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Financial and Trade Integration of Selected EU Regions: Dynamic Correlation and Wavelet Approach

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Abstract

Zuzana Kučerová, Jitka Poměnková: **Financial and Trade Integration of Selected EU Regions: Dynamic Correlation and Wavelet Approach**

We evaluate the relation between financial and trade integration in new (formerly central-planned economies) and old (developed) EU countries. Classical and moving correlation shows the strong relation in the pre-crisis period. Dynamic correlation confirms strong relation for long and business cycle frequencies. Specification via wavelet cospectrum reveals that the long frequencies are correlated in 2000-09, business cycle frequencies in 1993-94, 2003-04 and middle frequencies generally in 2008-2010. The process of financial integration was stronger in the old EU member countries, the process of trade integration in the new member countries. The progress was smaller in financial compared to the trade integration.

Key words

financial integration, foreign trade, international financial markets, correlation analysis, wavelet cospectrum

JEL: E44, F15, F21, F36, G15, C23, C36

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Introduction

The integration of financial markets contributes to the overall integration and economic growth by removing the exchange rate risk and the barriers and frictions in cross-border capital movement. This allows the capital to be allocated more efficiently (Baele et al., 2004). Financial integration helps to increase the efficiency of a financial system and lower the costs for businesses as well as for consumers. There was another argument for greater financial market integration: the execution of the monetary policy, which is implemented through the financial system. It should be efficient and functioning well to provide a predictable, smooth, and effective transmission of the monetary policy. Mundell (1973) also supported the capital mobility as one of the main criteria for sustainable fixed exchange rate arrangements. Financial integration and international diversification of assets helps to reduce the risk of economic recession in the case of negative macroeconomic shocks. However, integration can lead to a higher specialisation of production and countries may become more vulnerable to asymmetric shock (see Krugman, 1993).

Nevertheless, the process of financial integration of the past decade was associated with the accumulation of risks and the national and supranational financial regulation and supervisory practices lagged behind the highly integrated, fast expanding and sophisticated financial sector (European Commission, 2011). Therefore, international supervisory cooperation becomes important in the light of globalisation in order to address the weaknesses of the international financial system and to ensure overall financial stability. As a consequence, it is important to monitor and measure the state of integration in all segments of financial markets to identify the areas of further co-ordination and assistance. These measures could help the process of financial integration to be smooth and fast.

Foreign trade (i.e. trade integration) is one of the most important factors influencing the financial integration. Lane and Milesi-Ferreti (2000) or Lane and Milesi-Ferreti (2003) specify three important linkages between foreign trade and trade with foreign assets and liabilities. Firstly, trade with goods and services evokes the corresponding financial transactions. Foreign direct investments had a great impact on the external balance of the "new" EU member countries from Central and Eastern Europe; large trade deficits originating from the transformation process were compensated by investment inflows (i.e. by increasing financial integration). International trade and international financial flows are thus able to equilibrate the balance of payment. Secondly, a high share of bilateral trade linkages between countries leads to a higher portion of financial transactions; investors have a better knowledge of foreign companies from these countries and are thus more prone to buying the shares

of these companies (the "familiarity effect"). And thirdly, a high degree of trade openness reflects the liberal approach of macroeconomic policy authorities not only in the area of foreign trade, but also in the area of cross-border capital flows.

In our article, we follow the line of research investigating the relationships between financial and trade integration to analyse the interconnectedness and character of these processes. We aim to answer the questions whether the EU countries face the same level of integration, whether the financial crisis has influenced the integration, and whether there has been a potential difference between the “new” and “old” EU member country groups so far. By doing so, we can distinguish between the processes in these which are quite different and are thus worth examining. We do not differentiate between the Eurozone and non-Eurozone member countries because some of the new Eurozone member countries (i.e. Slovenia, Slovakia, Estonia, and Latvia) have only recently entered the Eurozone and our intention is to analyse particularly the long term integration processes.

The aim of the article is to assess the relation between financial and trade integration in the country groups EU10, EU16, and EU26 over the period 1993-2012. We use quantity-based measures of financial integration derived from the countries' international investment positions with a view to the foreign trade and the methods of static, moving and dynamic correlation. The text is structured as follows. First chapter is introduction. In chapter two we provide literature review. In chapter three, the method, data, countries and indicators of financial and trade indicators are defined. In chapter four, we describe preliminary results, i.e. overview of indicators used for analysis and the results of static correlation. Chapter five contains the core results of correlation analysis (moving and dynamic) of financial and trade integration processes. In Chapter six, the wavelet analysis is performed to confirm and specify previous results. Chapter seven brings conclusions.

