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HOW DIFFERENT ARE THE ALTERNATIVE ECONOMIC POLICY UNCERTAINTY INDICES? THE CASE OF EUROPEAN COUNTRIES.

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How Different are the Alternative Economic Policy Uncertainty Indices? The Case of European Countries.

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Abstract:
Several alternative news-based Economic Policy Uncertainty indices have been developer for Spain and a few other European countries. These alternative indices differ in the selection of keywords, newspaper coverage, and a scaling factor that is used to calculate the EPU index from the raw news data. Using the generalized forecast error variance decompositions of the time-varying parameter VAR model and the analysis of dynamic connectedness, we show that the restriction to include only domestic news affects estimated spillovers substantially, leading to different qualitative and quantitative assessments of uncertainty spillovers in Europe. Therefore, not all EPU indices are the same.

JEL: C32, F42, F45
Keywords: Uncertainty, Forecast error variance decomposition, Spillovers

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Bank or any other institution with which the authors are associated. The responsibility for all remaining errors and omissions rests solely on the authors.

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1 Introduction

Baker *et al.* (2016) constructed their news-based Economic Policy Uncertainty Index, the EPU, for the five largest European economies: Germany, France, Italy, Spain, and the United Kingdom, along with the United States and other prominent global economies. After the EPU gained popularity, other teams also used similar text methodologies to develop the EPU index for other European countries.

However, these additional EPU-like indices do not always perfectly match the construction of the index by Baker *et al.* (2016). For example, Ghirelli *et al.* (2019) developed an alternative EPU index for Spain with a different set of keywords than in Baker *et al.* (2016) and with an additional restriction on articles explicitly related to Spain to track the uncertainty of Spanish economic policy uncertainty more closely. A similar restriction was adopted by Kok *et al.* (2015) for the Netherlands and by Bergman & Worm (2021) for Denmark. Furthermore, Baxa *et al.* (2023) proposed to scale the raw counts of news related to economic policy uncertainty by a count of economic policy articles rather than by a count of all articles to eliminate inconsistent trends in the EPU indices of European countries resulting from the use of different databases for the uncertainty indices of different countries.

This paper focuses on spillovers in uncertainty tracked by the EPU indices across European countries to show how different the uncertainty spillovers are when these alternative indicators are used. In this way, we investigate the differences between the alternative uncertainty indices themselves. Therefore, we start our analysis by estimating generalized forecast error variance decompositions of a time-varying parameter VAR model, in which we include the country-specific EPU indices of Germany, France, Italy, Spain, and the United Kingdom, developed by Baker *et al.* (2016). Then, we estimate the contribution of common uncertainty by means of the dynamic total connectedness, and we assess which countries are the primary source of shocks to EPU that affect the other countries. After that, we extend the sample by six additional countries with available EPU indices, i.e., Belgium, Denmark, Greece, Ireland, the Netherlands, and Sweden, and we also re-estimate the models with the alternative EPU indices when those are available.

The evidence that developments in uncertainty are often correlated across countries due to spillovers of large uncertainty shocks has grown rapidly (see, for example, Klößner & Sekkel (2014); Georgiadis (2016); Ozturk & Sheng (2018); Antonakakis *et al.* (2018); Mumtaz & Musso (2021), among others). Our analysis is based on the connectedness methodology, introduced by Diebold & Yilmaz (2009; 2012), and used to evaluate uncertainty spillovers between advanced countries by Klößner & Sekkel (2014). Nevertheless, they derived the spillovers from the time-invariant VAR model, and some time variation has been accounted for by rolling estimations only. The total connectedness for the time-varying VAR model has been introduced by Antonakakis *et al.* (2020) and used for an evaluation of uncertainty spillovers among the United States and Japan (Gabauer & Gupta 2018) and among the United States, the European Union, the United Kingdom, Japan, and Canada (Antonakakis *et al.* 2018). However, an analysis of the EPU spillovers within Europe has not yet been provided, and this paper fills this gap.

However, our main contribution to this literature is in analyzing the robustness of estimated spillovers based on the chosen variant of the EPU index. To anticipate our results, we show that uncertainty spillovers explain significant shares of the variances of EPU indices in Europe. However, the contributions of specific countries depend on the choice of the EPU variant. In particular, when alternatives to the EPU with the additional restriction on articles directly relevant to the domestic economy are used, the uncertainty spillovers from those countries decrease significantly. Therefore, in the case of European countries, the standard EPU indices by Baker *et al.* (2016) are contaminated by uncertainties originating from other countries and potentially unrelated to domestic events. The choice of normalization of the raw count of articles on economic policy uncertainty underlying the EPU index discussed by Baxa *et al.* (2023) also matters and leads to a higher average total connectedness and its higher variation over time, with a more pronounced decline in connectedness during the European debt crisis. These results indicate that the alternative EPU indices convey qualitatively and quantitatively different information, which shall be kept in mind when using these indices to monitor short-term economic activity and when studying the transmission of uncertainty shocks within countries.

The remainder of this paper is organized as follows. Section 2 describes the methodology. The main data and the baseline results are shown in Section 3. Section 4 shows the results with alternative EPU indices. The main implications close the paper.

2 Methodology

Our analysis of uncertainty spillovers starts with estimating the time-varying parameter VAR model with stochastic volatility (Koop & Korobilis 2014) that is used to estimate the comovement and codependence of the individual EPU indices:

$$y_t = c_t + B_{t,1}y_{t-1} + \ldots + B_{t,p}y_{t-p} + \epsilon_t \qquad \epsilon_t \sim \mathcal{N}(0, Q_t) \tag{1}$$

where y is a vector of m endogenous variables, c_t is time-varying constant, $B_{t,1} \ldots B_{t,p}$ denote time-varying regression coefficients. Disturbances ϵ_t follow a normal distribution with zero mean and covariance Q_t, which ensures stochastic volatility in the system.

All parameters are stacked to the vector β_t

$$\beta_t = (c_t^{'}, vec(B_{t,1})^{'}, \ldots, vec(B_{t,p})^{'}) \tag{2}$$

$$\beta_t = \beta_{t-1} + \eta_t \qquad \eta_t \sim \mathcal{N}(0, R_t) \tag{3}$$

where β_t evolves as a random walk over time with a normally distributed error term η_t.[1]

We employ a fast two-step algorithm developed by Koop & Korobilis (2014) with error covariance matrices R_t, and Q_t estimated dynamically using exponentially weighted moving averages (EWMA) to estimate the time-varying parameters. The priors on the time variation in volatility and coefficients are set by the forgetting factors κ_1 and κ_2. Their values are between 0 and 1, with higher values implying lower time-variation. Hence, a time variation is absent if the forgetting parameters are set to one. Following Koop & Korobilis (2014), we set the values of parameters $\kappa_1 = 0.96$ and $\kappa_2 = 0.99$. Details about initialization and algorithm are provided in the Appendix A.1.

To analyze spillovers, generalized forecast error variance decompositions are obtained in the spirit of Pesaran & Shin (1998). First, define the generalized impulse response function $\psi^g_{ij,t}$ as a difference between two conditional forecasts:

$$\psi^g_{ij,t}\left(n, \delta_j, F_{t-1}\right) = E\left(y_{i,t+n}|\varepsilon_{j,t} = \delta_j, F_{t-1}\right) - E\left(y_{i,t+n}|F_{t-1}\right) \tag{4}$$

[1] Note that the time-varying parameter VAR reduces to linear VAR if the covariance matrix $R_t = 0$. The stochastic volatility reduces to homoskedasticity if $Q_t = Q$.

where n is the horizon, δ_j is a one standard deviation shock to variable j, i denotes the i-th variable from a vector y and F_{t-1} represents the set of information available at time $t-1$. Then, the generalized forecast error variance decomposition $\phi^g_{ij,t}$ is defined as

$$\phi^g_{ij,t}(n) = \frac{\sum_{t=1}^{n-1}(\psi^{2,g}_{ij,t})}{\sum_{j=1}^{m}\sum_{t=1}^{n-1}\psi^{2,g}_{ij,t}}. \tag{5}$$

with m being the dimension of the vector of endogenous variables and i being the i-th variable from a vector y.

The generalized forecast error variance decompositions are then used to calculate *total connectedness*, $TC_t(n)$, between the uncertainty indices of individual countries as proposed by Antonakakis *et al.* (2020):

$$TC_t(n) = \frac{\sum_{ij=1,i\neq j}^{m}\phi^g_{ij,t}(n)}{\sum_{ij=1}^{m}\phi^g_{ij,t}(n)} * 100 = \frac{\sum_{ij=1,i\neq j}^{m}\phi^g_{ij,t}(n)}{m} * 100. \tag{6}$$

The $TC_t(n)$ measures how a shock in a variable i spills over to all other variables j for a given horizon n.

Furthermore, the effect of a shock in the variable i on other variables j is called the *total directional connectedness to others* and is defined as follows:

$$TC_{i\rightarrow j,t}(n) = \frac{\sum_{j=1,i\neq j}^{m}\phi^g_{ij,t}(n)}{\sum_{j=1}^{m}\phi^g_{ij,t}(n)} * 100. \tag{7}$$

Similarly, we define *total directional connectedness from others* as a directional connection that the variable i receives from the variables j, that is,

$$TC_{i\leftarrow j,t}(n) = \frac{\sum_{j=1,i\neq j}^{m}\phi^g_{ij,t}(n)}{\sum_{i=1}^{m}\phi^g_{ij,t}(n)} * 100. \tag{8}$$

Subtracting *total directional connectedness to others* from *total directional connectedness from others*, we obtain *net total directional connectedness*

$$TC_{i,t}(n) = TC_{i\rightarrow j,t}(n) - TC_{i\leftarrow j,t}(n) \tag{9}$$

where $TC_{i,t}(n)$ shows how the variable i affects the analyzed system. If $TC_{i,t}(n)$ is positive, then the variable i influences other variables more than it is influenced by others. On the contrary, if $TC_{i,t}(n)$ is negative, the variable i is driven by the network.

Finally, it is possible to calculate the *net pairwise directional connectedness* from the *net total directional connectedness*

$$TC_{ij,t}(n) = (\phi^g_{ji,t}(n) - \phi^g_{ij,t}(n)) * 100. \tag{10}$$

Positive $TC_{ij,t}(n)$ means that the variable i dominates the variable j. The opposite holds for negative $TC_{ij,t}(n)$.

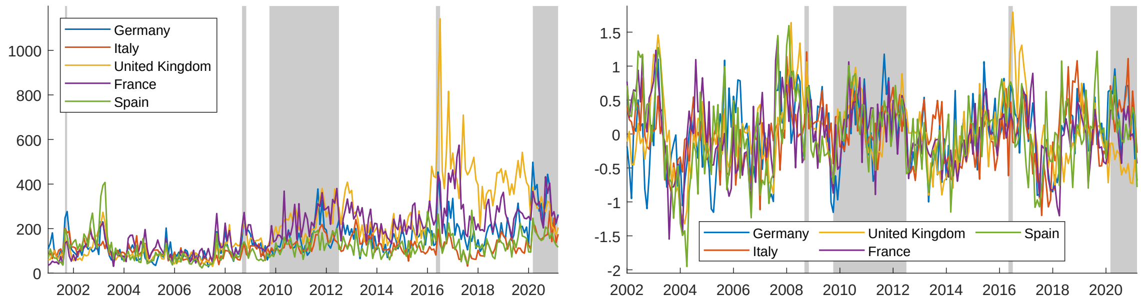
3 Uncertainty spillovers: The five largest European countries

3.1 Data

We start with the analysis of spillovers between the five largest European economies, Germany, France, Italy, Spain, and the United Kingdom, with the EPU indices developed by Baker *et al.* (2016) and obtained from their website `www.policyuncertainty.com/europe_monthly.html`. The dataset covers the period between January 2001 and March 2021, and the indices are shown in Figure 1a.

Figure 1: EPU Indices

(a) Level (b) Centered Year-on-Year Log-Differences



Note: Shaded areas depict major uncertainty events worldwide. 2001M09-2001M10: 9-11 Terrorist Attack; 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

All indices show significant comovement, confirmed by the correlation coefficients in Table 1. The average correlation between particular countries reaches 54 % for data in levels and 46 % for centered year-on-year logarithmic differences. These correlations correspond to a strong integration of the countries in our sample.

