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Historical Decoupling in the EU: Evidence from Time-Frequency Analysis

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Abstract

Svatopluk Kapounek, Zuzana Kučerová: **Historical Decoupling in the EU: Evidence from Time-Frequency Analysis**

We investigate economic cycle comovements across the European Union after twenty years from euro adoption. We demonstrate the cycle comovement between France and the EU and the decoupling of Germany, the United Kingdom and countries in Southern Europe. We find that the Baltic countries represent a single economic area with common shocks. Using wavelet coherence analysis with phase shift, we identify directions of causal relationships and discuss the spread of asymmetric shocks across the European Union. Our results do not fully support the idea that monetary integration increases the synchronisation of economic cycles of monetary union members.

Key words

OCA Theory, Economic Cycles, Time-series co-movements, Wavelet Analysis, Phase Shift

JEL: E32, F15, C14

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Introduction

The paper aims to open a discussion concerning the positive impact of a euro adoption on the economic cycle synchronisation of the euro area countries after a relatively long period (twenty years from the euro adoption). Hence, we focus on the synchronisation of the whole EU region, selected sub regions[1] and their main trading partners (the US and the Russian Federation).

There are many structural events causing a variation in the experience of different European countries that can be exploited to identify the effects of integration on the symmetry of macroeconomic shocks. The first shock is expected to appear in 1995 when the EFTA countries accessed the EU, including their national specifics (Norway has not joined the process of the European integration, Switzerland joined the European Economic Area, Sweden joined the EU and only Austria and Finland joined the euro area). Second, the introduction of the euro common currency in 1999 represents the factual creation of a monetary union. Third, the accession of the CEECs and Mediterranean new member states to the EU in 2004 and their later accession to the euro area (Slovenia in 2007, Cyprus and Malta in 2008, Slovakia in 2009, Estonia in 2011, Latvia in 2014 and Lithuania in 2015) implies the significant expansion of the EU covering countries with formerly centrally planned economies, with a relatively lower economic level and still converging to the level of the more developed European countries. Fourth, the impact of the global financial crisis is in contrast to the above-mentioned events because it represents a largely symmetric external shock but with differing intensities and persistence across economies. Finally, the excessive capital inflows in the Europe's periphery countries (especially Greece, Ireland, Portugal and Spain) resulted in the EU sovereign debt crisis that was initiated at the end of 2009 and led to the phenomenon of a Two-Speed Europe.

There is a sizeable empirical literature on business cycle asymmetry in the EU before and after the euro adoption in 1998 (Economidou and Kool, 2009; Rua, 2010; Aguiar-Conraria and Soares, 2011; Lehwald, 2013; Artis et al. 2011). However, despite the obvious policy relevance of this issue, there are only a very few contributions on causal inferences on the effects of the European integration process on business cycle synchronisation in the last decade. In this paper, we try to extend this line of research, analyse the evolution of business cycle synchronisation across the current European Union, and identify the probable decoupling of specific country groups in the context of the European integration process.

[1] We focus mostly on potential EU core leading countries, the Southern European particularly hit by the debt crisis, as well as the Baltic countries, which are historically influenced by external shocks coming from Russian Federation.

The contribution of our paper is twofold. First, we identify the historical decoupling of heavily-indebted countries in Southern Europe (Portugal, Italy, Greece and Spain) and the UK economy. Moreover, we confirm the conclusions of Ahlborn and Wortmann (2018) about the decoupling of Germany after the Hartz reforms were applied and the conclusions of Aguiar-Conraria and Soares (2011) who identify France as a country leading the common euro area business cycle. Secondly, we apply frequency domain techniques to assess the dynamic properties of times series and their comovements including phase shift enabling to identify spill-over effect directions and asymmetries of business cycle shocks of causal relationships which is quite unique in this field.

The paper is organised as follows. Section 1 contains the literature review. A detailed overview of methods and data is provided in Section 2. Section 3 presents the results of the wavelet coherence and section 4 contains a robustness analysis based on the wavelet cross-spectrum. Section 5 offers concluding remarks.

1 Literature Review

The European integration process is theoretically supported by optimum currency area theory (the OCA theory) which originates from debates about fixed versus flexible exchange rates, treating a common currency as an extreme case of a fixed exchange rate (Mundell, 1961). Mundell (1961) and Mundell (1973a; 1973b) define the mobility of factors of production (labour and capital) as a criterion for successful OCA existence; high labour mobility facilitates adjustment to the adverse effects of asymmetric shocks and thus reduces the pressure for exchange rate adjustments. The key issues of the OCA theory are contributed by McKinnon (1963), Kenen (1969) and Krugman (1993). They argue that openness of the economy and structural synchronisation are important conditions of the OCA which affect the efficiency of a market-based adjustment mechanism. In this sense, economic activity comovements are fostered by trade integration. The traditional version of OCA theory was supplemented by Corden (1972) who argues that joining a currency area is related to loss of autonomous monetary policy and exchange rate controls. These arguments are followed by new theoretical developments of OCA theory which focus more on the benefits and costs of adopting a common currency.

On the basis of the theoretical principles, the costs are minimised and benefits maximised with a high degree of cyclical and structural synchronisation. However, Frankel and Rose (1998) argue that OCA criteria are endogenous (*the OCA endogeneity hypothesis*), i.e. that single currency adoption increases trade integration endogenously as a result of transaction costs and exchange-rate risk elimination. Thus, countries with close international trade linkages would benefit from a common currency and are more likely to be members of an OCA. Many authors use the gravity model of international trade to verify this hypothesis. The results of works of Rose (2000), Frankel and Rose (2002), Rose and Wincoop (2001), Persson (2001), Glick and Rose (2002) and Mélitz (2004) show a positive impact of a currency union on bilateral trade of its members. Rose (2004) performs a meta-analysis and summarises the debate on this topic concluding that a currency union doubles bilateral trade.

Tighter trade integration can be also expected to affect the nature of national business cycles: countries that enter a currency union are likely to experience dramatically different business cycles than before (before the adoption of a common currency). Rose and Engel (2002), Alesina *et al.* (2002), Tenreyro and Barro (2007) focus on the correlation of business cycles of countries that are part of a currency area[2]; they also confirm the validity of the endogeneity hypothesis. Fontagné and Freudenberg (1999) and Fidrmuc (2004) emphasise the role of intra-industry trade in the process of trade integration and conclude that the level of intra-industry trade may be viewed as a major adjustment force inducing the convergence of business cycles between trading partners, i.e. the coordination of the business cycles of trading partners is not driven by the simple aggregation of overall foreign trade but by the structure of the foreign trade.