1 Literature Review

1.1 Financial and Trade Integration

The paper focuses on changes in financial integration (a country's international investment position) with respect to trade integration. One of the first attempts to study the foreign assets and liabilities is study of Lane and Milesi-Ferretti (1999). They developed a methodology to produce a unique data set containing the estimation of foreign assets and liabilities for a large set of both industrial and developing countries for the last three decades. This data set has helped them to analyse the behaviour of net foreign assets in a more complex way. Later on, Lane and Milesi-Ferretti (2003) studied international balance sheets to examine the relation between foreign assets and liabilities on one side and a set of various regressors (trade openness, GDP per capita, external liberalisation,

financial depth etc.) on the other side. They find that international trade and stock market capitalisation are the two most important variables influencing international balance sheets. This study was updated in Lane and Milesi-Ferretti (2008).

According to Spiegel (2009), foreign trade requires external financing, i.e. trade integration intensifies financial integration. Thus, a common currency fosters the foreign trade of the euro area countries (the "euro effect"). Sebnem et al. (2010) investigate the underlying channels of the "euro effect" on financial integration, i.e. increased goods trade, the elimination of the currency risk among euro area countries or various financial sector legislative-regulatory reforms. They find that the impact of this effect on financial integration is primarily driven by eliminating the currency risk. While financial and trade integration are highly correlated processes, trade in goods does not play a key role in explaining the positive effect of euro on financial integration.

Kose et al. (2006) focuses on cross-country trade and financial linkages and produce a comprehensive analysis of the roles of both trade and financial integration in driving the growth-volatility relationship. They conclude that both trade and financial integration significantly weaken the negative association between output volatility and growth. Kose et al. (2011) analyse the impact of selected macroeconomic variables (trade openness, real GDP per capita, macroeconomic policies stability etc.) on the level a country’s financial openness represented by the sum of financial assets and liabilities relative to nominal GDP. They deduce that foreign direct investments and cross-border flows of equity securities are safer for the economy than cross-border flows of debt securities especially in the case of a low level of a country's financial openness (and also the quality of institutions).

Aviat and Coeurdacier (2007) explore the complementarity between bilateral trade in goods and bilateral asset holdings in a simultaneous gravity equations framework. According them, trade in goods and trade in assets are closely related. They find an effect of trade on financial asset holdings vice versa; however, the impact of asset holdings on trade in goods is smaller. Kučerová (2009) confirms the same results by using the simultaneous equation model. Aizenman and Noy (2009) study the endogenous determination of financial and trade openness. They construct a theoretical framework leading to two-way feedbacks between financial and trade openness and then verify these feedbacks empirically. They find that countries cannot choose the degree of financial openness independently of their degree of trade openness.

In our paper, we follow this line of empirical research and assess the relation between two processes – financial and trade integration – in the EU member countries and also separately in the EU16 and

EU10 countries. Considering individual country groups is innovative approach with respect to the above mentioned papers.

1.2 Common Features

The key question of analysis of common features between economic indicators is how to quantify the degree of synchronisation and how to analyse the evolution of such a synchronisation during time. Traditionally, the analysis of co-movement measurements was performed in the time domain. The basic approach is a correlation analysis and its modification such as moving correlation. The extension of the standard correlation analysis discussed in the literature is cointegration (Engle and Granger, 1987), common features (Engle and Kozicki, 1993), common cycles and codependence (Vahid and Engle, 1993, 1997).

The great attention paid in the literature to the co-movement research arises from the optimum currency area theory and from the European integration process (DeHaan et al., 2008; Darvas and Szapáry, 2008). Consequent methodological approaches have proceeded to usage of spectral and cross spectral analysis for the past several decades. This allows a detailed study of the comovement of time series (Iacobucci and Noullez, 2005). Thus, the analysis of comovement can be based on the dynamic correlation and phase shift methods, coherency or squared coherency. Croux et al. (2001) provide the theoretical background with a practical application on business cycles in Europe and the USA. Fidrmuc et al. (2013) use dynamic correlation to analyse the business cycles in China and in selected OECD countries between 1992 and 2006 and Fidrmuc et al. (2012) use it to estimate the determinants of output comovements among OECD countries. Kučerová and Poměnková (2013) assess the relationship between financial and trade integration in the new European Union member countries using the method of classical, moving and finally dynamic correlation.

Interconnection of both time and frequency domain provides methods developed in time-frequency domain, such as a wavelet analysis (Yogo, 2008, Poměnková et al., 2014, Maršálek et al., 2013) which allows a more efficient means of a statistical analysis. Rua (2010) measures co-movement among Germany, France, Italy, and Spain via the wavelet cross-spectrum. The same approach is extended to the wavelet power spectrum, the wavelet cross-spectrum and to wavelet coherence and significance tests by Jiang and Mahadevan (2011). Aguiar-Conraria and Soares (2011) use wavelet analysis to study business cycle synchronisation across the EU-15 and the Euro-12 countries. An advantage of the wavelet analysis is that it can capture the features of non-stationarity time series due to the simultaneous time-frequency decomposition of inputs (Jiang and Mahadevan, 2011).

