Business Cycle Spillovers in the EU15: What is the message transmitted by the periphery?

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Abstract

We examine business cycle spillovers in the EU15 countries by employing the spillover index approach of Diebold and Yilmaz (2009, 2012), over the period 1977–2012. The propagation mechanisms of business cycle shocks among EU15 is becoming a major interest due to unprecedented recent economic turbulence. The results of our analysis reveal the following empirical regularities. (i) The total spillover index suggests that 54.57% of the forecast error variance in all EU15 countries' business cycles can be attributed to spillovers. (ii) The index is very responsive to extreme economic events. (iii) There is an intertemporal alternation in the direction of spillovers between the Eurozone core and the Eurozone periphery. (iv) In terms of country specific results, we find that Spain is the dominant transmitter of business cycle shocks among the EU15 countries. (v) Finally, the widening of the European debt crisis can be explained by business cycle shocks in the whole Eurozone periphery. Thus, appropriate policy measures aiming to steer peripheral economies towards growth, away from turbulence and close to recovery, should be formulated.

Keywords: EMU, Business cycles, Spillovers, Variance decomposition, Vector autoregression, Impulse response function

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1. Introduction

The recent global economic developments have revived the interest on the propagation mechanisms of economic shocks among European countries. The transmission of business cycle shocks among member–states is now becoming of major interest and concern, given that the effects of the debt crisis are still rippling through the European economy. To this end, there is an ongoing discussion concerning the origins of the European crisis among member–states. Yet, there is only anecdotal evidence as to which country was responsible for initiating this crisis, as well as, on how shocks are transmitted both within and between European economies.

This research contributes to the understanding of the relationships among business cycle fluctuations, as well as, to the analysis of the origins of business cycle shocks and their associated repercussions. In particular, we examine the extent of cyclical interdependencies among the EU15 member–countries over the period 1977–2012, using the novel spillover index approach of Diebold and Yilmaz (2009, 2012). The chosen period allows us to examine these interdependencies over a span of time where many significant economic events took place in Europe but also globally (e.g. the financial crisis of 1987, the collapse of the Soviet Union in 1989, the ERM II crisis in 1992, the Asian crisis of 1997, the inception of the EMU in 1999, the Great Recession of 2007–2009 and the ongoing European Debt crisis that begun in the late 2009).

Research on business cycles can be traced back in time to the work of Mitchell (1927), Burns and Mitchell (1946), Kuznets (1958), Mundell (1961) and McKinnon (1963). Investigating the factors that drive fluctuating levels of economic activity, as well as, purporting to decipher the forces that determine the duration of business cycles became a rather promising field of research and gained much prominence especially during the 1990s when it was initially established that output fluctuations in both industrialised and developing countries share many common characteristics (see, *inter alia*, Backus et al., 1993; Gregory and Smith, 1996; Baxter and King, 1999; Lumsdaine and Prasad, 2003; Kose et al., 2003). A thorough description of the relevant literature can be found in Inklaar et al. (2008) and Papageorgiou et al. (2010).

The importance of European business cycle synchronisation lies on the fact that it is a pre-requisite for the smooth and efficient operation of monetary policy within a currency-union. Indicatively we quote Rogoff (1985), Gertler et al. (1999), Fidrmuc and Korhonen (2006), as well as, Savva et al. (2010), who among others put forward the argument that unless business cycles within the currency union are synchronised, then asymmetric shocks that will hit each individual economy (or asymmetric individual responses to symmetric shocks) will inevitably lead to predicaments in a uniform monetary policy implementation and to destabilisation.

However, making inferences about economic phenomena is rarely as simple as it initially appears and empirical evidence can at times be contradicting. Thus, the current literature of the European business cycle synchronisation has produced inconclusive findings. In particular, many authors (see, *inter alia*, Fatas, 1997; Angeloni and Dedola, 1999; Belo, 2001; Altavilla, 2004; Weyerstrass et al., 2011) argue that higher levels of synchronisation can indeed be reported early on in the 1990s. Even more, some provide evidence that cyclical interdependencies have increased even further with the establishment of the EMU (see, *inter alia*, Gayer, 2007; Darvas and Szapry, 2008; Michaelides et al., 2013). De Pace (2013) pertaining to both the globalisation and the currency union effects on business cycle synchronisation, also reports that the establishment of the European Monetary Union (EMU) in 1999 was followed by clear evidence of higher correlations among the business cycles of certain European countries.

Contrary to the exponents of business cycle convergence due to the establishment of currency-union, other authors voice the opinion that what happened in the years that followed the establishment of the EMU was actually quite the opposite. To begin with, Lehwald (2012) argues that higher levels of cyclical interdependence are a fact only for core European economies rather than for the whole EMU member countries. Along a similar vein, authors such as Hallett and Richter (2008) and Crespo-Cuaresma and Fernández-Amador (2013) provide evidence to suggest that since the adoption of the common currency, business cycles among European member–countries have become rather divergent. Lee (2012, 2013) further reports that the degree of synchronisation among European countries was actually higher before the EMU. On a final note regarding the EMU, Canova et al. (2012) in a recent study opine that researchers should be very cautious when linking developments in the behaviour of European cyclical interdependencies to institutional changes in Europe.

A recent strand of the literature examines the effects of the latest financial crisis on synchronisation levels in Europe. Authors such as Gaechter et al. (2012) and Gomez et al. (2012) in analysing a group of European countries for the period during and after the Great Recession provide evidence that, since the outbreak of the crisis, the prevailing pattern was the decoupling of business cycles. On top of that, some studies stress the necessity to investigate not only the contemporaneous synchronisation of business cycles but also their lead/lag relationship (see, for instance Darvas and Szapry, 2008; Gouveia and Correia, 2008; Weyerstrass et al., 2011, among others), which refers to the transmission mechanisms of business cycle shocks. In this regard, empirical research should also turn its focus to spillover effects among business cycles.

Business cycle shocks may be transmitted across economies via four main channels. In short, there is the trade channel, the exchange rate channel, the financial integration channel, as well as, the confidence channel (Eickmeier, 2007). More specifically, the trade channel is explained on the basis of higher exports in one country as a result of higher demand for imports in another country (Canova and Dellas, 1993; Kose and Yi, 2006). According to Clark and van Wincoop (2001) and Calderon et al. (2007) this channel is of particular importance to EMU countries, as monetary unions tend to foster trade among their members. Furthermore, Calderon et al. (2007) maintain that the positive impacts of trade intensity are better realised when countries exhibit similar production structures. A different perspective is offered by Ng (2010) who puts forward the argument that the effects of trade intensity on business cycle synchronisation are stronger when countries specialise in different stages of the production process. On a final note, Davis and Huang (2011) provide evidence to support the view that changes in the terms of trade (i.e. the relative price of exports in terms of imports) affect countries' business cycles and their synchronisation.

The exchange rate channel, on the other hand, pertains to positive shocks in foreign economies which result in the depreciation of the local currency. Subsequently this could lead to an increase of domestic country's competitiveness and thus to an improvement of the domestic trade balance. On the downside, this depreciation could also result in importing inflation (Eickmeier, 2007).

Turning to the financial integration channel, this can bear both positive and negative spillover effects. In particular, we maintain that financial markets and business cycles are closely related and thus higher level of integration among financial markets could lead to stronger spillover effects among business cycles. This is in line with Claessens et al. (2012) who argue that disturbances in financial markets are associated with bust phases of business cycles. The Great Recession of 2007–2009 is a representative example supporting this argument. Furthermore, financial integration allows for greater capital mobility and in this regard, capital flows from a domestic economy to a foreign economy may very well harm the former and improve output levels in the latter (see, *inter alia,* Canova and Marrinan, 1998; Imbs, 2004).

Finally, the confidence channel reflects the response of domestic agents to potential spillovers deriving from foreign shocks to the local economy. In addition, the strength of the spillover depends on whether agents over- or under-react to (asymmetric) information about foreign shocks (Eickmeier, 2007).

