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Working Paper

Uncertainty and spillover effects across the euro area

Cardiff Economics Working Papers, No. E2018/15

Provided in Cooperation with:

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Suggested Citation: Angelini, Giovanni; Costantini, Mauro; Easaw, Joshy Z. (2018) : Uncertainty and spillover effects across the euro area, Cardiff Economics Working Papers, No. E2018/15, Cardiff University, Cardiff Business School, Cardiff

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Cardiff Economics Working Papers



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June 2018

ISSN 1749-6010

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Uncertainty and spillover effects across the Euro area

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Abstract

This paper investigates how macroeconomic uncertainty shocks spillover over four Eurozone countries. It also evaluates their impact on real economic activity. The paper proposes a simple two-country model with a core and a periphery economy, where uncertainty shocks spread from one country to another, with potential feedback from the periphery economy to the core one. An empirical analysis is conducted using a Structural Vector Autoregressive (SVAR) model with two regimes: pre-crisis period and crisis period. The findings point to uncertainty spillovers among the Eurozone countries, with some feedback from periphery economies to the core economies during the financial crisis period. Further, there is a need to account for spillovers when studying the impact of uncertainty on real economic activity.

Keywords: Uncertainty, Euro Area, Spillover effects, Real Economic Activity

JEL Codes: C32, C50, E32

1 Introduction

In recent years there has been a considerable debate on the effect of macroeconomic uncertainty on fluctuations (see, for example, Bloom et al., 2007; Bloom, 2009; Bachmann et al., 2013; Jurado et al., 2015; Rossi and Sekhposyan, 2015; Caldara et al., 2016; Ludvigson et al., 2017; Meinen and Roehe, 2017). A number of empirical studies have used a variety of measures for macroeconomic uncertainty, such as implied volatility of stock market or cross-sectional dispersion of stock returns.

Jurado et al. (2015) argue that, while these measures may be preferable to others because of their observability, their effectiveness largely relies on the degree of correlation with the latent processes. Consequently, Jurado et al. (2015) proposed a new measure of uncertainty that does not rely on a particular theoretical model specification or depends on a single or few observable economic indicators, but is related to the potential unpredictability of the state of the economy rather than its variability. In their empirical analysis, based on a macro VAR, Jurado et al. (2015) show that uncertainty is counter-cyclical and far more persistent than common uncertainty proxies.

In a related paper, Meinen and Roehe (2017) use different measures of uncertainty to investigate the impact of those on the investment dynamics for four Euro countries, namely France, Germany, Italy, and Spain. They use a variety of uncertainty measures, but find that the measure proposed by Jurado et al. (2015) “generates remarkably robust investment dynamics across model specifications and countries” (Meinen and Roehe, 2017, page 162).

The purpose of the present paper is to investigate macroeconomic uncertainty spillovers across the main four Eurozone countries, notably Germany, France, Italy and Spain. Following the financial crisis, there has been a heightened interest on the impact of uncertainty on the macroeconomy. Therefore, the analysis in this paper distinguishes between the pre-crisis and crisis periods. We use the uncertainty measure proposed by Jurado et al. (2015) and complied by Meinen and Roehe (2017) for these economies. The paper makes a number of contributions to the literature.

First, the paper proposes a simple two-country model with a core and a periphery economy, where macroeconomic uncertainty shocks spillover from one country to another, with potential feedback from the periphery economy to the core one. The model implies that macroeconomic uncertainty spillovers take place through respective aggregate productivity shocks. This is consistent with the macro, or aggregate, productivity shocks that are encapsulated in the uncertainty index by Jurado et al. (2015). In particular, we assume that integrated economies, such as those in the Euro area, have integrated aggregate productivity shocks, that is shocks that are both common and shared.

Second, the paper investigates the extent to which uncertainty spreads across the four euro countries and impacts on the real economic activity, namely industrial production and unemployment rate. Consistently with the model proposed, the initial tremors in the core economy may be not confined to itself and may propagate to the periphery country, especially when a single currency exists and monetary policy operates. The paper evaluates the impact of uncertainty shocks on those macroeconomic variables one after another. Potential transmission channels are considered. Initially, we consider the effect of uncertainty on real economic activity while accounting for the possibility of spillover effects. Then, we investigate scenarios without spillover effects.

Importantly, findings of regime-dependent effects in uncertainty shocks are observed in empirical analyses (see, for example, Alessandri and Mumtaz, 2014; Caggiano et al., 2014, 2017; Angelini et al., 2017). This literature highlights that uncertainty shocks are

larger in magnitude and more persistent if the economy is in extreme conditions, such as an economic or financial recession.

Third, the empirical analysis is undertaken by distinguishing the pre-crisis period, 1996:M7-2007:M12, and the crisis period, 2008:M1-2015:M12, separately. In doing so, the paper uses a Structural Vector Autoregressive (SVAR) model which has been recently proposed by Bacchiocchi and Fanelli (2015) and Bacchiocchi et al. (2018). This approach is particularly useful in this context for two main reasons: i) it takes into account reverse causality (or feedback) between the variables considered during the financial crisis period, and ii) it allows for spillover effects in the pre-financial crisis and the period of the financial crisis and afterwards, respectively. We also undertook a Monte Carlo study that considers three different scenarios with and without spillover effects.

The empirical results clearly indicate that there are macroeconomic spillovers between Eurozone countries. In addition, some feedback from periphery economies, notably Italy, to the core economies is observed during the financial crisis period. Interestingly, we find that spillover effects matter and the impact of uncertainty on real economic activity is dampened when the spillover effects are accounted for. Our Monte Carlo study corroborates these results.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 describes the methodology. Section 4 presents and discusses the empirical and Monte Carlo results. Section 5 concludes.

2 Integrated two-country model for macroeconomic uncertainty spillovers

In this section, we present a simple two-country model that evaluates how macroeconomic or aggregate uncertainty is transmitted (spillover) among integrated economies (such as those in the Eurozone). Regards to integrated economies, there are number of sources of uncertainty spillovers, such as trade and investment flows and common monetary policies.¹

Essentially, we argue that the spillover takes place via the aggregate productivity shocks of the respective economies. This is consistent with the uncertainty measure proposed by Jurado et al. (2015), which encapsulates unforecastable macro, or aggregate, productivity shocks. The aggregate productivity shocks of each economy, at least in part, is assumed to encompass the aggregate productivity shock of the other economies.

The stylized two-country model embodies a core and a periphery economy, where the core economy is the largest, or dominant, one. While it is plausible to assume that trade and investment flow from the core to the periphery economy (along with uncertainty shocks), uncertainty may also be transmitted from periphery to core economies (or feedback). The core economies are reliant on the markets and industries in the periphery economy for trade and investments. Consider two integrated economies: core and periphery; denote by i and j . The core or ith country's aggregate output $Y_{i,t}$ is as follows:

$$Y_{it} = A_{it}f(K_{it}, N_{it}) \quad (1)$$

where A_{it} is the ith economy's aggregate productivity or stochastic Hicks-neutral shock to revenue generating capacity and $f(K_{it}, N_{it})$ is its aggregate production function. Similarly, the periphery or jth country's aggregate output $Y_{j,t}$ is as follows:

¹Fernández-Villaverde et al. (2011) and Mumtaz and Theodoridis (2015) both make important recent contributions to understanding macroeconomic uncertainty spillovers. Nevertheless, they consider countries that are not economically integrated.

$$Y_{jt} = A_{jt}f(K_{jt}, N_{jt}) \quad (2)$$

where A_{jt} is the j th economy's aggregate productivity or stochastic Hicks-neutral shock to revenue generating capacity and $f(K_{jt}, N_{jt})$ is its aggregate production function. The respective aggregate productivity are assumed to be log-normal and follow an AR(1) process with stochastic volatility: $a_{it} = \rho_i a_{it-1} + \sigma_{it-1} \epsilon_{it}$ and $a_{jt} = \rho_j a_{jt-1} + \sigma_{jt-1} \epsilon_{jt}$, where σ_{it-1} and σ_{jt-1} depict the uncertainties and form the source of macro (or aggregate) uncertainty of the respective economies, and $\epsilon_t \sim N(0, 1)$. We assume that the respective macroeconomic uncertainties incorporate the uncertainties of both integrated economies: $\sigma_{it-1} = \lambda \sigma'_{it-1} + (1 - \lambda) \sigma'_{jt-1}$ and $\sigma_{jt-1} = \gamma \sigma'_{jt-1} + (1 - \gamma) \sigma'_{it-1}$, where λ and γ denote the respective weights.

