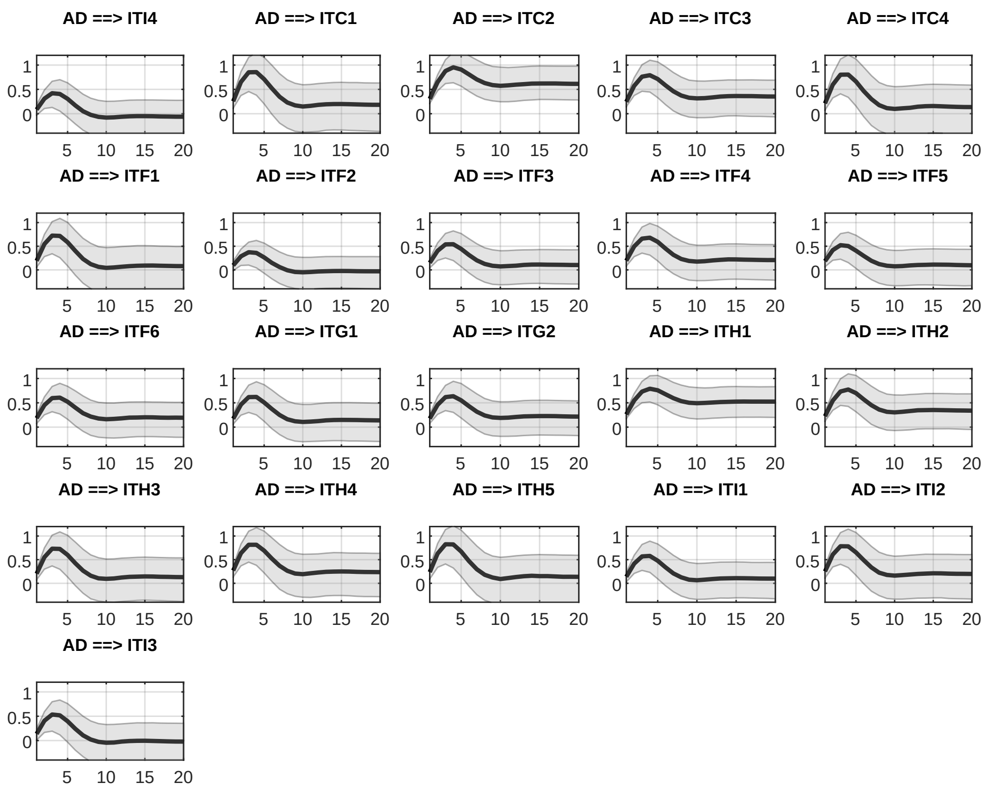


Figure 55: Regional impulse response functions: Aggregate supply shock - Italy