Apparently, despite the fact that many studies have been carried out relating to business cycle synchronisation (see, Artis et al., 2011; Antonakakis, 2012a; Lee, 2012; Crespo-Cuaresma and Fernández-Amador, 2013; Degiannakis et al., 2014, among others) only a few concentrate on the spillovers among business cycles per se (Yilmaz, 2009; Antonakakis and Badinger, 2012; Michaelides et al., 2014). Even more so, only Michaelides et al. (2014), focus on Europe. Thus, this study adds to the European business cycle literature by investigating business cycle spillovers in a time-varying environment, purporting to explore how output shocks are transmitted among EU15 member-countries.

Our empirical analysis is predicated upon the spillover index methodology developed by Diebold and Yilmaz (2009, 2012), which has already attracted significant attention by both the economic and the finance literature (see, *inter alia*, McMillan and Speight, 2010; Yilmaz, 2010; Bubák et al., 2011; Antonakakis, 2012b; Zhou et al., 2012; Antonakakis and Vergos, 2013).

The remainder of the paper is organized as follows. Section 2 discusses the application of the spillover index approach and describes the data used. Section 3 presents the empirical findings. Section 4 summarizes the results and concludes the study.

2. Empirical Methodology and Data

2.1. Spillover methodology

The spillover index approach introduced by Diebold and Yilmaz (2009) builds on the seminal work on VAR models by Sims (1980) and the well-known notion of variance decompositions. It allows an assessment of the contributions of shocks to variables to the forecast error variances of both the respective and the other variables of the model. Using rolling-window estimation, the evolution of spillover effects can be traced over time and illustrated by spillover plots. For the purpose of the present study, we use the variant of the spillover index in Diebold and Yilmaz (2012), which extends and generalizes the method in Diebold and Yilmaz (2009).

Starting point for the analysis is the following P-th order, N-variable VAR

$$y_t = \sum_{p=1}^{P} \Theta_i y_{t-i} + \varepsilon_t \tag{1}$$

where $y_t = (y_{1t}, y_{2t}, \ldots, y_{Nt})$ is a vector of N endogenous variables, $\Theta_i, i = 1, ..., P$, are $N \times N$ parameter matrices and $\varepsilon_t \sim (0, \Sigma)$ is vector of disturbances that are independently distributed over time; $t = 1$, ..., T is the time index and $n = 1$, ..., N is the variable index.

Key to the dynamics of the system is the moving average representation of model (1), which is given by $y_t = \sum_{j=0}^{\infty} A_j \varepsilon_{t-j}$, where the $N \times N$ coefficient matrices A_j are recursively defined as $A_j = \Theta_1 A_{j-1} + \Theta_2 A_{j-2} + \ldots + \Theta_p A_{j-p}$, where A_0 is the $N \times N$ identity matrix and $A_j = 0$ for $j < 0$.

Following Diebold and Yilmaz (2012) we use the generalized VAR framework of Koop et al. (1996) and Pesaran and Shin (1998), which produces variance decompositions invariant to the variable ordering. According to this framework, the H-step-ahead forecast error variance decomposition is

$$\phi_{ij}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}, \tag{2}$$

where Σ is the (estimated) variance matrix of the error vector ε, σ_{jj} the (estimated) standard deviation of the error term for the j-th equation and e_i a selection vector with one as the i-th element and zeros otherwise. This yields a $N \times N$ matrix $\phi(H) = [\phi_{ij}(H)]_{i,j=1,\dots N}$, where each entry gives the contribution of variable j to the forecast error variance of variable i. The main diagonal elements contain the (own) contributions of shocks to the variable i to its own forecast error variance, the off-diagonal elements show the (cross) contributions of the other variables j to the forecast error variance of variable i.

Since the own– and cross–variable variance contribution shares do not sum to one under the generalized decomposition, i.e., $\sum_{j=1}^{N} \phi_{ij}(H) \neq 1$, each entry of the variance decomposition matrix is normalized by its row sum, such that

$$\tilde{\phi}_{ij}(H) = \frac{\phi_{ij}(H)}{\sum_{j=1}^{N} \phi_{ij}(H)} \tag{3}$$

with $\sum_{j=1}^{N} \tilde{\phi}_{ij}(H) = 1$ and $\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H) = N$ by construction.

This ultimately allows to define a total (volatility) spillover index, which is given by

$$TS(H) = \frac{\sum_{i,j=1,i\neq j}^{N} \tilde{\phi}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H)} \times 100 = \frac{\sum_{i,j=1,i\neq j}^{N} \tilde{\phi}_{ij}(H)}{N} \times 100 \tag{4}$$

which gives the average contribution of spillovers from shocks to all (other) variables to the total forecast error variance.

This approach is quite flexible and allows to obtain a more differentiated picture by considering directional spillovers: Specifically, the directional spillovers received by variable i from all other variables j are defined as

$$DS_{i\leftarrow j}(H) = \frac{\sum_{j=1,j\neq i}^{N} \tilde{\phi}_{ij}(H)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ij}(H)} \times 100 = \frac{\sum_{j=1,j\neq i}^{N} \tilde{\phi}_{ij}(H)}{N} \times 100 \tag{5}$$

and the directional spillovers transmitted by variable i to all other variables j as

$$DS_{i\to j}(H) = \frac{\sum_{j=1,j\neq i}^{N} \tilde{\phi}_{ji}(H)}{\sum_{i,j=1}^{N} \tilde{\phi}_{ji}(H)} \times 100 = \frac{\sum_{j=1,j\neq i}^{N} \tilde{\phi}_{ji}(H)}{N} \times 100. \tag{6}$$

Notice that the set of directional spillovers provides a decomposition of total spillovers into those coming from (or to) a particular source.

By subtracting Equation (5) from Equation (6) the net spillovers from variable i to all other variables j are obtained as

$$NS_i(H) = DS_{i \to j}(H) - DS_{i \leftarrow j}(H), \tag{7}$$

providing information on whether a country (variable) is a receiver or transmitter of shocks in net terms. Put differently, Equation (7) provides summary information about how much each variable contributes to the volatility in other variables, in net terms.

The spillover index approach provides measures of the intensity of interdependence across countries and variables and allows a decomposition of spillover effects by source and recipient.

2.2. Data description

We collect monthly observations of industrial production as a proxy measure for economic activity for each of the EU15 countries[1] over the period 1977M1 – 2012M12 from the International Financial Statistics (IFS) maintained by the International Monetary Fund (IMF). All series are seasonally adjusted. Given that we are interested in business cycles interdependencies, we use the Hodrick-Prescott (HP) filtered series of the natural logarithm of seasonally adjusted industrial production series (with a smoothing parameter of 129,600), as this is the most common indicator of business cycles.[2]

[Insert Table 1 here]

Table 1 reports the descriptive statistics of the business cycle series for each country. The table suggests that business cycles of higher magnitude can be observed for Belgium, Finland,

[1] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherland, Portugal, Spain, Sweden and UK.

[2] However, we have explored the robustness of our empirical findings by employing alternative measures of business cycles, such as the band pass filter and the 12-difference growth rates of industrial productions, and our results described below remain qualitatively similar.

Greece, Ireland, Luxemburg, Denmark and Sweden. On the other hand, lower magnitude can be found in Austria, France and the UK. All series' distributions are leptokurtic and exhibit negative skewness. The only exception is Sweden, where a positive skewness is observed. The negative skewness indicates that bust phases of business cycles have a higher magnitude compared to boom phases. This could potentially be attributed to the effect of the two latest Euro Area (EA) recessions. Furthermore, all series apart from the one concerning Portugal reveal non–normality. Finally, according to the ADF–test statistic, all cycles are stationary.

3. Empirical findings

In this section we present the results from our empirical analysis, starting with the estimates of the spillover index and its subindices, defined in Equations (4)-(7). We then consider the time-varying nature of spillovers indices.