As previously highlighted, we assume that the macro uncertainty spillovers take place via the aggregate productivity shocks of the respective economies. The aggregate productivity of each country comprises of the aggregate productivity of both the core and periphery economies, as they are integrated economies. Hence, the respective aggregate productivities are weighted averages of each other and are assumed to be log-normal:

$$a_{it} = \lambda a'_{it} + (1 - \lambda) a'_{jt} \quad (3)$$

$$a_{jt} = \gamma a'_{jt} + (1 - \gamma) a'_{it} \quad (4)$$

where a'_{it} and a'_{jt} pertain to the aggregate productivities that are generated directly, or the source is specifically from the i th and j th countries respectively. We also assume they follow an AR(1) process with stochastic volatility

$$a'_{it} = \rho_i a'_{it-1} + \sigma'_{it-1} \epsilon_{it} \quad (5)$$

$$a'_{jt} = \rho_j a'_{jt-1} + \sigma'_{jt-1} \epsilon_{jt} \quad (6)$$

where $\epsilon_t \sim N(0, 1)$.

By substituting equations (5) and (6) into equations (3) and (4), one yields the dynamic relationship between the respective countries' aggregate productivity shocks:

$$a_{it} = \lambda(\rho_i a'_{it-1} + \sigma_{it-1} \epsilon_{it}) + (1 - \lambda)(\rho_j a'_{jt-1} + \sigma_{jt-1} \epsilon_{jt}) \quad (7)$$

$$a_{jt} = \gamma(\rho_j a'_{jt-1} + \sigma_{jt-1} \epsilon_{jt}) + (1 - \gamma)(\rho_i a'_{it-1} + \sigma_{it-1} \epsilon_{it}) \quad (8)$$

Equations (7) and (8) can be expressed in matrix form:

$$\begin{bmatrix} a_{it} \\ a_{jt} \end{bmatrix} = \begin{bmatrix} \lambda \rho_i & (1 - \lambda) \rho_j \\ (1 - \gamma) \rho_i & \gamma \rho_j \end{bmatrix} \begin{bmatrix} a'_{it-1} \\ a'_{jt-1} \end{bmatrix} + \begin{bmatrix} \lambda \sigma'_{it-1} \epsilon_{it} + (1 - \lambda) \sigma'_{jt-1} \epsilon_{jt} \\ \gamma \sigma'_{jt-1} \epsilon_{it} + (1 - \gamma) \sigma'_{it-1} \epsilon_{jt} \end{bmatrix} \quad (9)$$

The above system of equations can be reparameterized such that the coefficient matrix is of reduced rank:

$$\begin{bmatrix} \Delta a_{it} \\ \Delta a_{jt} \end{bmatrix} = \begin{bmatrix} (\lambda \rho_i - 1) & (1 - \lambda) \rho_j \\ (1 - \gamma) \rho_i & (\gamma \rho_j - 1) \end{bmatrix} \begin{bmatrix} a'_{it-1} \\ a'_{jt-1} \end{bmatrix} + \begin{bmatrix} \lambda \sigma'_{it-1} \epsilon_{it} + (1 - \lambda) \sigma'_{jt-1} \epsilon_{jt} \\ \gamma \sigma'_{jt-1} \epsilon_{it} + (1 - \gamma) \sigma'_{it-1} \epsilon_{jt} \end{bmatrix} \quad (10)$$

In the case of no feedback ($\lambda = 1$ in (10)), that is there is only spillover of macro uncertainty from the core to the periphery country, then:

$$\begin{bmatrix} \Delta a_{it} \\ \Delta a_{jt} \end{bmatrix} = \begin{bmatrix} (\rho_i - 1) & 0 \\ (1 - \gamma)\rho_i & (\gamma\rho_j - 1) \end{bmatrix} \begin{bmatrix} a'_{it-1} \\ a'_{jt-1} \end{bmatrix} + \begin{bmatrix} \sigma'_{it-1}\epsilon_{it} \\ \gamma\sigma'_{jt-1}\epsilon_{it} + (1 - \gamma)\sigma'_{it-1}\epsilon_{jt} \end{bmatrix} \quad (11)$$

3 Methodology

In order to evaluate the spillover effect of uncertainty shocks across the four countries under investigation, and the interactions between the real economic activity and the uncertainty measures, we use a SVAR model. Let Y_t be an $n \times 1$ vector of time series of interest. The SVAR model has the following representation:

$$Y_t = C + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + B e_t, \quad e_t \sim \text{WN}(0_{n \times 1}, I_n), \quad t = 1, \dots, T \quad (12)$$

where T is the sample length, p is the system lag order, C is a $n \times 1$ constant, A_i , $i = 1, \dots, p$ are $n \times n$ matrices of parameters, $\eta_t = B e_t$, e_t is the vector of mean zero, unit variance and uncorrelated structural shocks, and η_t is a $n \times 1$ vector of reduced form innovations with covariance matrix $\Sigma_\eta = B B'$. It is straightforward to derive the Vector Moving Average (VMA) representation from (12):

$$Y_t = \mu + \Psi(L) B e_t \quad (13)$$

where $\Psi(L)I_n + \Psi_1 L + \Psi_2 L^2 + \dots$ is a polynomial in the lag operator L of infinite order. In this setup the Impulse Response Functions (IRF) can be easily computed as follows:

$$\frac{\partial Y_{t+h}}{\partial e_{jt}} = \Psi_h b_j = J(A)^h J' b_j, \quad h = 0, 1, 2, \dots, \quad j = 1, \dots, n \quad (14)$$

where Ψ_h is the matrix associated with the h -lag of $\Psi(L)$, $J = (I_n, 0_{n \times n}, \dots, 0_{n \times n})$ is a selection matrix, A is the companion matrix associated with (12), and b_j is the j th column of the matrix B . A necessary condition for the calculation of the IRF is that b_j (and the matrix B) is identified, that is it can not be expressed as a linear combination of the other columns of B . The identification of the matrix B in (12) can be achieved using a different technique. In this paper we follow the idea proposed by Bacchiocchi and Fanelli (2015), who make the identification possible using potential heteroschedasticity in the data, as an additional information (see also Angelini et al., 2017). This approach has two merits. First, it allows us to compute regime dependent IRFs. Therefore, it makes possible to evaluate IRFs during the pre-crisis period and the crisis period (see Section 4), which is the focus of this paper. Second, there is no need to impose strong 0 restrictions on the structural matrix.