2 Methods and data

2.1 Methods

We use dynamic correlation according to Croux et al. (2001) as measurement of comovements between two time series. Thus, measuring the similarity of two time series *y* and *z* and can be defined as

$$\rho_{yz}(\omega_1,\omega_2)=\frac{\int_{\omega_1}^{\omega_2} C_{yz}(\omega)d\omega}{\sqrt{\int_{\omega_1}^{\omega_2} S_z(\omega)d\omega \int_{\omega_1}^{\omega_2} S_y(\omega)d\omega}}, \tag{1}$$

where *Cyz* is a co-spectrum (the real part of the cross-spectrum) and *Sy*, *Sz* are the individual spectra of time series *y* and *z* for frequencies ω. Integrating the equation (1) in the frequency band from ω_1 to ω_2 evaluates the common behaviour of two time series in the given band of frequencies. For ω_1=0, ω_2 =π the integration is done over the whole defined frequency range and thus the dynamic correlation coefficient corresponds to the classical correlation coefficient (Fidrmuc et al. 2012, 2013).

We are also going to apply the continuous wavelet transform (CWT) of output time series *s*(*t*) with respect to the mother wavelet $\psi(t)$, which is defined as

$$S_{CWT}(a,b)=\int_{-\infty}^{\infty} s(t)\frac{1}{\sqrt{b}}\psi\left(\frac{t-a}{b}\right)dt, \quad b>0, a\in R \tag{2}$$

where *a* is the time position (time shift) and *b* is the parameter of dilatation (scale) of the mother wavelet $\psi(t)$. The CWT transforms input time series from the time representation to the time-scale domain and provides in-deep view to the time and frequency structure of time series (Jiang and Mahadevan, 2011).

For the analysis of the relation between two time series in the frequency domain, a cross-spectral analysis can be performed. The wavelet cross-spectrum between two inputs, $s_i(t)$ and $s_j(t)$, for their time-scale representation $S_{CWTi}(a,b)$ and $S_{CWTj}(a,b)$ can be defined as

$$S_{ij}=SO\left(S_{CWTi}(a,b)S_{CWTj}(a,b)\right), \tag{3}$$

where *SO* is the smoothing operator (Jiang and Mahadevan, 2011).

2.2 Data and Countries

We use yearly data 1993-2012 (*n*=20) to calculate the measures of financial integration. The data are sourced from the International Monetary Fund International Financial Statistics (IMF IFS) database, a

category the international investment position (IMF, 2014a). An economy's IIP is a balance sheet of the stock of external financial assets and liabilities. In other words, these data summarise the total holdings of financial claims by domestic residents on the rest of the world (financial account total assets) and non-residents' claims on the domestic economy (financial account total liabilities).

Incomplete data for some countries and some years have been completed from the on-line database External Wealth of Nations Mark II (Lane and Milesi-Ferretti, 2007). Data concerning nominal exports and imports (in USD) are also extracted from the on-line database IMF IFS. Data concerning nominal GDP (in USD) are extracted from the on-line database IMF World Economic Outlook (WEO) Database (IMF, 2014b).

Each variable defined in the section 3.3 was calculated as the average of corresponding values for 26 representative EU countries, namely Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom (EU26). Luxembourg has been dropped from the sample by reason of an extremely high level of financial integration. In order to separate and compare the processes of financial and trade integration in the developed countries and formerly central-planned economies, which underwent the process of the transformation of central planned economies to market economies after 1989, we decided to divide the EU countries into two subsamples: EU16 (Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Malta, Netherlands, Portugal, Spain, Sweden, and the United Kingdom) and EU10 (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia).

2.3 Indicators

Indicators used in our analysis are derived from the international investment position and its structure and defined in Lane and Milesi-Ferretti (2003). Foreign assets include several categories: foreign assets, foreign direct investment abroad, portfolio investment equity securities, portfolio investment debt securities, financial derivatives, other investments, reserve assets. Foreign liabilities assets include these categories: foreign direct investment in the economy, portfolio investment equity securities, portfolio investment debt securities, financial derivatives, other investments.

The variable IFI_{it} is *a quantity-based measure* indicator of financial integration. This overall indicator is constructed as follows:

$$IFI_{it} = \frac{(FA_{it} + FL_{it})}{GDP_{it}}, \tag{4}$$

where FA_{it} is the stock of total foreign assets of country *i* in time *t*, FL_{it} is the stock of total financial liabilities of country *i* in time *t* and GDP_{it} is the nominal GDP of country *i* in time *t*. Absolute levels of any variable do not reflect the size of the economy properly, can be misleading and are thus not convenient for direct comparisons of different countries. Therefore, it is better to adjust the *IFI* indicator by including the nominal GDP of countries in order to take into account the size of the economy and reveal the true differences in the level of financial integration.