3.1. Spillover Indices

Table 2 presents the results of the spillover indices based on 24-month ahead forecast error variance decompositions. Before discussing the results, however, we shall first describe the elements of the table. The $ij-$th entry in Table 2 is the estimated contribution *to* the forecast error variance of variable i coming *from* innovations to variable j (see Equation (2)). Note that each variable is associated with one of the EU15 business cycles. Hence, the diagonal elements ($i = j$) measure own–country spillovers of business cycles, while the off–diagonal elements ($i \neq j$) capture cross–country spillovers of business cycles. In addition, the row sums excluding the main diagonal elements (labeled 'Directional from others', see Equation (5)) and the column sums (labeled 'Directional to others', see Equation (6)) report the total volatility spillovers 'to' (received by) and 'from' (transmitted by) each variable. The difference between each (off-diagonal) column sum and each row sum gives the net spillovers from variable i to all other variables j (see Equation (7)). The total volatility spillover index defined in Equation (4), given in the lower right corner of Table 2, is approximately equal to the grand off-diagonal column sum (or row sum) relative to the grand column sum including diagonals (or row sum including diagonals), expressed in percentage points.[3]

[Insert Table 2 here]

Several interesting results emerge from Table 2. First, own–country business cycle spillovers explain the highest share of forecast error variance, as the diagonal elements receive higher values compared to the off-diagonal elements. For example, innovations to business cycles in Greece explain 76.7% of the 24-month forecast error variance of business cycles in Greece, while only 0.87% in Germany and 1.05% in France. However, innovations to business cycles in Germany explain 21.86% of the 24-month forecast error variance of business cycles in Germany, while only 1.16% in Greece and 8.29% in France. This is a preliminary evidence that shocks originating from the Greek economy tend to be contained within the Greek borders.

Second, Spain is the dominant transmitter of business cycle shocks followed by Luxembourg, France, UK, Germany and Italy, while Portugal, Ireland, Finland, Austria and Greece are dominant receivers of business cycles shocks in the EU15. These results are supported by the 'directional to others' row and the 'directional from others' column in Table 2. They are also supported by the net directional spillovers values, which measure the net spillovers from country i to all other economies j, reported in the last column of Table 2. Specifically, Spain is the dominant country in business cycle transmission with a net spillover of 155.81%[4] to all other countries' business cycles followed by Luxembourg (42.09%), UK (40.98%), France (12.55%) and Germany (0.26%), while Austria is the dominant net receiver of business cycle shocks from all other countries' business cycles with a net spillover of -69.08%, followed by Finland (-37.50%), Denmark (-32.25%), Belgium (-26.08%), Sweden (-25.54%), Portugal (-21.28%), Ireland (-15.88%), the Netherlands (-15.67%), Greece (-7.46%) and Italy (-0.95%).

[3]The approximate nature of the claim stems from the fact that the contributions of the variables in the variance decompositions do not sum to one and have to be normalized (see Equation (3)).

[4]Note that according to the generalised spillover index approach of Diebold and Yilmaz (2012), directional and net spillovers do not sum to 100%.

The results for Luxembourg may at first glance seem implausible; however, Gaechter et al. (2012) also report an unexpected strong influence of Luxembourg's cyclical component on the business cycles of other European economies. These results are of great importance as, for instance, business cycle shocks in any individual EU15 country may have certain repercussions for other countries and thus, it can be a good indicator of future changes in their business cycles.

Third, and most importantly, according to the total spillover index reported at the lower right corner of Table 2, which effectively distils the various directional spillovers into one single index, on average, 54.47% of the forecast error variance in EU15 countries' business cycles comes from spillovers of shocks across countries, while the remainder can be explained by own-country shocks.

In summary, the results reported in Table 2 suggest that, on average, both the total and directional spillovers of business cycles within the EU15 countries were extremely high during our sample period, denoting the high level of business cycle interdependencies.[5]

3.2. Spillover Plots

While the use of an average measure of business cycle spillovers provides a good indication of business cycle transmission mechanism, it might mask interesting information on movements in spillovers due to secular features of business cycles. Hence, we estimate the model in Equation (1) using 60-month rolling windows and obtain the variance decompositions and spillover indices.[6] As a result, we obtain time-varying estimates of spillover indices, allowing us to assess the intertemporal evolution of total and directional business cycle spillovers within and between EU15 countries.

[Insert Figure 1 here]

[5] We have explored the robustness of our results using alternative n–month ahead forecast error variance decompositions (12, 36 and 48 months) and the results remain qualitatively similar.

[6] Our results reported below remain robust to alternative choices of window length (i.e. 36, 48 and 72 months).

Figure 1 presents the results for the time-varying total spillover index obtained from the 60-month rolling windows estimation. Large variability in the total spillover index is, indeed, present and the index is very responsive to extreme economic events. For instance, the total spillover index reaches a peak during Euro Area (EA) recessions, e.g. during the 1980s, 1992–1993, 2008–2009, as well as, at the onset of the Great Recession of 2007–2009. Furthermore, the index follows a decreasing trend starting at the beginning of 1980s and reaches a minimum just before the ERM II 1992 crisis. The road to the introduction of the Euro starts with a short-lived decline in spillovers between 1997 and 2001, and then follows an increasing trend since the inception of the common currency. During the Great Recession, business cycle spillovers reach unprecedented levels. In turn, the ongoing European debt crisis keeps business cycle spillovers at very high levels. These results indicate that during economic downturns, interdependencies across countries tend to increase significantly and are in line with previous studies (Imbs, 2010; Yetman, 2011; Antonakakis, 2012a).

Despite results for the total spillover index being informative, they might discard directional information that is contained in the "Directional to others" row (Equation (5)) and the "Directional from others" column (Equation (6)) in Table 2. Figure 2 presents the estimated 60-month rolling windows directional spillovers from each of the business cycles to others (corresponding to the "Directional to others" row in Table 2), while Figure 3 presents the estimated 60-month rolling windows directional spillovers from the others to each of the business cycles (corresponding to the "Directional from others" column in Table 2).

[Insert Figure 2 here]

[Insert Figure 3 here]

According to these two figures, the bidirectional nature of business cycle spillovers between the EU15 countries is evident. Nevertheless, they behave rather heterogeneously over time. Specifically, according to Figure 2, only in the case of Greece and Spain directional spillovers from each of these two countries' business cycles exceed the 30% level, in the beginning and during the EA recession of 2008–2009, respectively. Other than that, directional spillovers from or to each business cycle range between 5%–20%. Interestingly enough, the directional spillovers deriving from all other EU economies to each individual business cycle appear to remain constant over time at a level of 5% for all countries. This is suggestive of the fact that business cycle shocks are spread evenly across individual countries.

A similar picture emerges when looking at the net directional spillover indices obtained from the 60-month rolling window estimation. According to Figure 4, which plots the time-varying net directional spillovers, we see that Ireland, Italy, Luxembourg, Spain and the UK are mostly net transmitters of business cycles shocks during the sample period, while Austria, Belgium, Denmark, Finland, France and Germany are mainly at the receiving ends of net business cycle transmissions. The picture is not clear for Greece, the Netherlands, Portugal and Sweden. Nevertheless, Greece appears to be a significant net transmitter during the period just before the introduction of the Euro (possibly due the uncertainty surrounding the country's non compliance with the convergence criteria laid out in the Maastricht Treaty) and prior the EA recession of 2008–2009. Thought-provokingly, during the European debt crisis, Greece's business cycle is not a net transmitter, while Spain's is. This is in line with Michaelides et al. (2014) who maintain that the Greek business cycle does not Granger-cause any of the other European business cycles. Finally, this finding also suggests that the European debt problem may not actually originate in the Greek economy, as has been anecdotally claimed by the press, but rather, it is rooted in the uncertainty stemming from the turbulence in the Spanish economy. Possibly, there may be other channels (e.g. via the financial sector) through which shocks in the Greek economy may have an impact on European economies.

[Insert Figure 4 here]

3.3. Net Spillover Indices among Groups of Countries

To examine further the net spillover effects among the EU15 countries, we turn our attention to net spillover effects among groups of countries, namely Eurozone core countries, Eurozone peripheral countries and non-EMU countries. Figure 5 illustrates these net spillovers among the three groups.

