The endogeneity of optimum currency area criteria in the context of financial crisis: Evidence from the time-frequency domain analysis

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Abstract: We provide the wavelet analysis of the economic cycle synchronization during the recent financial crisis. However, the global financial crisis caused economic cycles in most European countries to become more strongly synchronized without increasing of the real convergence process. Our contribution is an application of the singular value decomposition to identify and remove the long-term trend including outliers appearing in the year 2007–2010. We found that the historically greater integration provides more highly synchronized cycles in the core Euro area member countries.

Key words*:* Euro area, singular value decomposition, synchronization, wavelet analysis

The global financial crisis caused economic cycles in most European countries to become more strongly synchronized without increasing of the real convergence process. While there is a wide range of literature focused on the economic cycle synchronization within the Euro area, the developments since the crisis have not yet been researched in detail. The point is to filter the country-specific economic activity in order to eliminate this global symmetric shock from the time series. We apply the singular value decomposition to estimate the long-term trend in time series and the wavelet co-spectrum to identify the changes of co-movements at different frequencies over time.

From the theoretical point of view, a currency union is expected to increase trade and financial integration because of the decrease in transaction costs and the elimination of the exchange rate risk. Frankel and Rose (1998) argued that the business cycles synchronization would be higher because of the demand shocks or the intra-industry trade. As well, they pioneered the idea of the hypothesis of the endogeneity of the Optimum Currency Area (OCA) criteria significant relation between the historically greater integration and the more highly synchronized cycles.

The endogeneity of the OCA criteria was discussed by many authors in several branches, which are not isolated between themselves. Artis and Zhang (1997, 1999) identified the positive impact of the fixed exchange rate on the business cycles synchronization, contributed by growing trade links between the EU countries. The endogeneity of symmetric shocks and trade was followed by Fontagné (1999), Fidrmuc (2004), Artis et al. (2008) and many others. Blanchard and Wolfers (2000) focused on the endogeneity of labour market institutions, Kalemli-Ozcan et al. (2003) provide the empirical evidence that the risk sharing within the Euro area enhances specialization in production.

The hypothesis assumes that the EU accessing countries would be expected to meet the OCA criteria better ex post than ex ante, which is an important topic in discussion about the benefits and costs of adopting a common currency. Joining a currency area is related with the loss of autonomous monetary policy and the exchange rate control. The traditional version of the OCA theory argues that joining costs are minimized and the benefits maximized with a high degree of cyclical and structural synchronization (Corden 1972).

However, the recent financial crisis confirmed the Lucas Critique. Lucas (1976) assumed that the structure of all econometric models is not applicable for

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policy decisions. He argued with the optimal decision rules of economic agents which vary systematically without any changes in the structure of series relevant to the change in policy. Therefore, any experiments based on the historical data cannot provide the probability of the future asymmetric shocks within the Euro area.

Still, despite the critics, the empirical evidence of the endogeneity of the OCA criteria is important to assess the integration and homogeneity effects after the Euro adoption, especially the economic cycle synchronization. The most common methods in this field are the unconditional correlation between the two countries in different time periods, the identification of delays of various phases of business cycles, the volatility of cyclical fluctuations in economic activity, the stability and similarity of sudden and unexpected fluctuations in economic activity or the shock responses at the regional level within the Euro area (Darvas and Szapáry 2008) or the index of cyclical conformity, called the Concordance Index (Harding and Pagan 2006).

Growing literature in this area induced creation of new methodological approaches. The traditional analyses of the co-movements in time domain were supplemented by the frequency domain (Croux et al. 2001; Messina et al. 2009; Fidrmuc and Korhonen 2010) and developed into the time-frequency approaches (Rua 2010; Aguiar-Conraria and Soares 2011).

We follow the time-frequency domain approach and focus on the business cycles co-movements before and during the global financial crisis of 2008. The crisis period and its consequences are recently discussed in many working papers. However, the authors provide markedly different results depending on the applied approaches. Dées and Zorell (2011) applied the system of equations to identify production structures and concluded that the financial integration tends to raise the business cycle co-movement between the EU countries. Antonakakis (2012) applied the dynamic conditional correlation and identified an unprecedented synchronization of business cycles between the G7. On the contrary, Gaechter et al. (2012) identified the divergent development of the business cycles in the Euro area after the year 2008 and Filis et al. (2011) concluded that the recent financial crisis has halted and reversed the process of convergence of the business cycle synchronization in Europe. Similarly to Fidrmuc and Korhonen (2006), we consider that the results of analysis are significantly influenced by the choice of the method for the business cycle estimation.