Table 1: Correlation of EPU Index

Levels						*Centered year-on-year log-differences*				
Germany	Italy	UK	France	Spain		Germany	Italy	UK	France	Spain
1.00	0.56	0.62	0.72	0.56	Germany	1.00	0.39	0.45	0.53	0.52
0.56	1.00	0.31	0.50	0.47	Italy	0.39	1.00	0.25	0.47	0.43
0.62	0.31	1.00	0.74	0.42	UK	0.45	0.25	1.00	0.46	0.52
0.72	0.50	0.74	1.00	0.50	France	0.53	0.47	0.46	1.00	0.54
0.56	0.47	0.42	0.50	1.00	Spain	0.52	0.43	0.52	0.54	1.00

For estimation, we use year-on-year log differences of the EPU, centered and standardized (Figure 1b), because the ADF test does not reject unit roots in the EPU of Germany, France and the United Kingdom, and the volatility of series differs as well. We use four lags, as suggested by the Akaike information criterion. The horizon at which spillovers are calculated is set to 24 months.[2]

3.2 Results

The role of domestic and foreign uncertainty shocks is presented first with the generalized forecast error variance decompositions (Figure 2) and then with the estimates of total and directional connectedness (Table 2). Most importantly, 49 to 65 % of the variance is driven by shocks to the EPU of the country itself (see the diagonal in Table 2), with some time variation in the contributions of foreign shocks. The largest share of domestic uncertainty appears in Italy, particularly after the European debt crisis (Figure 2b). It peaks at more than 80 %, leaving a small space for influences from other countries. Domestic uncertainty

[2]We also experimented with shorter horizons, but the results were reasonably robust to this choice.

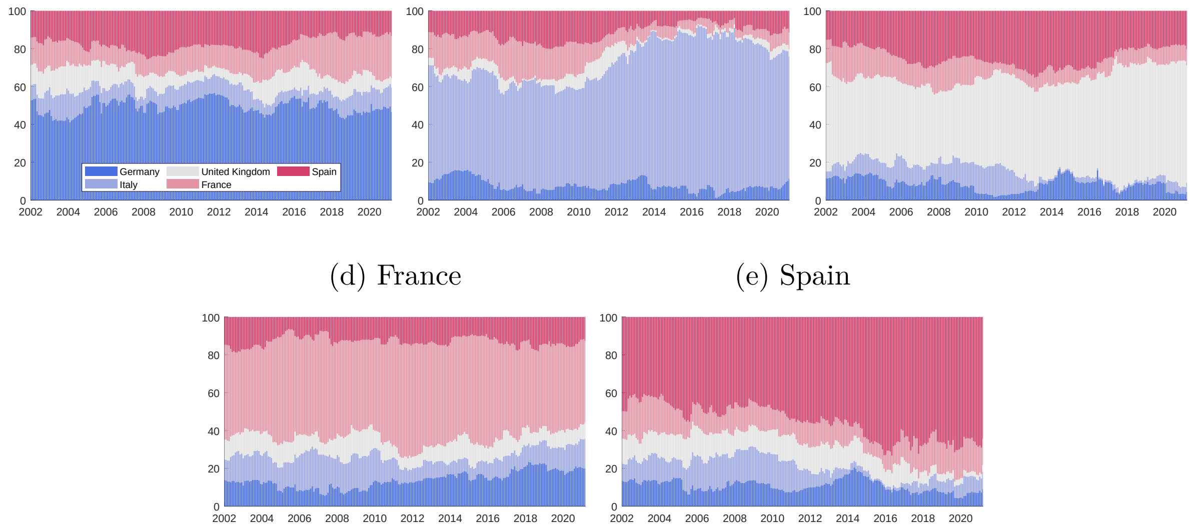
increased over time in Spain and in the United Kingdom as well, although not as much as in the case of Italy (Figures 2c and 2e).

These results reflect differences in the dynamics of economic growth over the past decade. Germany recovered swiftly from the Great Recession and experienced fast and robust economic growth, interrupted by the COVID-19 pandemic in 2020. The rebound of the French economy was slower. Still, the impact of the Great Recession was less intense and less persistent than in Italy and Spain, which experienced sovereign debt crises. These debt crises sparked political turmoil in both countries, led to the increased popularity of new political parties, and reshaped political systems. However, the political instabilities in Italy and Spain did not significantly impact the core countries that were not forced to consolidate their public finances. Therefore, the growing role of domestic uncertainty in Italy and Spain appears plausible.

Similarly, the moderately increasing role of British political uncertainty in its own EPU since 2015/2016 coincides with Brexit turmoil, before and after Britain voted to leave the EU (Figure 2c). On the other hand, we do not observe any long-term increase in the impact of British uncertainty on other countries after the Brexit referendum in 2016. Instead, the impact of the United Kingdom on other countries gradually decreased.[3] This finding suggests that the remaining EU countries quickly realized that they would be affected by Brexit much less than the United Kingdom.

Figure 2: Generalised Forecast Error Variance Decomposition

(a) Germany (b) Italy (c) United Kingdom (d) France (e) Spain



Note: EPU indices by Baker *et al.* (2016), TVP-VAR model with stochastic volatility, four lags, and 24-month horizon.

Table 2 provides estimates of total and directional connectedness for each country. The numbers on the diagonal express the share of the domestic EPU that is explained by domestic shocks. The off-diagonal elements show the directional connectedness, that is, the proportion of uncertainty of the country on the line i is determined by the country in the column j.[4]

[3] Plots of spillovers from and to the countries are in Figures A1 - A4 in Appendix.

[4] Note that the numbers in lines correspond to averages of the general forecast error variance decom-

Quite surprisingly, Spain appears as the primary source of uncertainty, as its contribution to other countries is the largest. We will examine the role of Spain in more detail in the next section.

Table 2: Spillovers: Directional and Total Connectedness Indices

	Germany	Italy	UK	France	Spain	FROM others
Germany	49.3	9.0	9.6	14.5	17.6	50.7
Italy	7.8	65.5	4.1	10.9	11.7	34.5
UK	8.4	7.0	49.6	10.3	24.8	50.4
France	14.0	12.4	9.8	50.8	13.0	49.2
Spain	10.8	9.8	10.8	13.2	55.3	44.7
Contribution TO others	41.0	38.2	34.4	48.8	67.0	229.5
NET directional connectedness	-9.6	3.7	-16.0	-0.3	22.4	TCI
NPDC transmitter	0.0	3.0	1.0	3.0	3.0	45.9

Note: Interpretation of numbers in the table: Diagonal - share of variance explained by own shock. Lines - share of uncertainty received by country i from countries j in columns. *FROM others* - how much uncertainty did country i receive from others. *To others* - how much uncertainty country in a column j sent to others. *NPDC transmitter*: net pairwise total connectedness transmitter shows how many countries a country i exports uncertainty to. *TCI*: total connectedness index.

The time variation in total connectedness is shown in Figure 3. The results suggest that total connectedness decreased slightly with time, from connectedness levels of about 50 % to around 40 %. Most of this decline occurred during the European debt crisis, and we interpret it as a sign of disintegration and desynchronization of the most important economies in Europe. Our results show that connectedness did not return to pre-2010 levels even a decade after the European debt crisis.

Interestingly, the persistently lower connectedness after the European debt crisis mirrors the developments of bond yields in Europe, where the lower connectedness after the crisis was identified byDe Santis & Zimic (2018). After market disintegration during the European debt crisis, the correlation of bond yields across European countries was restored again, but it did not return to the pre-2008 levels (see De Grauwe & Ji 2022, and De Santis & Zimic 2018). Thus, mainly Italian and Spanish bonds remained priced differently than the rest of the eurozone, although the difference was lower than in the case of Greece.

The decrease in connectedness after the European debt crisis also corresponds to findings by Śmiech *et al.* (2020), who show that spillovers in financial, consumer and industrial uncertainty decreased after the European debt crisis, and to Fernandez-Perez *et al.* (2023) confirming a similar decrease in total connectedness in consumer confidence in the euro area and business confidence in the euro area periphery.[5]

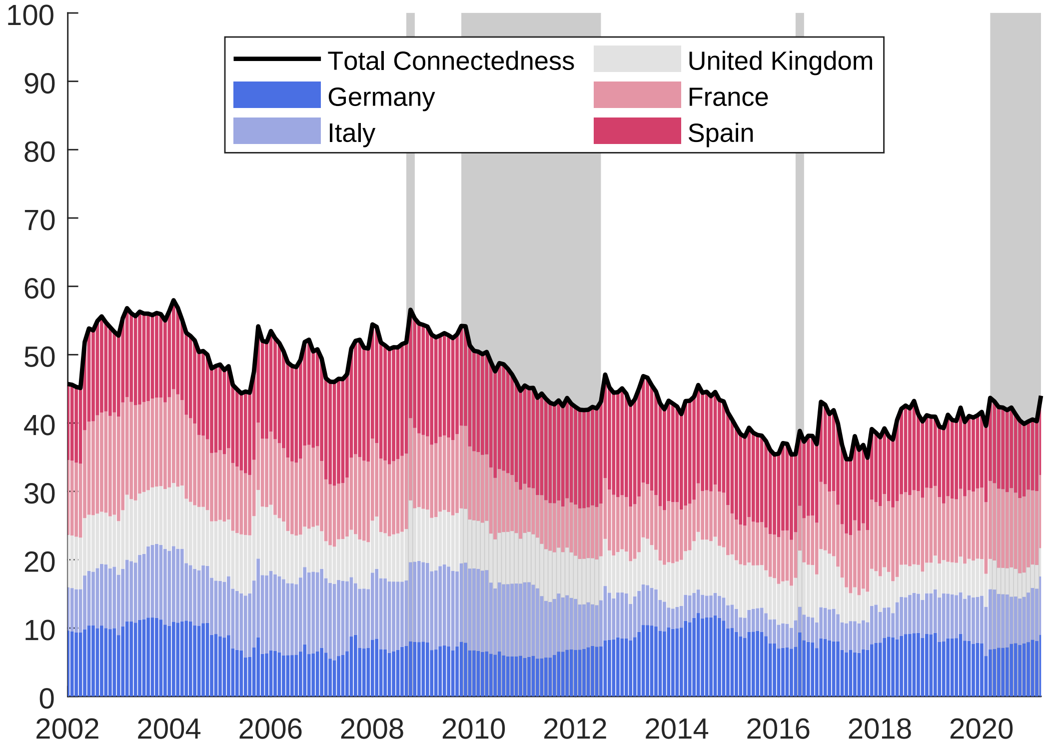
The contributions of individual countries to total connectedness mimic the information from the GFEVDs and Table 2. In particular, the large spillovers of Spain to the uncertainty of other countries are prominent and contrast notably with the decreasing

position of the country i depicted in Figure 2. The column *FROM others* indicates how much variance of the EPU is driven by other countries (equation (8)), and the line *Contribution TO others* shows how much variance is sent to other countries (equation (7)).

[5]The results by Śmiech *et al.* (2020) indicate that the decrease in the connectedness of various types of survey-based uncertainties started in 2011 and accelerated in 2013. However, the authors tackled the time variation using rolling regression with a five-year window. Consequently, their results for the year 2010 are based on the 2005-2009 sample, so the results before 2013 are strongly affected by the precrisis years. Therefore, we consider our results to be consistent with theirs.

contribution of Italy to the total connectedness after the European debt crisis and the small role of the United Kingdom over the whole sample.

Figure 3: Total Connectedness in European Uncertainty



Note: TVP-VAR model with stochastic volatility, four lags, and 24-month horizon. Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

The relatively large role of Spain and the minor role of the United Kingdom contrast with the findings of Ahir *et al.* (2022) who, with the World Uncertainty Index, showed the dominant role of uncertainty of the United States and the United Kingdom for the developments of other countries and argue that the relative importance of uncertainty spillovers from other countries is relatively minor.[6] Their conclusions fit the developments during the 2008 global financial crisis, which began with the crisis in the subprime mortgage markets in the United States and spread to European countries, mainly through the United Kingdom. Spain had been severely affected by the crisis, but Italy too, particularly by the European Debt Crisis, and our EPU results do not reveal such large spillovers from Italian uncertainty to other countries as in the case of Spain. Therefore, the large contribution of uncertainty originating in Spain needs a more profound analysis, which we will provide in the next section.