[Insert Figure 5 here]

In principle, net spillovers tend to be of great magnitude between core and peripheral Eurozone countries, followed by those between core and non-EMU countries. The lowest magnitude of net spillovers is observed between the peripheral and non-EMU countries. Starting with net spillovers among core and peripheral countries we observe that both groups can either be net transmitters or net receivers of business cycles shocks at different time periods. In particular, during the period between the late 80s and the early 90s (i.e. the ERM II period), as well as, in the years that followed the introduction of the euro currency, core countries can be credited with transmitting business cycles shocks to the Eurozone periphery. By contrast, during the years that followed the collapse of ERM II and until the introduction of the euro, as well as, the post-2007 period (which is characterised by two EA recessions and the Great Recession of 2007–2009) peripheral countries were the main transmitters of business cycles shocks to the core countries.

Possibly the intertemporal change in the nature (i.e. net transmitter or net receiver) of each group can be explained by the transmission channels of business cycles shocks identified by the literature. More specifically, these changes can be attributed to the trade channel, the exchange rate channel, the financial integration channel, as well as, the confidence channel. The fact that core countries are the main transmitters during the ERM II period can be explained by the dominant character of the German economy and by the fact that all other countries pegged their currency to the Deutsche Mark and thus followed the German monetary policy (see, for instance, Degiannakis et al., 2014). Thus, the transmission of business cycles shocks during this period can be mainly explained via the exchange rate channel. Turning to the Maastricht Treaty period, the effort put by peripheral economies to meet the convergence criteria and thus qualify to member EMU states, serves as a plausible explanation as to why peripheral countries are the net transmitters of the period (i.e. mainly the trade channel of business cycles shocks transmission is identified here).

The following period; that is, the period after the adoption of the common currency and until 2007, core countries become net transmitters and this can be explained by three transmission channels of business cycles shocks (i.e. the trade, the financial integration and the confidence channel). In particular, adopting a common currency was conducive of the intensification of the intra-EU trade, as well as, of the higher degree of financial integration in Europe. The countries which led these developments in Europe were mainly the core European countries. In addition, the confidence channel is potentially useful in explaining the net transmitting character of core European countries. More explicitly, expectations deriving from peripheral countries regarding the growth potential of core countries and Europe in general, acted as positive shocks in these economies.

Furthermore, results for the later period of our study (i.e. the post–2007 period) imply that the same three transmission channels are also present. More specifically, the fact that peripheral countries become net transmitters comes as no surprise as the GIIPS (i.e. Greece, Ireland, Italy, Portugal and Spain) were heavily affected by the economic turbulence during the aforementioned period. Their economic conditions resulted in lower trade activity with core European countries and also confidence for these economies waned during the crisis leading to higher levels of uncertainty throughout Europe. In addition, this high uncertainty resulted in a greater sovereign risk premia not only for the beleaguered peripheral economies but also for stronger Eurozone economies such as France (see, for instance, Antonakakis and Vergos, 2013), leading to negative economic developments even in stronger economies. The fact that increased increased risk premia have spilled over to core European countries can be explained by the increased integration of the European financial sector.

Turning to the net spillovers between core and non-EMU countries, we observe that the former are the main transmitters, apart from the period 2011–2012 when non-EMU countries become net transmitters of business cycles shocks. This could potentially be attributed to economic conditions in the UK. Similarly, the main net transmitters between peripheral and non-EMU countries are the former. It is worth noting that the magnitude of net spillovers effects is higher during the last two EU recessions, as well as, in the period between them.

3.4. Cumulative Generalised Impulse Response Functions

We now proceed with the analysis of the generalised cumulative impulse response functions which will allow us to identify the direction of the response to and the bottom line effects of business cycle shocks. Figures 6, 7 and 8 illustrate the cumulative generalised impulse responses of output growth in each of the EU15 countries to output shocks originating in Eurozone core, Eurozone peripheral and non–EMU countries, respectively.

As far as shocks from Eurozone core countries are concerned, Figure 6 reveals that responses from all countries tend to be highly similar. However, there are two exceptions. Shocks originating from Austria and Belgium seem to lead to the decoupling of their business cycles mainly with those in the periphery and non–EMU countries. EU15 responses to shocks deriving from peripheral countries are alike (see, Figure 7); however, the magnitude of these response is higher for shocks originating in Italy and Spain. This is anticipated considering that these are the two largest economies of the European periphery. Finally, Figure 8 presents the responses to shocks deriving from non–EMU countries. In principle all responses to both Swedish and UK output shocks are positive although magnitude appears to be higher for core countries as opposed to peripheral countries. On the contrary, Danish output shocks result in the decoupling of its business cycle with the remaining EU countries.

[Insert Figure 6 here]

[Insert Figure 7 here]

[Insert Figure 8 here]

We further our analysis by providing a summary picture of the bottom line effect of business cycle shocks. To achieve that, we calculate for each country the cumulative effects of a one–standard deviation shock to business cycle on the respective country's business cycle, referred to as 'within–country' response, and the cumulative effects of a one–standard deviation shock to business cycle on the other country's business cycle, referred to as 'between–

country' response.[7] Table 3 reports the averages of the cumulative effects i) of business cycle shocks on within–country business cycle, and ii) of business cycle shocks on between–country, for the full sample period and for each group of countries (Eurozone core, Eurozone periphery and non–EMU). The cumulative effects are reported for time horizons of 12, 24, 36 and 48 months. As the effects of business cycle shocks have fully materialized after 4 years (see, Figures 6–8), the cumulative 48–month responses can be interpreted as overall bottom line effects of incipient shocks including spillover effects and the associated repercussions.

[Insert Table 3 here]

Overall, all shocks have positive and multiplicative effects suggesting a positive (negative) shock in a country leads to a positive (negative) response in other countries. In terms of the within–country effects, we observe fairly low and of similar magnitude cumulative responses for all three groups. In particular, the within–periphery responses amount to 3.9% followed by those of within–core (3.447%) and within–non–EMU (3.358%). Of particular interest are the cumulative response effects between–countries. First, own group shocks matter less than cross group shocks. Put differently, responses are more sizeable to other group shocks as opposed to own group shocks. For instance, the response of core countries business cycles to shocks originating in the core are lower (10.589%) compared to their responses to shocks originating in the periphery (16.096%) and non–EMU countries (15.930%). A similar pattern is also observed in the periphery and non–EMU responses to own– and cross–group business cycle shocks. Second, the largest in magnitude cumulative response effects is observed for the non–EMU to shocks in the core (24.938%), while the lowest are the responses of non–EMU to own–group shocks (2.134%). Third, the responses of core countries to shocks in the periphery are higher than the other way around suggesting that shocks in the periphery are crucial determinants of core countries business cycles. Fourth, the responses of Eurozone core to shocks in the non–EMU are sizeable (15.93%) and can be attributed to the effects

[7]Notice that with a stationary VAR the cumulative effects of one–time business cycle shock have to be interpreted as level effects and should not be confused with permanent effects on the business cycle.

of the UK business cycle to Eurozone core countries. This result is in line with the fact the UK is shown to be a key net transmitter of business cycle shocks during the sample period.

4. Conclusions

This study investigates the business cycle spillover effects in EU15 countries over the period 1977–2012. In particular, it contributes to the understanding of the relationship among European business cycles fluctuations. Monthly industrial production observations are considered to be a proxy for EU15 countries' GDP, while their cyclical components are extracted from the HP filter.

Our main findings can be summarised, as follows. According to the total spillover index, 54.57% of the forecast error variance in all EU15 countries' business cycles can be explained by cross–country spillovers. Using 60–month rolling windows we obtain time–varying estimates of the spillover index. We find that the index exhibits large intertemporal variability while it can be very responsive to economic events, such as downturns of economic activity.

With regard to directional spillovers over time, prominent among our findings is that only in the case of Spain and Greece does the level of these spillovers exceed the relatively high level of 30%. That aside, most business cycles shocks are evenly spread across all other individual countries. However, if we turn our focus to the recent European debt crisis, it appears that it is Spain which is the dominant transmitter of business cycle shocks among the EU15 countries, while shocks in the Greek business cycle are primarily confined within the country's borders. Given the magnitude of the spillovers of the period originating in the Spanish economy, it could be suggested that it is the Spanish business cycle, rather than the Greek, that can be credited with bolstering the European debt crisis.