The second average measure is *the investment-based measure* of financial integration (*GI*): it contains only foreign direct investments and portfolio investments (equity and debt securities). The other categories were dropped from this measure because they are either volatile (other investments) or time series are not long enough (financial derivatives). The construction of this adjusted measure is as follows:

$$GI_{it} = \frac{(FDIA_{it} + FDIL_{it} + PEQA_{it} + PEQL_{it} + PDEA_{it} + PDEL_{it})}{GDP_{it}} \tag{5}$$

where $FDIA_{it}$ is the stock of foreign direct investment assets of country *i* abroad, $FDIL_{it}$ is the stock of foreign direct investment liabilities of the rest of the world in country *i*, $PEQA_{it}$ is the stock of portfolio equity assets of country *i* abroad, $PEQL_{it}$ the stock of portfolio equity liabilities in country *i*, $PDEA_{it}$ the stock of portfolio debt assets of country *i* abroad, and $PDEL_{it}$ is the stock of portfolio debt liabilities in a country *i*.

A third possible average measure – *the equity-based measure* of financial integration (*GEQ*) – is based solely on the equity cross-holdings – that is, flows of portfolio equity and foreign direct investments. As international trade in debt instruments can be sometimes influenced by special factors, it was omitted in this indicator:

$$GEQ_{it} = \frac{(FDIA_{it} + FDIL_{it} + PEQA_{it} + PEQL_{it})}{GDP_{it}}. \tag{6}$$

Trade openness is expressed by using the *TRADE* indicator and this indicator of trade integration is constructed as follows:

$$TRADE_{it} = \frac{(EX_{it} + IM_{it})}{GDP_{it}}, \quad (7)$$

where EX_{it} is the total sum of exports of country *i* in time *t*, IM_{it} is the total sum of imports of country *i* in time *t* and GDP_{it} is the nominal GDP of country *i* in time *t*. The higher the value of this indicator, the higher the country's trade openness is.

In order to explain the overall trends in more detail, we also use other indicators described above, such as *FDI* (the turnover of foreign direct investment inflows and outflows to nominal GDP), *PEQ* (the turnover of portfolio equity inflows and outflows to nominal GDP), *PDE* (the turnover of portfolio debt inflows and outflows to nominal GDP) in the following analysis.

3 Preliminary Results

3.1 Indicators Overview

The financial and trade integration indicators are defined in the section 3.3. For all country groups there is an overall growing tendency of the trade integration process in 1993-2012 (see Figures 1a-f). The financial crisis caused a short drop in the level of all indicators. The growing trend was shortly renewed in most cases (with the exception of *FDI* in the EU16 countries). However, the level of the overall *IFI* indicator together with the average growth rate is substantially higher in the EU16 countries (the average level of this indicator in the period 1993-2012 is 5.3 and the average growth rate is 380.1%) than in the EU10 countries (the average level is 1.6 and the average growth rate is 94.0%).[1] The highest level of the *IFI* indicator is in Ireland (18.2); it is more than twice as high as in the United Kingdom (8.0), Malta (7.5), Belgium (7.0), Cyprus (6.6), and the Netherlands (6.5). The same holds for the other financial integration indicators. It is also worth mentioning that the *PEQ* indicator (containing shares, stocks and depository receipts) is not as rising as the other indicators in the EU16 countries; it is also more volatile. The decrease of the indicator in 2001-2002 (and the simultaneous increase of the *PDE* indicator) may reflect the fact that investors from the EU16 countries transferred their investments from equity to debt instruments as a result of the collapse of the Internet bubble in 2000/2001 and the subsequent crisis in this period. After 2008, the overall level of the financial integration has been quite volatile as a result of the financial crisis.

[1] The initial level of financial integration was also determined by the different role of banks in the national financial system. According to Chami et al. (2010) most of the EU10 countries are small and open economies and the small domestic banks have been purchased by large foreign banks. These foreign owners transferred new technologies, know-how, expertise, and willingness into these countries in order to use the opportunity in the financial markets. Hence, the foreign competition in the banking and securities markets was also used to facilitate the financial market development and financial integration.

As far as the process of trade integration is concerned, the tendency is slightly different: the average level of the *TRADE* indicator is higher in the EU10 countries (0.95) than in the EU16 countries (0.66), i.e. the EU10 countries can be regarded as more open according to this indicator. However, the growing trend is slightly faster and less volatile in the EU16 countries (the average growth rate is 40.3%) than in the EU10 countries (34.1%). The drop of the trade indicator in 2001–2003 in the EU16 countries was not caused by the drop of the overall level of trade in the EU16 countries but only by the higher rise of nominal GDP in these countries. The indicator did not even react to the financial crisis; there was only a slight cut in 2009 in the EU16 while the EU10 countries suffered from a decrease of this indicator during 2007-2009. The highest rate of trade openness for the period 1993–2012 was in Belgium (1.5), Slovakia (1.2), and Estonia (1.2). On the other hand, the lowest rate of trade openness was measured in Greece (0.3), Spain (0.4), and the United Kingdom (0.4).