On the contrary Krugman (1991 and 1993) argues that the increased trade in a common currency area might lead to industrial specialisation between regions that have a comparative advantage (*the OCA specialisation hypothesis*) and that closer international trade could result in looser correlation of national business cycles. Therefore, members of a currency area would become less diversified and more vulnerable to asymmetric shocks. The problem of the symmetry of shock in euro area countries is further discussed by Bayoumi and Eichengreen (1993) and (1997), Frenkel *et al.* (1999), Babetski *et al*. (2002), Fidrmuc and Korhonen (2003), Frenkel and Nickel (2005) or Eichengreen (2007).

De Haan *et al.* (2008) summarise the empirical literature on the business cycle correlation in the euro area countries; many authors use the method of classical correlation, dynamic correlation, phase-adjusted correlation, the concordance index or the diffusion index. Some of these authors try to identify a common business cycle such as Forni et al. (2000), Camacho et al. (2006) or Harding and Pagan (2006). Artis et al. (2004) study factors determining the European business cycle and use Markov switching vector autoregression models to identify a common unobserved component.

[2] In the case of the euro area, which started only in 1999, empirical papers concentrate on *potential* members of the euro area because of missing time series. Hence, it is an ex ante approach, i.e. the authors assess the potential members of the currency area before its creation.

Traditionally, the analysis of comovement measurements is based on static correlation analysis (Engle and Kozicki, 1993; Vahid and Engle, 1993 and 1997) or sigma convergence methods (Crespo-Cuaresma et al., 2013a and 2013b). This literature primarily focuses on univariate methods such as shock accounting (Clark and Shin, 2000 and Kose et al. 2003), correlation analysis or dynamic factor models (Forni and Reichlin, 2001). It finds that trade intensity has a strong positive effect on business cycle symmetries between regions, whereas industrial specialisation, exchange rate volatility, distance and borders have a negative effect. Results with respect to business cycle convergence in the EU, by contrast, differ between authors. Barrios et al. (2003) find cyclical divergence between the UK regions and the Euro cycle and Barrios and Lucio (2003), as well as Montoya and de Haan (2008) find regional business cycle convergence in the EU. However, Artis et al. (2011) find no signs of cyclical convergence among the EU15 regions, Landesmann (2003) points out that differentiation across regions and countries is particularly large in the Central and Eastern Europe due to the industrial 'up-grading' and remaining 'locked in' in low-skill areas of production and Monfort et al. (2013), Bandrés et al. (2017) or Ahlborn and Wortmann (2018) show that asymmetries have remained unchanged up to now. In addition, Ahlborn and Wortmann (2018) point out the decoupling of Germany and provide evidence that the German business cycle cannot be used as a proxy for the euro area cycle. Poissonnier (2017) shows that the Baltic countries share common shocks and represent a single economic cluster.

Alternatively, some authors apply frequency domain techniques, which provide deeper insights into the dynamic properties of analysed time series and their comovements. This approach is based on a spectral and cross-spectral analysis; thus, the cyclical comovements are measured by coherency, squared coherency (denoted as coherence), dynamic correlation and phase shift (Croux et al., 2001; Iacobucci, 2005; Iacobucci and Noullez, 2005; Messina et al., 2009; Fidrmuc and Korhonen, 2010; Marczak and Beissinger, 2012; Fidrmuc et al., 2013). However, these methods cannot define a time-varying measure of synchronisation over different sub-periods. Therefore, we merge the time and the frequency domain and apply approaches based on the time-frequency domain which provides a more efficient means of statistical analysis for the assessment of cyclical comovements.

There are already several applications of time-frequency analysis in economics which focuses on time series before the financial crisis (Crowley, 2007; Crowley and Mayes, 2008; Woźniak and Pacziński, 2007; Ge, 2008; Rua, 2010; Aguiar-Conraria and Soares, 2011; Hughes-Hallett and Richter, 2011; Jiang and Mahadevan, 2011). After the financial crisis, Maršálek et al. (2014) applied wavelets to filter out the cycles that are caused by the global symmetric shock, Fidrmuc et al. (2014) focus on the bilateral trade in China and G7 countries, Verona (2016) focuses on financial cycles in US economy and Aloui et al. (2016) provide evidence of Gulf Cooperation Countries' business cycle synchronisation. Thus, to our best knowledge, we are probably among the first who have applied time-frequency analysis to economic cycle synchronisation in Europe after the financial crisis.

2 Data and Methodology

Our empirical approach is based on the modelling of fluctuations in economic activity represented by the unemployment rate in 24 European countries[3], the Russian Federation, and the United States. Following Fatas (1997) we use unemployment as a proxy of economic activity fluctuations for longer time series availability and also because the unemployment rate is not affected by exchange rate movements. In the spirit of Burns and Mitchell (1946) we focus on classical cycles of the economic activity movements. However, we do not delimit business cycles by the lowest frequency limit and focus on cyclical movements in economic activity lower than 12 months frequency (higher frequencies are considered as seasonal).

We use the monthly unemployment rate measured as a percentage of the economically active population provided by Eurostat[4] employment statistics and the Federal Reserve Economic Database[5] in the period 1983M01–2016M12.[6] The average unemployment rate in the selected groups of European countries is weighted by the total population provided by Eurostat statistics.

We assume that comovements are changing with different frequencies and apply frequency domain techniques which provide deeper insights into the dynamic properties of the analysed time series and their comovements. Our analysis of cyclical comovement is based on squared coherency (so-called coherence), cross-spectrum and phase shift identification. Our time-frequency domain analysis enables differentiation between short- and long-term comovements and their changes in time. We apply Continuous Wavelet Transform (CWT) as a band pass filter to time series $(x_n, n = 1, \dots, N)$ with uniform time steps δt, where the time step is defined as the convolution of x_n with the scaled and normalised wavelet. We follow Grinsted et al. (2004) and define the wavelet power as $|W_n^X(s)|^2$ and:

[3] Austria, Belgium, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia and Sweden.

[4] Czech Republic, Denmark, Spain, Estonia, Finland, United Kingdom, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Netherlands, Norway, Romania, Slovenia, Sweden and the United States.