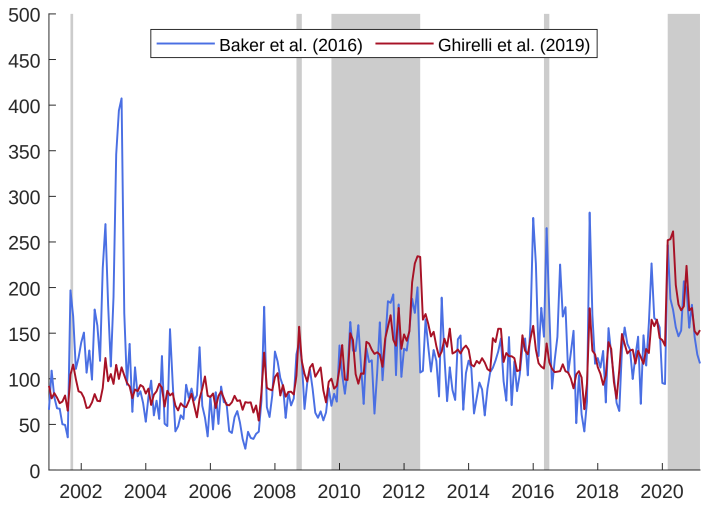
[6]The World Uncertainty Index (WUI) by Ahir *et al.* (2022) is based on the occurrence of the word uncertainty in the Economist Intelligence Unit Country Reports. Although the WUI is not completely equivalent to the EPU, its construction and developments are similar.

4 Robustness

4.1 Are spillovers from Spain so important?

To verify the importance of uncertainty shocks that originate in Spain for other countries, we replace the EPU index of Spain with the alternative EPU index developed by Ghirelli *et al.* (2019). The authors aimed to address several shortcomings of the EPU by Baker *et al.* (2016). In particular, Ghirelli *et al.* (2019) criticized the original index for covering only two newspapers for Spain (El País and El Mundo) and for relying on a too restrictive set of keywords used to identify whether or not any particular article is about economic policy uncertainty. After expanding the number of newspapers to seven, increasing the number of keywords, and, more importantly, restricting search queries to articles related only to Spain, they obtained a new index with a pattern that was distinctly different from the original index by Baker *et al.* (2016).

Figure 4: Different EPU Indices for Spain



Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

Most importantly, the Ghirelli et al. index peaks in the summer of 2012 when financial aid for Spain, suffering from the debt crisis, was negotiated, while the index of Baker *et al.* (2016) reached the maximum value during the invasion of Iraq in 2003, an event not directly related to the Spanish economy (see Figure 4). Furthermore, the peak associated with the Brexit vote is less pronounced in the Ghirelli et al. index compared to Baker *et al.* (2016). The reason for these differences can be understood with the help of the subsequent contribution by Ghirelli *et al.* (2021), who used Spanish newspapers to calculate the EPU of Latin American countries by searching for articles on economic policy uncertainty along with the names of those countries. These indices often peak in 2002-2003, when several countries in the region went through political or economic turmoil.[7] Because the Economic Policy Uncertainty Index for Spain by Baker *et al.* (2016) does not distinguish between articles devoted to Spain and other countries, it might overestimate the Spanish

[7]For instance, Argentina was still recovering from the currency crisis; in Brazil, Luiz Inácio Lula da Silva was elected president for the first time, and Chile suffered a currency crisis.

uncertainty in periods of economic instability in other countries.[8]

Consequently, once we replace the original EPU index by Baker *et al.* (2016) with the alternative index (Ghirelli *et al.* 2019), the role of spillovers from Spain decreases markedly, as seen in the contribution of Spain to the total connectedness (compare the graphs in Figure 5). Spain becomes a country that receives more uncertainty from other countries than it sends, and the average total connectedness decreases from 46.9 to 39.9. Total connectedness appears to decrease gradually, especially since the European debt crisis, suggesting a lower role for the common component than in the baseline exercise (Figure 6). This relatively lower contribution of Spain corresponds to the analysis of spillovers in bond yields by De Santis & Zimic (2018), who found that the impact of Spain on systemic risk was lower than that of Italy.

Table 3: Spillovers: Directional and Total Connectedness Indices for the Alternative Spain EPU Index

	Germany	Italy	UK	France	Spain	FROM others
Germany	51.7	9.3	10.8	15.9	12.3	48.3
Italy	9.0	69.9	4.0	12.1	5.1	30.1
UK	10.5	7.6	61.6	13.0	7.4	38.4
France	15.8	13.1	10.6	55.2	5.3	44.8
Spain	14.0	5.9	9.4	8.7	62.0	38.0
Contribution TO others	49.2	35.9	34.8	49.7	30.1	199.6
NET directional connectedness	0.9	5.8	-3.6	4.9	-7.9	TCI
NPDC transmitter	1.0	4.0	2.0	3.0	0.0	39.9

Note: Interpretation of numbers in the table: Diagonal - share of variance explained by own shock. Lines - share of uncertainty received by country i from countries j in columns. *FROM others* - how much uncertainty did country i receive from others. *To others* - how much uncertainty country in a column j sent to others. *NPDC transmitter*: net pairwise total connectedness transmitter shows how many countries a country i exports uncertainty to. *TCI*: total connectedness index.

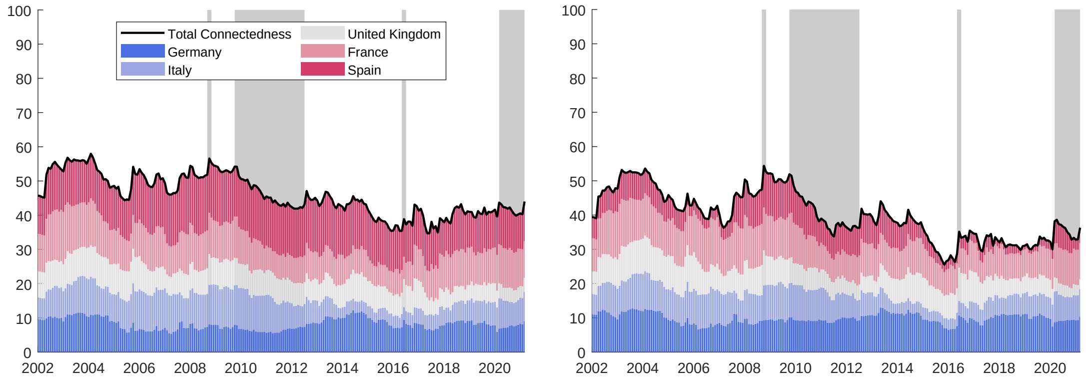
These results confirm that the use of the EPU index for Spain by Baker *et al.* (2016) overestimates the spillovers of uncertainty from Spain to other countries because the index is strongly affected by economic policy from other countries than Spain. From a methodological point of view, these differences suggest that when constructing new uncertainty indices, a larger set of newspapers and excluding articles referring to foreign events lead to a more intuitive assessment of uncertainty in a given country.[9] However, the pattern of increasing importance of the own uncertainty shocks in Italy, Spain and the United Kingdom identified in our baseline setup with all indices by Baker *et al.* (2016) remains robust after replacing the EPU index for Spain with the one developed by Ghirelli *et al.* (2019).

[8]To verify this claim, one would have to compare the articles selected for the construction of both alternative indices. Unfortunately, we did not have such an option.

[9]On the other hand, extending the scope for more newspapers increases the effort needed to calculate the index markedly.

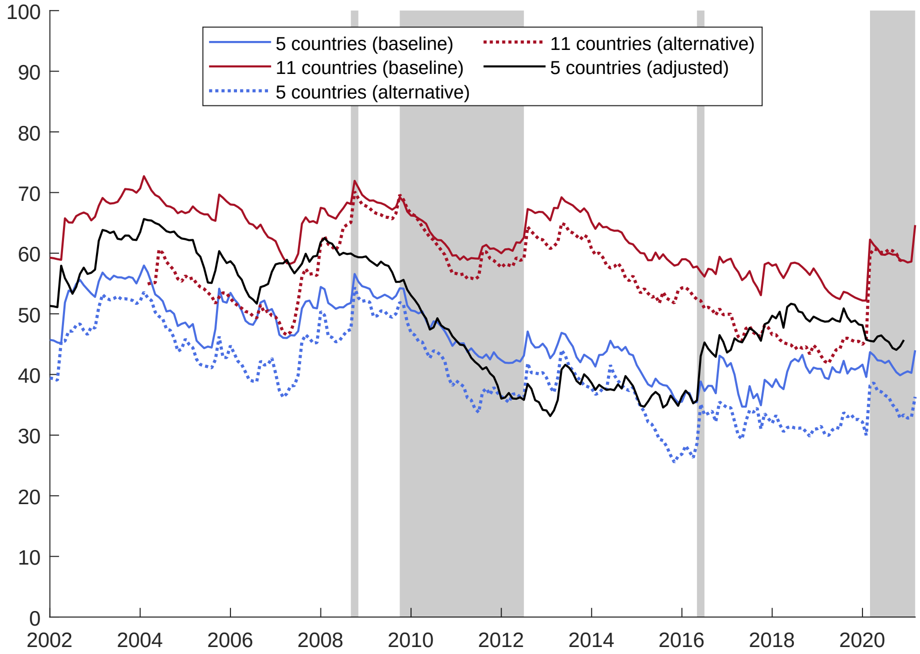
Figure 5: Total Connectedness in European Uncertainty: Sensitivity to Spain Index

(a) Original EPU Index (b) Alternative Spain EPU Index



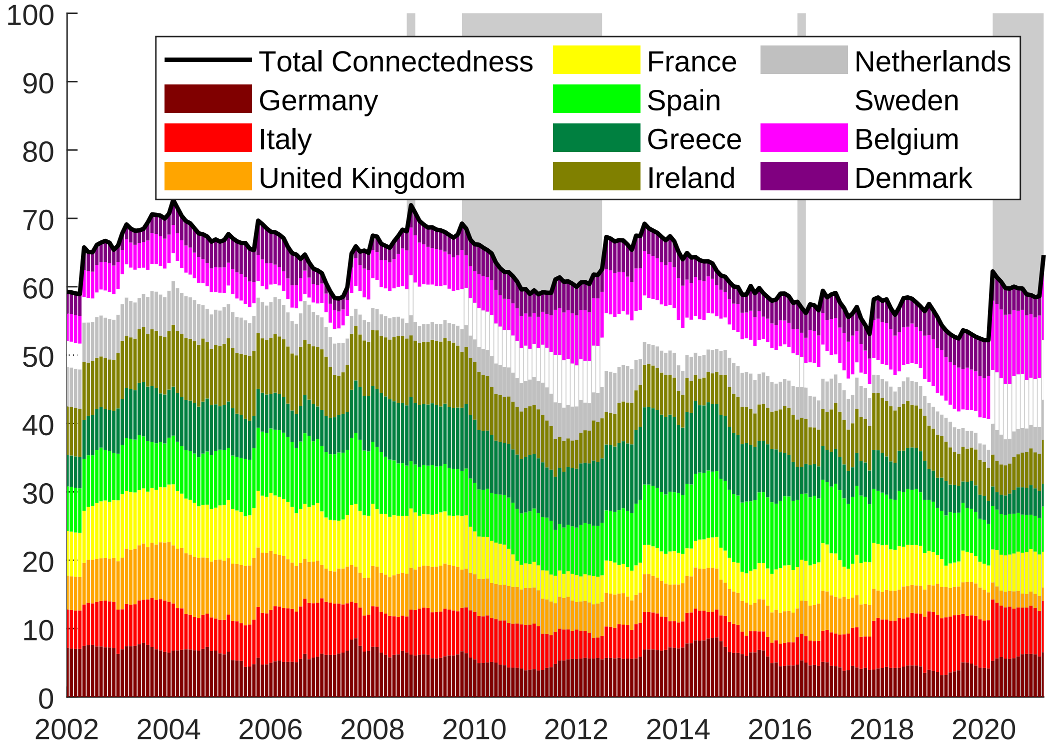
Note: TVP-VAR model with stochastic volatility, lags selected by the AIC (4 lags for the baseline, 3 lags for the sample with Spanish EPU replaced by the alternative index by Ghirelli *et al.* (2019)). 24-month horizon. Shaded areas depict major events in the world. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

Figure 6: Total Connectedness in European Uncertainty: Comparison of Different Estimations



Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent total connectedness with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015). The adjusted index follows Baxa *et al.* (2023).