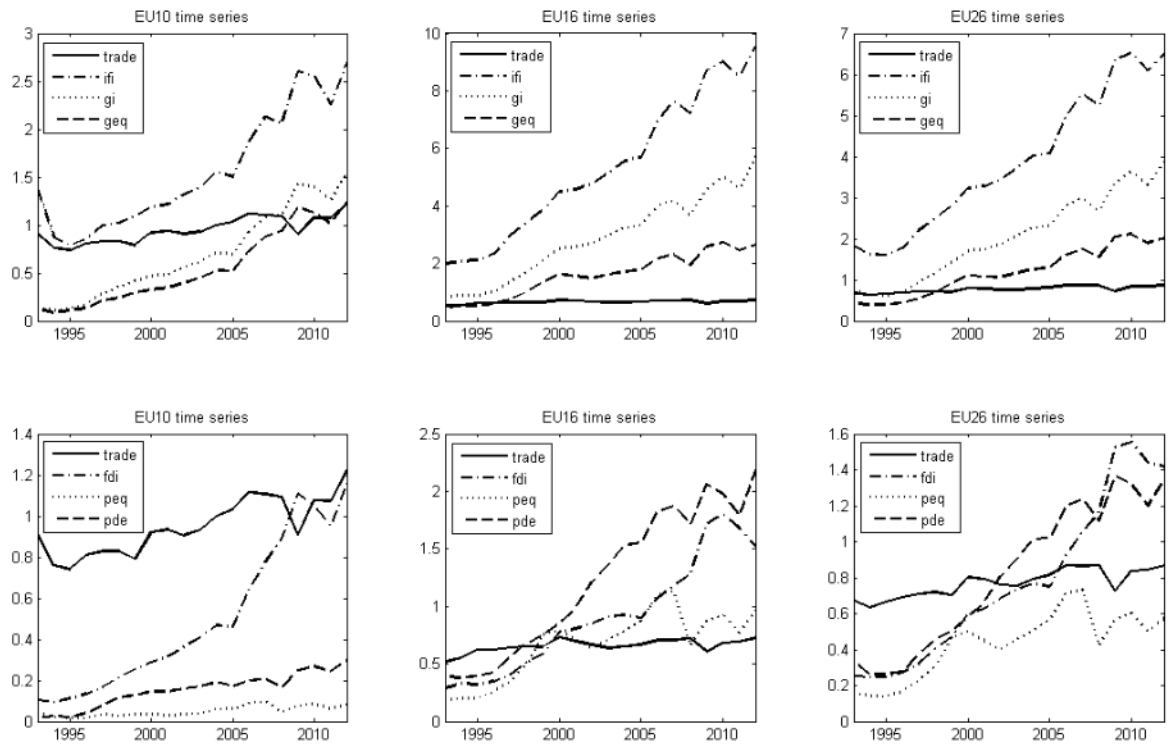

Figure 1a-f Time series representation of financial indicators

Source: International Monetary Fund (2014a, 2014b), Lane and Milesi-Ferretti (2007)

3.2 Correlation Analysis

Empirical analysis aims to measure the relationship between financial and trade integration in the analysed country groups and follows several steps. The first one is focused on the calculation of classical (static) correlation coefficients for the annual data 1993-2012 for EU10, EU16 and EU26. The second step follows the dynamic correlations calculation according eq. (1) for ω_1=0, ω_2 =π, which

should confirm results given by the classical correlation coefficient. Correlated variables are denoted as bold in the Table 1.

Table 1 (lower left triangle) shows a significant (p-value=0,000 for all coefficients) positive dependence between trade and other measures of financial integration measured by static correlation for all selected regions (EU10, EU16 and EU26). Calculation of the dynamic correlation over the whole frequency range (Table 1, upper right triangle) confirms the same results as in the case of the classical correlation. Minor changes are due to the computational precision of the software Matlab R2011b of calculation. It is apparent that the level of correlation between *TRADE* and indicators of financial integration is higher in the EU10 countries than in the EU16 countries. This is a result of the overall growing trend of trade and financial integration of the EU10 countries during and after the transformation process and almost constant trend of trade integration in the EU16 countries during the analysed time period.

Table 1. Correlation coefficients: static and dynamic correlation

EU10	**TRADE**	**IFI**	**GI**	**GEQ**		**TRADE**	**FDI**	**PEQ**	**PDE**
TRADE	1	0,8287	0,8252	0,8168	**TRADE**	1	0,8034	0,8369	0,8715
IFI	0,8270	1	0,9739	0,9802	**FDI**	0,8013	1	0,8183	0,9412
GI	0,8233	0,9736	1	0,9975	**PEQ**	0,8350	0,8160	1	0,8830
GEQ	0,8148	0,9799	0,9975	1	**PDE**	0,8696	0,9410	0,8815	1
EU16	**TRADE**	**IFI**	**GI**	**GEQ**		**TRADE**	**FDI**	**PEQ**	**PDE**
TRADE	1	0,6156	0,6428	0,6581	**TRADE**	1	0,5401	0,7249	0,5912
IFI	0,6142	1	0,9923	0,9842	**FDI**	0,5380	1	0,7641	0,9380
GI	0,6413	0,9923	1	0,9873	**PEQ**	0,7231	0,7626	1	0,8704
GEQ	0,6564	0,9840	0,9871	1	**PDE**	0,5894	0,9375	0,8692	1
EU26	**TRADE**	**IFI**	**GI**	**GEQ**		**TRADE**	**FDI**	**PEQ**	**PDE**
TRADE	1	0,8145	0,8349	0,8211	**TRADE**	1	0,7491	0,8415	0,8326
IFI	0,8127	1	0,9943	0,9947	**FDI**	0,7467	1	0,7541	0,9458
GI	0,8331	0,9943	1	0,9940	**PEQ**	0,8395	0,7525	1	0,8743
GEQ	0,8191	0,9947	0,9940	1	**PDE**	0,8304	0,9455	0,8731	1