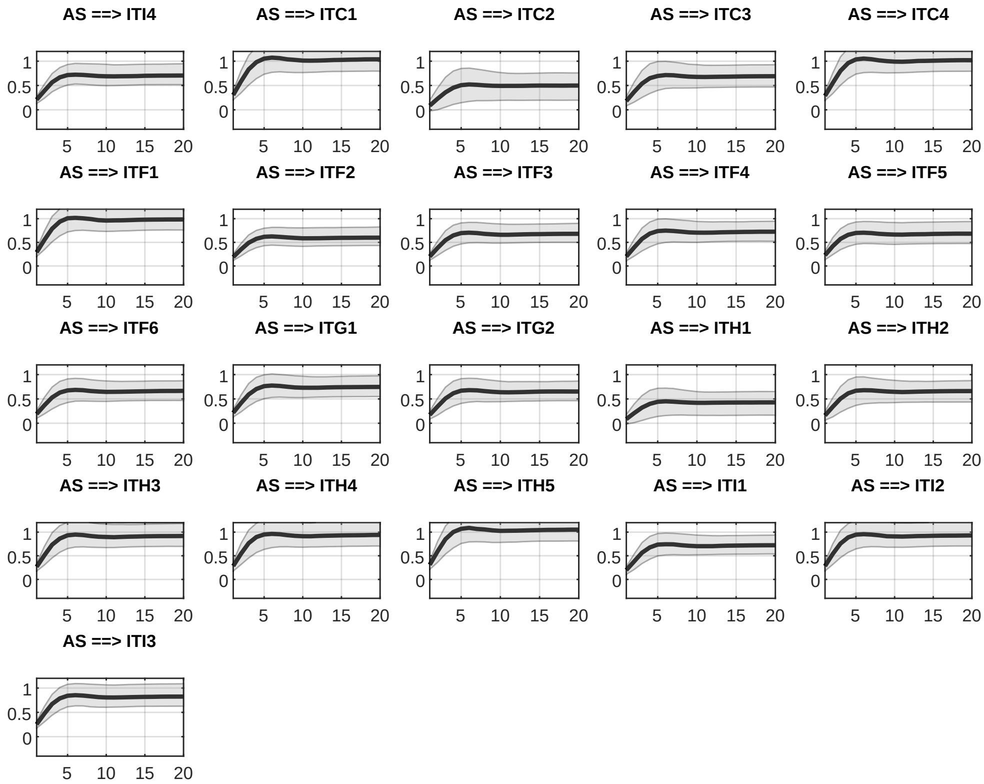


Figure 56: Regional impulse response functions: Monetary policy shock - Italy