As for the reduced covariance matrix, the following is required: $\Sigma_{\eta,pre} \neq \Sigma_{\eta,crisis}$. In particular, we specify $\Sigma_{\eta,pre} = B_{pre} B'_{pre}$ and $\Sigma_{\eta,crisis} = (B_{pre} + B_{crisis})(B_{pre} + B_{crisis})'$. In our notation, the subscripts 'pre' and 'crisis' indicate the matrices related to the pre-crisis period and the period of crisis, respectively. The SVAR model in (12) can then be generalized as follows:

$$Y_t = A(t)W_t + \eta_t, \quad \Sigma_\eta(t) = E(\eta_t \eta'_t), \quad t = 1, \dots, T \quad (15)$$

where W_t contains lagged regressors and a constant. In this formulation, both the slope autoregressive matrix $A(t)$ and the covariance matrix $\Sigma_\eta(t)$ are regime dependent:

$$A(t) = A_{pre} \times \mathbf{1}(t \leq T_B) + A_{crisis} \times \mathbf{1}(t > T_B) \quad (16)$$

$$\Sigma_\eta(t) = \Sigma_{\eta,pre} \times \mathbf{1}(t \leq T_B) + \Sigma_{\eta,crisis} \times \mathbf{1}(t > T_B). \quad (17)$$

The regime-dependent SVAR described in (15) has different IRFs for each regime. In particular, we have:

$$IRF_{pre}(h) = J(A_{pre})^h J' b_{pre,j} \quad (18)$$

$$IRF_{crisis}(h) = J(A_{crisis})^h J'(b_{pre,j} + b_{crisis,j}) \quad (19)$$

where $b_{pre,j}$ is the j -th column of the matrix B_{pre} and $b_{pre,j} + b_{crisis,j}$ is the j -th column of the matrix $B_{pre} + B_{crisis}$. For details about the estimation of the SVAR described in (15)-(17), see Bacchiocchi and Fanelli (2015) and Angelini et al. (2017).

4 Empirical analysis

The theoretical framework outlined in Section 2 focuses on the spillover of macroeconomic uncertainties. Nevertheless, the empirical analysis not only considers the uncertainty spillover effects across the four Eurozone economies, but it also investigates whether macroeconomic uncertainty in one of these economies can affect the others' real activity.

In this section, we use the approach described in Section 3 to evaluate the economic model proposed in Section 2. In Section 4.1, we evaluate the spillover effects amongst uncertainty measures, and in Section 4.2 their effects on the real economic activity, namely industrial production and unemployment rate (see, for example, Jurado et al., 2015; Ludvigson et al., 2017; Meinen and Roehe, 2017; Moore, 2017).

We use the same uncertainty measures for the four economies based on 1-step ahead forecast considered in Meinen and Roehe (2017), while data for industrial production (IP) and unemployment rate (UR) are taken from Federal Reserve Economic Data (FRED). In line with Angelini et al. (2017), the structural break is assumed to be at $T_B = 2007:M12$, so the first regime is 1996:M7-2007:M12, while the second one is 2008:M1-2015:M12.²

Figure 1 illustrates the dynamics of the uncertainty measures across the four Eurozone countries. Overall, uncertainty levels in Spain appear to be higher than the uncertainty in the other countries over the period under investigation. Furthermore, there are periods where uncertainties seem to co-move (for example during the financial crisis). Indeed, when looking at the cross correlations of the uncertainty measures (see Table 1), it emerges that the highest correlations are registered for the pair of Germany and France, and Italy and Spain, respectively. Further, there is clear-cut evidence of larger cross-correlations over the second sample period.

²In order to test for the presence of a structural break at $T_B = 2007:M12$ for the SVAR models used in the empirical analysis (see Sections 4.1 and 4.2), a likelihood ratio test for the null hypothesis $\mathcal{H}_0 : \Sigma_{\eta,pre} = \Sigma_{\eta,crisis} = \Sigma_\eta$ is performed. The results show that the null hypothesis \mathcal{H}_0 can be rejected in all the cases since the p-values are close to zero. Therefore, two different covariance matrices are set for the pre-crisis and the period of crisis, respectively. The results of the likelihood ratio test are not reported here and are available upon request from the authors.

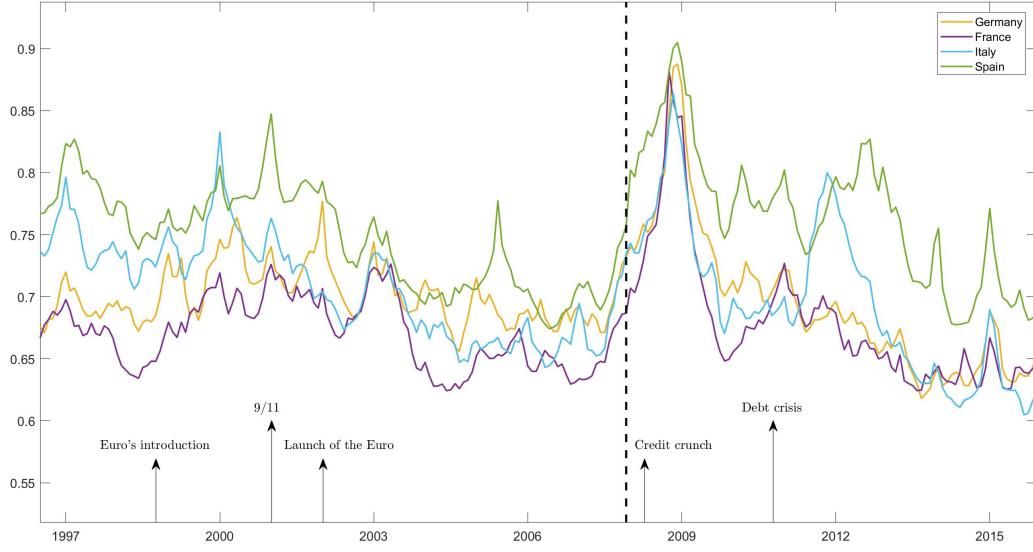


Figure 1: Uncertainty measures for the four Eurozone countries, 1996:M7-2015:M12. The dashed black line indicates $T_B = 2007:M12$.

Table 1: Cross-correlations of uncertainty measures across Germany, France, Italy and Spain

Full sample period: 1996:M7-2015:M12									
	U_{Ger}	U_{Fra}	U_{Ita}	U_{Spa}					
U_{Ger}	1.000								
U_{Fra}	0.858***	1.000							
U_{Ita}	0.737***	0.750***	1.000						
U_{Spa}	0.716***	0.762***	0.802***	1.000					
First sample period: 1996:M7-2007:M12					Second sample period: 2008:M1-2015:M12				
	U_{Ger}	U_{Fra}	U_{Ita}	U_{Spa}	U_{Ger}	U_{Fra}	U_{Ita}	U_{Spa}	
U_{Ger}	1.000				U_{Ger}	1.000			
U_{Fra}	0.676***	1.000			U_{Fra}	0.936***	1.000		
U_{Ita}	0.557***	0.661***	1.000		U_{Ita}	0.825***	0.834***	1.000	
U_{Spa}	0.540***	0.674***	0.836***	1.000	U_{Spa}	0.874***	0.823***	0.866***	1.000

Note: *** denote significance at 1% level.