Figure 7: Total Connectedness in European Uncertainty: Extended Sample of Countries



Note: TVP-VAR model with stochastic volatility, four lags, and 24-month horizon. Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

4.2 The results for extended sample of countries

Next, we extended the sample of the five largest European countries to other European countries for which the uncertainty indices were developed. These include Greece (Hardouvelis *et al.* 2018)[10], Ireland (Rice 2020), Belgium (Borms *et al.* 2020), Netherlands (Kok *et al.* 2015), Denmark (Bergman & Worm 2021), and Sweden (Armelius & Hull 2017).[11]

Most of these indices bring the methodology of Baker *et al.* (2016) to these countries quite closely. They usually refer to the same or very similar selection of keywords to scrape the database of the leading newspapers, and the counts of articles are normalized with the count of all articles in a given month.[12]

Compared to our benchmark estimates on a sample of five countries, the total connectedness has increased from 45.9 to 60.4 %. Although there is some time variation in the estimated level of connectedness, fluctuations occur at frequencies higher than the

[10]We opted for the index by Hardouvelis *et al.* (2018) since it is based on text mining in four newspapers, while the alternative index by Fountas *et al.* (2018) uses just one newspaper to derive the uncertainty index.

[11]For those countries, the uncertainty indices are regularly updated and the updates are available at `www.policyuncertainty.com/europe_monthly.html`, too.

[12]Sweden is an exception, the count of uncertainty-related articles is scaled by the count of economic articles. For a broad discussion on the impact of this scaling, see Baxa *et al.* (2023). In addition, the indices for the other European countries differ in selecting a period to normalize the average and variance. Baker *et al.* (2016) use the sample until December 2009, and the samples used by other countries differ markedly; some end in 2009-2011, and the Irish index by Rice (2020) is normalized to a full period of 1982-2022. Still, since these are the best available estimates of economic policy uncertainty indices available up to now, and since we use standardized data, we can abstract from these differences in reference periods.

usual frequencies of business cycles, and no clear trend emerges (Figure 7). Furthermore, the country-specific shocks account for 28.9 - 43.3 % of the EPU dynamics, less than in the case of five countries, where the share of country-specific shocks was between 51.7 and 69.9 % (for more details see Table A3 in Appendix). Thus, foreign shocks are relatively more important than in our estimates on the sample of five countries, since the shocks from relatively smaller countries also spill over to large and stable EU economies.

Figure 7 proves that no country dominates the common component, although there are relatively higher contributions from Spain, France, and, most notably, Greece, which was hit by the European debt crisis at most. The spillovers from Greece to other countries have already increased with increasing financial instability in late 2007 and peaked in 2013, a year after the Outright Monetary Transactions were pulled out, bringing relief to other crisis-hit countries. The contribution of Greece finally decreased after the final deal on bailouts was reached in July 2015 and when Brexit started to dominate policy discussions in Europe.[13]

As a sensitivity check, we use the alternative indices for Spain (Ghirelli *et al.* 2019), the Netherlands (Kok *et al.* 2015) and Denmark (Bergman & Worm 2021). In line with the sample of five countries, the role of Spain in the dynamics of other countries decreased markedly, while the proportion of variance explained by its own shocks increased. However, a similar difference arises also in the case of the Netherlands, now with a more prominent role of its own uncertainty, especially in the years preceding the Great Recession and the COVID-19 pandemic. Denmark is a slightly different case, with mean contributions to other countries' uncertainties remaining small and broadly consistent between both indices.[14]

4.3 Adjusted EPU index

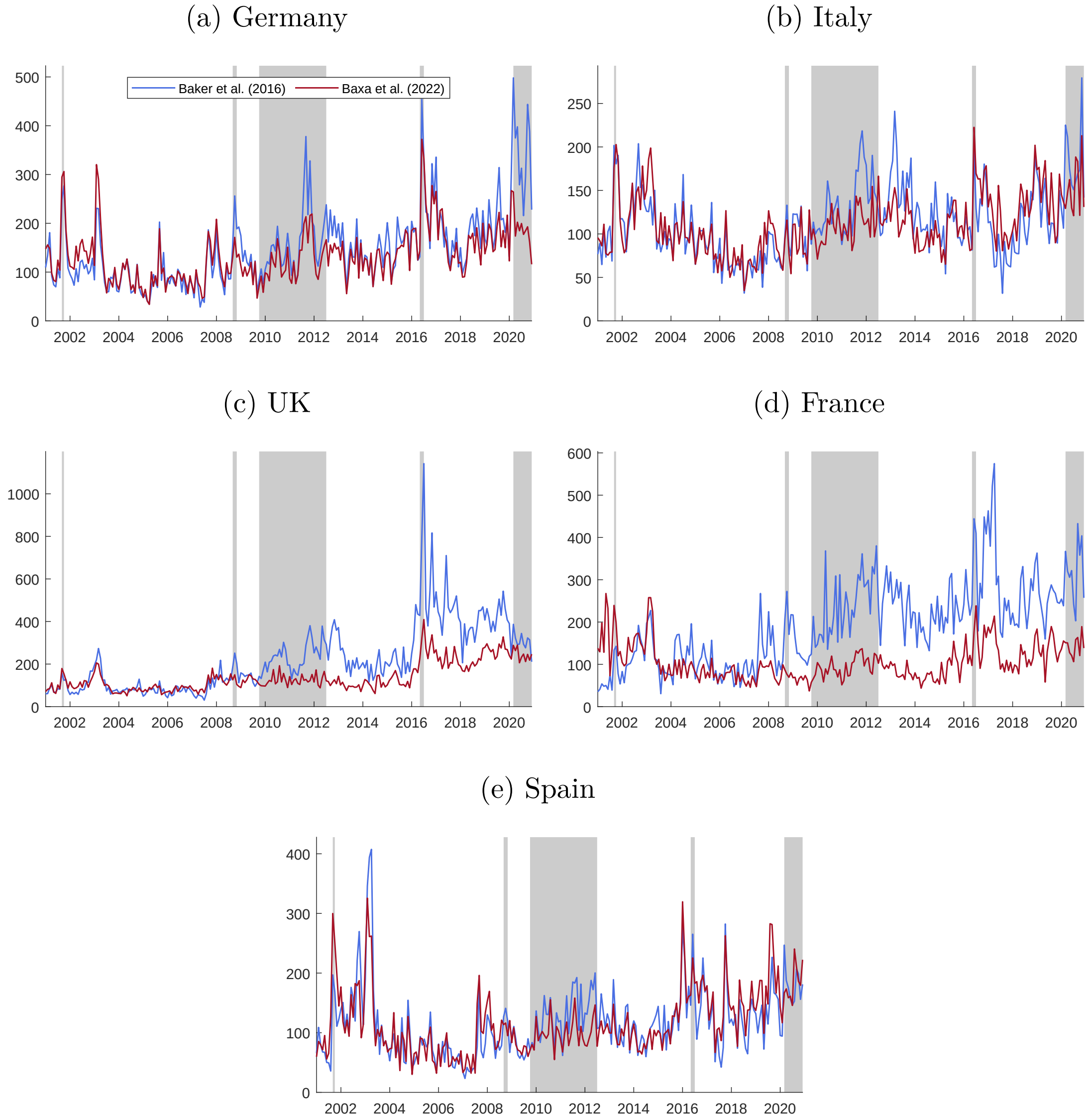
Baxa *et al.* (2023) analyzed the long-term trends in the EPU of European countries, pointing out that the relatively flat indices of Italy and Spain with the rising indices of Germany and France seem to be in conflict with political stability in Germany and France and rather turbulent politics in Italy and Spain after the European debt crisis. Based on these considerations, the authors proposed normalizing the uncertainty-related articles by articles dealing with economic policy issues rather than by all articles, which removes a large part of the trend of Germany, France, and the United Kingdom, but maintains much of the short-term dynamics pattern (Figure 8). On the other hand, the developments of the EPU in Italy and Spain are less affected by this alternative scaling and remain broadly consistent with the original EPU by Baker *et al.* (2016).[15]

[13]Detailed results for Greece are provided in Appendix, Figures A2a and A6a.

[14]The decomposition of the total connectedness for alternative indices is provided in Figure A12.

[15]Note that the database Factiva used for text-scraping in several countries does not allow searching for the number of all articles directly and that in those cases, the number of uncertainty-related articles is scaled by the occurrence of the word "today" in a given month. This approach was chosen by Baker *et al.* (2016), who consider the word "today" to be frequent, general, and disassociated with economic development so that it can be used to normalize the raw counts of articles related to uncertainty.

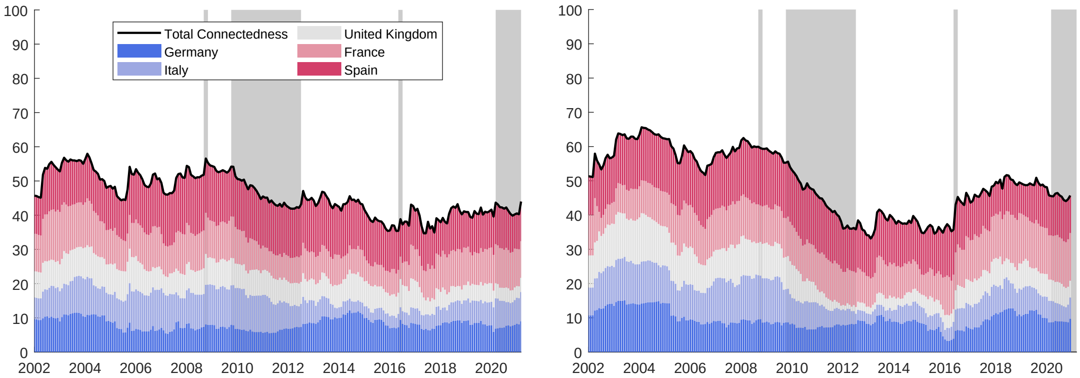
Figure 8: Adjusted EPU Indices



Note: Shaded areas depict major uncertainty events. 2001M09-2001M10: 9-11 Terrorist Attack; 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

Figure 9: Total Connectedness in European Uncertainty: Sensitivity to Adjusted Index

(a) Original EPU Index (b) Adjusted EPU Index



Note: TVP-VAR model with stochastic volatility, lags selected by the AIC (4 lags for the baseline, 3 lags for the alternative adjusted index by Baxa *et al.* (2023)). 24-month horizon. Shaded areas depict major events in the world. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

The differences between the original EPU and the adjusted EPU translate into estimates of total connectedness despite using normalized log differences that filter out the long-term information in all indices. The spillovers from and to all countries increased compared to the baseline EPU indices, particularly those from Germany to other countries. The average total connectedness is higher than in the case of the baseline EPU index, and it increased from 45.9 to 49.6. In addition, the time variation of total connectedness is higher (Figure 6), with a more pronounced decline in connectedness during the European debt crisis due to the rapidly decreasing role of the Italian and British adjusted EPU indices in total connectedness. However, following the Brexit referendum, the total connectedness increased, and this sharp increase contrasts with the development of the baseline index.

The main cause of these differences is that in the case of the adjusted index, the British contribution to the common uncertainty is most prominent in the first half of the sample until 2010, decreases with the European debt crisis, and increases after the Brexit referendum again, while it remains flat in our baseline exercise with the original EPU indices (compare graphs in Figure 9). Similarly to our findings, but with the World Uncertainty Index, Ahir *et al.* (2022) identified significant spillovers of uncertainty from the United Kingdom to other countries after the Brexit referendum of 2016, corresponding to estimates of spillovers from the adjusted EPU rather than from the baseline EPU.[16] Furthermore, relatively larger spillovers from the United Kingdom to other countries before the year 2010, indicated by the adjusted EPU, correspond to the outbreak of financial instability in the British economy before 2008, shortly after the U.S. subprime mortgage crisis, preceding the full-fledged crisis in other large EU countries. On the other hand, news from other countries dominated the European debt crisis period. Hence, the

[16] It shall be noted that the World Uncertainty Index was developed to proxy broader aspects of uncertainty than those solely related to economic policy. However, since the index is based on the occurrence of words *uncertain* and *uncertainty* within the Economist Intelligence Unit reports, it remains related to large economic and geopolitical events that often affect economic policy. Therefore, we consider the comparison between the WUI and the EPU as reasonable.

relatively lower contribution of British uncertainty to total connectedness between 2010 and 2016 indicated by adjusted EPU indices appears more intuitive.[17]

5 Conclusions

This paper investigates uncertainty spillovers across Europe, intending to uncover differences in estimated spillovers when alternative versions of the Economic Policy Uncertainty Index are used.

First, we estimate the generalized forecast error decompositions derived from the time-varying parameter VAR model with the benchmark EPU indices for Germany, France, Italy, Spain, and the United Kingdom by Baker *et al.* (2016). Then, the total connectedness is estimated. We show that almost half of the variation of the EPU index is explained by the common component.