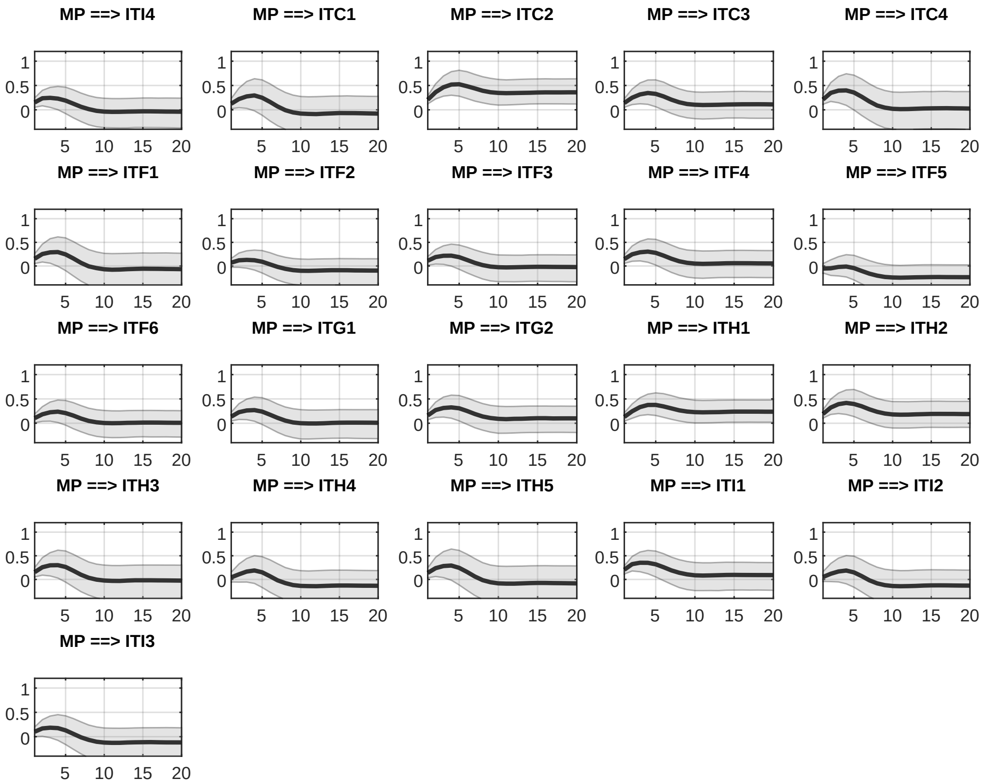
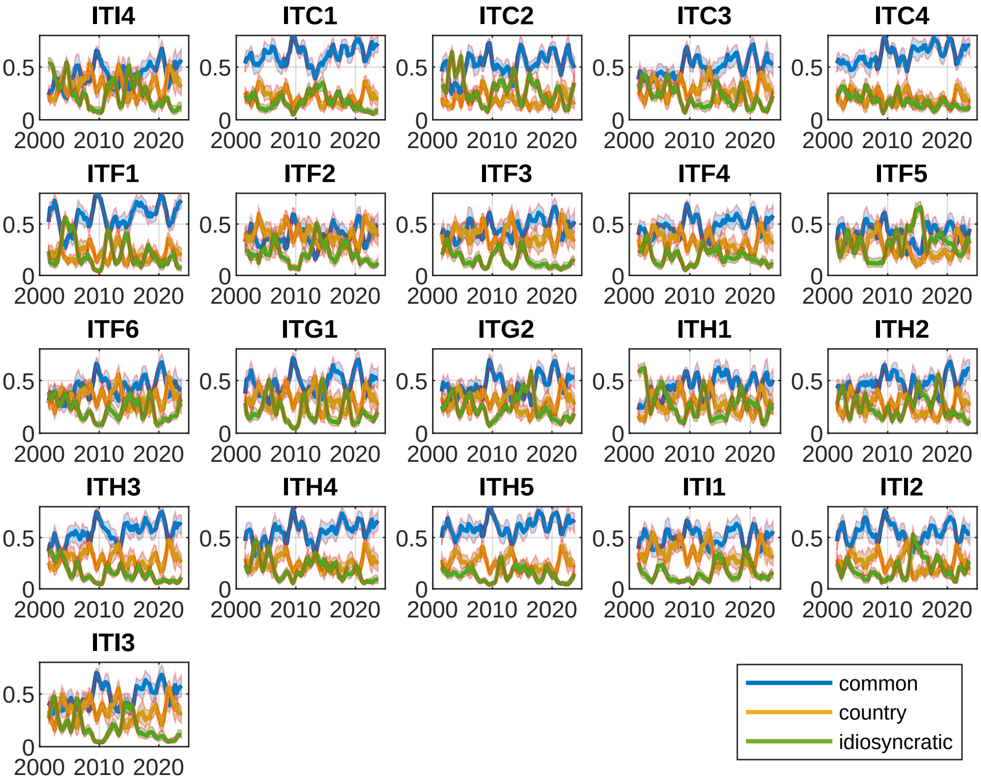
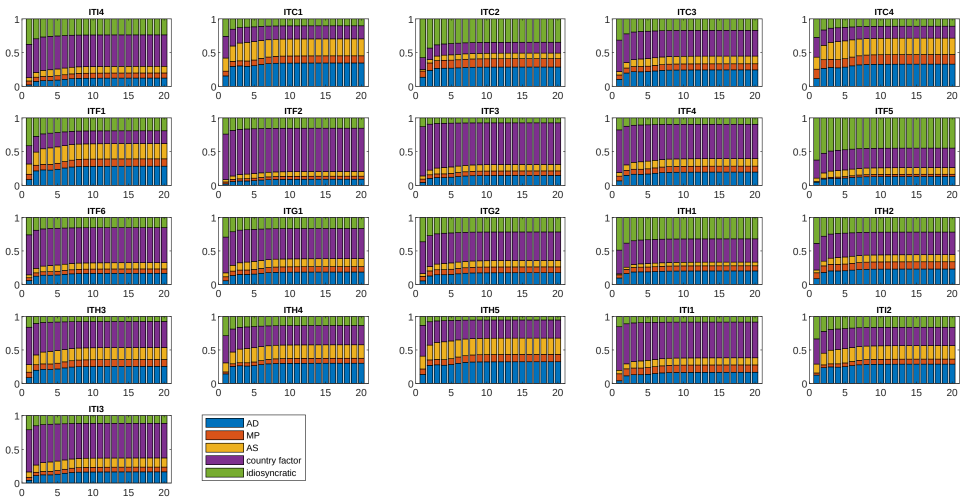