As far as core Eurozone countries, peripheral Eurozone countries, as well as, non–EMU countries are concerned, net spillovers tend to be of greater magnitude between core and peripheral Eurozone countries. In addition, evidence suggests that the net transmitting or net receiving character of each group of countries is time–specific. This intertemporal alternation in the direction of the spillovers regarding each group can be explained by the various transmission channels of business cycle shocks that have been reported by the literature and mainly pertain to developments relating to the terms of trade, the level of financial integration, exchange rate dynamics, as well as, the underlying confidence of economic agents.

We also provide evidence suggesting that non–EMU countries have been net receivers of business cycles shocks from either core or peripheral Eurozone countries for the most part of the sample period. It should be noted however, that between the years 2011 and 2012, non–EMU countries appear to have contributed to the transmission of business cycle shocks to core Eurozone countries.

Additional evidence further implies that output shocks in each one of the core Eurozone countries tend to give rise to similar output responses from all other EU15 countries, with the exception of Austria and Belgium. In addition, output shocks in peripheral Eurozone countries also result in similar output responses from all other EU15 countries; however, the responses from Italy and Spain appear to be of greater magnitude. In addition, core Eurozone countries' output responses tend to be bigger – compared to the responses of peripheral Eurozone countries – when it comes to non–EMU output shocks. Finally, the cumulative response effects are more sizeable to cross group shocks compared to shocks originating from own group business cycles.

Overall, this study provides new insights on the transmission mechanism and the feedback effects of business cycle shocks in Europe. Prominent among our results is the fact that peripheral countries such as Spain (mainly) and Portugal and Greece (at a secondary level) exhibit a rather net–transmitting character when it comes to business cycles shocks in the years that followed the onset of the Great Recession. In this regard, shocks originating in the business cycles of peripheral Eurozone countries are very important for the EU15 economic conditions. This finding stresses the importance of adopting – at both the national and the international level – the appropriate policy measures; that is, measures aiming to steer the peripheral economies on an even keel, away from turbulence and close to recovery.

As an avenue of future research, our analysis of business cycle shock transmission mechanisms could be extended to include additional channels, such as the financial sector, trade and the uncertainty channel.

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Table 1: Descriptive statistics of EU15 member countries' business cycles (1977M1–2012M12)

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	ADF
AUT	0.0006	0.0966	-0.1822	0.0421	-0.8912	5.4412	164.453***	-5.7831***
BEL	0.0001	0.2876	-0.2113	0.0550	-0.0742	6.0878	172.022***	-4.8235***
FIN	0.0009	0.1846	-0.2471	0.0574	-1.0612	6.4572	296.226***	-8.6035***
FRA	0.0001	0.1021	-0.1897	0.0341	-1.3124	8.5516	678.775***	-6.8192***
GER	0.0002	0.1377	-0.2784	0.0522	-1.6536	9.5262	963.507***	-5.6856***
GRC	-0.0003	0.2601	-0.2200	0.0479	-0.2012	6.4308	214.778***	-4.8636***
IRL	0.0000	0.2159	-0.1928	0.0615	-0.1178	3.6000	7.479**	-5.2326***
ITA	-0.0003	0.1291	-0.2613	0.0515	-1.1378	7.5525	466.268***	-4.9293***
LUX	0.0011	0.2343	-0.2975	0.0721	-0.3696	5.0228	83.484***	-5.6229***
NED	0.0000	0.1230	-0.2136	0.0402	-0.5152	5.3632	119.642***	-5.4161***
PRT	0.0019	0.1616	-0.1357	0.0447	-0.0221	3.3387	2.100	-6.0440***
ESP	0.0006	0.0983	-0.2162	0.0428	-1.2669	7.2864	446.280***	-7.8837***
DNK	-0.0009	0.2397	-0.2412	0.0675	-0.1462	3.7811	12.522***	-5.6222***
SWE	-0.0004	0.3787	-0.2375	0.0667	0.1855	8.1273	475.678***	-5.5813***
UK	0.0000	0.0808	-0.1197	0.0312	-0.9379	4.8262	123.368***	-5.6223***

Note: ADF denotes Augmented Dickey Fuller tests with 10%, 5% and 1% critical values of -2.5704, -2.8682 and -3.4457, respectively. *, ** and *** indicate significance at 10%, 5% and 1% level, respectively.

Table 2: Spillover table of business cycle shocks in EU15 (1977M1–2012M12)

	From (j)															
To (i)	AUT	BEL	DNK	FIN	FRA	GER	GRC	IRL	ITA	LUX	NED	PRT	ESP	SWE	UK	From Others
AUT	16.84	1.67	0.35	2.57	8.30	11.58	1.74	0.18	5.93	9.63	3.86	0.45	22.85	5.25	8.81	83.16
BEL	1.21	41.76	0.83	1.41	9.02	7.68	0.57	2.67	7.43	5.79	2.06	0.82	11.89	0.70	6.17	58.24
DNK	0.51	1.32	55.33	0.91	5.80	4.32	2.03	0.19	3.26	6.11	2.47	1.77	8.27	1.71	5.99	44.67
FIN	1.09	1.84	0.53	38.56	4.74	3.81	2.02	0.58	7.46	7.14	4.99	0.44	16.79	3.55	6.47	61.44
FRA	0.92	3.52	1.04	1.90	20.29	8.29	1.05	0.48	8.41	9.29	4.12	0.35	26.56	3.83	9.95	79.71
GER	1.22	3.65	0.35	1.47	9.24	21.86	0.87	0.13	6.90	10.25	4.16	1.50	25.41	4.18	8.80	78.14
GRC	0.88	0.67	2.28	0.71	1.85	1.16	76.77	0.46	0.71	2.02	2.34	1.55	4.37	1.61	2.63	23.23
IRL	0.55	3.43	0.27	0.61	4.39	0.74	0.35	71.93	2.82	2.80	1.21	0.82	6.63	1.55	1.91	28.07
ITA	0.71	5.20	0.32	2.59	12.20	6.63	0.96	0.27	26.20	9.53	2.51	0.67	23.97	2.82	5.42	73.80
LUX	1.54	3.15	0.86	0.32	7.11	6.65	0.07	1.10	6.01	48.78	2.48	1.42	12.24	0.98	7.29	51.22
NED	1.26	1.41	0.60	0.71	7.25	7.07	0.93	0.47	5.10	8.02	46.15	0.62	11.64	3.32	5.45	53.85
PRT	2.06	0.80	1.82	0.65	4.58	1.92	0.76	2.07	2.62	4.84	0.49	66.87	8.77	0.28	1.47	33.13
ESP	0.27	2.01	0.23	2.39	6.82	6.40	0.54	0.47	6.29	6.54	0.48	0.76	57.18	3.59	6.05	42.82
SWE	0.41	1.29	0.37	4.55	4.82	8.66	2.99	0.59	4.27	6.76	4.36	0.34	11.24	39.61	9.74	60.39
UK	1.44	2.20	2.56	3.14	6.14	3.51	0.91	2.54	5.65	4.60	2.67	0.34	8.01	1.47	54.83	45.17
Contr. to others	14.08	32.16	12.42	23.94	92.26	78.40	15.77	12.19	72.85	93.31	38.18	11.85	198.63	34.85	86.15	Total Spillover
Contr. incl. own	30.91	73.93	67.75	62.50	112.55	100.27	92.54	84.12	99.05	142.09	84.34	78.72	255.82	74.45	140.98	Index = 54.47%
Net spillovers	-69.08	-26.08	-32.25	-37.50	12.55	0.26	-7.46	-15.88	-0.95	42.09	-15.67	-21.28	155.81	-25.54	40.98	