[5] Austria, Belgium, Germany, France, Portugal, Poland, Slovakia and the Russian Federation.

[6] Non-seasonally adjusted data are used because frequency analysis allows us to eliminate seasonal frequencies.

$$W_n^X(s) = \sqrt{\frac{\delta t}{s}} \sum_{n'=1}^{N} x_{n'} \psi_0 \left[(n' - n) \frac{\delta t}{s} \right]. \tag{1}$$

where s represents scale in time. In practice, the complex argument of $W_n^X(s)$ can be interpreted as the local phase. To localise a function in frequency and time we use the Morlet wavelet ψ_0 which provides an optimal trade-off between both time and frequency localisation (Teolis, 1998):

$$\psi_0(\eta) = \pi^{-1/4} e^{i\omega_0\eta} e^{-1/2\eta^2}, \tag{2}$$

where $\omega_0 = 6$ is dimensionless frequency and $\eta = s \times t$ dimensionless time by varying its scale s. To identify shocks in comovements between the analysed time series x_n and y_n we apply the Cross Wavelet Transform (XWT):

$$W^{XY} = W^X W^{Y*}, \tag{3}$$

where * denotes complex conjugation (Grinsted et al., 2004). Additionally, we apply Wavelet Coherence (WTC) to identify common time-localised oscillations in nonstationary time series that can be interpreted as comovement or correlation. Following Torrence and Webster (1999) and Grinsted et al. (2004) we define the wavelet coherence of time series x_n and y_n as:

$$R_n^2(s) = \frac{\left| S\left(s^{-1} W_n^{XY}(s)\right) \right|^2}{S\left(s^{-1} \left| W_n^X(s) \right|^2 \right) \times S\left(s^{-1} \left| W_n^Y(s) \right|^2 \right)}, \tag{4}$$

where the smoothing operator S is defined as $S(W) = S_{scale}\left(S_{time}\left(W_n(s)\right)\right)$. S_{scale} represents a smoothing operator along the wavelet scale axis and S_{time} a smoothing operator in time, suitable for the Morlet wavelet (Torrence and Webster, 1998).

Moreover, it is very important to identify the direction of causality which is given by the relative lag between the two time series. In this sense we apply phase shift to identify a time offset between the reflection and the maximum value on the waveform. Thus, we interpret phase shift as a lead or a lag between time series. We follow Grinsted et al. (2004) and estimate the mean and confidence interval of the phase difference. The mean phase calculation is based on the circular mean of a set of angles $(a_i, i = 1, \ldots, n)$:

$$\bar{a} = \arg(X, Y) \text{ with } X = \sum_{i=1}^{n} \cos(a_i) \text{ and } Y = \sum_{i=1}^{n} \sin(a_i). \quad (5)$$

For a better understanding of this issue, it is comparable to causality in Granger sense. However, the interpreting of the phase as a lead or a lag has to be done relative to the anti-phase, because a lead of 90° is also a lag of 270°.

Finally, we focus on the edge effects because wavelets are not completely localised in time in the case of very low frequencies. We follow the concept provided by Torrence and Compo (1998) who estimated statistical significance against an autocorrelation model with lag 1 and an error term represented as white noise. The same approach is applied to identify the significance levels of cross-wavelet power and wavelet coherence.

3 Empirical Results

According to the OCA endogeneity hypothesis, a common currency supports bilateral trade and induces the convergence of business cycles which is a necessary condition for the successful existence of a monetary union. Table 1 confirms trade openness increasing after euro adoption in 1998 (a positive percentage change) and the Visegrad Group countries faced the highest increase in openness in the second period even though three of these countries had not adopted the common currency in 1999 (except for Slovakia), which is quite surprising. Conversely the core euro area countries, such as Italy, France, Belgium or the Netherlands, experienced a lower increase in the trade openness. These results thus contradict OCA theory conclusions. Therefore there are probably additional factors, and not only the endogeneity process resulting from the adoption of a common currency, which determine the degree of trade openness and then the business cycle synchronisation of the analysed countries.

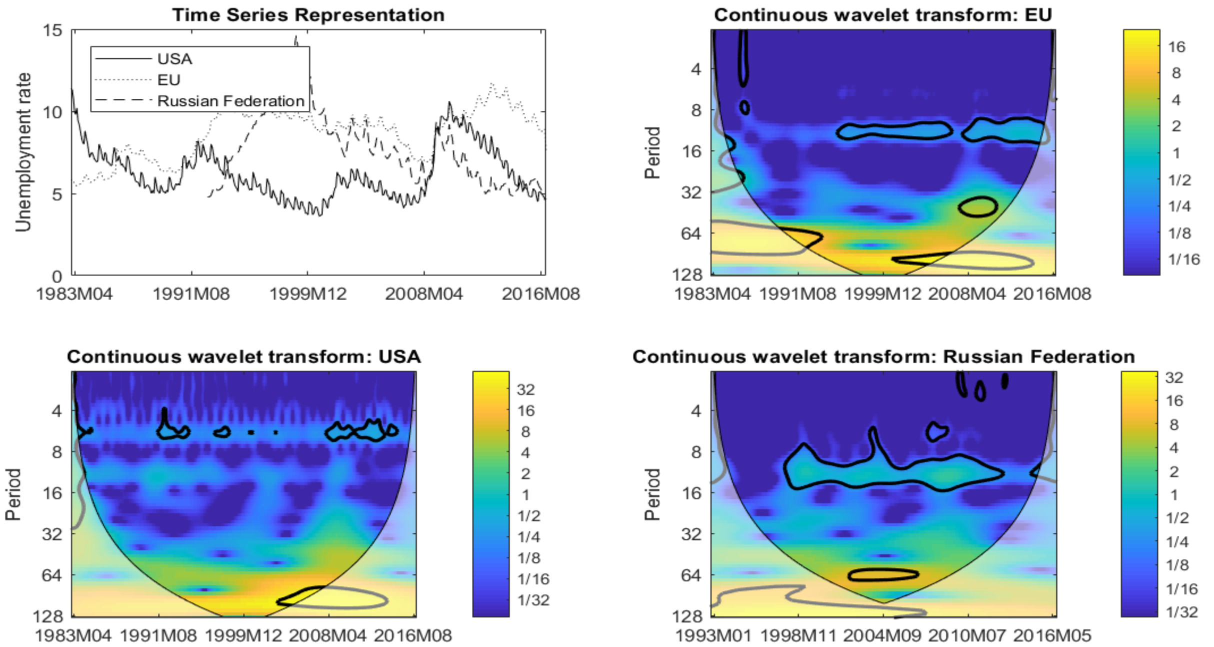
Table 1: Trade openness measured by exports and imports to GDP