Figure 57: Regional relative importance of common shocks: historical decomposition - Italy



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 58: Regional relative importance of common shocks: forecast error variance decomposition - Italy



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.14 Netherlands (NL)

Figure 59: Regional impulse response functions: Aggregate demand shock - Netherlands

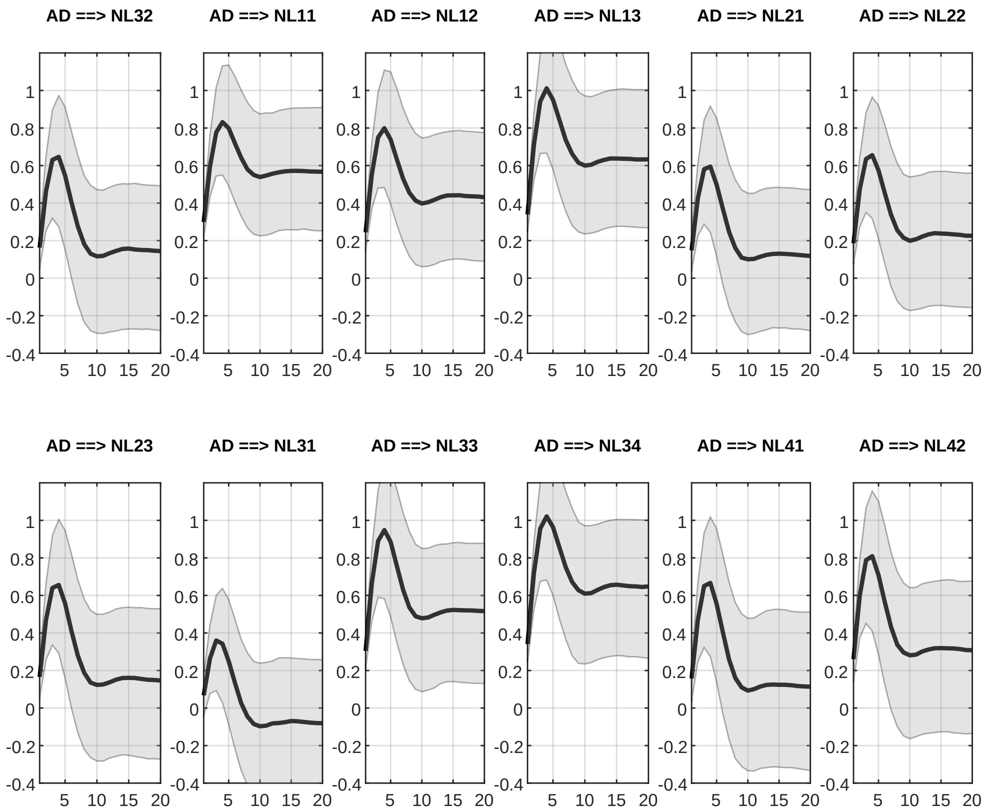


Figure 60: Regional impulse response functions: Aggregate supply shock - Netherlands

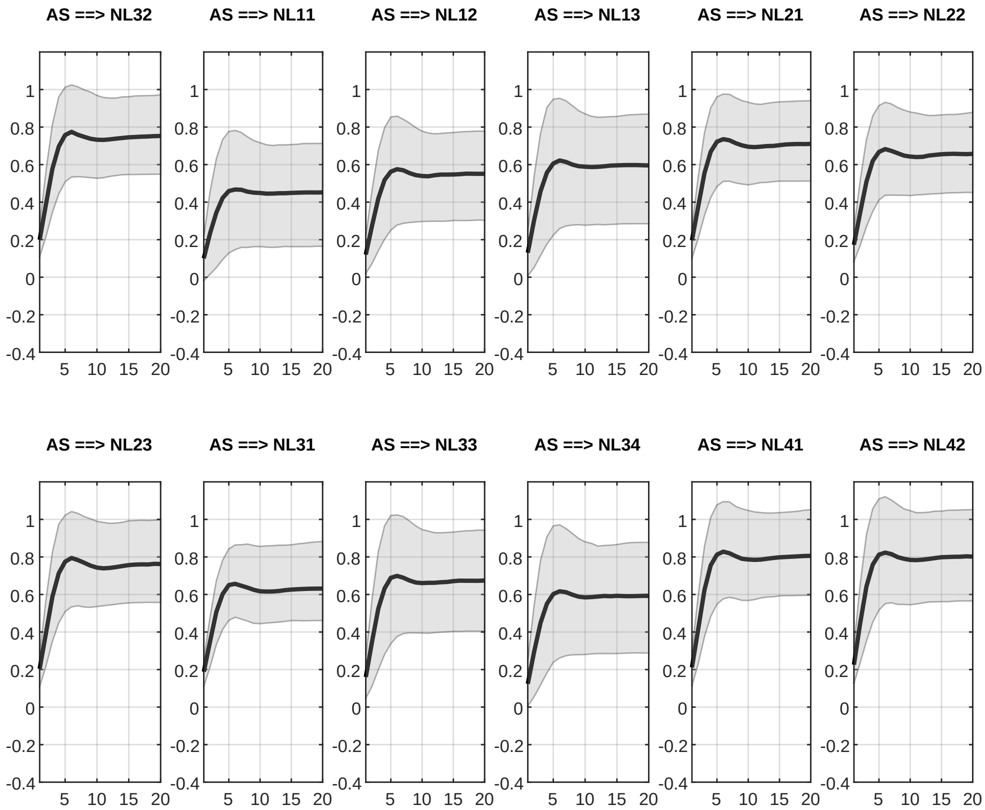


Figure 61: Regional impulse response functions: Monetary policy shock - Netherlands