Note: Lower left triangle contains correlation coefficient; upper right triangle presents dynamic correlation.

Source: authors' calculations

In the case of the EU16 countries, the indicator *PEQ* shows a bit higher correlation with *TRADE* compared to the *FDI* and *PDE* indicators. It can be explained by the fact that the growing trend of this indicator was not as strong as the trend of *FDI* and *PDE* (especially after the burst of the dot-com bubble in 2000/2001 when some investors switched from equity to debt securities, see also above) while the evolution of the *TRADE* was stable and almost constant. *FDI* was strongly rising especially between 2005 and 2010 and *PDE* between 1996 and 2007.

However, these integration processes were broken by the world financial crises, which began in 2007 and has turned into economic and debt crisis (the process of financial integration in 2008 and the process of trade integration in 2009). The deepening integration trend was restored one year later in the case of trade integration. The level of the IFI indicator in the EU16 countries increased in 2009 and 2010; decreased in 2011 and finally increased in 2012. In the EU10 countries, the situation was only slightly different: *IFI* increased in 2009, decreased in 2010 and 2011 and then increased in 2012.

As we can see, static correlation gives us information just about strong positive linear relation between trade and all other indicators. Unfortunately, this information is insufficient and does not provide a deep view to the structure of dependence between trade and other indicators. To solve it we can use simple descriptive technique describing time development of input time series and comparison of level or growth rate of indicators. Alternatively, we can use other techniques or modification of simple techniques.

4 Moving and Dynamic Correlation Results

To get a detailed view of the structure of dependence between trade and all other indicators we proceed with two approaches – moving correlation and dynamic correlation analysis.

The first one denoted as moving correlation between *TRADE* and all indicators is the modification of classical correlation. The modification consists of the calculation of static correlation on the moving time window which is moved per established number of observation (usually one) till the last observation in the data sample. Denote the starting time window is the part of the data sample which starts with the first observation of the data sample and has the length established by the analysis according to the available data range. The moving correlation can provide quick view to the evolution of correlation with respect to the time even in case of yearly data. This look can reveal some “structural” break which can occurs and which is suitable to analyse in economic context.

The second approach proceeds to calculation in frequency domain and has been called dynamic correlation. The idea of dynamic correlation is similar to the classical one; it is the proportion of co-

spectrum and multiplication of the individual spectra of two time series measured in frequency domain (see eq. (1)). Therefore, the result of dynamic correlation calculation can be represented as a curve in two dimensional space where *x*-axis is represented by frequencies (the range of frequencies is (0;1)) and *y*-axis is represented by the value of dynamic correlation between two variables measured with respect to the frequency. The lower the frequency of inputs the longer the cyclical component is. For example, business cycles are defined between 6 quarters (rapid moving periodic component) and 8 years (slow moving periodic component); in frequency range it is between 0.0625 (6 quarters) and 0.33 (8 years).

4.1 Moving Correlation

Moving correlation (Table 2) is calculated as static correlation, but on the moving time window. We establish the moving part of the size of 10 observations; we start with time window 1993-2002 and move per one observation, i.e. 1994-2003, 1995-2005 etc.

Table 2. Correlation coefficients, EU10: moving correlation

EU10		IFI		GI		GEQ		FDI		PEQ		PDE	
1993-2002	1	0,8786	***	0,6314	**	0,6598	**	0,6409	**	0,6635	**	0,5670	*
1994-2003	2	0,8997	***	0,8836	***	0,8845	***	0,8839	***	0,6769	***	0,8677	***
1995-2004	3	0,9228	***	0,9018	***	0,9052	***	0,9039	***	0,7596	***	0,8717	***
1996-2005	4	0,9102	***	0,8811	***	0,8992	***	0,8983	***	0,806	***	0,7910	***
1997-2006	5	0,9468	***	0,9355	***	0,9402	***	0,9363	***	0,8726	***	0,8475	***
1998-2007	6	0,9253	***	0,9269	***	0,9196	***	0,9182	***	0,9001	***	0,9208	***
1999-2008	7	0,9163	***	0,9086	***	0,8913	***	0,8709	***	0,7835	***	0,8299	***
2000-2009	8	0,3730		0,3739		0,3887		0,3523		0,6569		0,1829	
2001-2010	9	0,3805		0,3808		0,3931		0,3596		0,6532		0,2333	
2002-2011	10	0,3254		0,3324		0,3453		0,314		0,5835		0,1853	
2003-2012	11	0,3847		0,4008		0,3941		0,3729		0,4866		0,3857	