Country Name	1983-1998	1999-2016	% change	Country Name	1983-1998	1999-2016	% change
Hungary	0.73	1.47	1.00	Sweden	0.63	0.84	0.34
Poland	0.45	0.78	0.71	Lithuania	0.92	1.23	0.33
Germany	0.45	0.74	0.64	Italy	0.40	0.52	0.31
Czech Republic	0.78	1.24	0.58	Slovenia	0.95	1.24	0.31
Ireland	1.17	1.76	0.51	France	0.43	0.55	0.27
Malta	1.76	2.63	0.50	Belgium	1.18	1.49	0.26
Slovakia	1.07	1.52	0.43	Netherlands	1.06	1.33	0.26
Greece	0.40	0.56	0.41	Croatia	0.68	0.83	0.22
Spain	0.41	0.57	0.40	Latvia	0.86	1.02	0.19
Romania	0.53	0.75	0.40	Portugal	0.60	0.69	0.15
Austria	0.68	0.95	0.39	United Kingdom	0.49	0.55	0.12
Denmark	0.68	0.93	0.37	Cyprus	1.13	1.18	0.04
Finland	0.56	0.75	0.35	Estonia	1.47	1.42	-0.04

Note: Time series of Czech Republic, Poland, Romania, and Slovakia starting in 1990, Russian Federation in 1989, Hungary in 1991, and Croatia, Estonia, Latvia, Lithuania and Slovenia in 1995.

Following the proposed methodology, we apply the CWT and Morlet wavelets to identify cyclical movements in the analysed time series which explore regularities in time series' movements in time and specific frequencies. Figure 1 represents the unemployment rates of the US, the EU and the Russian Federation in time domain (upper left) and frequency domain (upper-right, bottom-left and bottom-right). Obviously there are significant seasonal cyclical movements in all the analysed time series, especially at a period of 6 months (the US) and 12 months (the EU, the Russian Federation). However, these short cycles imply the existence of seasonality in time series and do not represent the long-term comovement of business cycles which is important in order to examine the effect of common currency on the synchronisation of economic cycles. Moreover, we identify long-term cycles in analysed countries which exceed the period of 32 months; these cycles illustrate the existence of a long-term trend in data which we aim to analyse in more detail.

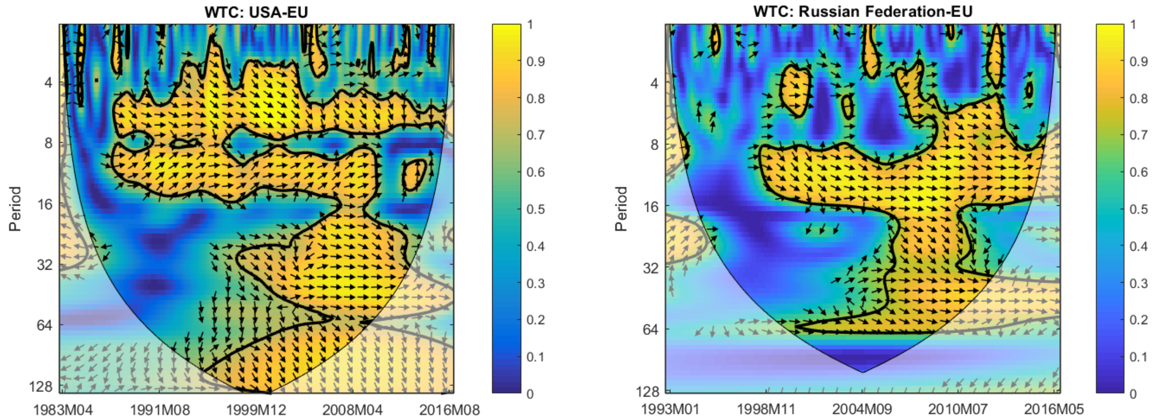
Figure 1: Time and time-frequency domain representation of unemployment rates in US, EU and RU



Note: The colour scales represent wavelet power using the Morlet wavelet, the black contours denote the results of the Monte Carlo significance test and light shading shows the region influenced by edge effects.

In the next step, we provide a detailed analysis of comovements in the time-frequency domain represented by the wavelet coherence. Figure 2 illustrates the comovement between the EU and the US and between the EU and the Russian Federation. It is clear that there are large areas of coherence between the US and the EU across the analysed time span; in the case of long cycles (at longer frequencies between 16 and 128 months) there is a significant comovement before and after euro adoption and also before, during and after the financial crisis. Furthermore, and the EU cycle was following the US cycle in most cases which is not surprising. These results could indicate the existence of a higher level of economic synchronicity even before euro adoption until now and the leading role of the US economy for the EU economy which is not surprising. As far as the comovement of the EU and the Russian Federation is concerned, the period of strong coherence in long cycles is rather shorter and is much more evident only in the case of seasonal cycles (at frequencies around 12 months). In addition, we identify phase differences from 0° to 90° in long-term comovement between the US and the EU cycles and phase differences from 0° to 45° at frequencies between 16 and 32 months in the comovement of the Russian Federation and the EU. Therefore, it could be assumed that the US cycle is a leading cycle of the economic activity in the EU and that the EU cycle is a leading cycle of the economic cycle in the Russian Federation. These results probably reflect the fact that the EU region and the Russian federation are not so intensively interconnected by the mutual foreign trade as in the case of the US which results in the low synchronicity of these business cycles.