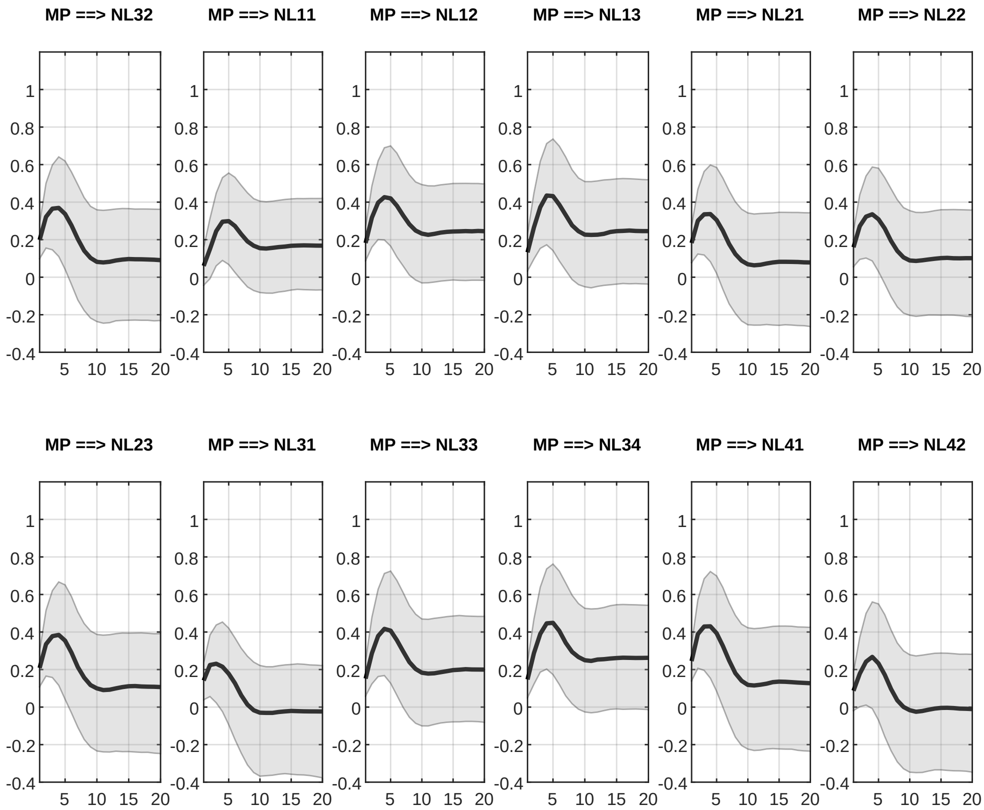
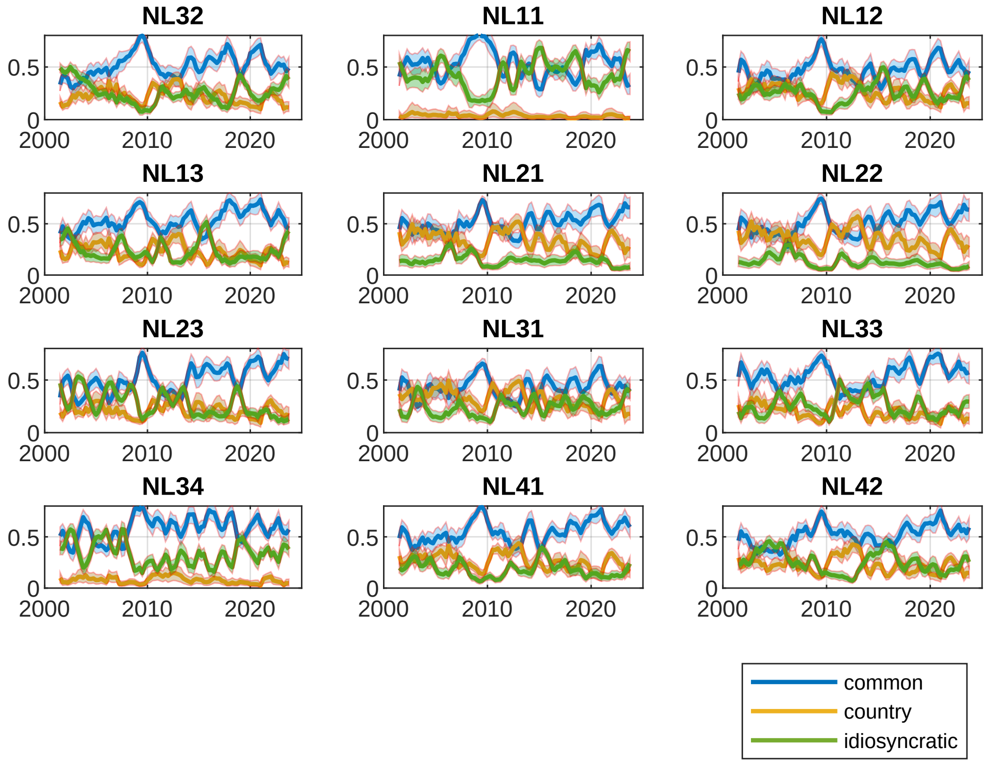
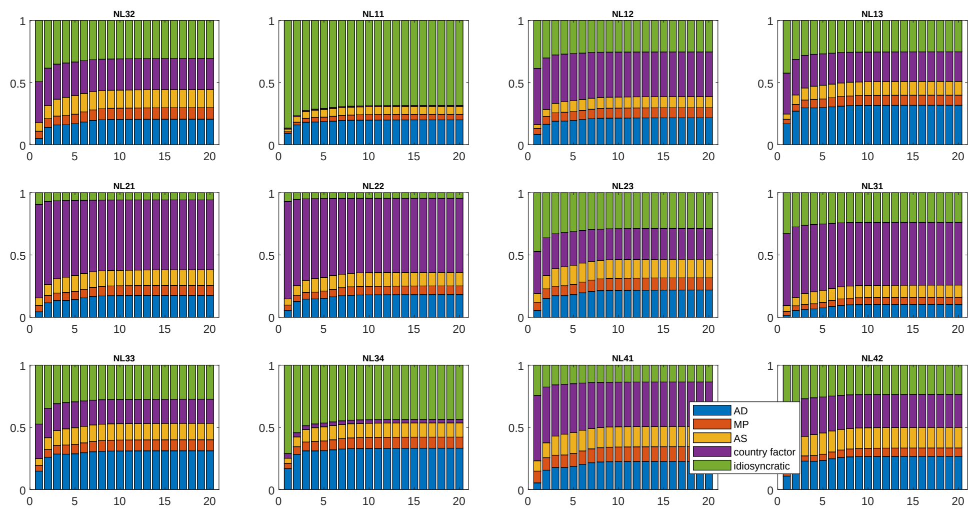