4.1 Macroeconomic uncertainty spillovers

In order to evaluate the spillover effects between uncertainty measures across the four countries under investigation, we estimate the regime-dependent SVAR model in (15) with:

$$Y_t = \begin{pmatrix} U_{Ger,t} \\ U_{Fra,t} \\ U_{Ita,t} \\ U_{Spa,t} \end{pmatrix} \quad (20)$$

where $U_{j,t}$, $j = Ger, Fra, Ita$ and Spa , denotes the uncertainty measures taken from Meinen and Roehle (2017) for Germany, France, Italy and Spain, respectively. Using the standard information criteria³, the number of lags p in (12) is set to 2. The two volatility regimes that have been identified provide us with 20 moment conditions (the parameters in the matrices η_{pre} and η_{crisis} , see Section 3). Since 32 parameters in the matrices B_{pre} and B_{crisis} should be estimated, at least 12 restrictions should be placed so to achieve identification. To do so, we impose a triangular (Cholesky) structure in the first sub-sample (pre-financial crisis period), which implies a more exogenous role of the core countries (Germany and France), but a complete non-recursive structure during the financial crisis period. On the other hand, during the crisis period, the impact matrix $B_{pre} + B_{crisis}$ is full, and there are no restrictions on the causality direction between countries. Therefore, feedbacks can be observed from core economies (Germany and France) to the periphery countries (Italy and Spain), and viceversa. The matrices B_{pre} and B_{crisis} are as follows:

$$B_{pre} = \begin{pmatrix} b_{pre,11} & 0 & 0 & 0 \\ b_{pre,21} & b_{pre,22} & 0 & 0 \\ b_{pre,31} & b_{pre,32} & b_{pre,33} & 0 \\ b_{pre,41} & b_{pre,42} & b_{pre,43} & b_{pre,44} \end{pmatrix} \quad (21)$$

$$B_{crisis} = \begin{pmatrix} b_{crisis,11} & b_{crisis,12} & b_{crisis,13} & b_{crisis,14} \\ 0 & b_{crisis,22} & b_{crisis,23} & b_{crisis,24} \\ 0 & 0 & b_{crisis,33} & b_{crisis,34} \\ 0 & 0 & 0 & b_{crisis,44} \end{pmatrix} \quad (22)$$

$$B_{pre} + B_{crisis} = \begin{pmatrix} b_{pre,11} + b_{crisis,11} & b_{crisis,12} & b_{crisis,13} & b_{crisis,14} \\ b_{pre,21} & b_{pre,22} + b_{crisis,22} & b_{crisis,23} & b_{crisis,24} \\ b_{pre,31} & b_{pre,32} & b_{pre,33} + b_{crisis,33} & b_{crisis,34} \\ b_{pre,41} & b_{pre,42} & b_{pre,43} & b_{pre,44} + b_{crisis,44} \end{pmatrix} \quad (23)$$

The on-impact matrices B_{pre} and B_{crisis} capture the instantaneous (structural) relationships between uncertainties. As pointed out earlier (see Section 3), the matrix B_{pre} contains the pre-crisis on-impact effects, while the matrix $B_{pre} + B_{crisis}$ in (23) reports the instantaneous effects during and after the financial crisis. The estimates of the structural parameters are reported in Table 2. Interestingly, the structural parameters $b_{crisis,12}$, $b_{crisis,13}$ and $b_{crisis,14}$ are not statistically different from 0, indicating that Germany plays an exogenous role even during the financial crisis, that is uncertainty in Germany does not respond instantaneously to shocks to uncertainty in other countries. As such, Germany plays a dominant role among the four Euro countries, in the sense that any external shock

³The AIC (Akaike information criterion), the BIC (Bayesian information criterion) and the HQC (Hannan-Quinn information criterion) criteria are used in the analysis.

to the Eurozone, such as that resulting from the US sub-prime mortgage markets, affects the German economy directly and not via the other Eurozone countries, while the other Eurozone countries may also be affected by the German economy. Moreover, looking at the elements on the main diagonal of the two matrices, the magnitude of the coefficients is higher during the financial crisis for all the countries except for Germany, denoting that, differently from the other countries, the variance of the shock related to the German uncertainty does not augment during the financial crisis. It would appear that German was not unduly affected by the financial crisis, that is effects on German uncertainty appear to be the same in the crisis period as they are in the pre-crisis period.

Table 2: B_{pre} and B_{crisis} estimates

$$\hat{B}_{pre} = \begin{pmatrix} 0.011^{***} & 0 & 0 & 0 \\ (0.001) & & & \\ 0.005^{***} & 0.007^{***} & 0 & 0 \\ (0.001) & (0.000) & & \\ 0.005^{***} & 0.002^{**} & 0.010^{***} & 0 \\ (0.001) & (0.001) & (0.001) & \\ 0.005^{***} & 0.002^{**} & 0.004^{***} & 0.009^{***} \\ (0.001) & (0.001) & (0.001) & (0.001) \end{pmatrix}$$

$$\hat{B}_{pre} + \hat{B}_{crisis} = \begin{pmatrix} 0.010^{***} & 0.002 & 0.001 & 0.002 \\ (0.001) & (0.002) & (0.005) & (0.002) \\ 0.005^{***} & 0.012^{***} & 0.003^{***} & 0.003^{***} \\ (0.001) & (0.001) & (0.001) & (0.001) \\ 0.005^{***} & 0.002^{**} & 0.010^{***} & 0.002 \\ (0.001) & (0.001) & (0.001) & (0.002) \\ 0.005^{***} & 0.002^{**} & 0.004^{***} & 0.013^{***} \\ (0.001) & (0.001) & (0.001) & (0.001) \end{pmatrix}$$

Note: Standard errors in brackets. *** and ** denote statistical significance at 1% and 5% level, respectively.

The IRFs are reported in Figure 2, where 90% confidence bands are computed following the bootstrap approach proposed in Kilian (1998). As previously highlighted, the analysis distinguishes between pre-financial crisis period (1996:M7-2007:M12) and crisis period (2008:M1-2015:M12) (see also Angelini et al., 2017). The Eurozone countries were affected by the credit crunch originating from the US and the resulting financial crisis. In addition, Eurozone countries are blighted by the deficit crisis, as well as Italian banking crisis. Both have had a prolonged effect on these economies.

Four main results emerge. First, during the pre-financial crisis period (first regime), shocks to individual country's uncertainty seem to affect their own uncertainty ('self-effects') (see Figure 2). In particular, a rapid increase in uncertainty is observed across the four countries, with Germany showing the fastest decline thereafter. France, Italy and Spain display the more persistence. Secondly, also in the pre-crisis period, there is clear evidence indicating that shocks to core countries uncertainty propagate to periphery countries.⁴ Notably, a shock on uncertainty in France propagates to Italy (the effect on Spain is substantially non-existent) and remains significant for more than a year. Similarly, spillover effects from Germany to Italy and Spain are observed, albeit for a shorter period.

Third, in the crisis period (second regime), the self-effects are still present, with a larger magnitude than that in the pre-crisis period. This finding is unsurprising in view of the financial crisis: Figure 1 points to a rise in uncertainty, especially over the period 2008-2012, in contrast to the level of uncertainty right before the period of the financial crisis.

⁴The identification scheme previously discussed does not allow for feedbacks from periphery to core countries in the pre-financial crisis.

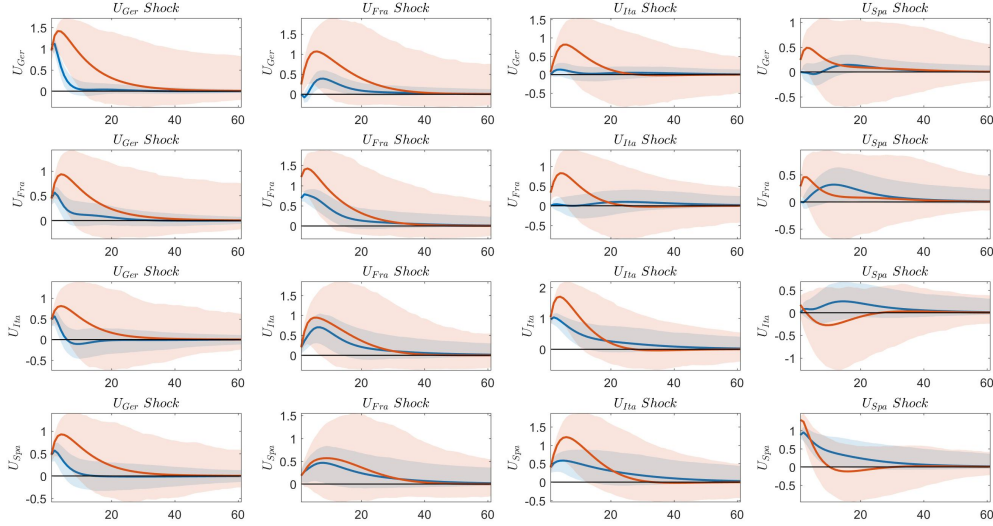


Figure 2: Uncertainty spillovers across Germany, France, Italy and Spain. *Note:* U_{Ger} , U_{Fra} , U_{Ita} , and U_{Spa} denote the uncertainty measures for Germany, France, Italy and Spain. Blue and red lines indicate the impulse response functions for the period 1996:M7-2007:M12 and 2008:M1-2015:M12, respectively. The VAR in (20) is estimated. 90% confidence bands are computed following the bootstrap approach proposed by Kilian (1998).