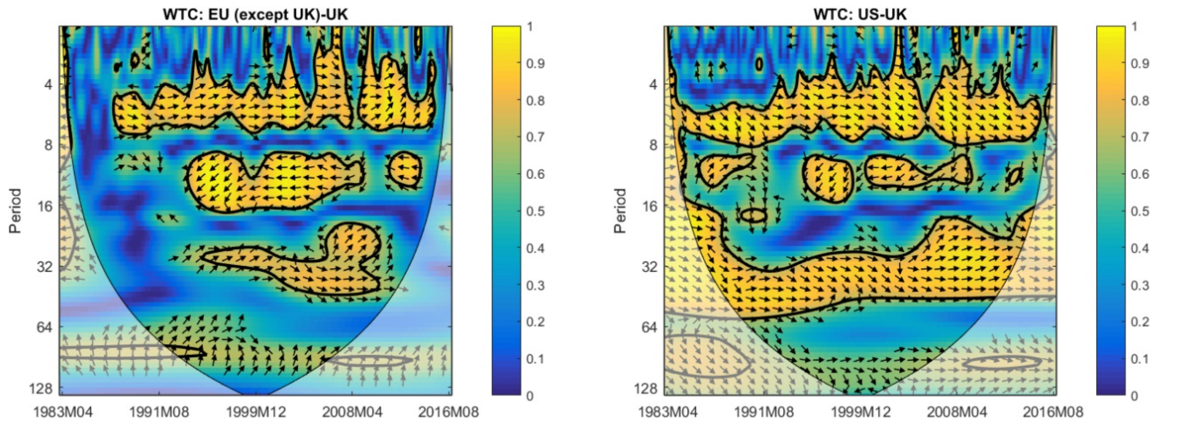
Figure 2: Wavelet coherence of the US, the EU and the Russian Federation



Note: The Colour scales represent wavelet squared coherencies, the black contours denote significance at 5% against red noise, and the light shading shows regions probably influenced by edge effects. The direction of the causal relationship is represented by arrows (a left arrow denotes anti-phase (180°) while a right arrow denotes in-phase (0° or 360°).

Figure 3 presents the UK economic cycle comovement with the EU and the US. Excluding seasonality identified at frequencies around 16 months, we show a significant and long-period stable comovement between the US and the UK cycles at frequencies between 30 and 50 months. However, we must be very careful to interpret the comovement at higher frequencies or the comovement before 2005 because there are phase differences from 270° to 360° which denote the UK cycles as the leading cycle of the US economic activity. Similarly, it is very difficult to identify the long-term comovement over 64 months because of the risk of edge effects. In the case of synchronisation with the EU, we identify only temporary in-phase comovement at frequencies below 32 months between 2005 and 2009, i.e. before, during and after the financial crises when the world economy was hit by a negative symmetric shock. These results may be partly explained as a result of the independent monetary policy of the Bank of England which had followed the policy of quantitative easing of the Fed well before the same policy was adopted by the ECB. To sum up, these results could indicate the existence of the decoupling process of the UK economy from the EU economy before 1995 and after 2009 together with a strong and significant in-phase comovement with the US throughout the whole period. In addition, we can identify phase differences before 1990 and between 1996 and 2002 which denote the US leading cycle. Thus, the Britain's decision to leave the EU is not as unexpected as it may seem because it's economic background.

Figure 3: Wavelet coherence of the UK and the US



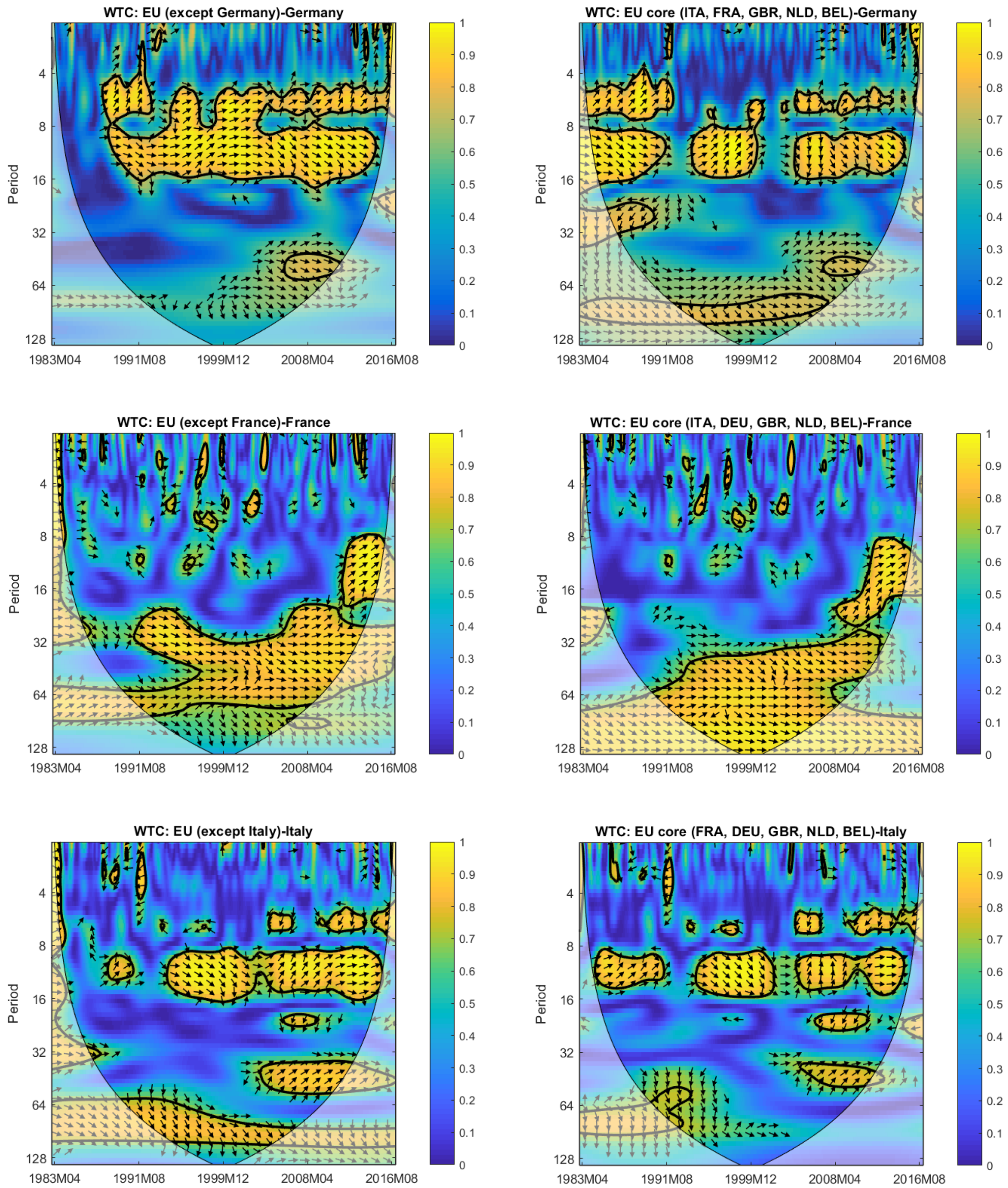
Note: The colour scales represent wavelet squared coherencies, the black contours denote significance at 5% against red noise, and the light shading shows regions probably influenced by edge effects. The direction of the causal relationship is represented by arrows (a left arrow denotes anti-phase (180°) while a right arrow denotes in-phase (0° or 360°).