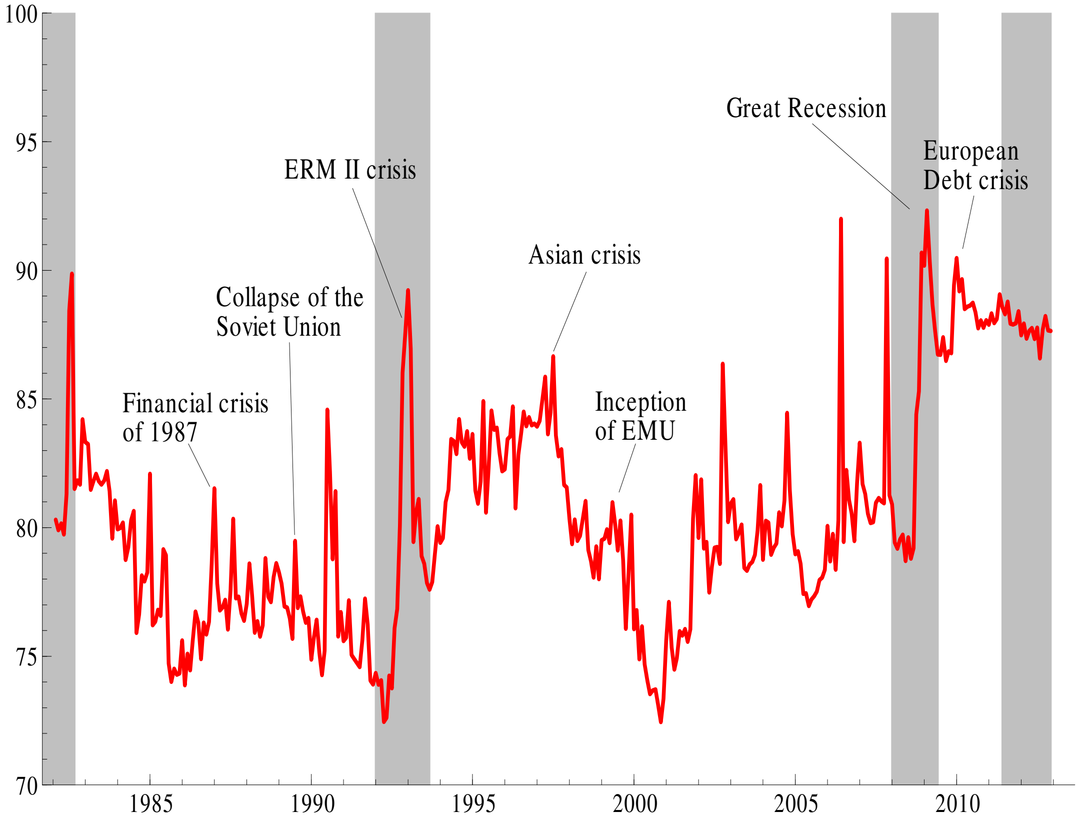
Note: Spillover indices, given by Equations (2)–(7), calculated from variance decompositions based on 24–step-ahead forecasts.

Table 3: Generalised cumulative impulse responses (1977M1–2012M12)

		Cumulative response[1] *From (j)*					
		Within–country			*Between–country*		
	To(i)	Core	Periphery	Non-EMU	Core	Periphery	Non-EMU
12-months	Core	3.209			8.531	12.145	13.324
	Periphery		3.360		13.715	3.926	5.607
	Non-EMU			2.977	22.727	9.994	0.524
24-months	Core	3.417			10.255	14.990	15.406
	Periphery		3.795		15.312	4.822	7.127
	Non-EMU			3.303	24.913	11.364	1.399
36-months	Core	3.429			10.464	15.760	15.769
	Periphery		3.871		15.324	4.993	7.425
	Non-EMU			3.345	24.789	11.314	2.044
48-months	Core	3.447			10.589	16.096	15.930
	Periphery		3.900		15.470	5.078	7.535
	Non-EMU			3.358	24.938	11.376	2.134

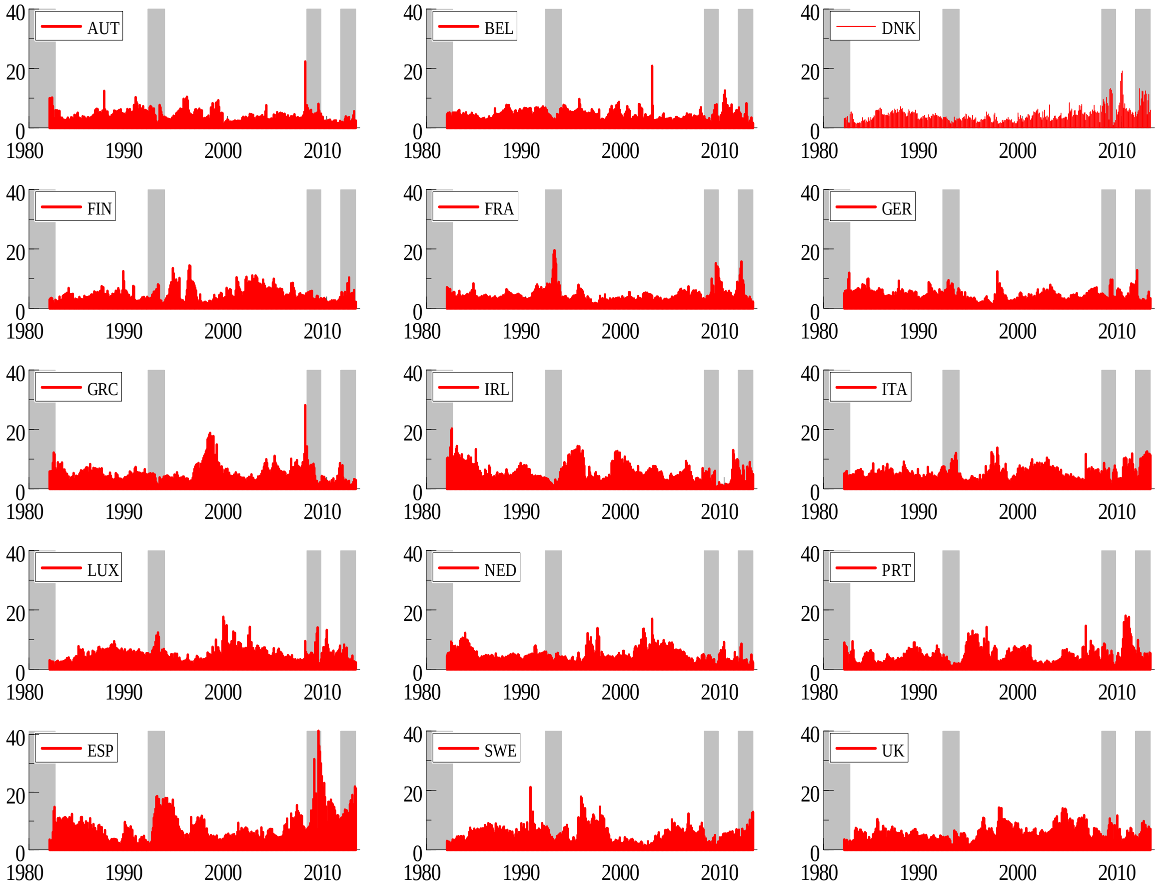
Notes: [1] Cumulative generalized impulse response to one standard deviation shock, multiplied by 100 (in %).
All entries are averages over country-specific shocks to the respective business cycle.