Fourth, the spillover effects from the core economies to the periphery countries seem to mimic those in the pre-financial crisis period, though Germany plays now a more relevant role in the transmissions of uncertainty over the two periphery countries. Interestingly, uncertainty in periphery economies now seems to exert some impact on the core countries. In particular, there is clear evidence of spillover effects from Italy to the core countries. The spillover effects last for a few horizons with a similar magnitude. On the other hand, in case of Spain, these effects are significant for a very short horizon.⁵ In the Italian case, the prolonged and individual-specific nature of the aftermath of the financial crisis on the Italian economy clearly had an effect on the core economies. Indeed, the ensuing banking crisis meant that the idiosyncratic shock has prolonged the recovery of the Italian economy and its effects were felt by other Eurozone economies.

4.2 Macroeconomic uncertainty shocks and their effects on the real economic activity

This section focuses on the effect of uncertainty shocks on the real economic activity, namely industrial production and unemployment rate. We consider the impact of uncertainty shocks on these macroeconomic variables one after another.

We investigate the potential transmission channels of macro uncertainty on real economic activity. Specifically, we assess empirically the transmission in two scenarios: with and without spillover effects. First, we consider all the four uncertainties (with spillover effects) when studying the impact of these on the real economic activity of the country in question (see equation (24)), and then the macroeconomic uncertainty in this country

⁵While Germany and France are the two largest Eurozone economies, Italy and Spain are still large economies with significant investments from the core economies, and Italy has a significant industrial base (mainly located in the north).

only (without spillover effects) is considered for the impact on real economic activity (see equation (25)).

In the case with spillover effects, the SVAR model in (15) is expanded by adding one measure of economic activity:

$$Y_t = \begin{pmatrix} U_{Ger,t} \\ U_{Fra,t} \\ U_{Ita,t} \\ U_{Spa,t} \\ E_t \end{pmatrix} \quad (24)$$

where the variable E_t is the measure of economic activity. For the analysis, the SVAR model in (24) is estimated 8 times, i.e. replacing E_t with $\Delta IP_{j,t}$ and $\Delta UR_{j,t}$, respectively, where $j = Ger, Fra, Ita$ and Spa . To this end, let the structural matrices B_{pre} and B_{crisis} be as follows:

$$B_{pre} = \begin{pmatrix} b_{pre,11} & 0 & 0 & 0 & 0 \\ b_{pre,21} & b_{pre,22} & 0 & 0 & 0 \\ b_{pre,31} & b_{pre,32} & b_{pre,33} & 0 & 0 \\ b_{pre,41} & b_{pre,42} & b_{pre,43} & b_{pre,44} & 0 \\ b_{pre,51} & b_{pre,52} & b_{pre,53} & b_{pre,54} & b_{pre,55} \end{pmatrix}$$

$$B_{crisis} = \begin{pmatrix} b_{crisis,11} & b_{crisis,12} & b_{crisis,13} & b_{crisis,14} & 0 \\ 0 & b_{crisis,22} & b_{crisis,23} & b_{crisis,24} & 0 \\ 0 & 0 & b_{crisis,33} & b_{crisis,34} & 0 \\ 0 & 0 & 0 & b_{crisis,44} & 0 \\ b_{crisis,51} & b_{crisis,52} & b_{crisis,53} & b_{crisis,54} & b_{crisis,55} \end{pmatrix}$$

This specification is consistent with the analysis reported in Section 4.1, where the reverse causality between uncertainties is only allowed for the financial crisis period. Also, in line with Bloom (2009), Ludvigson et al. (2017) and Angelini et al. (2017), the real economic activity has no instantaneous impact on uncertainty measures (see zeros in the last column of B_{pre} and B_{crisis} matrices).

Figures 3 and 4 illustrate IRFs for the SVAR model in (24) with ΔIP and ΔUR , respectively. In general, it emerges that uncertainty shocks have a minimal effect on both real activities under consideration. More specifically, macroeconomic uncertainty shocks in France exerts a significant effect on the industrial production of the other economies, even though this effect is marginal (especially on the Spanish economy) and only found in the period of the crisis. Further, uncertainty shocks on the other economies affects Spanish unemployment significantly in the period of the crisis, with a largely similar magnitude. Finally, German uncertainty shocks have a negative effect on French unemployment in the pre-financial crisis period, with a reduction in French unemployment, a result that seems to be replicated, albeit to a different extent, in case of Italy against France.

In brief, these findings seem to suggest that uncertainty does not play a relevant role in affecting the real economic activity. If any, the role is a modest one, which seems to contrast with the empirical literature. However, these result may be due to spillover effects. Therefore, it is worthwhile investigating whether this is the case. This is done in the next exercise.

In the case without spillover effects, the SVAR model in (24) is now estimated considering one uncertainty measure and one measure of economic activity at a time:

$$Y_t = \begin{pmatrix} U_{j,t} \\ E_t \end{pmatrix} \quad (25)$$

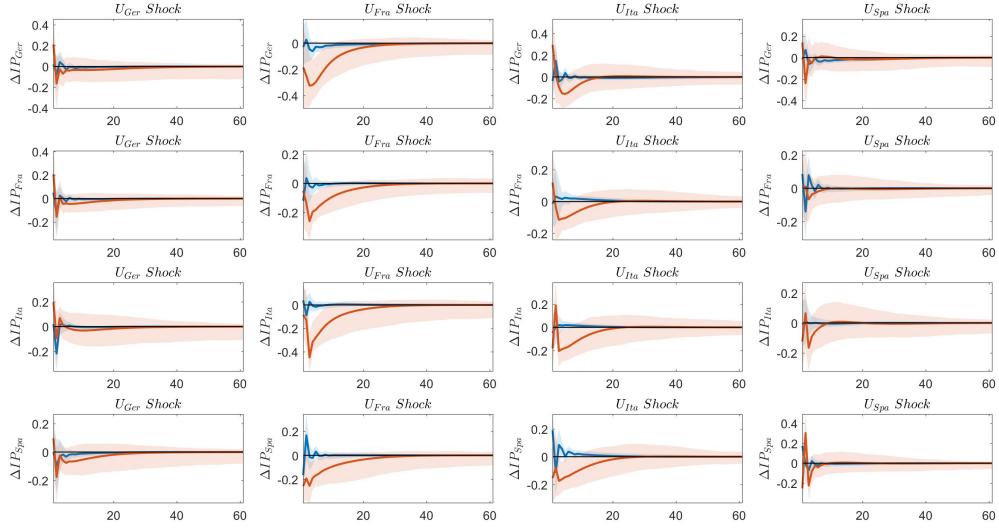


Figure 3: Uncertainty impact on industrial production (with spillover effects). *Note:* ΔIP_{Ger} , ΔIP_{Fra} , ΔIP_{Ita} , and ΔIP_{Spa} denote the first difference of industrial production series for Germany, France, Italy, and Spain. The VAR in (24) is estimated. For other details, see note in Figure 2.