Blumenstein et al. (2012) compared different approaches in the time-frequency domain (wavelet analysis, multiple window method using Slepian sequences, time-frequency varying autoregressive process estimation and time-frequency Fourier transform representation) to identify cyclical movements in the Euro area industrial production index. They found contrasting cyclical movements in the years 2007–2010, especially two significant shocks and effects in long-term cyclical movements. This shock caused that other cyclical movements in the time series were suppressed. Therefore, we suppose that the commonly used filtering techniques overestimate cyclical movements in the time series during the financial crisis and co-movements as well. Subsequently, the results of the analysis in the time-frequency domain may be significantly biased. The generally used methodological background in the time-frequency domain provides only the identification of the significant symmetric shock in the years 2007–2010. The problem is in the trend elimination. The standard filtering techniques identify financial crisis as the business cycle. To contribute to the recent methodology, we have to answer the key question, whether the financial crisis changed the business cycle frequency or not.

Now, let us focus on the shape of the time economic activity during the financial crisis. We follow the US experiences now. The economy was affected by the subprime mortgage crisis and lost household wealth, which led to a drop in consumer spending and investment activities. Before this demand shock, the US experienced a rapid increase in the total loans. Increased aggregate demand was followed by the increase of prices at the asset market. Thus, the expansion stage with the peak in the year 2007 was replaced by economic recession with the trough in the year 2009 and the subsequent recovery. Note, that the described development is a textbook example of business cycle with driving force in the financial market deregulation, credit money creation and financial instability.

However, the drop in economic activity after the year 2008 is more than a cyclical discrepancy from the potential output. Halmai and Vasary (2012) showed that the European recession has an impact on the growth through three different channels: capital accumulation, labour input and the total factor productivity. Applying the production function approach, they concluded that the potential growth rate both in the Euro area and the US falls in 2009–2010 (it is lower by 1.5% in the US and by 0.8% in the Euro area).

The problem is that filtering techniques provide nothing less than a well defined statistics which measures nothing that would have a direct connection to the economic theory. Therefore, the results of the

economic cycle synchronization during the financial crisis are rather the outliers than the evidence of the convergence process.

Prior to the application of time-frequency analysis methods the input data of the industry production index is transformed by the natural logarithm and the long-term trend is removed. Instead of using the common filtering techniques (e.g. Hodrick-Prescott, Kalman, Baxter-King or Christiano–Fitzgerald filter), we apply the singular value decomposition to remove the long-term trend (Carvalho et al. 2012). Our methodological contribution is in the decomposition into components which allow not only the elimination of the trend but also the outliers caused by the financial crisis in the years 2007–2010.

The main objective of this paper is to identify changes of the co-movements in the time-frequency domain to verify the hypothesis of the endogeneity of the OCA. We focus on the crisis period during the years 2007–2010 when a significant symmetric shock affected economic activity across the whole Euro area. The proposed methodological approach will be applied on the economic activity in the core Euro area countries (Germany, France, Belgium, Austria and the Netherlands), where the hypothesis of the endogeneity of the OCA criteria is generally assumed. Obviously, the acceptance of the hypothesis of endogeneity in these countries is a significant contribution for the policy makers to implement unconditionally the real and nominal convergence criterions at the time of joining the Euro area.

MATERIAL AND METHODS

In order to demonstrate the performance of the investigated methods, we used the monthly data of the industrial production index in the period 1958/M2-2012/M4 (volume index year 2005 = 100). The datasets were provided by the OECD open database of short-term economic indicators. The additive decomposition is applied in the following form:

$$y_t = g_t + c_t + e_t, \quad t = 1, \ldots, n \tag{1}$$

where g_t denotes the long-term trend, c_t is the cyclical component and e_t is the irregular component. For the identification of long-term trend we use the singular value decomposition (SVD) (Carvalho et al. 2012).