Figure 62: Regional relative importance of common shocks: historical decomposition - Netherlands



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 63: Regional relative importance of common shocks: forecast error variance decomposition - Netherlands



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

B.15 Portugal (PT)

Figure 64: Regional impulse response functions: Aggregate demand shock - Portugal

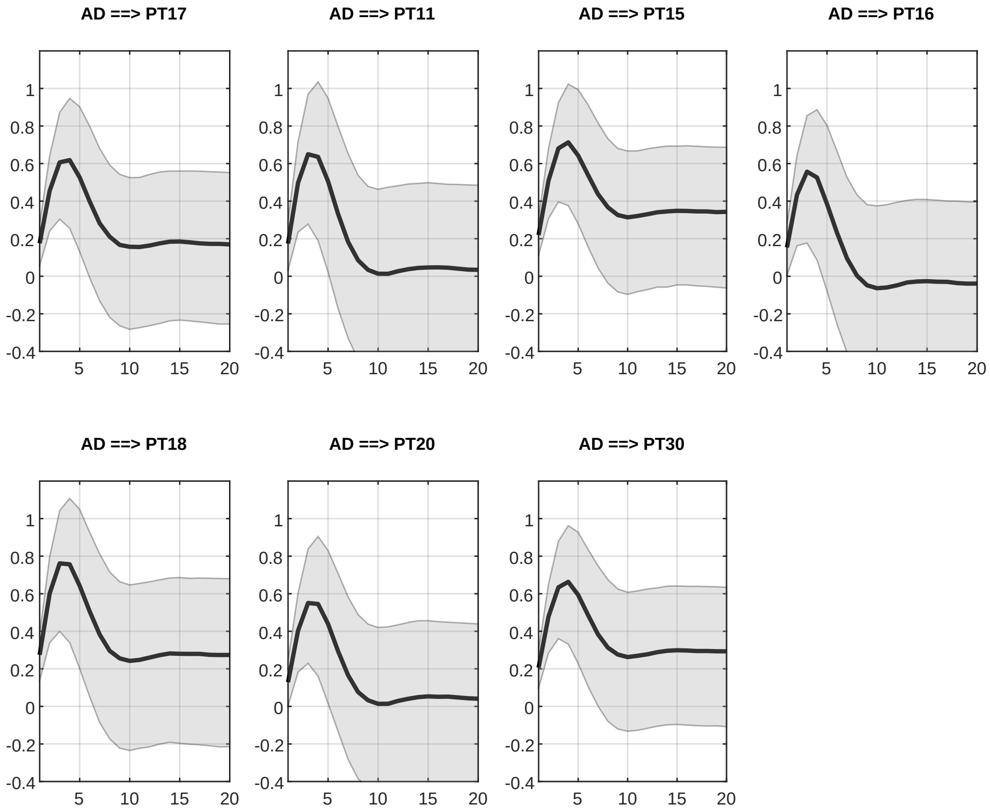


Figure 65: Regional impulse response functions: Aggregate supply shock - Portugal