Source: authors' calculations

In Table 2, we can see the statistically significant dependence for the EU10 data till the year 2008. After that, a moving part containing values after 2008 indicates a substantial decrease in the level of correlation caused by the financial crisis (see also Figures 1b, 4b). There is only one indicator – *PEQ* – which shows a significant dependence with trade after year 2008. In this case the drop in the level of correlation coefficients was not as large as in the case of the others indicators. This result reflects the fact that the level of equity investments (*PEQ*) in the EU10 countries is low compared to debt

investments (*PDE*) and especially foreign direct investments (*FDI*). However, *PDE* experienced the worst drop in moving correlation with *TRADE* after 2008.

Table 3. Correlation coefficients, EU16: moving correlation

EU16		IFI	GI	GEQ	FDI	PEQ	PDE
1993-2002	1	0,8412 ***	0,8245 ***	0,8460 ***	0,8121 ***	0,8288 ***	0,7314 **
1994-2003	2	0,6889 **	0,6767 **	0,7471 ***	0,6601 **	0,7582 **	0,5100
1995-2004	3	0,4856	0,4889	0,6220 *	0,5170	0,6332 **	0,2601
1996-2005	4	0,3707	0,3788	0,5382	0,4257	0,5436	0,1492
1997-2006	5	0,3715	0,3677	0,5239	0,3998	0,5339	0,1715
1998-2007	6	0,3831	0,3589	0,5174	0,3859	0,5272	0,1748
1999-2008	7	0,4229	0,3339	0,4936	0,4531	0,2776	0,1665
2000-2009	8	-0,2139	-0,2584	-0,2050	-0,3806	0,1411	-0,3388
2001-2010	9	-0,0064	-0,0244	-0,0492	-0,1696	0,2024	-0,0753
2002-2011	10	0,1605	0,1478	0,0852	-0,0176	0,2553	0,1249
2003-2012	11	0,3323	0,3774	0,2222	0,0608	0,3109	0,3250

Source: authors' calculations

Correlation coefficients for the EU16 countries presented in the Table 3 indicate insignificancy of most of the values except for periods till 2003 (*GI*, *FDI*, *PEQ*) and till 2004 (*GEQ*, *PEQ*). We can see substantial decline in the level of moving correlation for all variables after period 1999-2008 (Figures 2b, 5b) as in the case of the EU10 countries. Let us remark the fall down of correlation to negative correlations after 2008 (moreover insignificant). This situation occurs only in the case of EU16 data. In other words, the process of rising financial and trade integration within the EU16 countries (unlike the EU10 countries) were seriously disrupted by the crisis.

In the Table 4 and Figures 3b, 6b, the results of moving correlation for the EU26 countries are presented. Similarly to the results for the EU10 countries (Table 2) we can also see the statistically significant dependence for the EU26 data till the year 2008 as well as a considerable drop in the level of moving correlation after 2008. The level of correlation of the main financial integration coefficients of the EU26 countries is similar during the analysed time period.

Table 4. Correlation coefficients, EU26: moving correlation

EU26		IFI		GI		GEQ		FDI		PEQ		PDE	
1993-2002	1	0,9101	***	0,8974	***	0,9029	***	0,9006	***	0,8495	***	0,8401	***
1994-2003	2	0,8681	***	0,8516	***	0,8768	***	0,8515	***	0,8408	***	0,7652	***
1995-2004	3	0,863	***	0,8514	***	0,879	***	0,8591	***	0,8272	***	0,7672	***
1996-2005	4	0,8463	***	0,8383	***	0,8599	***	0,8377	***	0,8011	***	0,7693	***
1997-2006	5	0,8839	***	0,8683	***	0,8906	***	0,8578	***	0,8493	***	0,8033	***
1998-2007	6	0,89	***	0,8861	***	0,9115	***	0,8773	***	0,8748	***	0,8185	***
1999-2008	7	0,8891	***	0,8722	***	0,9064	***	0,8646	***	0,5997	**	0,7906	***
2000-2009	8	0,211		0,2179		0,1779		0,0097		0,4908		0,2153	
2001-2010	9	0,2919		0,3043		0,2604		0,1235		0,5106		0,3081	
2002-2011	10	0,3178		0,3316		0,2814		0,1585		0,4566		0,3266	
2003-2012	11	0,2844		0,3245		0,2348		0,123		0,3517		0,2613	

Source: authors' calculations

4.2 Dynamic Correlation

In the following empirical step we provide additional detailed view of the structure of correlation via the dynamic correlation (eq. (1)) and its variability. We present the development of dynamic correlation between *TRADE* and the selected indicators in relation to different frequencies in Figures 2a-4a (*FDI, PEQ, PDE*) and Figures 5a-7a (*IFI, GI, GEQ*). For a better illustration, we present moving correlation figures too (Figures 1b - 6b).