The first step of the SVD is to make the trajectory matrix from the input time series $y = (y_1, y_2, \ldots, y_N)'$ of the length N without any missing values. The trajectory matrix T with $K \times L$ dimension and takes the form:

$$T = \begin{pmatrix} y_1 & y_2 & \cdots & y_L \\ y_2 & y_3 & \cdots & y_{L+1} \\ \vdots & \vdots & \ddots & \vdots \\ y_K & y_{K+1} & \cdots & y_N \end{pmatrix} \tag{2}$$

The parameter L such that $2 < L < N/2$ to embedded into the initial time series y is defined by the user. Consequently we apply the trajectory matrix T SVD to obtain the trajectory matrices T_i, $i = 1, \ldots, L$. From an eigenanalysis of TT' we collect the eigenvalues $\lambda_1 \geq \ldots \geq \lambda_r$, where $r = \text{rank}(TT')$ and the corresponding left and right singular vectors, respectively denoted as U_i and V_i. We can write:

$$T = \sum_{i=1}^{r} U_i \lambda_i V_i'$$

In the following analytical step, we use the wavelet transform (Mertins 1999). The continuous wavelet transform of the time series y_t with respect to the mother wavelet $\Psi_{a,\tau}(t)$ is defined as

$$S_{CTW}(a,\tau) = \int_{-\infty}^{\infty} y_t \frac{1}{\sqrt{a}} \psi\left(\frac{t-\tau}{a}\right) dt \qquad a > 0,\ \tau \in R \tag{3}$$

where the mother wavelet takes the form $\psi_{a,\tau}(t) = \psi\left(\frac{t-\tau}{a}\right)$ is the time position, a is the parameter of dilatation (scale), which is related to the Fourier frequency and the numerator of the fraction $\sqrt{a}$ ensures the conservation of energy.

To be the invertible transform, the basis (mother wavelets) functions must be mutually orthogonal, have zero mean value and limited to finite time interval. That is

(i) $\int_{-\infty}^{\infty} \psi_{a,\tau}(t)dt = 0$

(ii) $\int_{-\infty}^{\infty} \psi_{a,\tau}^2(t)dt = 1$

(iii) $0 < C_\psi = \int_0^{\infty} \frac{|\Psi(\omega)|^2}{\omega} d\omega < \infty \quad \Psi(\omega) = \int_{-\infty}^{\infty} \psi_{a,\tau}(t) e^{-i\omega t} dt$ (4)

Where $\Psi(\omega)$ is the Fourier transform of $\Psi(t)$. There is an inverse wavelet transformation defined as

$$y_t = \frac{1}{C_\psi} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \psi_{a,\tau}(t) S_{CWT}(a,\tau) \frac{da d\tau}{a^2} \tag{5}$$

To satisfy the assumptions for the time-frequency analysis, the waves must be compact in time as well as in the frequency representation. There are a number of wavelets used, such as the Daubeschie, Morlet, Haar or Gaussian wavelet (Gençay et al. 2002).

All results are processed in the MATLAB software.

RESULTS

The used time series comprise a very long time period including several significant and temporary economic recessions called crises. The singular value decomposition provides the band-pass filtered output (Figure 1). Figure 1 presents the input time series and the estimated trend including the slow-moving component (trend) and the cyclical movements with a frequency noticeably larger than 32 quarters (movements regarded outside from the range of business cycle). In the similar manner as in Carvalho et al. (2012), we discard these two components for the subsequent wavelet analysis. Noticeably, the singular value decomposition provides an instrument to eliminate long waves from the time series caused by the most significant global crisis. We can distinguish the drop in economic activity after the first oil crisis in the year 1973, the EMS currency crisis in the years 1992–1993 and the last financial crisis in the years 2007–2010.

Figures 2– 4 provide the co-spectrum of movements in economic activity of the selected core Euro area countries. The figure presents the dynamic of business cycles during the last 50 years. A few countries show co-movements at shorter waves than the assumed business cycle frequencies (range between 6 and 32 quarters or 32 and 96 months). Specifically, we can find the most significant co-movements among France, the Netherlands and Belgium. These countries were synchronized in business cycles during the oil crisis. On the contrary, we can find a lower degree of business cycles synchronization in Germany and Austria. In the all selected countries, we can find significant co-movements before and during the recent financial crisis, especially after the year 2004 with the centre in 2009.

Evidently, global macroeconomic shocks play an important role in the business cycle synchronization. However, we did not identify a symmetric shock because the symmetric declines in economic activity during the crises periods were eliminated from the input time series. The identified co-movements concentrated on the residual fluctuation only. Of course, the identified synchronization of cyclical movements is related to the macroeconomic shocks, but only as an indirect consequence sources reallocation between the economic sectors, the impact of changes in macroeconomic policies or the mutual integration of the Western European countries.