Figure 1: Total spillover of business cycles in the EU15



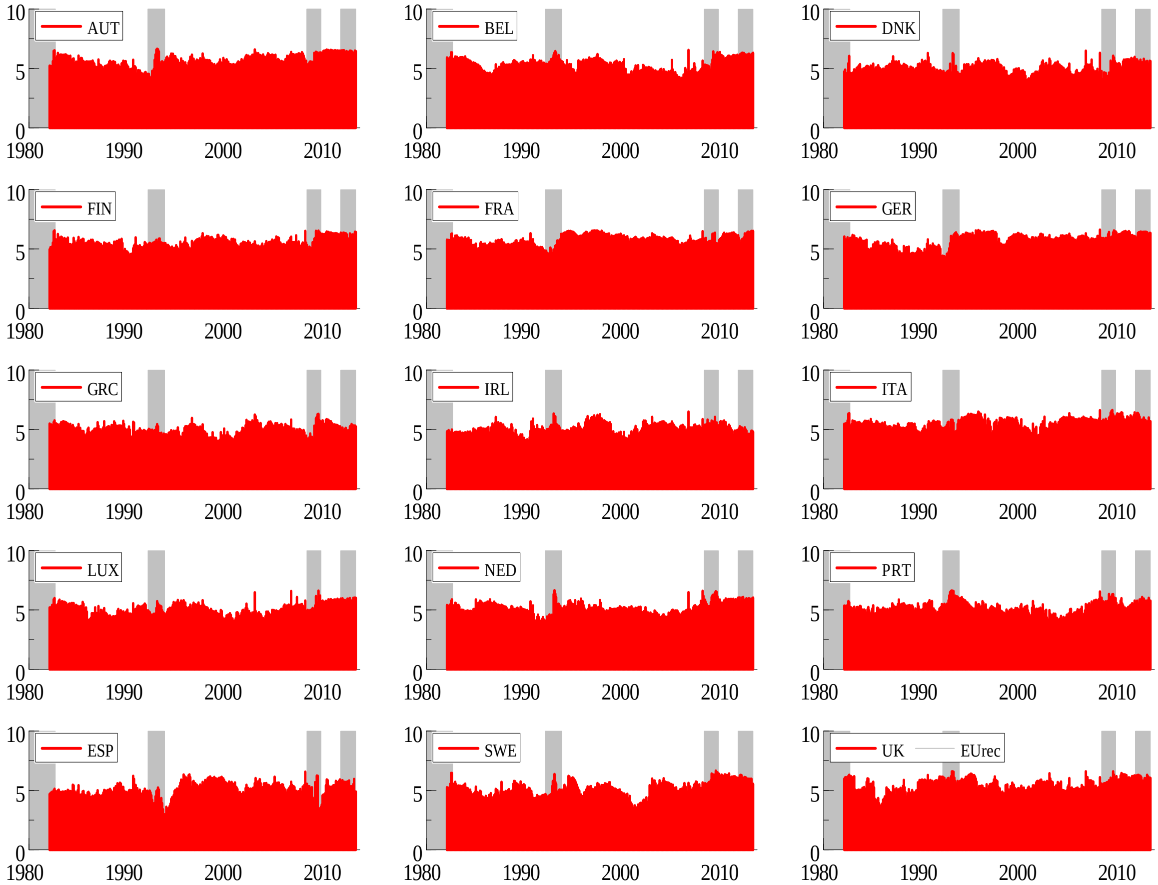
Note: Grey shaded areas denote EA recessions based on CEPR business cycle dating committee.

Figure 2: Directional spillovers *FROM* each of the EU15 business cycles to all others



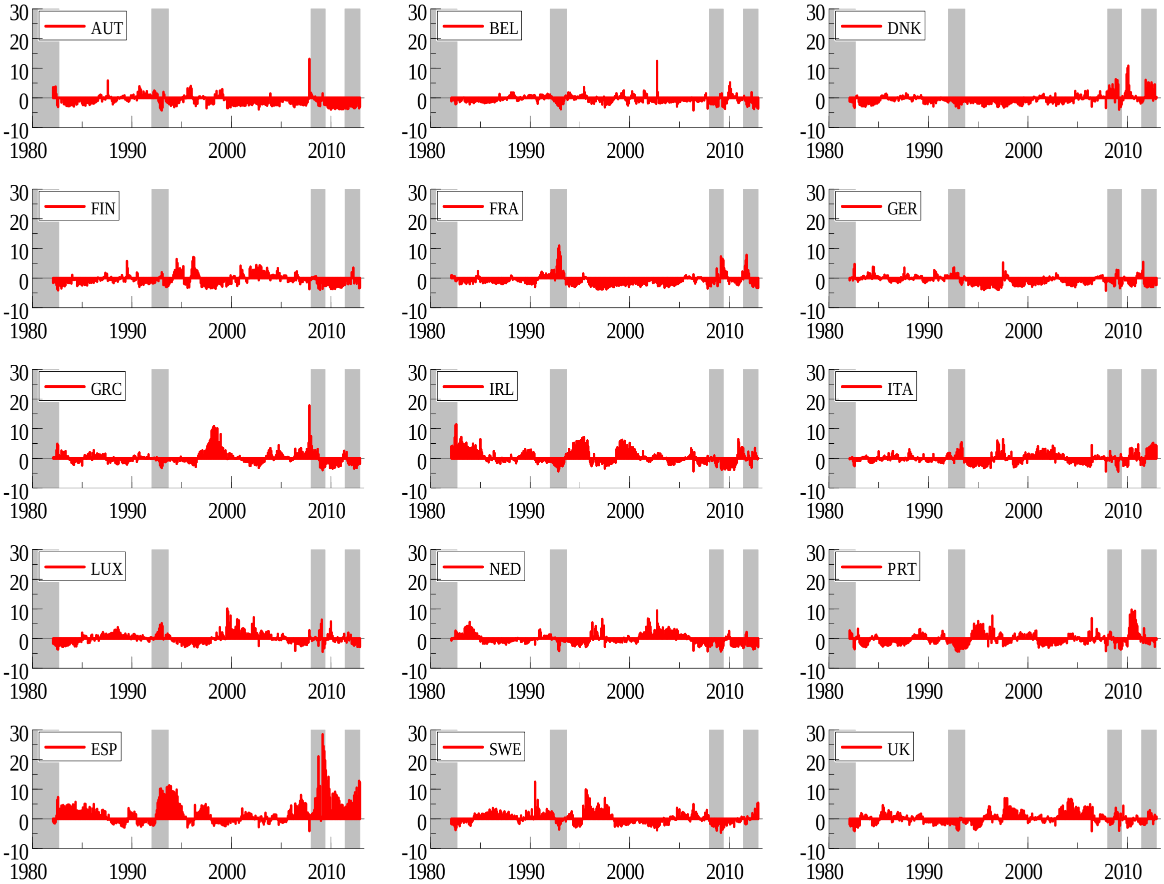
Note: Grey shaded areas denote EA recessions based on CEPR business cycle dating committee.

Figure 3: Directional spillovers TO each of the EU15 business cycles from all others



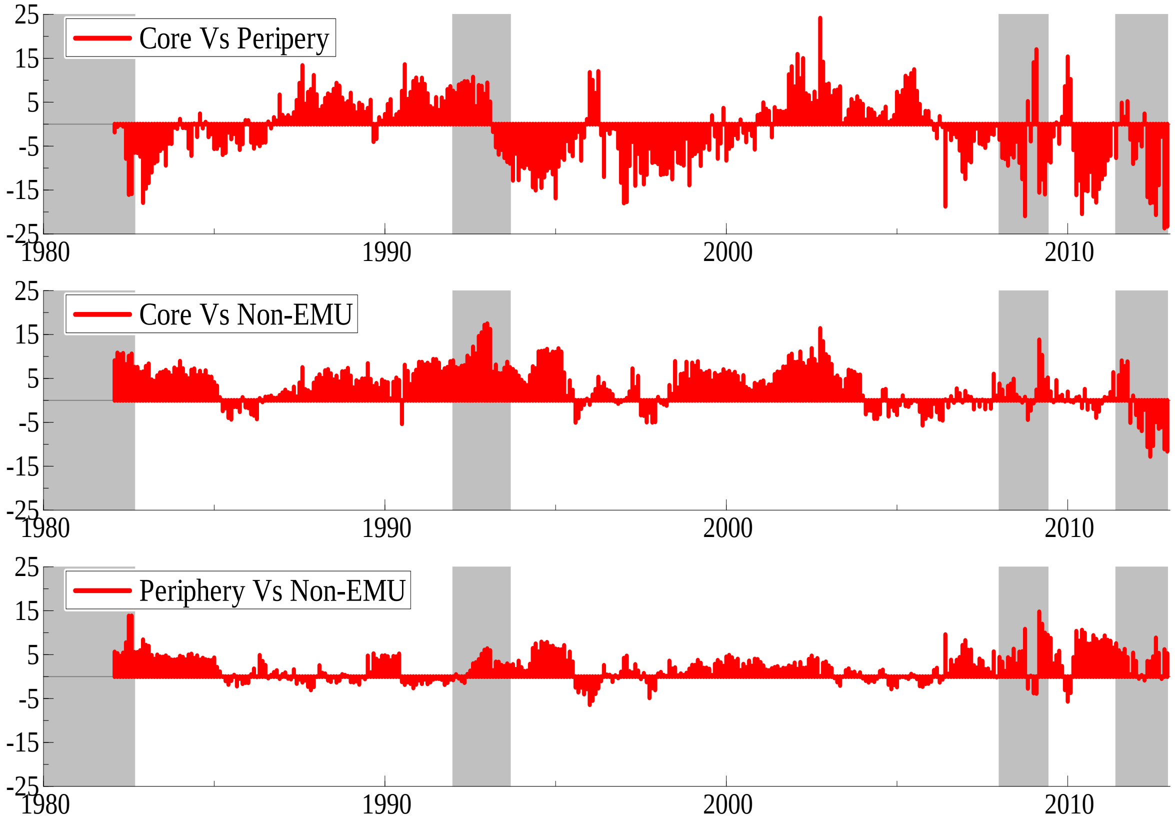
Note: Grey shaded areas denote EA recessions based on CEPR business cycle dating committee.