However, the assessment of spillovers from individual countries, their contributions to the common factor relative to others, and the time variation of connectedness indices is not consistently robust across the specifications we have considered. In particular, the large spillovers from Spain to other countries decrease markedly when the EPU index developed by Baker *et al.* (2016) is replaced by the index proposed by Ghirelli *et al.* (2019). Their index relies on an expanded set of keywords referring to economic policy uncertainty and restricts the scraper to keep articles related only to Spain explicitly. Our results confirm that the original index for Spain is biased toward global uncertainty. Similarly, using the adjusted EPU indices of Baxa *et al.* (2023) with less pronounced trends in uncertainty indices compared to the original EPU leads to lower estimated spillovers from Britain since the global financial crisis of 2007-2008 and somewhat higher variation in connectedness. Therefore, our results based on generalized forecast error variance decompositions and spillovers derived from the time-varying parameter VAR model show that different EPU indices contain different information.

Our results are important for the future development of uncertainty indices based on text mining in newspapers in small open economies. We show that the set of keywords used in the original Economic Policy Uncertainty index leads to the selection of articles that do not distinguish between domestic and foreign uncertainty events. Therefore, restricting text mining via additional restrictions on news related to the domestic economy leads to indices that might track domestic uncertainty better.

[17] The generalized forecast error variance decompositions and the details of the total connectedness are in the Appendix (Figure A13 and Table A5).

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6 Appendix

A.1 Estimation algorithm of TVP-VAR model

The estimation is initialized by setting the initial conditions for all unknown parameters of the system:

$$\beta_0 \sim \mathcal{N}(0, \Sigma^{\beta}_{0|0}) \tag{A1}$$

$$Q_0 \sim 1 \times I_n \tag{A2}$$

where the covariance matrix $\Sigma^{\beta}_{0|0}$ has Minnesota prior. The diagonal contains $\frac{0.1}{r}$ with $r = \{1, ..., p\}$ representing the associated lag $B_{0|0,r}$, other elements are zero.

The algorithm consists of the following steps:

1. Given the initial conditions, obtain filtered estimates of β_t, Q_t using the following recursion for $t = 1, \ldots, T$.

   (a) Kalman filter gives

   $$\beta_t | data_{1:t-1} \sim \mathcal{N}(\beta_{t|t-1}, \Sigma^{\beta}_{t|t-1}), \tag{A3}$$

   where

   $$\beta_{t|t-1} = \beta_{t-1|t-1} \tag{A4}$$

   $$\Sigma^{\beta}_{t|t-1} = \Sigma^{\beta}_{t-1|t-1} + \hat{R}_t \qquad \hat{R}_t = (1 - \kappa_2^{-1})\Sigma^{\beta}_{t-1|t-1}. \tag{A5}$$

   (b) Calculate estimates Q_t for use in the updating step using the following EWMA specifications:

   $$\hat{Q}_t = \kappa_1 Q_{t-1|t-1} + (1 - \kappa_1)\hat{\epsilon}_t \hat{\epsilon}_t^{'} \qquad \hat{\epsilon}_t = y_t - \tilde{y}_t \beta_{t|t-1} \tag{A6}$$

   (c) Update β_t given information at time t using the Kalman filter:

   $$\beta_t | data_{1:t} \sim \mathcal{N}(\beta_{t|t}, \Sigma^{\beta}_{t|t}), \tag{A7}$$

   where

   $$\beta_{t|t} = \beta_{t|t-1} + \Sigma^{\beta}_{t|t-1}\tilde{y}_{t-1}\left(\hat{Q}_t + \tilde{y}_{t-1}\Sigma^{\beta}_{t|t-1}\tilde{y}_{t-1}^{'}\right)^{-1}\left(\tilde{y}_t - \tilde{y}_{t-1}\hat{\beta}_{t|t-1}\right) \tag{A8}$$

   $$\Sigma^{\beta}_{t|t} = \Sigma^{\beta}_{t|t-1} - \Sigma^{\beta}_{t|t-1}\tilde{y}_{t-1}\left(\hat{Q}_t + \tilde{y}_{t-1}\Sigma^{\beta}_{t|t-1}\tilde{y}_{t-1}^{'}\right)^{-1}\tilde{y}_{t-1}\Sigma^{\beta}_{t|t-1} \tag{A9}$$

   (d) Update Q_t with the information given at time t using EWMA specification:

   $$Q_{t|t} = \kappa_1 Q_{t-1|t-1} + (1 - \kappa_1)\hat{\epsilon}_{t|t}\hat{\epsilon}_{t|t}^{'} \tag{A10}$$

2. Obtain smoothed estimates of β_t and Q_t using recursion for $t = T - 1, \ldots, T$.

(a) Update β_t given information at time $t+1$ using fixed interval smoother:

$$\beta_t | data_{1:T} \sim \mathcal{N}(\beta_{t|T}, \Sigma^{\beta}_{t|T}) \tag{A11}$$

$$\Sigma^{\beta}_{t|T} = \beta_{t|t} + C^{\beta}_t(\beta_{t+1|T} - \beta_{t+1|t}) \qquad C^{\beta}_t \equiv \Sigma^{\beta}_{t|t}\left(\Sigma^{\beta}_{t+1|t}\right)^{-1} \tag{A12}$$

$$\Sigma^{\beta}_{t|T} = \Sigma^{\beta}_{t|t} + C^{\beta}_t\left(\Sigma^{\beta}_{t+1|T} - \Sigma^{\beta}_{t+1|t}\right)C^{\beta\prime}_t \tag{A13}$$

(b) Update Q_t given the information at time $t+1$

$$Q^{-1}_{t|t+1} = \kappa_1 Q^{-1}_{t|t} + (1-\kappa_1)Q^{-1}_{t+1|t+1} \tag{A14}$$

A.2 Estimates of spillovers and common uncertainty

A.2.1 Connectedness: Additional tables and figures

Table A1: Optimal Number of Lags for TVP-VAR Model with Stochastic Volatility

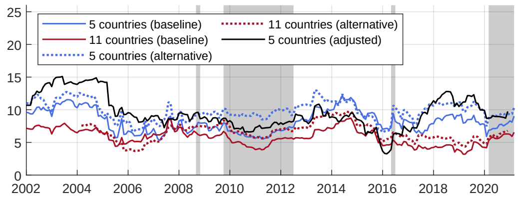
	AIC	HQC	SIC
5 countries: Baseline	**4**	2	1
5 countries: Alternative index for Spain	**3**	2	1
5 countries: Adjusted index	**3**	1	1
11 countries: Baseline	**4**	1	1
11 countries: Alternative index for Spain, Nederland, and Denmark	**3**	1	1

Table A2: Range of Sample

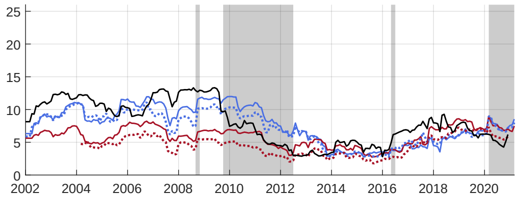
Sample	Range
Five countries: Baseline	2001M01-2021M03
Five countries: Alternative index for Spain	2001M01-2021M03
Five countries: Adjusted index	2001M01-2020M12
11 countries: Baseline	2001M01-2021M03
11 countries: Alternative index for Spain, Nederland, and Denmark	2003M03-2020M12

Figure A1: Total Directional Connectedness to Others

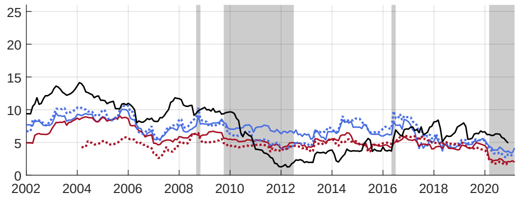
(a) Germany



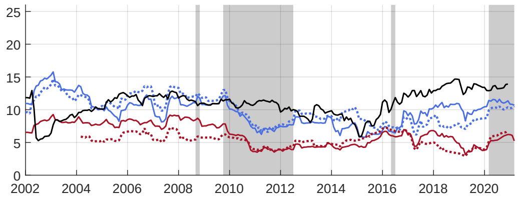
(b) Italy



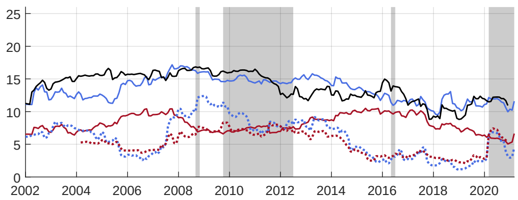
(c) United Kingdom



(d) France

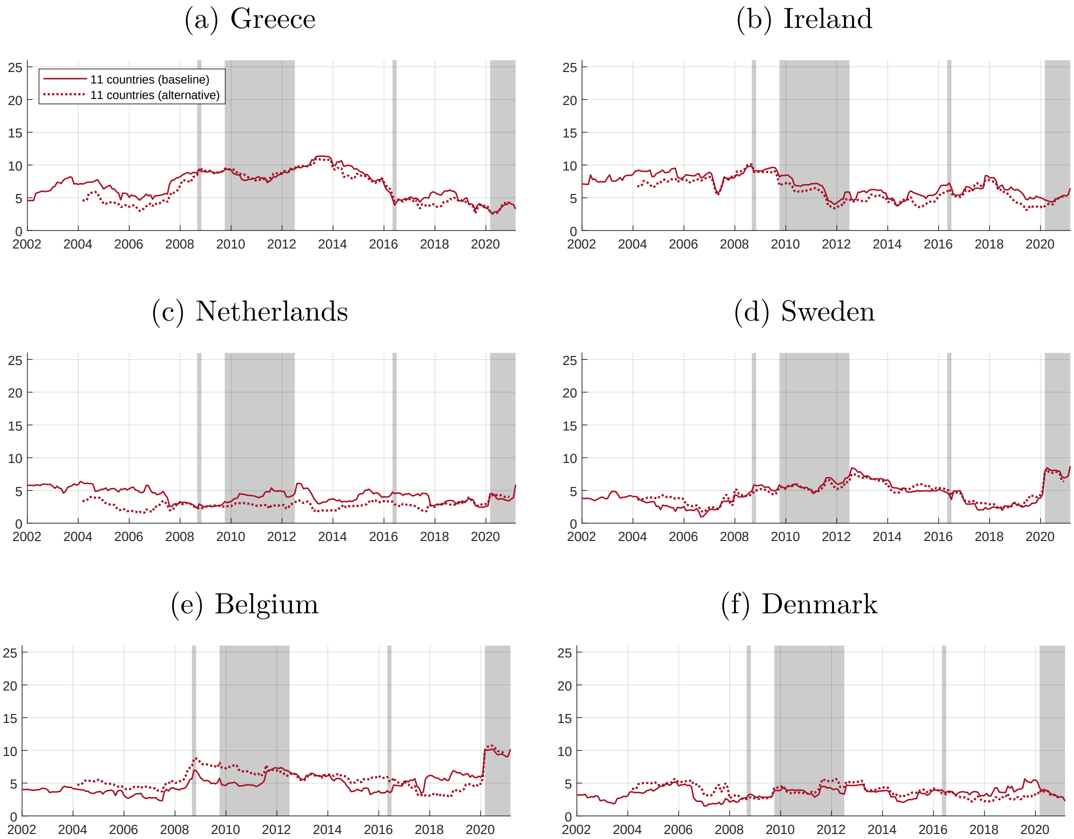


(e) Spain



Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent estimations with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015). The adjusted index follows Baxa *et al.* (2023).

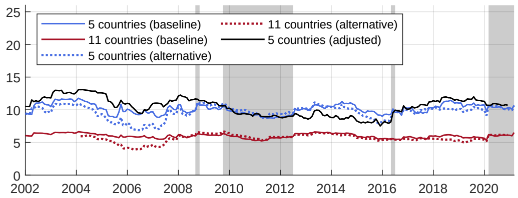
Figure A2: Total Directional Connectedness to Others: Country Extension



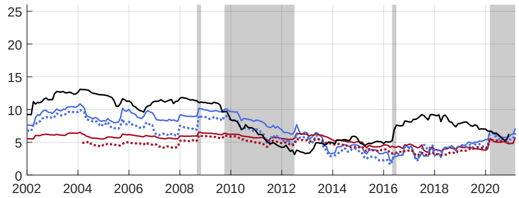
Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent estimations with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015).