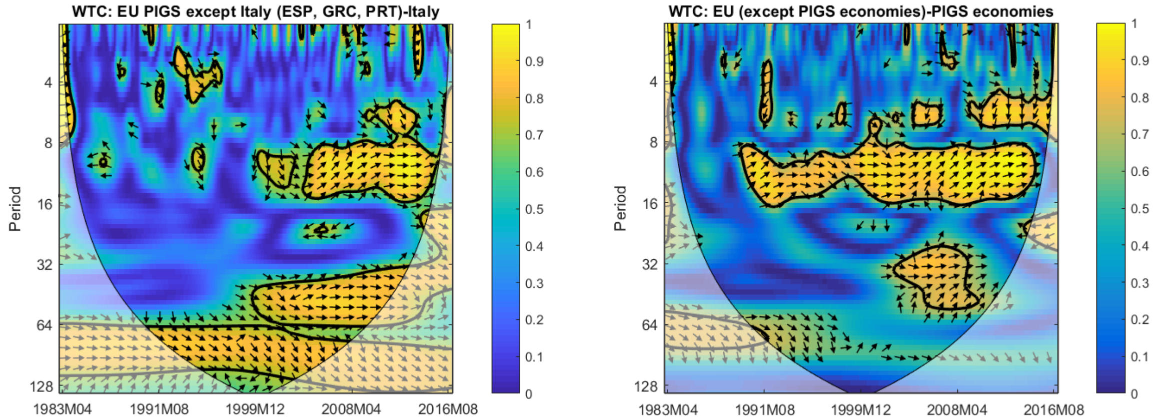
Figure 4 illustrates a weak economic cycle comovement between Germany, France and Italy and the EU countries. There is only a small region of coherence of Germany with the EU at long frequencies between 32 and 64 months in the period around the financial crisis (even smaller than in the case of the UK economy) which could be interpreted as a symmetric shock caused by the financial and subsequent debt crisis. When we restrict the EU region only to the core EU countries (Italy, France, UK, the Netherlands and Belgium), we can observe a region of high coherence in very long cycles (at frequencies between 64 and 128 months) only until 2008. Unsurprisingly, the EU cycle was leading the German cycle (phase difference from 0° to 45°) and not conversely. These results signal that the EU region may face a problem of German decoupling both from the EU and the EU core partly as a result of different domestic economic policy (e.g. the application of the Hartz reforms to the labour market after 2003) and that Germany is probably not the core country of the EU any more. In this context, we could hypothesise whether euro adoption and common trade increased the synchronisation of economic cycles or not.

However, the picture is quite different in the case of France and partly in that of Italy. Both countries demonstrate long-term comovement with the EU; there is comovement between France and the EU at frequencies between 20 and 90 months and comovement between Italy and the EU at frequencies between 64 and 100 months. In both cases, the EU cycle is mostly a leading cycle, particularly after euro introduction in the year 1999. However, while the French cycle is coordinated with the cycle of the EU core countries (at frequencies over 32 months) the Italian cycle is not. This can be explained by the fact that there is coherence of Italy with the southern European countries instead.

These results confirm the conclusions of Aguiar-Conraria and Soares (2011) who state that France (surprisingly not Germany) is a leading country in the sense of the common euro area business cycle. Moreover, these conclusions are also consistent with Ahlborn and Wortmann (2018) who discuss whether Germany should be used as a reference country of the EU cycle and emphasise the important role of the French business cycle.