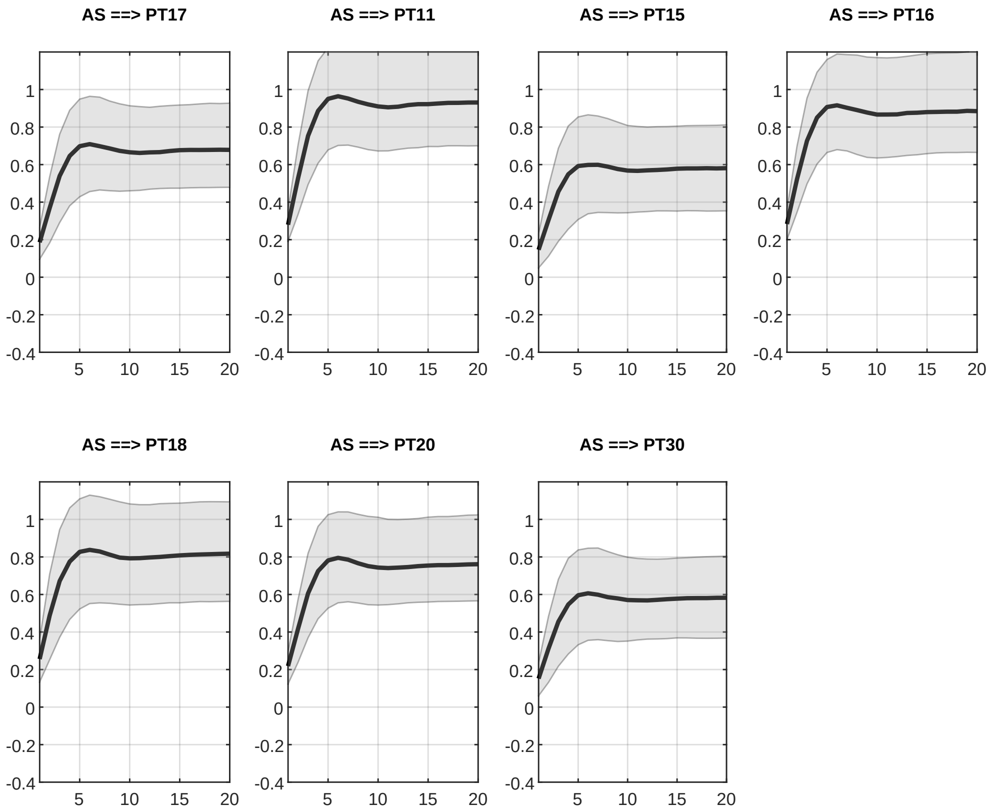


Figure 66: Regional impulse response functions: Monetary policy shock - Portugal

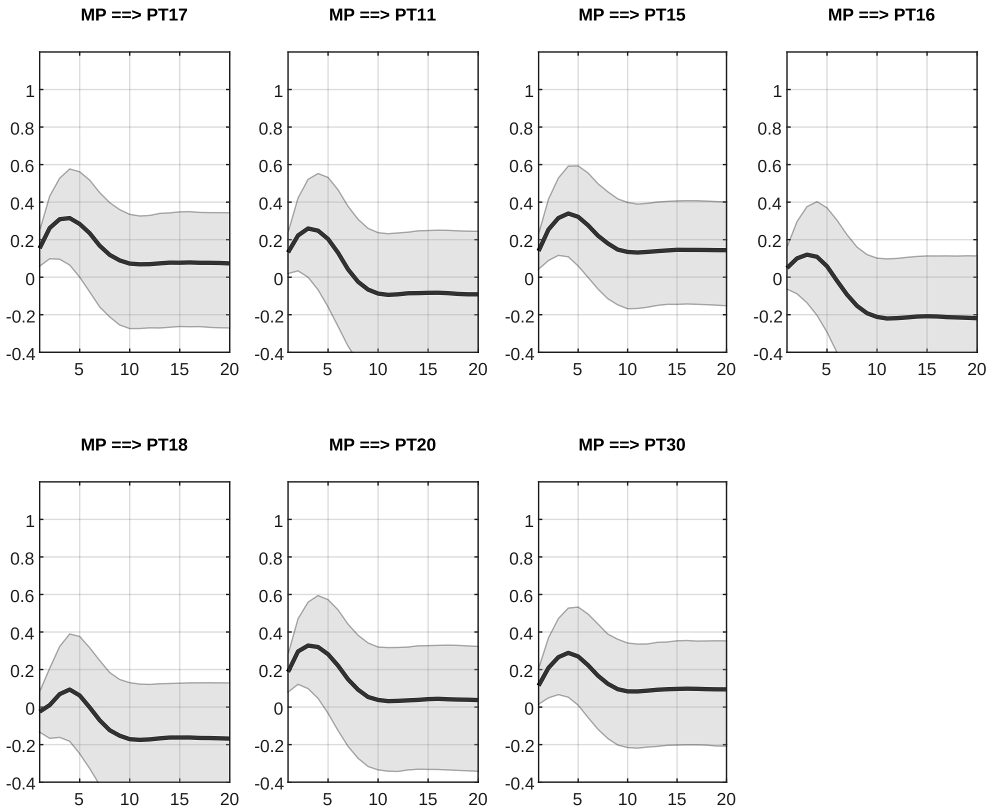
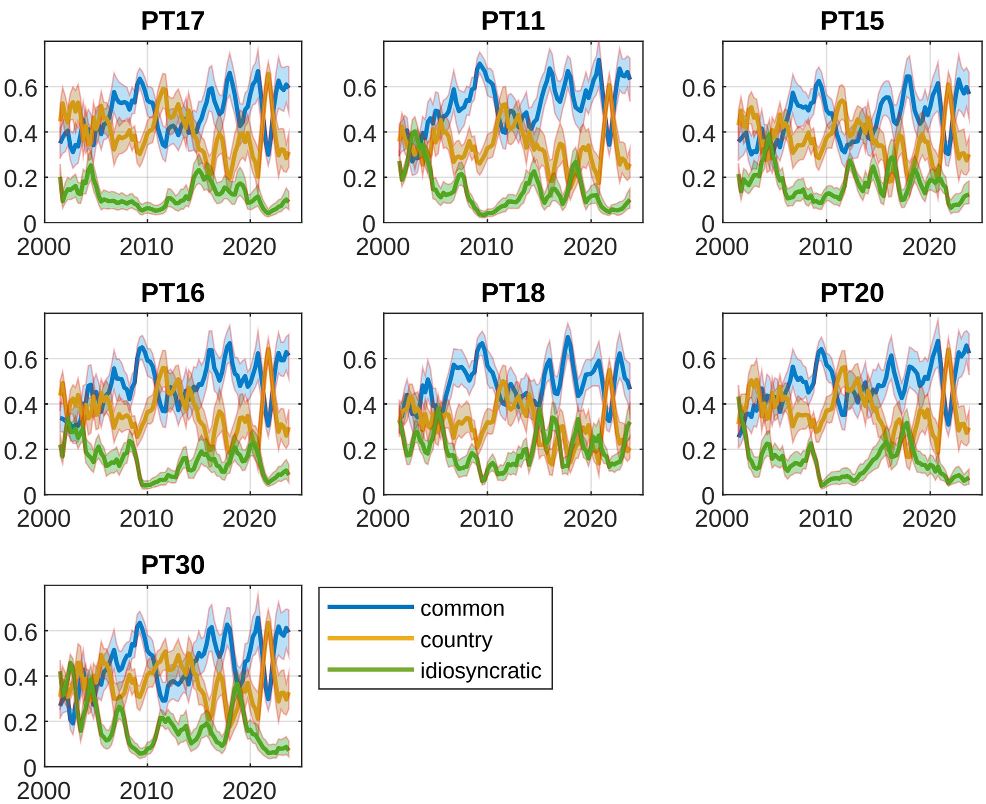
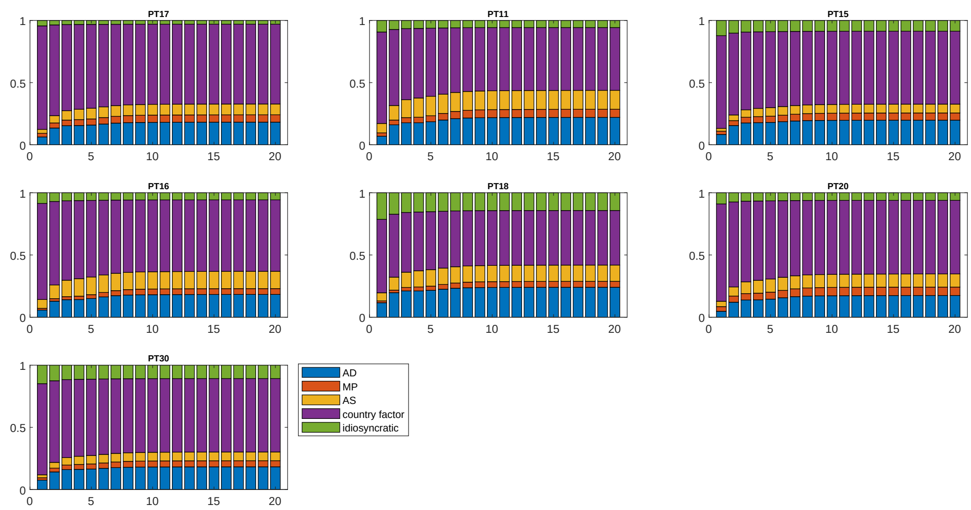


Figure 67: Regional relative importance of common shocks: historical decomposition - Portugal



Note: Share of output fluctuations attributed to each common shock, derived from the historical decomposition.

Figure 68: Regional relative importance of common shocks: forecast error variance decomposition - Portugal



Note: Share of regional output forecast error variance attributable to each common shock across horizons.

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