Figure A3: Total Directional Connectedness from Others

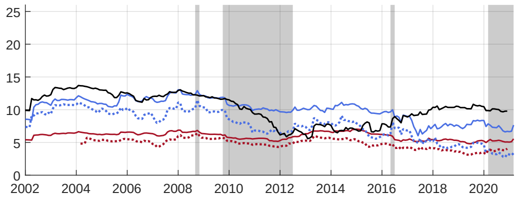
(a) Germany



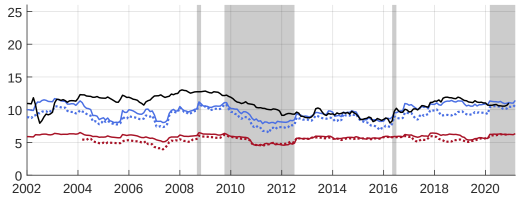
(b) Italy



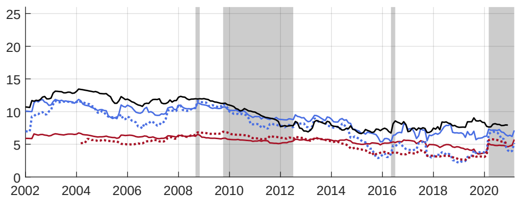
(c) United Kingdom



(d) France



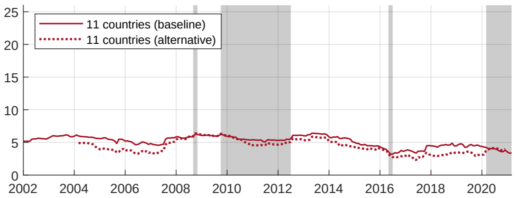
(e) Spain



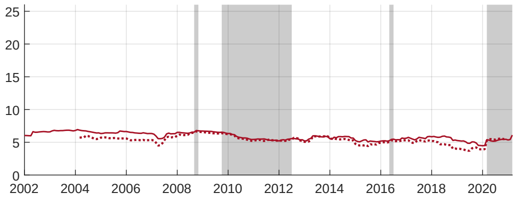
Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent estimations with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015). The adjusted index follows Baxa *et al.* (2023).

Figure A4: Total Directional Connectedness from Others: Country Extension

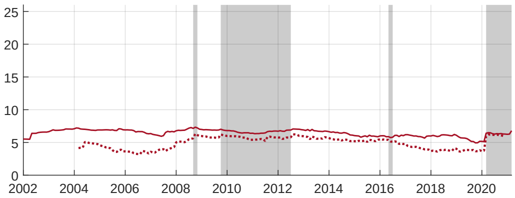
(a) Greece



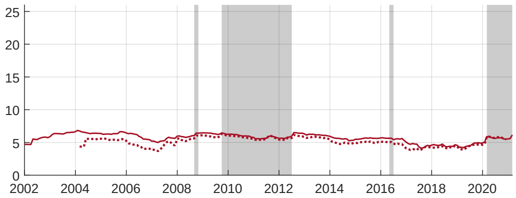
(b) Ireland



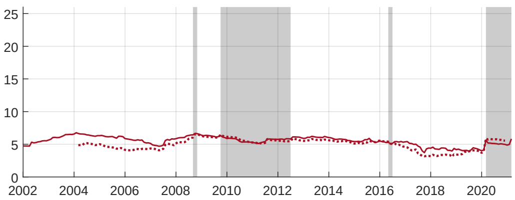
(c) Netherlands



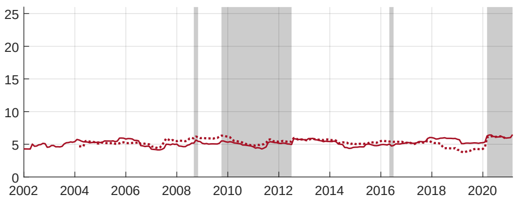
(d) Sweden



(e) Belgium



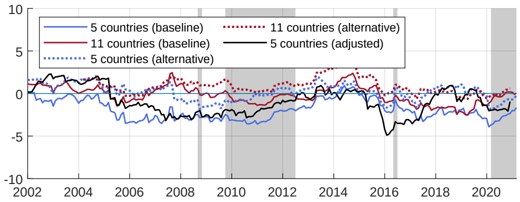
(f) Denmark



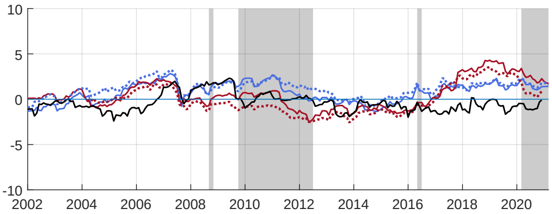
Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent estimations with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015).

Figure A5: Net Total Directional Connectedness

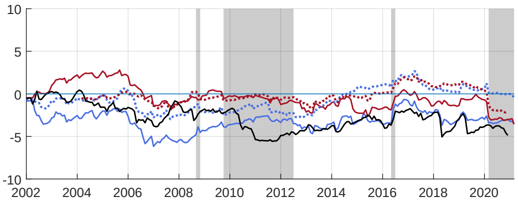
(a) Germany



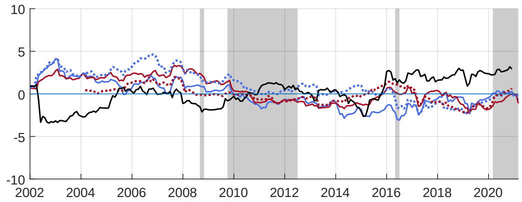
(b) Italy



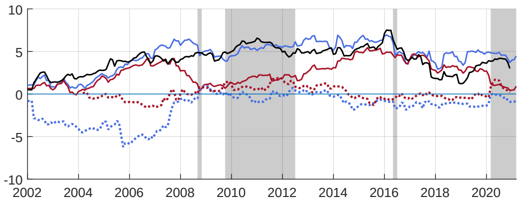
(c) United Kingdom



(d) France



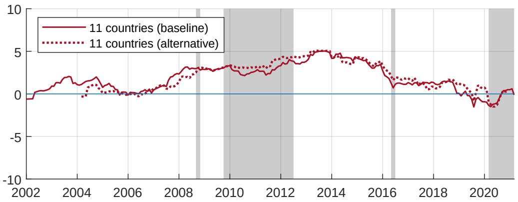
(e) Spain



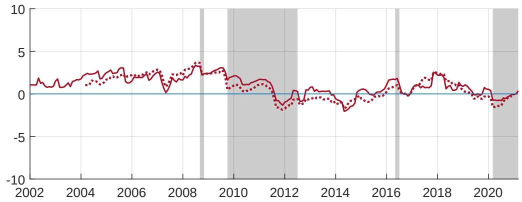
Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent estimations with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015). The adjusted index follows Baxa *et al.* (2023).

Figure A6: Net Total Directional Connectedness: Country Extension

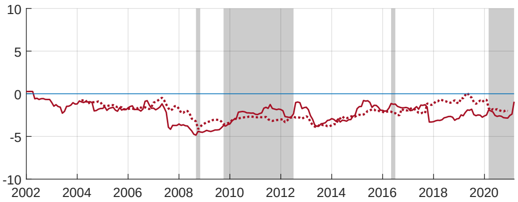
(a) Greece



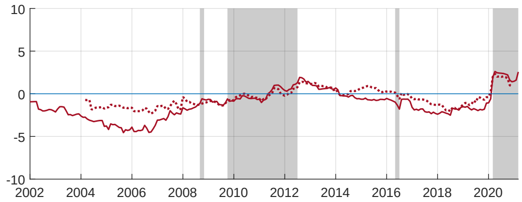
(b) Ireland



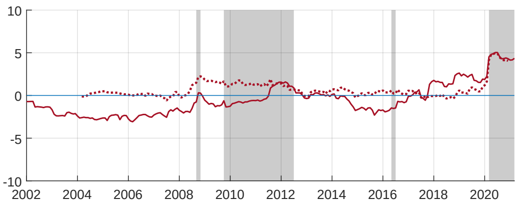
(c) Netherlands



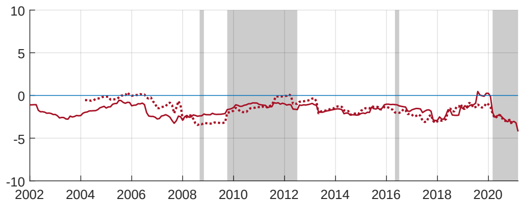
(d) Sweden



(e) Belgium



(f) Denmark

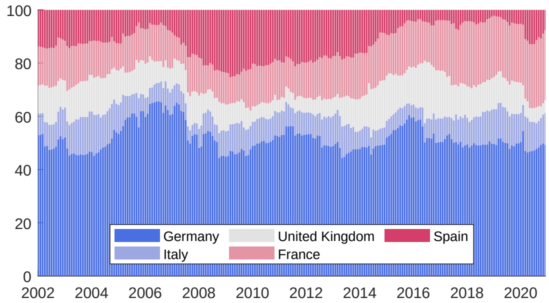


Note: Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19. The dotted lines represent estimations with the uncertainty index for Spain by Ghirelli *et al.* (2019), and, in the case of 11 countries, also with indices for Denmark and the Netherlands with a restriction on articles related to domestic economies by Bergman & Worm (2021) and Kok *et al.* (2015).

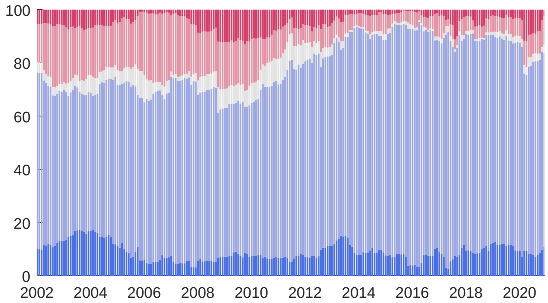
A.2.2 Spanish EPU: Ghirelli et al. (2019)

Figure A7: Generalised Forecast Error Variance Decomposition

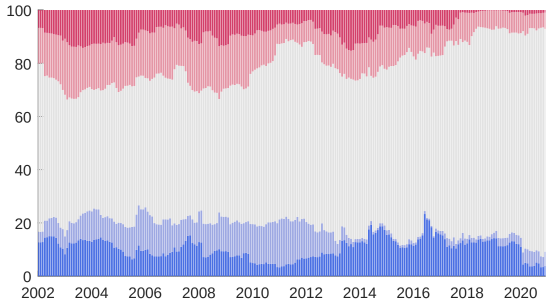
(a) Germany



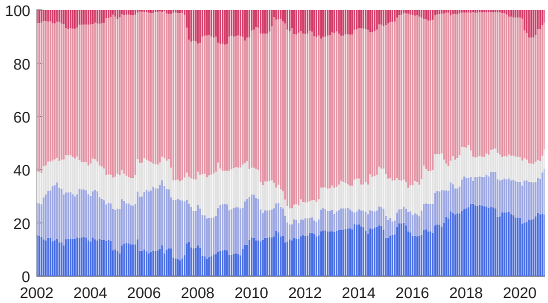
(b) Italy



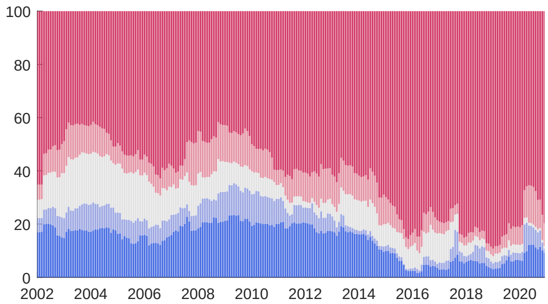
(c) United Kingdom



(d) France



(e) Spain

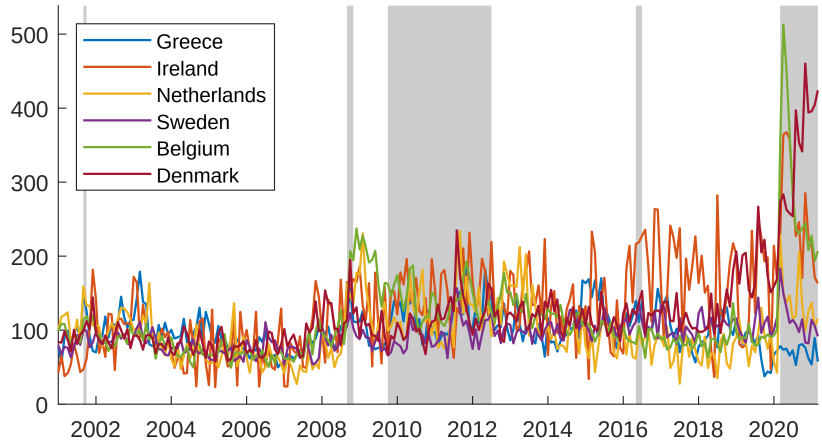


Note: TVP-VAR model with stochastic volatility, three lags, and 24-month horizon.