Figure 4: Wavelet coherence of the EU/EU core and Germany, France and Italy



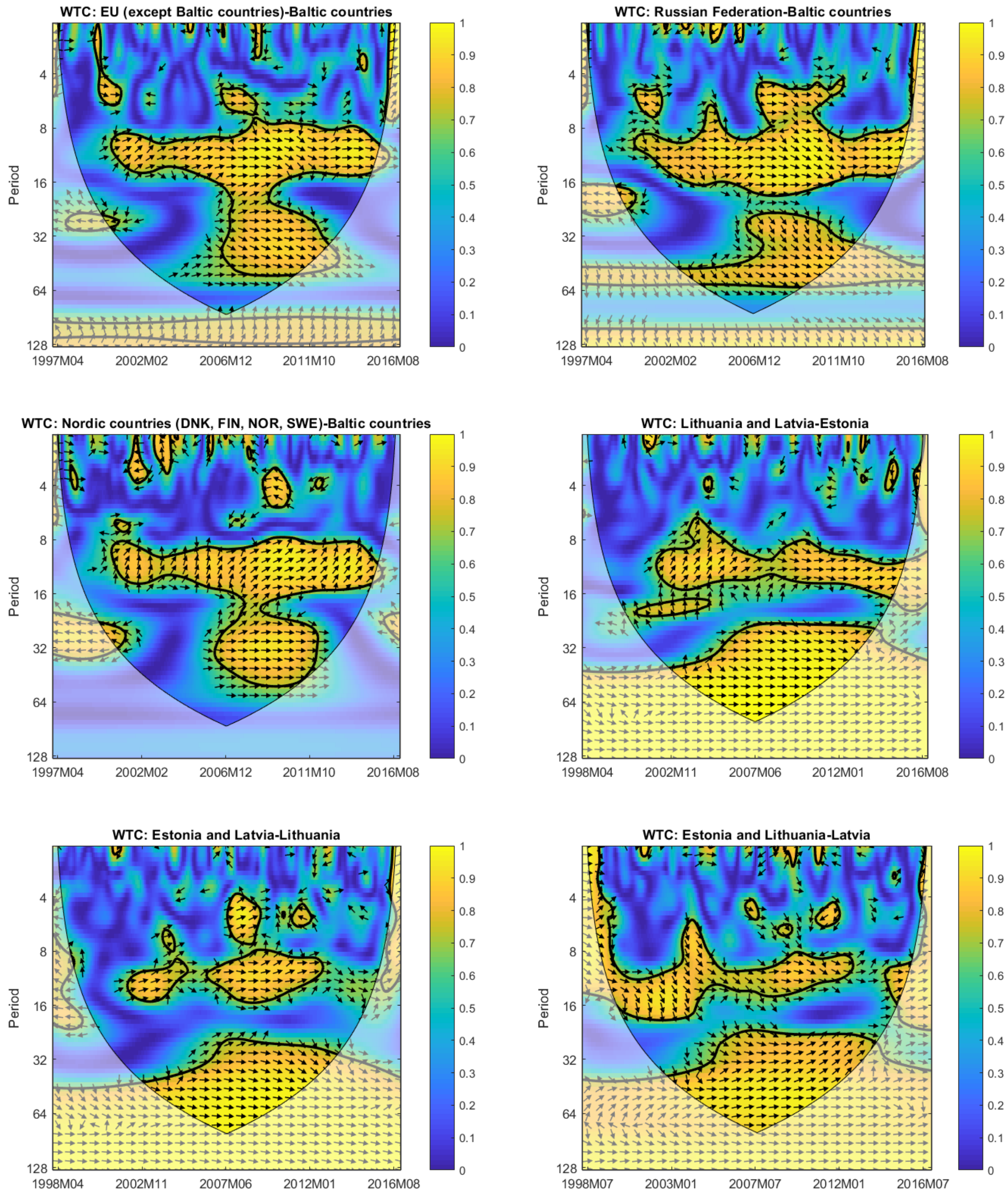


Note: The colour scales represent wavelet squared coherencies, the black contours denote significance at 5% against red noise, and the light shading shows regions probably influenced by edge effects. The direction of the causal relationship is represented by arrows (a left arrow denotes anti-phase (180°) while a right arrow denotes in-phase (0° or 360°).

In Figure 4, we also focus on the southern European countries (Portugal, Italy, Greece and Spain) and the comovement of their business cycles with that of the EU countries. The results show that there is a significant comovement in cycles at a frequency between 8 and 16 months which refers to seasonality. The short-term comovement is significant only during the financial crisis as a short-term symmetric shock. Thus, we did not find any significant evidence confirming the positive influence of monetary integration on economic cycles synchronisation and the endogeneity of the European integration process in the case of this region. Conversely our results rather point to a process of decoupling of the southern European countries from the rest of the EU region.

Unlike the previous results we find that the Baltic countries represent a single economic area and share common shocks (Figure 5); we identify a time robust significant in-phase comovement between all three Baltic countries at low frequencies exceeding 32 months. This finding is in accordance with Ahlborn and Wortmann (2018) or Kocenda (2001) who verify the existence of the business cycle cluster composed of the Baltic countries during and after the transformation process (i.e. well before the euro adoption) and then before the financial crisis. Moreover, the results unveil the significant and long-term coherence of the Baltic countries with the Russian Federation, partly thanks to geographical proximity. While the comovement of the Baltic countries with the EU is obviously identified only during the financial crisis, there is a stable and significant comovement at frequencies between 48 and 64 months with the Russian Federation. In addition, we identify phase differences from 0° to 90° which emphasises the leading role of the Russian cycle.

Figure 5: Wavelet coherence of the Baltic countries



Note: The colour scales represent wavelet squared coherencies, the black contours denote significance at 5% against red noise, and the light shading shows regions probably influenced by edge effects. The direction of the causal relationship is represented by arrows (a left arrow denotes anti-phase (180°) while a right arrow denotes in-phase (0° or 360°).

Thus, our results provide evidence of the Baltic countries' decoupling from the EU at low frequencies of less than 16 months.