It is generally agreed that Germany, France, Austria and the Benelux countries have a similar shape of the business cycle since the 70s, but it was not yet clear whether the European integration process contributed to the synchronization, especially after the Euro adoption. The results of the analysis provide clear evidence that the synchronization of cyclical movements in economic activity between the selected core

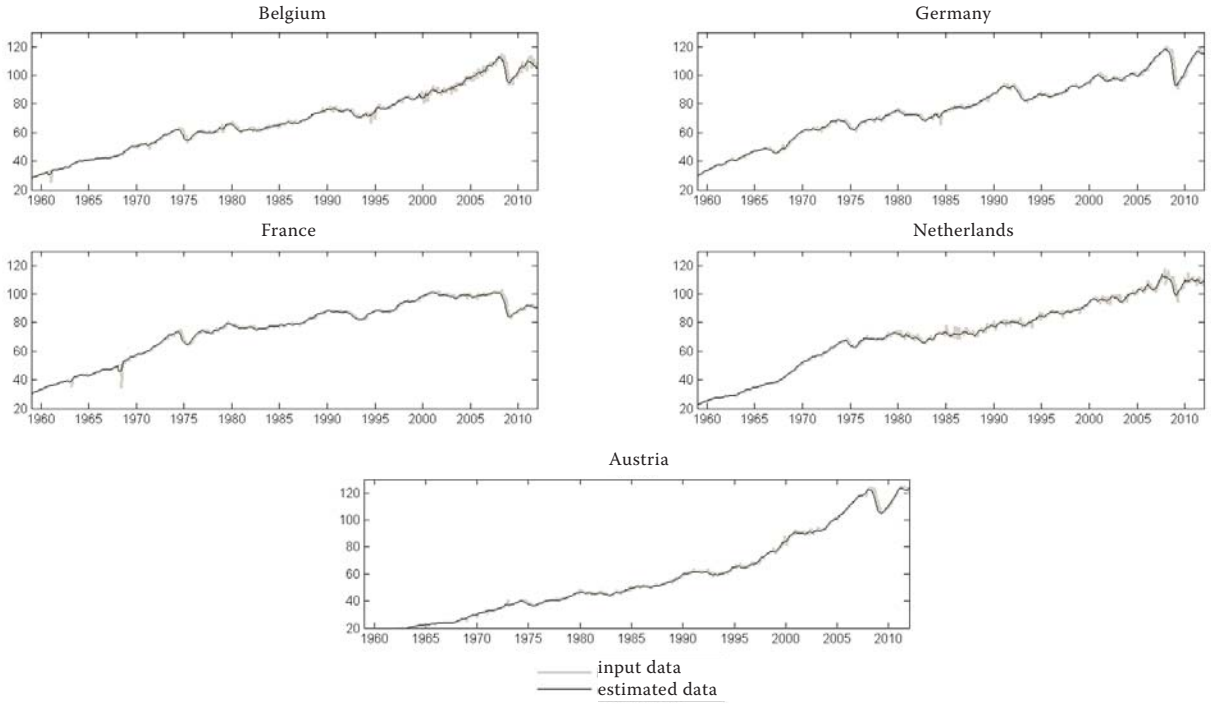

Figure 1. Singular value decomposition of the Industrial Production Index

Source: OECD database

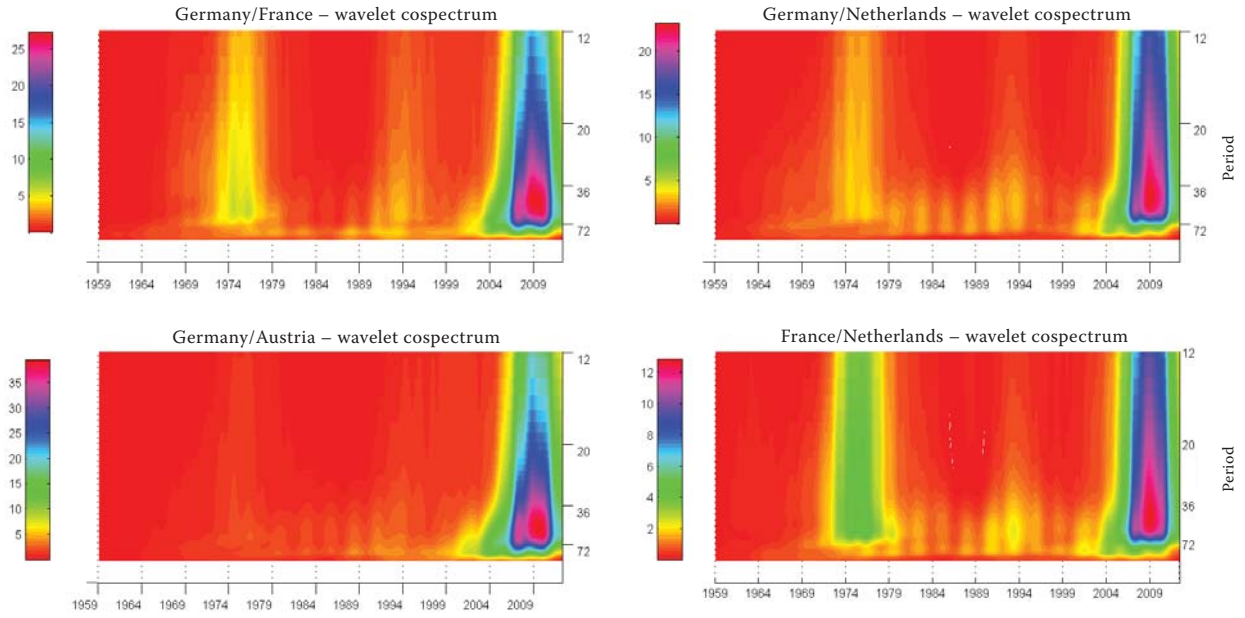

Figure 2. Economic cycle co-movements between Germany, France, Netherlands and Austria

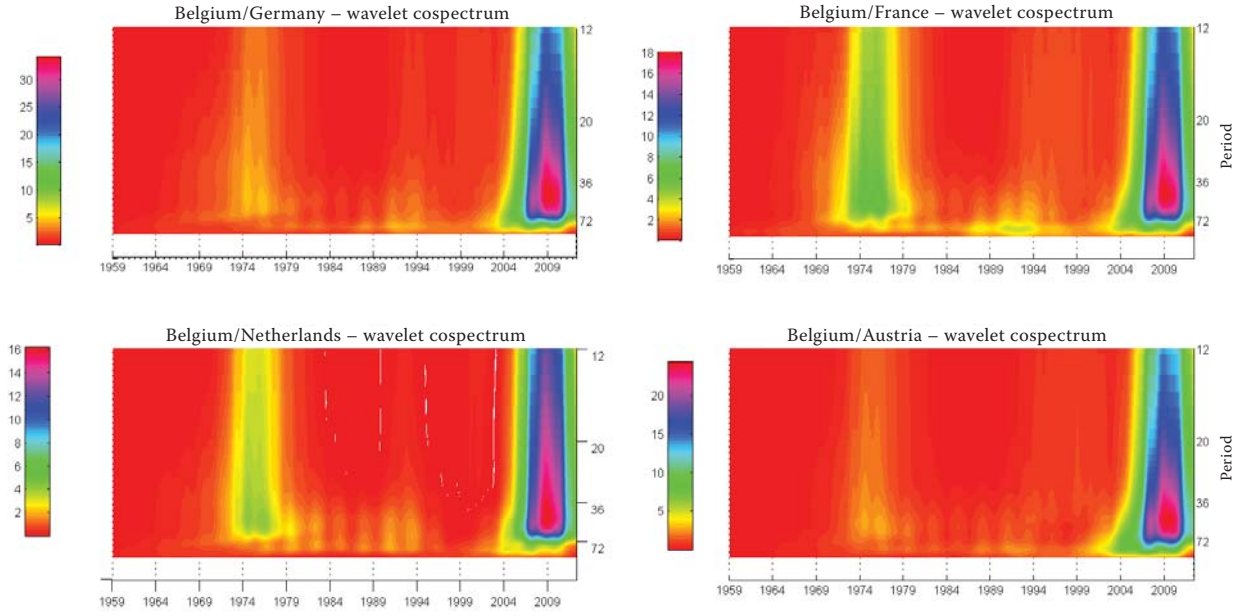

Figure 3. Economic cycle co-movements between Belgium, Germany, France, Netherlands and Austria