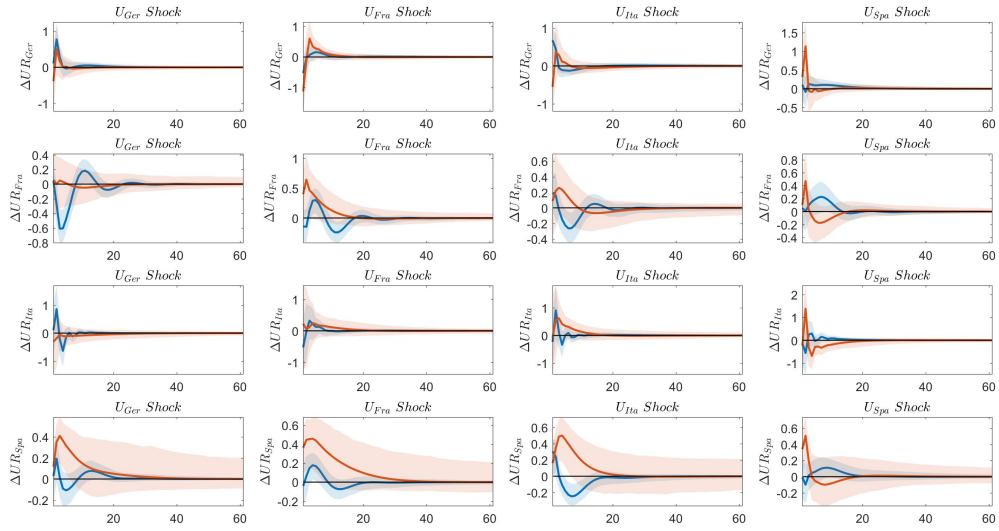


Figure 4: Uncertainty impact on unemployment rate (with spillover effects). *Note:* ΔUR_{Ger} , ΔUR_{Fra} , ΔUR_{Ita} , and ΔUR_{Spa} denote the first difference of unemployment rate series for Germany, France, Italy, and Spain. The VAR in (24) is estimated. For other details, see note in Figure 2.

The bivariate SVAR model in (25) is estimated 32 times, i.e. by replacing E_t with $\Delta IP_{j,t}$ and $\Delta UR_{j,t}$, respectively, where $j = Ger, Fra, Ita$ and Spa and $U_{j,t}$, with one uncertainty measures each time. The structural matrices B_{pre} and B_{crisis} are now as follows:

$$B_{pre} = \begin{pmatrix} b_{pre,11} & 0 \\ b_{pre,21} & b_{pre,22} \end{pmatrix}$$

$$B_{crisis} = \begin{pmatrix} b_{crisis,11} & 0 \\ b_{crisis,21} & b_{crisis,22} \end{pmatrix}$$

The structure of B_{pre} and B_{crisis} implies that the real economic activity has no instantaneous impact on uncertainty measures. When looking at the IRFs in case of the SVAR model in (25) (see Figures 5 and 6), the following emerge. Uncertainty shocks have a pronounced and significant effect on industrial production in the second period, while there are no effects in the pre-crisis period. The significant effects also take the forms of a feedback from periphery to core economies. As in the case of industrial production, uncertainty shocks have a significant effect on unemployment rate only in the second period.

When there are no spillover effects, the results show that macroeconomic uncertainty does impact on real economic activity. It is important to notice that these results are in line with those of the empirical literature for the Euro area (Popescu and Smets, 2010; Meinen and Roehle, 2017).⁶ The results also show that there is a feedback from periphery to core countries during the crisis period. This may be due to the fact that both Italy and Spain have experienced prolonged downturns during the crisis period, as result of individual-specific aggregate shocks. In particular, in the case of Italy, the banking crisis was severe and prolonged, and this may have had adverse effects on trade and investment flows from the core economies to the periphery, thereby affecting the formers' recovery. However, this was not the case for unemployment. The likelihood is that while the prolonged crisis in the periphery countries has affected the industrial production in the core countries, this has not necessarily translated to the laying off workers by firms. There may be number of reasons for this. For instances, the firms may anticipate a recovery in the foreseeable future and laying off workers in the short-term could be unproductive and costly.

4.3 Monte Carlo simulation study

The empirical findings in Section 4.2 show that uncertainty measures impact on real activity only marginally when the model with spillover effects is considered (see equation (24)). On the contrary, this impact becomes significant when the model without spillover effects is used (see equation (25)). In order to shed light on these differences, this section presents three Monte Carlo simulations studies to evaluate how the omission of spillover effects may have implications for the empirical analysis within the framework in Section 4.2.

For simplicity, an economy with only two countries, say i and j , is considered. Further, the true Data Generating Process (DGP) is based on a trivariate SVAR with $Y_t = (U_{i,t}, U_{j,t}, E_{j,t})$, where $U_{i,t}$ and $U_{j,t}$ denote the measures of uncertainty for country i and j , respectively, and $E_{j,t}$ is a measure of real economic activity of country j . The analysis is conducted for two different sample sizes, $T_1 = T_2 = 100$ and $T_1 = T_2 = 500$, where T_1 and T_2 refer to the sample size of the trivariate and bivariate SVAR, respectively, and for 10000 replications. Using the same identification scheme proposed in Section 4.2, we consider three different data generating processes (DGP).

⁶Results for different countries can be found in Bloom (2009), Caldara et al. (2016), and Ludvigson et al. (2017).

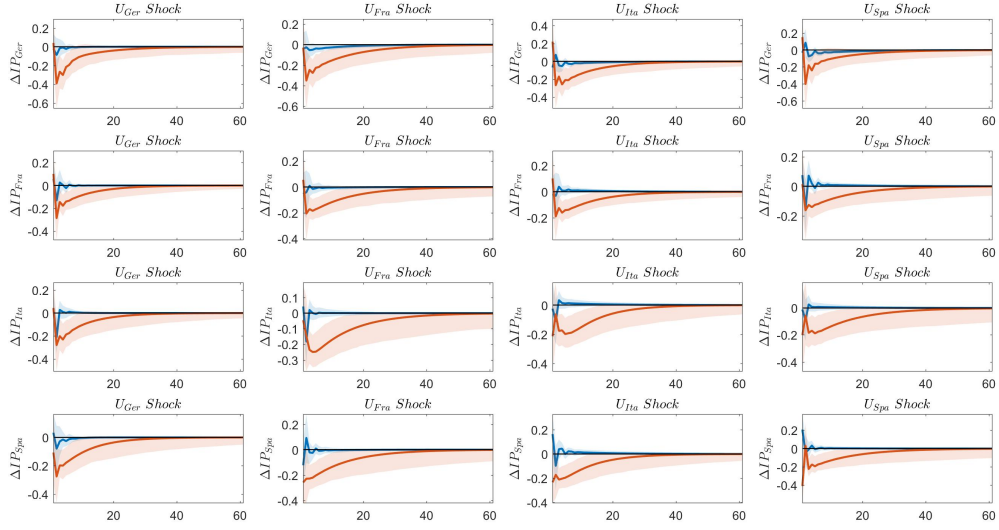


Figure 5: Uncertainty impact on industrial production (without spillover effects). *Note:* ΔIP_{Ger} , ΔIP_{Fra} , ΔIP_{Ita} , and ΔIP_{Spa} denote the first difference of industrial production series for Germany, France, Italy, and Spain. The VAR in (25) is estimated. For other details, see note in Figure 2.