Figure 4: Net spillovers of business cycles in the EU15



Note: Grey shaded areas denote EA recessions based on CEPR business cycle dating committee.

Figure 5: Net spillovers of business cycles among Eurozone core, Eurozone periphery and non–EMU



Note: Grey shaded areas denote EA recessions based on CEPR business cycle dating committee.

Figure 6: Cumulative impulse responses of output growth in the EU15 countries to shocks from the Eurozone core

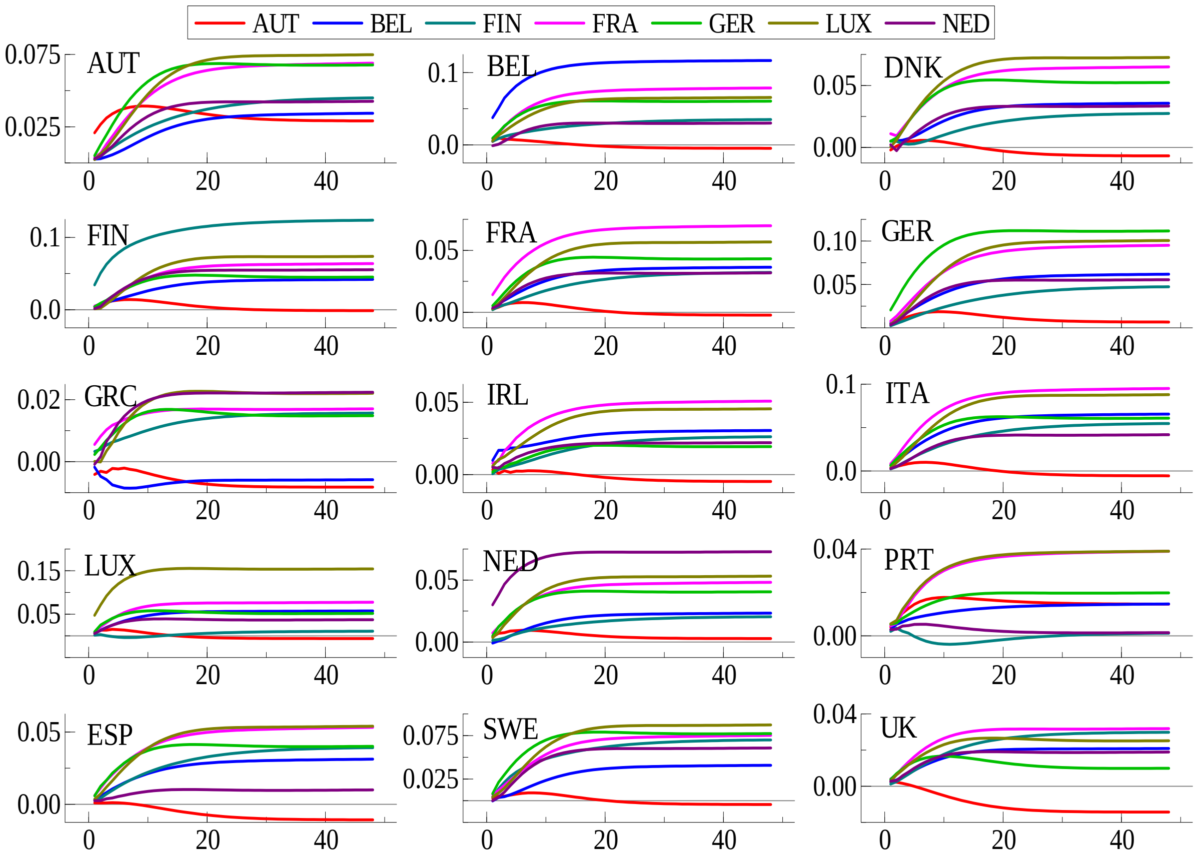


Figure 7: Cumulative impulse responses of output growth in the EU15 countries to shocks from the Eurozone periphery

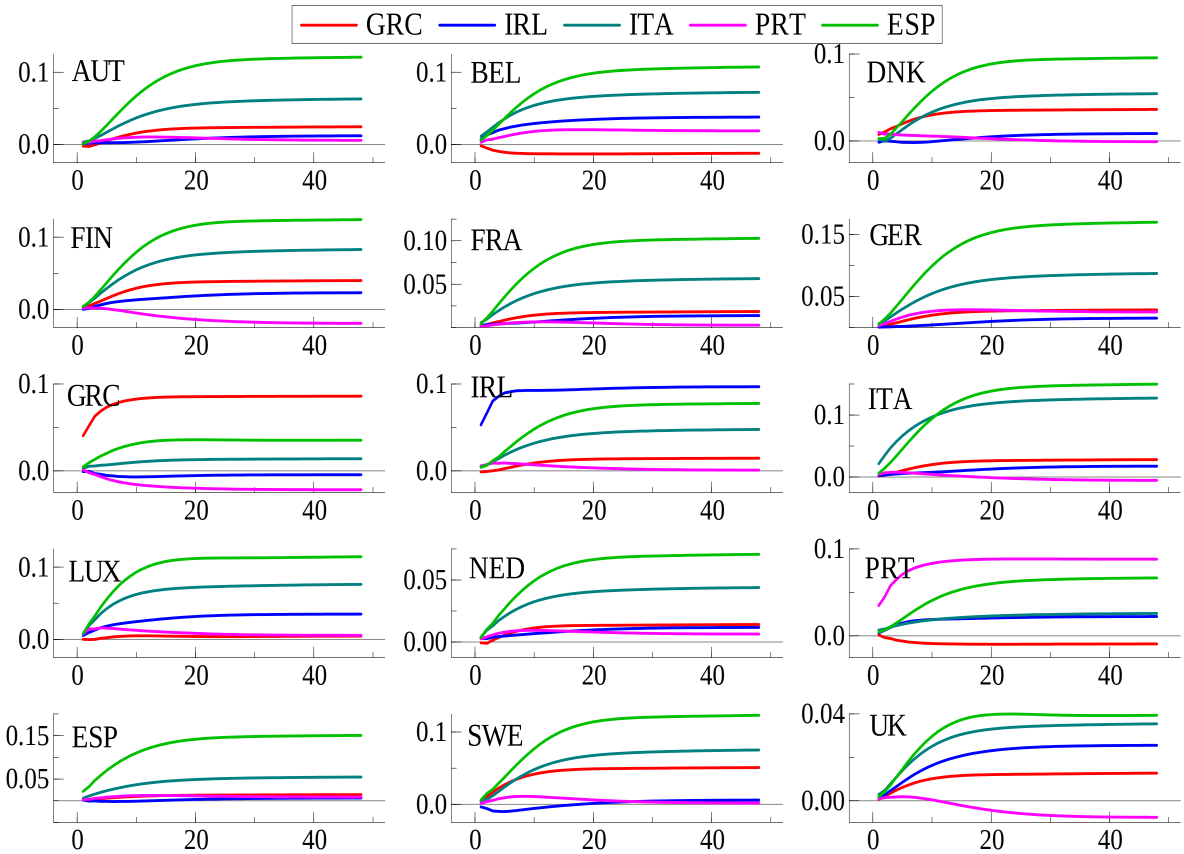


Figure 8: Cumulative impulse responses of output growth in the EU15 countries to shocks from non–EMU countries