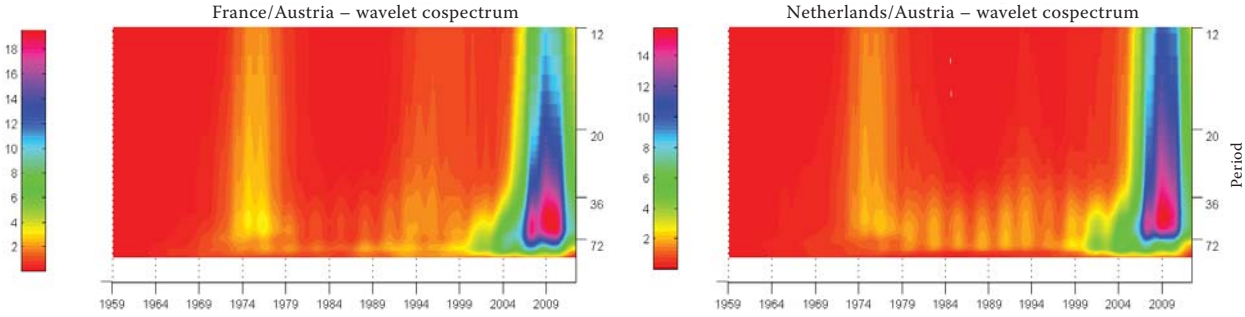

Figure 4. Economic cycle co-movements between France, Austria and Netherlands

Euro area member countries significantly increased after the year 2002. The frequency of co-movements was identified shorter than 6 years in all selected countries.

DISCUSSION AND CONCLUSIONS

Modelling fluctuations in economic activity through de-trending economic time series is common in the measurement of the business cycle synchronization among the Euro area member countries. There are many technical approaches applied in this area, including the analysis in frequency and the time-frequency domains. However, the common filtering techniques spuriously identify cyclical movements in economic activity during the deeper and longer lasting economic recessions. Therefore, we suppose that the results of the synchronization analysis are overestimated during the financial crisis. The results of co-movements in the time-frequency domain subsequently identify symmetric shocks that cannot be considered as the business cycle synchronization.

Our contribution is to provide an alternative methodological approach to eliminate the slow-moving component including the drop in economic activity caused by financial crisis. The subsequent wavelet analysis identified a significant increase in the business cycle synchronization in the core Euro area member countries after the year 2002. We cannot conclude that financial crisis contributed or reversed the process of convergence because there is an insufficient number of observations. However, we can confirm the hypothesis of the endogeneity of the OCA criteria during the last decade.

The conclusion provides important policy implications. The recent discussions deal with the asymmetries within the whole Euro area or the EU. The focus is mostly on the periphery countries (Greece, Ireland, Portugal, and Spain) and the new EU member countries. Kočenda (2001) or Kutan and Yigit (2005) discovered that the real convergence of the new EU member countries is rather idiosyncratic although there is an empirical evidence showing that it will take several decades for the convergence to be fully completed (Kočenda et al. 2006). The point is that many of the current Euro area members adopted the Euro as soon as they fulfilled the Maastricht criteria which means that just the nominal convergence has been achieved.

We focused on the core Euro area countries and confirmed that the business cycle synchronization is historically greater – the endogeneity of the OCA criteria was accepted. However, we assume that this aims only at the countries where both the nominal and real convergence to the OCA criteria is achieved. Therefore, the assumptions of the OCA theory, especially the real convergence criteria, should not be undervalued during the accession process.

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REFERENCES

Antonakakis N. (2012): Business cycle synchronization during US recessions since the beginning of the 1870's. MPRA Paper No. 38341, April 2012.

Aguiar-Conraria L., Soares M.J. (2011): Business cycle synchronization and the Euro: A wavelet analysis. Journal of Macroeconomics, *33*: 477–489.

Artis M.J., Fidrmuc J., Scharler J. (2008): The transmission of business bycles: Implications for EMU enlargement. The economics of transition. The European Bank for Reconstruction and Development, *16*: 559–582.

Artis M.J., Zhang W. (1997): International business cycles and the ERM: Is there a European business cycle? International Journal of Finance & Economics, *2*: 1–16.

Artis M.J., Zhang W. (1999): Further evidence on the international business cycle and the ERM: Is there a European business cycle? Oxford Economic Papers, *51*: 120–132.