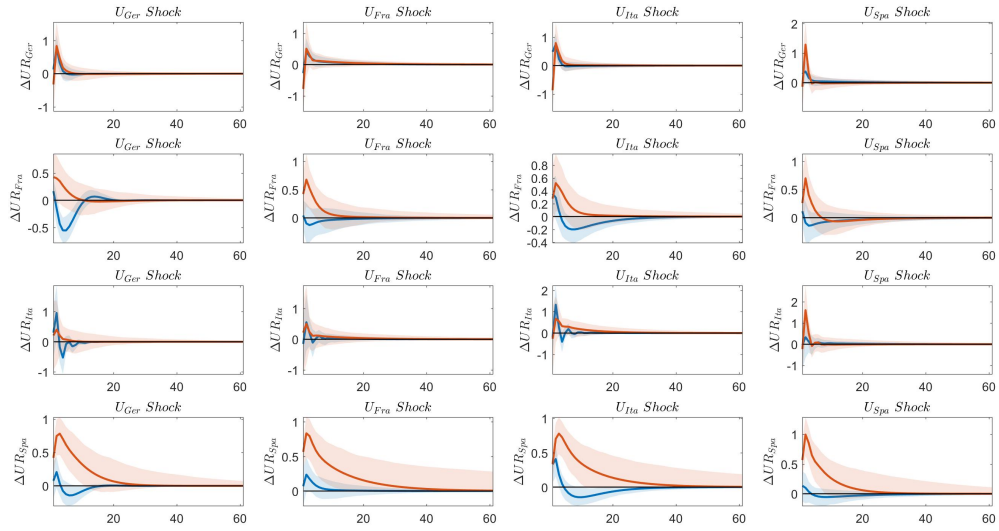


Figure 6: Uncertainty impact on unemployment rate (without spillover effects). *Note:* ΔIP_{Ger} , ΔIP_{Fra} , ΔIP_{Ita} , and ΔIP_{Spa} denote the first difference of industrial production series for Germany, France, Italy, and Spain. The VAR in (25) is estimated. For other details, see note in Figure 2.

For the DGP 1 illustrated in Table 3, the uncertainty measure of country j has no effects on the real economic activity in country j (the 0 element in the third row, second column of the matrices B_{pre} and $B_{pre} + B_{crisis}$ in Table 3), the uncertainty measure of country i has a negative effect on real economic activity in country j , and the uncertainty measures of the two countries are positively related.

We estimate a true trivariate SVAR model with $Y_t = (U_{i,t}, U_{j,t}, E_{j,t})$, using the same identification scheme as in equation (24) with only two countries, and a misspecified bivariate SVAR model with $Y_t = (U_{j,t}, E_{j,t})$ for the estimation of (25) (in the true DGP there are no direct effects from $U_{j,t}$ and $E_{j,t}$). The estimation results clearly show that the omission of spillover effects in the analysis may point to misleading findings. More specifically, looking at the right part of Table 3, it emerges that, when the spillover effects between U_i and U_j are not accounted for, the impact of U_j on E_j tend to be different from 0 (even when the sample size T increases). This result may imply that when spillover effects are omitted, a direct effect of U_j on E_j is observed. Therefore, potential spillover effects due to the characteristics of the economy should be taken into account.

The second Monte Carlo study is based on the DGP illustrated in Table 4. It differs from DGP 1, as the uncertainty measure of country j has now a low effect on the real economic activity in country j , -0.05 in pre-crisis period (see second element in the third row of B_{pre}), and -0.06 during the period of the crisis (see second element in the third row of $B_{pre} + B_{pre}$).

The results are similar to those obtained with DGP 1: the omission of spillover effects in the analysis may point to misleading results. Indeed, the impact of U_j on E_j tends to be higher (in absolute value) than true one. In particular, the true on-impact effect of U_j on E_j is -0.05 and -0.06 for the pre-crisis period and during the period of the crisis, respectively, while the estimated values in the mis-specified model for $T_1 = T_2 = 500$ are -0.19 and -0.37 .

The last simulation is based on an economy in which the uncertainty measures are not related across the two countries (no spillover effects). The matrices B_{pre} and B_{crisis} are described in Table 5.

Differently from previous DGPs, the impact of U_j on E_j in the mis-specified model is now not statistically significant indicating that, when no spillover effects are present, the omission of one of the uncertainty measure in the system does not affect the relationship between the other uncertainty measure and the real economic activity.

The Monte Carlo simulation based on the three different DGP produces a clear set of results. When no spillovers are present or accounted for, the results are statistically insignificant.

The results show that, when assessing the impact of macroeconomic uncertainty on real economic activity, the effects of uncertainty spillovers from other integrated economies must be taken into account. This, nevertheless, poses a conundrum why the impact of uncertainty on real economic activity is considerably smaller when spillovers are allowed. The model in Section 2 shows that a country's overall macroeconomic uncertainty effect is a weighted average of uncertainties that transpire directly from their own economy and those transpiring from the other integrated economies. The results in Section 4.1 indicate that the so-called self-effect of uncertainty is considerably higher than the spillover effect from other integrated economies. This is, of course, more evident and pronounced during the period of the crisis (second regime). Hence, if the overall uncertainty effect is a weighted average of both the self and spillover effects, the overall uncertainty effect on real activity will be less pronounced than when spillovers from other integrated economies are excluded.

Table 3: Monte Carlo results: DGP 1

True Data Generating Process	
$B_{pre} = \begin{pmatrix} 0.8 & 0 & 0 \\ 0.4 & 0.3 & 0 \\ -0.2 & 0 & 0.3 \end{pmatrix}$	
$B_{pre} + B_{crisis} = \begin{pmatrix} 1 & 0.2 & 0 \\ 0.4 & 0.4 & 0 \\ -0.5 & 0 & 0.9 \end{pmatrix}$	
Trivariate VAR (Correctly specified model)	Bivariate VAR (Mis-specified model)
$T_1 = T_2 = 100$	
$B_{pre} = \begin{pmatrix} 0.778 & 0 & 0 \\ (0.057) & & \\ 0.389 & 0.290 & 0 \\ (0.041) & (0.021) & \\ -0.194 & 0.000 & 0.289 \\ (0.033) & (0.030) & (0.021) \end{pmatrix}$	$B_{pre} = \begin{pmatrix} 0.531 & 0 \\ (0.064) & \\ -0.159 & 0.314 \\ (0.049) & (0.023) \end{pmatrix}$
$B_{pre} + B_{crisis} = \begin{pmatrix} 0.960 & 0.182 & 0 \\ (0.063) & (0.169) & \\ 0.389 & 0.381 & 0 \\ (0.041) & (0.076) & \\ -0.478 & 0.005 & 0.865 \\ (0.098) & (0.123) & (0.064) \end{pmatrix}$	$B_{pre} + B_{crisis} = \begin{pmatrix} 0.618 & 0 \\ (0.066) & \\ -0.324 & 0.602 \\ (0.121) & (0.042) \end{pmatrix}$
$T_1 = T_2 = 500$	
$B_{pre} = \begin{pmatrix} 0.796 & 0 & 0 \\ (0.026) & & \\ 0.398 & 0.298 & 0 \\ (0.018) & (0.009) & \\ -0.199 & 0.000 & 0.298 \\ (0.015) & (0.013) & (0.009) \end{pmatrix}$	$B_{pre} = \begin{pmatrix} 0.545 & 0 \\ (0.044) & \\ -0.165 & 0.321 \\ (0.031) & (0.011) \end{pmatrix}$
$B_{pre} + B_{crisis} = \begin{pmatrix} 0.992 & 0.196 & 0 \\ (0.027) & (0.072) & \\ 0.398 & 0.396 & 0 \\ (0.018) & (0.031) & \\ -0.496 & 0.001 & 0.893 \\ (0.044) & (0.054) & (0.029) \end{pmatrix}$	$B_{pre} + B_{crisis} = \begin{pmatrix} 0.634 & 0 \\ (0.043) & \\ -0.337 & 0.619 \\ (0.071) & (0.019) \end{pmatrix}$

Note: T_1 and T_2 refer to the sample size of the trivariate and bivariate SVAR, respectively. Standard errors are in brackets.