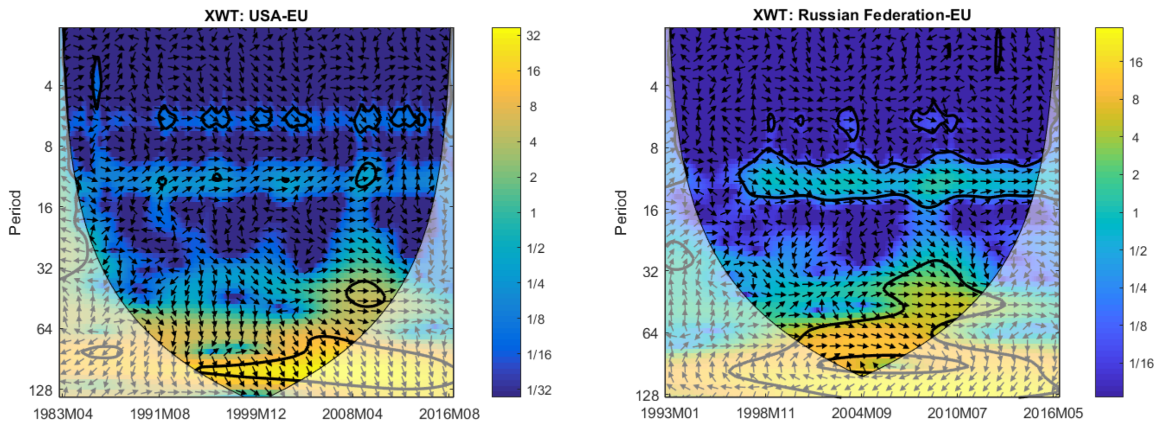
4 Robustness Analysis

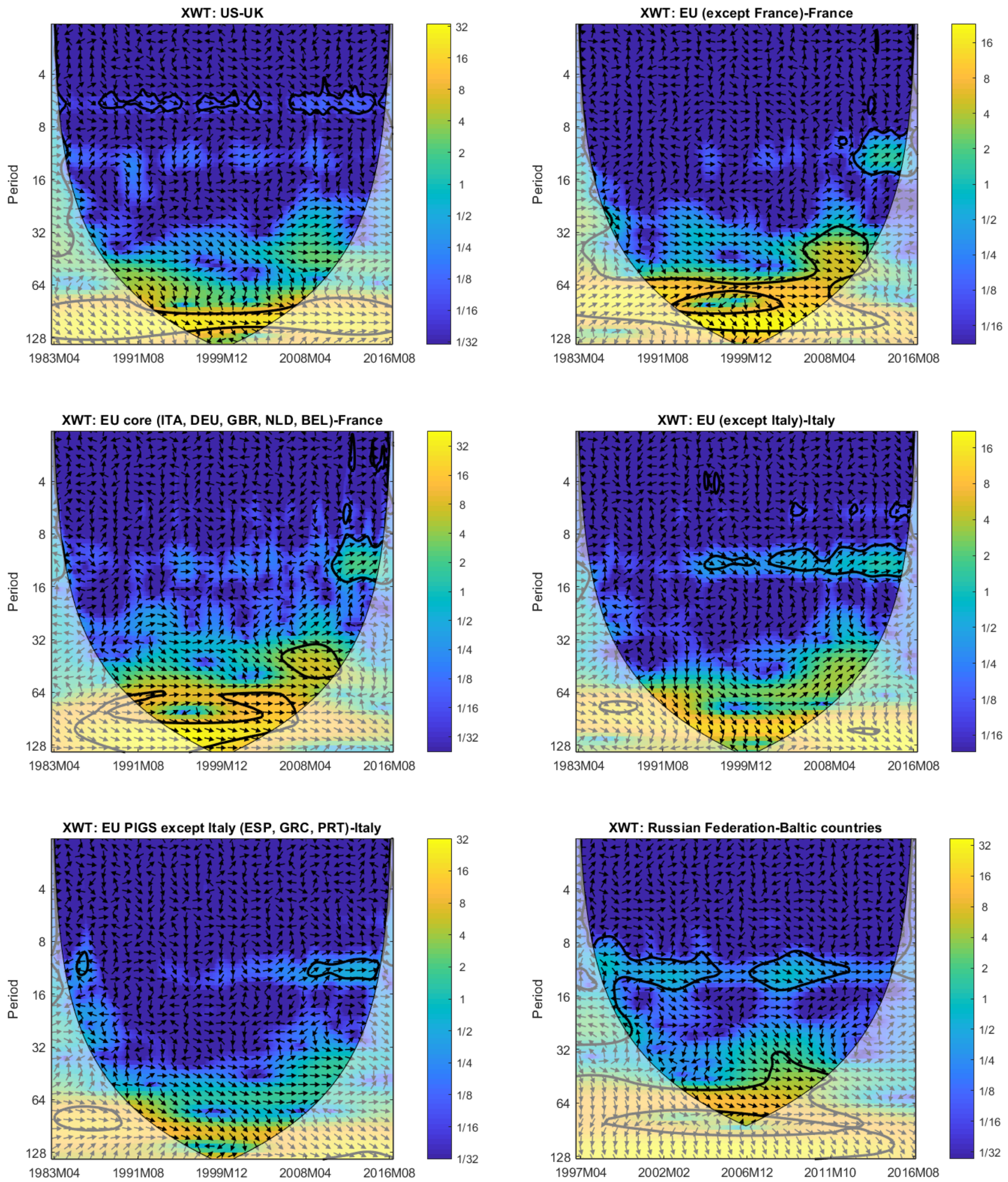
In the next step, we check the robustness of our analyses identifying shocks in comovements between the analysed time series. Employing the Cross Wavelet Power we reveal areas where the analysed time series show a high common power, especially in the case of global symmetric shocks when one spectrum is local and another one presents peaks. In such a case we must be very careful because all such peaks generate possible spurious correlations between the variables.

Figure 6 presents the Cross Wavelet Power of the selected time series where we identify significant and robust comovement using Wavelet coherence. Our results highlight the occurrence of the symmetric shock around the year 2007 in long-term cycles which represent the financial crisis and, therefore, this comovement cannot be interpreted as the result of the European integration process. This symmetric shock is significant at low frequencies over 64 months between the US and the EU and at frequencies over 30 months between the Russian Federation and the EU economic cycles.

In addition we identify significant Cross Wavelet Power (i.e. shocks) at low frequencies over 64 months between the UK and the US, the EU and France, and the Russian Federation and the Baltic countries. However, these symmetric shocks are identified at different frequencies in comparison with our results for the Wavelet coherence (i.e. cycle comovements). To summarise, we can confirm the robustness of Wavelet coherence results presented above in all other countries.

Figure 6: Cross Wavelet Power of unemployment rates





Note: The colour scales represent Cross Wavelet Power and Wavelet Coherence, the black contours denote the results of the Monte Carlo significance test, and the light shading shows regions influenced by edge effects. The direction of the causal relationship is represented by arrows (a left arrow denotes anti-phase (180°) while a right arrow denotes in-phase (0° or 360°).

These results of the robustness analysis confirm our previous results leading to questioning of the fact that the creation of the euro area and euro adoption leads to higher synchronisation of business cycles within the currency area as OCA theory predicts.

Conclusions

In our paper, we open a discussion concerning the effect of euro adoption on the euro area countries after twenty years from the start of this ambitious project. We aim to verify whether the European monetary integration in the form of the euro currency adoption increases the synchronisation of economic cycles after a relatively long period of twenty years. Instead, we could confirm the EU region faces the problem of worsened synchronisation and the process of the decoupling of Germany, the UK or the southern countries particularly in the period after the financial crisis. However, we also identify the important role of France as a country with a more synchronised business cycle with the EU countries compared to Germany as Aguiar-Conraria and Soares (2011) state. Italy also has a more synchronised long-term cycle with the EU (and the southern European countries) than Germany. These results could point to the fact that France and Italy remain in the core of the EU while Germany has been decoupling since euro adoption which indicates that different domestic economic policies implemented in Germany may induce a different business cycle movement which is not a good prerequisite for the existence of a currency area.

As such, using a different method, we follow the conclusions of Monfort et al. (2013) and Ahlborn and Wortmann (2018); while these authors use the method of cluster analysis, we apply frequency domain techniques to assess the dynamic properties of time series and their comovements including phase shifts enabling the identification of spill-over effect directions and asymmetries of business cycle shocks of causal relationships, which is quite unique in this field.

However, these results are in contrast with the fact that Italy and France are experiencing a lower increase in the trade openness even though our further results confirm that these countries have more synchronised business cycles with the EU than Germany or the Visegrad Group countries (which have not adopted the euro yet) with comparatively higher changes of trade openness. These findings contradict the some of the conclusions of the endogeneity hypothesis as more open economies either (1) have not shared a common currency or (2) have not synchronised their business cycles with other EU countries.

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