Blanchard O., Wolfers J. (2000): The role of shocks and institutions in the rise of European unemployment: The aggregate evidence. Economic Journal, Royal Economic Society, *110*: C1–33.

Blumenstein J., Poměnková J., Maršálek R. (2012): Comparative Study of Time-Frequency Analysis Approaches with Application to Economic Indicators. Discussion

paper. In: 26th European Conference on Modelling and Simulation. Koblenz, May 29–June 1 2012.

Carvalho M., Rodriguez P., Rua A. (2012): Tracking the US business cycle with a singular spektrum analysis. Economic Letters, *114*: 32–35.

Corden W.M. (1972): Monetary integration. Essays in international finance, No. 93 International Finance Section, Department of Economics, Princeton University, Princeton.

Croux Ch., Forni M., Reichlin L. (2001): A measure of comovement for economic variables: Theory and empirics. The Review of Economics and Statistics, *83*: 232–241.

Darvas Z., Szapáry G. (2008): Business cycle synchronization in the enlarged EU. Open Economies Review, *19*: 1–19.

Dées S., Zorell N. (2011): Business Cycle Synchronization Disentangling Trade and Financial Linkages. ECB Working Paper Series, No. 1332, April 2011.

Filis G., Duffy D., Degiannakis S. (2011): Time-varying Business Cycles Synchronisation in Europe. Discussion Paper. In: Annual International Conference on Macroeconomic Analysis and International Finance, Crete, May 2011.

Fidrmuc J. (2004): The endogeneity of the optimum currency area criteria, intraindustry trade, and EMU enlargement. Contemporary Economic Policy, *22*: 1–12.

Fidrmuc J., Korhonen I. (2006): Meta-analysis of the business cycle correlation between the euro area and the CEECs. Journal of Comparative Economics, *34*: 518–537.

Fidrmuc J., Korhonen I. (2010): The impact of the global financial crisis on business cycle in Asian emerging economies. Journal of Asian Economics, *21*: 293–303.

Fontagné L. (1999): Endogenous symmetry of shocks in a monetary union. Open Economies Review, *10*: 263–287.

Frankel J.A., Rose A.K. (1998): The endogeneity of the optimum currency area criteria. Economic Journal, Royal Economic Society, *108*: 1009–1025.

Gaechter M., Riedl A., Ritzberger-Gruenwald D. (2012): Business Cycle Synchronization in the Euro Area and the Impact of the Financial Crisis. Oesterreichische Nationalbank, Monetary Policy & the Economy, Discussion Paper, *2*: 33–60.

Gençay R., Selcuk F., Whitcher B. (2002): An Introduction to Wavelets and other Filtering Methods in Finance and Economics. Academic Press, Elsevier, San Diego; ISBN: 978-0122796708.

Halmai P., Vásáry V. (2012): Growth crisis in the main groups of the EU Member States Comparative analysis. IWH Halle Discussion Paper, Halle.

Harding D., Pagan A. (2006): Measurement of Business Cycles. Working Papers Series 966. Department of Economics, University of Melbourne.

Kalemli-Ozcan S., Sorensen B.E., Yosha O. (2003): Risk sharing and industrial specialization: Regional and international evidence. American Economic Review, *93*: 903–18.

Kočenda E. (2001): Macroeconomic convergence in transition economies. Journal of Comparative Economics, *29*: 1–23.

Kočenda E., Kutan A.M., Yigit T.M. (2006): Pilgrims to the Eurozone: How far, how fast? Economic Systems, *30*: 311–327.

Kutan A.M., Yigit T. (2005): Nominal and real stochastic convergence: are the new EU members ready to join the Euro zone? Journal of Comparative Economics, *33*: 387–400.

Lucas R. (1976): Econometric policy evaluation: A critique. In: Brunner K., Meltzer A. (eds.): The Phillips Curve and Labor Markets. Carnegie-Rochester Conference Series on Public Policy: 19–46.

Mertins A. (1999): Signal Analysis Wavelets, Filter Banks, Time-Frequency Transform and Applications. John Wiley & Sons Ltd., Chichester; ISBN 0-471-98626-7.

Messina J., Strozzi CH., Turunen J. (2009): Real Wages over the Business Cycle OECD Evidence from the Time and Frequency Domains. Working Paper No. 1003. European Central Bank.

Rua A. (2010): Measuring comovement in the time-frequency space. Journal of Macroeconomics, *32*: 685–691.

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