5 Conclusions

A large body of macroeconomic literature has debated on the effects of uncertainty on fluctuations. This literature has proposed several measures of uncertainty so to analyze the impact of those on economic activity (see, for example, Bloom, 2009; Caldara et al., 2016; Ludvigson et al., 2017).

The purpose of this paper is to investigate macroeconomic uncertainty spillovers across the main four Eurozone countries, notably Germany, France, Italy and Spain. The paper uses the uncertainty measure proposed by Jurado et al. (2015) and compiled by Meinen and Roehle (2017) for the four economies. The paper also evaluates the impact of the uncertainty measures on economic activities, namely industrial production and unemployment rate.

The paper contributes to the literature in a number of ways. First, it proposes a simple two-country model with a core and a periphery economy, where macroeconomic

Table 4: Monte Carlo results: DGP 2

True Data Generating Process	
$B_{pre} = \begin{pmatrix} 0.8 & 0 & 0 \\ 0.4 & 0.3 & 0 \\ -0.2 & -0.05 & 0.3 \end{pmatrix}$	
$B_{pre} + B_{crisis} = \begin{pmatrix} 1 & 0.2 & 0 \\ 0.4 & 0.4 & 0 \\ -0.5 & -0.06 & 0.9 \end{pmatrix}$	
Trivariate VAR (Correctly specified model)	Bivariate VAR (Mis-specified model)
$T_1 = T_2 = 100$	
$B_{pre} = \begin{pmatrix} 0.778 & 0 & 0 \\ (0.057) & & \\ 0.389 & 0.290 & 0 \\ (0.041) & (0.021) & \\ -0.194 & -0.049 & 0.289 \\ (0.034) & (0.030) & (0.021) \end{pmatrix}$	$B_{pre} = \begin{pmatrix} 0.534 & 0 \\ (0.063) & \\ -0.188 & 0.303 \\ (0.044) & (0.022) \end{pmatrix}$
$B_{pre} + B_{crisis} = \begin{pmatrix} 0.960 & 0.182 & 0 \\ (0.063) & (0.169) & \\ 0.389 & 0.381 & 0 \\ (0.041) & (0.076) & \\ -0.478 & -0.053 & 0.865 \\ (0.097) & (0.123) & (0.064) \end{pmatrix}$	$B_{pre} + B_{crisis} = \begin{pmatrix} 0.620 & 0 \\ (0.065) & \\ -0.363 & 0.591 \\ (0.116) & (0.042) \end{pmatrix}$
$T_1 = T_2 = 500$	
$B_{pre} = \begin{pmatrix} 0.796 & 0 & 0 \\ (0.026) & & \\ 0.398 & 0.298 & 0 \\ (0.018) & (0.009) & \\ -0.199 & -0.050 & 0.298 \\ (0.015) & (0.014) & (0.009) \end{pmatrix}$	$B_{pre} = \begin{pmatrix} 0.547 & 0 \\ (0.045) & \\ -0.193 & 0.310 \\ (0.028) & (0.010) \end{pmatrix}$
$B_{pre} + B_{crisis} = \begin{pmatrix} 0.992 & 0.196 & 0 \\ (0.027) & (0.072) & \\ 0.398 & 0.396 & 0 \\ (0.018) & (0.031) & \\ -0.496 & -0.059 & 0.893 \\ (0.043) & (0.054) & (0.029) \end{pmatrix}$	$B_{pre} + B_{crisis} = \begin{pmatrix} 0.634 & 0 \\ (0.044) & \\ -0.374 & 0.607 \\ (0.069) & (0.019) \end{pmatrix}$

Note: See note in Table 3

uncertainty shocks spread from one country to another, with potential feedback from the periphery economy to the core one. Spillover effects are assumed to occur through aggregate productivity shocks. More specifically, it is assumed that the Eurozone countries under investigation share aggregate productivity shocks.

Secondly, the paper investigates the extent to which uncertainty spreads across the four euro countries and impacts on the real economic activity, namely industrial production and unemployment rate. The impact of uncertainty shocks on those macroeconomic variables is evaluated one after another. Potential transmission channels are taken into account. We consider the impact on real economic activity with and without spillover effects.

Lastly, the empirical analysis is undertaken distinguishing the pre-crisis period, 1996:M7-2007:M12, and the crisis period, 2008:M1-2015:M12, separately. A SVAR model is considered. The approach used is suitable to take into account reverse causality between the variables considered and spillover effects. We also undertook a Monte Carlo study that considers three different scenario with and without spillover effects.

Table 5: Monte Carlo results: DGP 3

True data Generating Process	
$B_{pre} = \begin{pmatrix} 0.8 & 0 & 0 \\ 0 & 0.3 & 0 \\ -0.2 & 0 & 0.3 \end{pmatrix}$ $B_{pre} + B_{crisis} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 0.4 & 0 \\ -0.5 & 0 & 0.9 \end{pmatrix}$	
Trivariate VAR (Correctly specified model)	Bivariate VAR (Mis-specified model)
$T_1 = T_2 = 100$	
$B_{pre} = \begin{pmatrix} 0.778 & 0 & 0 \\ (0.057) & & \\ 0.000 & 0.290 & 0 \\ (0.030) & (0.021) & \\ -0.194 & 0.000 & 0.289 \\ (0.033) & (0.030) & (0.021) \end{pmatrix}$	$B_{pre} = \begin{pmatrix} 0.398 & 0 \\ (0.036) & \\ -0.046 & 0.352 \\ (0.037) & (0.028) \end{pmatrix}$
$B_{pre} + B_{crisis} = \begin{pmatrix} 0.964 & 0.000 & 0 \\ (0.070) & (0.126) & \\ 0.000 & 0.388 & 0 \\ (0.030) & (0.028) & \\ -0.481 & 0.000 & 0.865 \\ (0.097) & (0.110) & (0.064) \end{pmatrix}$	$B_{pre} + B_{crisis} = \begin{pmatrix} 0.527 & 0 \\ (0.048) & \\ -0.057 & 0.640 \\ (0.102) & (0.044) \end{pmatrix}$
$T_1 = T_2 = 500$	
$B_{pre} = \begin{pmatrix} 0.796 & 0 & 0 \\ (0.025) & & \\ 0.000 & 0.298 & 0 \\ (0.013) & (0.009) & \\ -0.199 & 0.000 & 0.298 \\ (0.015) & (0.013) & (0.009) \end{pmatrix}$	$B_{pre} = \begin{pmatrix} 0.405 & 0 \\ (0.022) & \\ -0.046 & 0.360 \\ (0.018) & (0.015) \end{pmatrix}$
$B_{pre} + B_{crisis} = \begin{pmatrix} 0.993 & 0.000 & 0 \\ (0.031) & (0.055) & \\ 0.000 & 0.398 & 0 \\ (0.013) & (0.013) & \\ -0.496 & 0.000 & 0.893 \\ (0.043) & (0.049) & (0.029) \end{pmatrix}$	$B_{pre} + B_{crisis} = \begin{pmatrix} 0.541 & 0 \\ (0.030) & \\ -0.061 & 0.658 \\ (0.047) & (0.022) \end{pmatrix}$

Note: See note in Table 3

The empirical results confirm that spillovers occur, with some feedback from the periphery economies, notably Italy, to the core ones during the period of the financial crisis. The results also indicate that spillovers matter when considering the impact of macroeconomic uncertainty on real economic activity. In particular, the impact of macroeconomic activity on industrial production and unemployment for the four Euro countries under investigation is somewhat moderated when spillovers are taken into account.

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