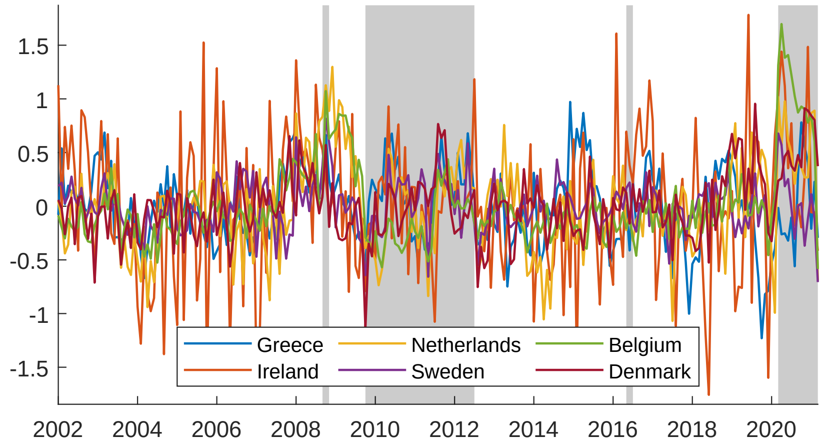
A.2.3 Country Extension

Figure A8: EPU Indices

(a) Level

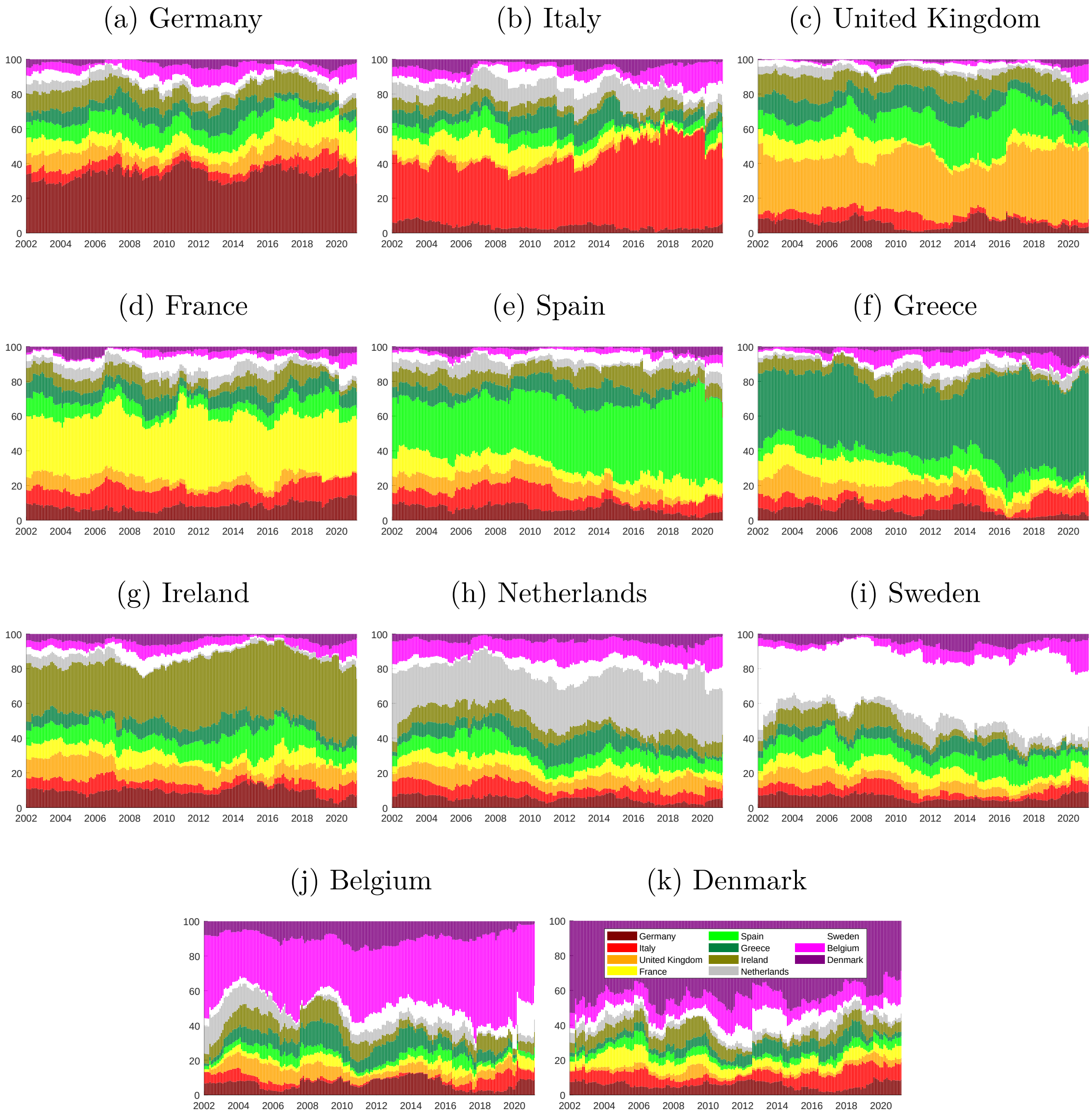


(b) Centered year-on-year log-differences



Note: Shaded areas depict major uncertainty events. 2001M09-2001M10: 9-11 Terrorist Attack; 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

Figure A9: Generalised Forecast Error Variance Decomposition for 11 Countries



Note: TVP-VAR model with stochastic volatility, four lags, and 24-month horizon.

Table A3: Spillovers: Directional and Total Connectedness Indices for 11 Countries

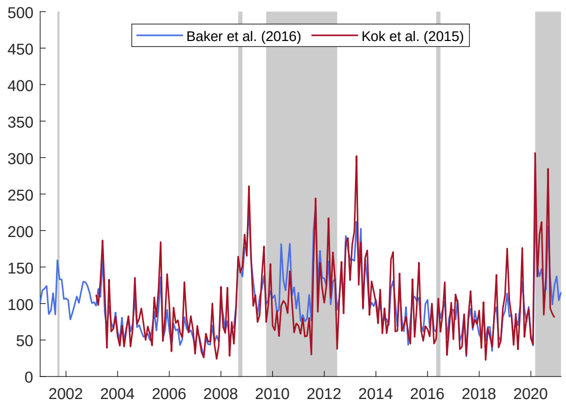
	DE	IT	GB	FR	ES	GR	IE	NL	SE	BE	DK	FROM others
DE	34.0	5.8	7.1	8.7	10.3	8.0	9.3	3.4	4.8	5.8	2.7	66.0
IT	3.9	40.7	2.4	7.8	6.4	8.2	5.4	9.5	5.2	6.4	4.0	59.3
GB	6.0	4.7	34.0	6.7	17.3	10.6	11.5	3.2	3.1	1.6	1.4	66.0
FR	8.4	10.7	5.4	35.8	8.0	8.3	7.2	4.7	5.8	2.7	3.0	64.2
ES	6.9	8.6	7.4	8.5	38.3	7.8	9.0	4.7	4.5	2.4	2.1	61.7
GR	5.6	7.4	7.8	7.9	8.8	43.3	5.7	2.8	3.2	4.8	2.8	56.7
IE	9.6	5.5	9.6	6.8	11.7	7.0	35.1	2.8	3.3	4.9	3.7	64.9
NL	5.2	6.8	7.6	5.9	8.6	8.0	7.5	28.9	6.5	10.9	4.0	71.1
SE	6.0	4.9	5.5	6.9	10.3	6.0	6.5	5.6	37.3	5.9	5.1	62.7
BE	6.6	3.4	5.8	3.5	4.1	7.8	7.7	6.2	6.4	39.2	9.3	60.8
DK	5.8	7.0	2.7	6.0	3.7	5.3	6.5	3.8	6.5	10.1	42.7	57.3
TO others	63.9	64.8	61.2	68.7	89.3	76.9	76.3	46.6	49.2	55.6	38.2	690.7
NTDC	-2.1	5.5	-4.7	4.6	27.6	20.2	11.4	-24.5	-13.5	-5.3	-19.1	TCI
NPDC transmitter	5.0	6.0	5.0	7.0	8.0	9.0	6.0	1.0	4.0	3.0	1.0	62.8

Note: Interpretation of numbers in the table: Diagonal - share of variance explained by own shock; Lines - share of uncertainty received by country i from countries j in columns. *FROM others* -how much uncertainty did country i received from others. *To others* - how much uncertainty country in a column j sent to others. *TCI*: total connectedness index. *NTDC*: net total directional connectedness *NPDC transmitter*: net pairwise total connectedness transmitter shows to how many countries a country i exports uncertainty. *DE*: Germany; *IT*: Italy; *GB*: United Kingdom; *FR*: France; *ES*: Spain; *GR*: Greece; *IE*: Ireland; *NL*: Netherlands; *SE*: Sweden; *BE*: Belgium; *DK*: Denmark.

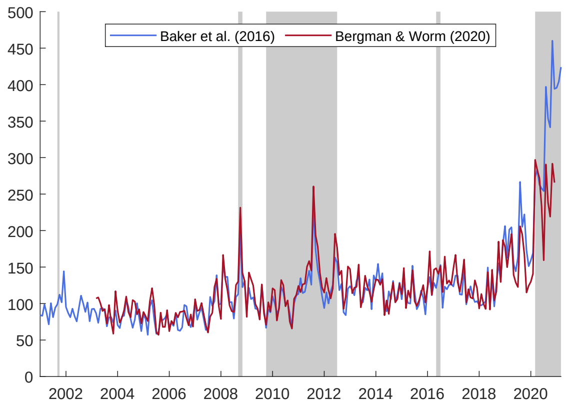
A.2.4 Alternative Country Extension

Figure A10: Alternative EPU Indices

(a) Netherlands

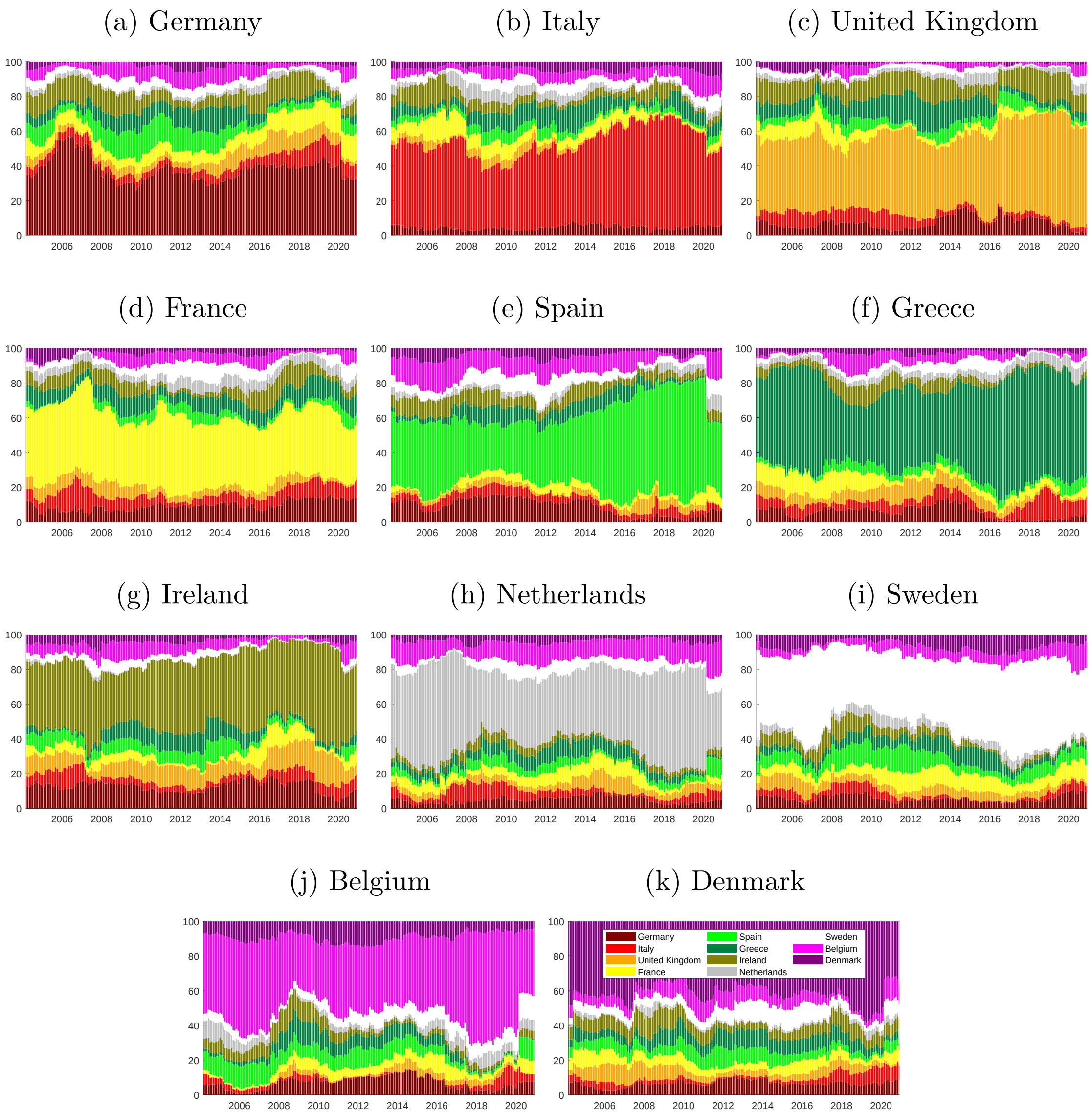


(b) Denmark



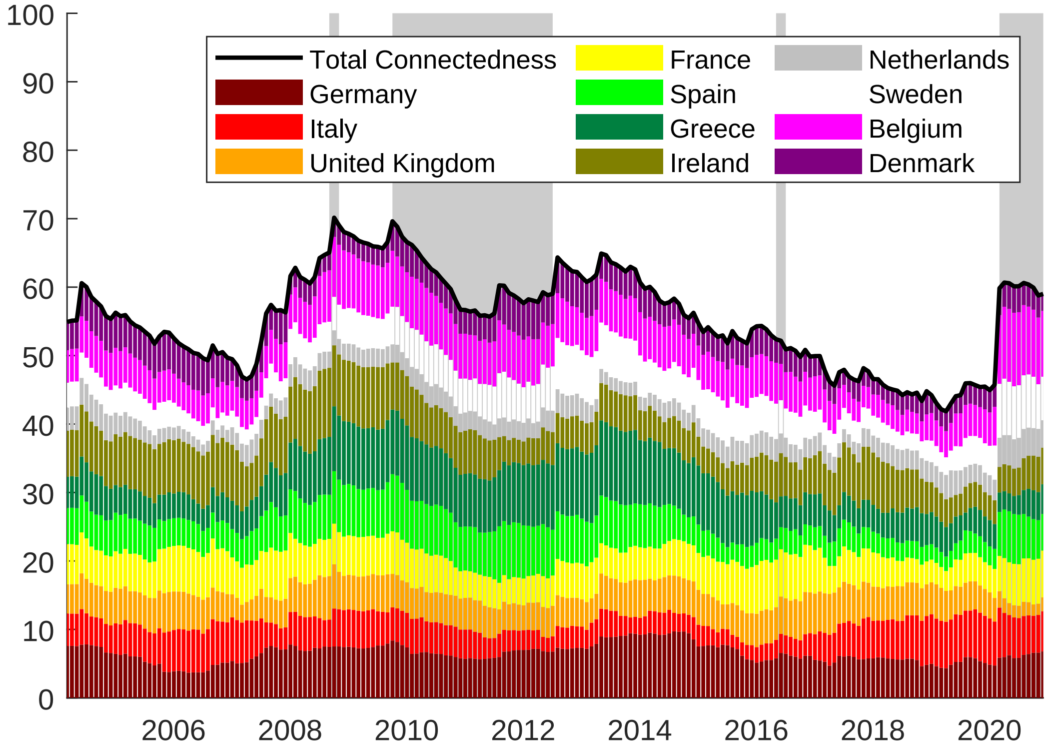
Note: Shaded areas depict major uncertainty events. 2001M09-2001M10: 9-11 Terrorist Attack; 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

Figure A11: Generalised Forecast Error Variance Decomposition



Note: TVP-VAR model with stochastic volatility, three lags, and 24-month horizon.

Figure A12: Total Connectedness in European Uncertainty



Note: TVP-VAR model with stochastic volatility, three lags, and 24-month horizon. Shaded areas depict major uncertainty events. 2008M09-2008M11: Bankruptcy of Lehman Brothers; 2009M10-2012M07: EU Debt Crisis; 2016M05-2016M07: Brexit Referendum; 2020M03-2021M03: Covid-19.

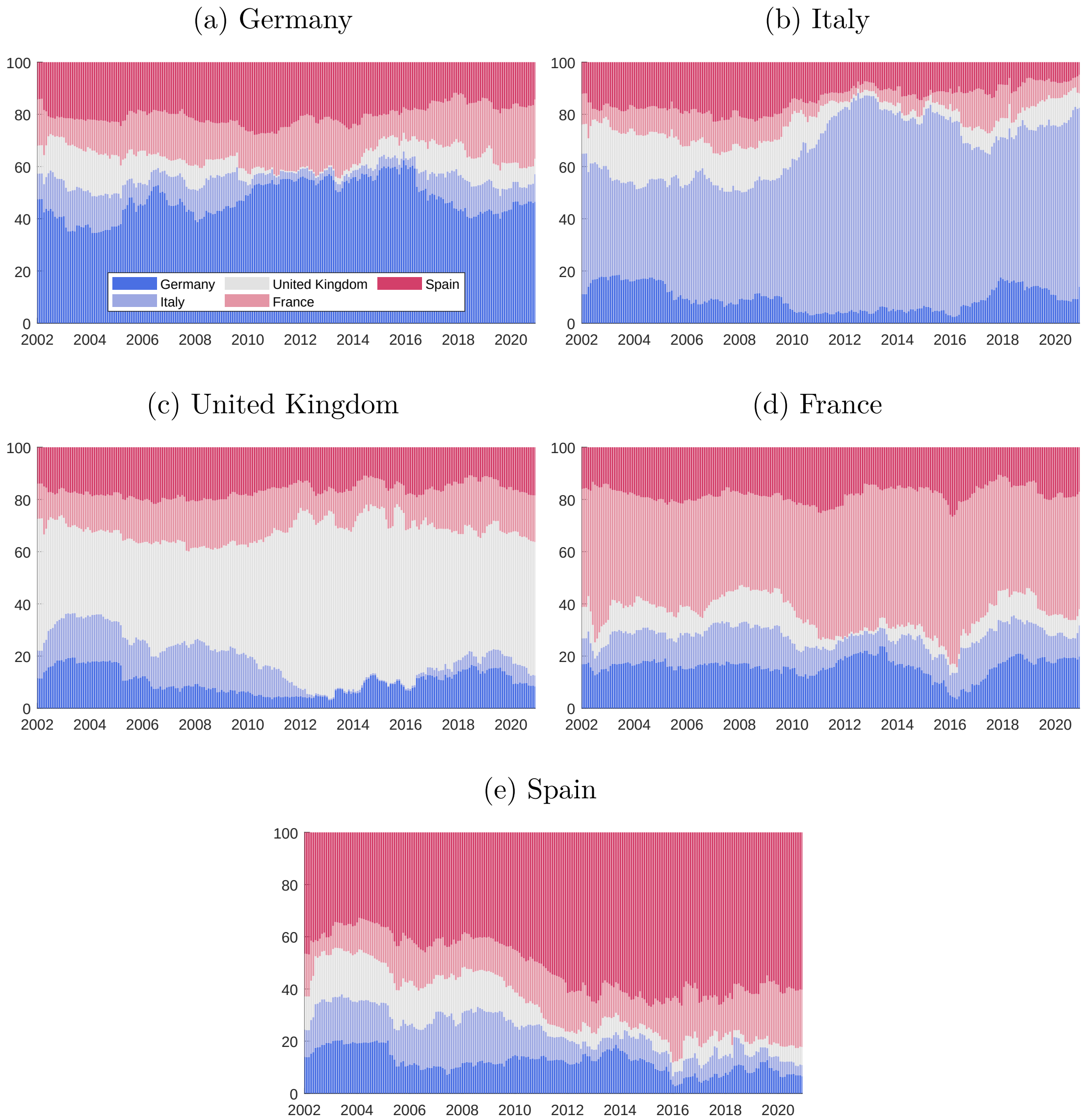
Table A4: Spillovers: Directional and Total Connectedness Indices for 11 Countries, Alternative Indices

	DE	IT	GB	FR	ES	GR	IE	NL	SE	BL	DK	FROM others
DE	38.0	6.1	5.8	8.6	8.7	7.1	9.9	2.2	5.1	6.2	2.2	62.0
IT	4.3	49.6	2.7	6.4	3.8	8.2	6.1	3.9	4.8	5.9	4.3	50.4
GB	7.1	5.4	46.9	5.1	4.5	9.7	11.7	2.8	2.6	2.2	2.0	53.1
FR	9.4	7.6	5.2	40.6	3.5	8.9	6.8	5.0	5.7	4.3	3.1	59.4
ES	8.8	4.2	3.0	3.4	44.2	6.0	6.7	2.5	6.4	10.4	4.2	55.8
GR	5.5	6.6	6.0	6.5	3.9	52.0	5.0	4.0	3.7	4.3	2.5	48.0
IE	12.6	5.3	10.6	5.0	5.9	6.1	41.1	0.6	3.2	5.8	3.7	58.9
NL	4.9	4.9	4.7	5.5	4.1	6.1	3.4	45.8	5.6	11.2	3.8	54.2
SE	5.7	3.2	5.0	7.6	8.2	5.9	4.8	3.6	43.6	5.7	6.7	56.4
BE	6.9	2.5	2.1	4.6	8.0	5.5	5.0	4.4	6.7	45.1	9.1	54.9
DK	6.6	3.5	5.6	5.5	6.3	7.3	7.4	1.8	7.2	7.1	41.6	58.4
TO others	71.8	49.3	50.7	58.3	56.8	71.0	66.8	30.8	51.2	63.1	41.6	611.4
NTDC	9.9	-1.1	-2.4	-1.1	1.0	23.0	8.0	-23.4	-5.2	8.2	-16.8	TCI
NPDC transmitter	8.0	5.0	4.0	4.0	5.0	10.0	7.0	0.0	4.0	5.0	3.0	55.6

Note: Note: Interpretation of numbers in the table: Diagonal - share of variance explained by own shock; Lines - share of uncertainty received by country i from countries j in columns. *FROM others* -how much uncertainty did country i received from others. *To others* - how much uncertainty country in a column j sent to others. *TCI*: total connectedness index. *NTDC*: net total directional connectedness *NPDC transmitter*: net pairwise total connectedness transmitter shows to how many countries a country i exports uncertainty. *DE*: Germany; *IT*: Italy; *GB*: United Kingdom; *Fr*: France; *Sp*: Spain; *Gr*: Greece; *IE*: Ireland; *NL*: Netherlands; *SE*: Sweden; *BE*: Belgium; *DK*: Denmark.

A.2.5 Adjusted EPU: Baxa et al. (2023)

Figure A13: Generalised Forecast Error Variance Decomposition



Note: TVP-VAR model with stochastic volatility, three lags, and 24-month horizon.

Table A5: Decomposition of the Total Connectedness Index for Adjusted EPU Indices

	Germany	Italy	UK	France	Spain	FROM others
Germany	47.6	8.3	8.1	15.8	20.4	52.4
Italy	9.4	57.9	10.4	8.3	14.0	42.1
UK	10.3	8.9	49.0	15.2	16.6	51.0
France	16.0	11.7	8.3	46.1	18.0	53.9
Spain	12.1	11.3	10.2	15.1	51.3	48.7
Contribution TO others	47.7	40.1	37.0	54.4	69.0	248.1
NET directional connectedness	-4.7	-2.1	-14.0	0.5	20.3	TCI
NPDC transmitter	3.0	1.0	1.0	1.0	4.0	49.6

Note: Interpretation of numbers in the table: Diagonal - share of variance explained by own shock. Lines - share of uncertainty received by country i from countries j in columns. *FROM others* - how much uncertainty did country i received from others. *To others* - how much uncertainty country in a column j sent to others. *NPDC transmitter*: net pairwise total connectedness transmitter shows how many countries a country i exports uncertainty to. *TCI*: total connectedness index.

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