In the case of dependencies between *TRADE* and the selected financial integration indicators (Figures 2a-4a), we can see the volatility of the dynamic correlation curve, which varies with respect to the frequencies. Different frequencies mean also different lengths of cyclical components (i.e. the lower the frequency of inputs the longer the cyclical component is). The overall variability of dynamic correlation curves provides Table 5.

All indicators show high correlation with the indicator of trade in low frequencies, i.e. the part of the dynamic correlation curve (*y*-axis) corresponding to the frequency values (*x*-axis) between 0.001 and 0.2. A high correlation was also achieved for the dynamic correlation curve belonging to the frequencies 0.0625 and 0.33 (subsample of the range 0.001 and 0.2) denoted as business cycles frequencies (3rd paragraph of the section 5); the correlation varies between 0.7 and 0.98. In the case of EU10 and EU26 data, there is no statistical difference between the level of dynamic correlation curves with respect to the frequency range 0.001 – 0.5, that is for long and business cycles for *TRADE*

and *IFI, GI, GEQ* indicators. After those frequencies (0.5 and higher), the basic tendency (increase, decrease) is quite similar but the level starts to be a little bit different. The dynamic correlation corresponding to the higher frequencies (the *x*-axis ranges between 0.65-0.85) achieves a high value especially in the EU10 and EU26 countries (the correlation is varying between 0.5 and 0.7). Unfortunately, the tendency of curves is not as similar as in long cycles corresponding to the low frequencies (Figures 6a, 7a). Especially in the case of EU16 and the *FDI, PEQ, PDE* indicators, the curves for moving correlation (Figure 6b) and dynamic correlation (Figure 6a) both show the same discrepancy. We can see (Figure 3a) the slow oscillation of dynamic correlation curve for the *IFI* and *GI* indicators with respect to the frequencies 0.43-0.75 (i.e. cycles of the length 4.5-2.6 quarters belonging to the short cycles).

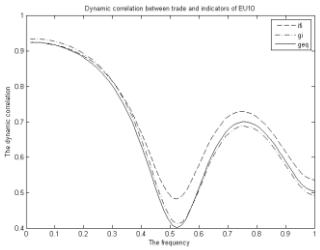

Figure 2a Dynamic correlation curves EU10

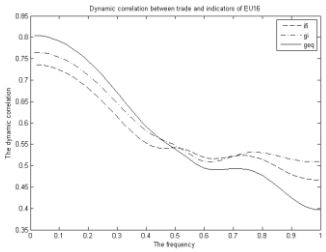

Figure 3a Dynamic correlation curves EU16

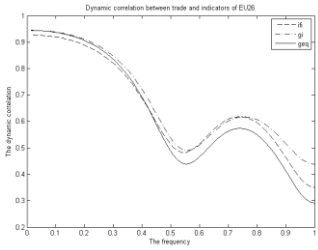

Figure 4a Dynamic correlation curves EU26

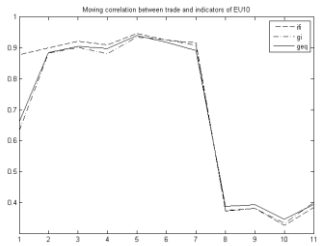

Figure 2b Moving correlation curves EU10

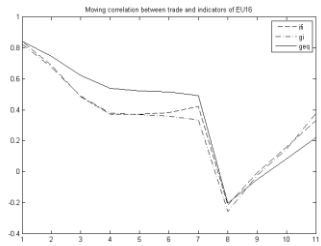

Figure 3b Moving correlation curves EU16

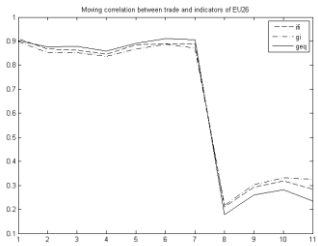

Figure 4b Moving correlation curves EU26

Source: authors' calculations

The volatility of the dynamic correlation for the *IFI, GI, GEQ* indicators in the EU16 countries (Table 5) is the lowest among the analysed country groups; the slowing-down decreasing tendency of the dependency is apparent. Comparing the charts for moving correlations for the *IFI, GI, GEQ* indicators (Figures 2b-4b), we can see the structural break in 2008. As we mentioned previously, this moment occurs in times of the world financial crises.

The situation for *FDI, PEQ, PDE* indicators is different than for the previous three indicators presented in the Figures 2a-4a. Firstly, the tendency of dynamic correlation curves across the EU is

not so similar; there is a high level of volatility of dynamic correlation curves (compare Figures 2a-4a and 5a-7a).

Having detailed look on the dynamic correlation curves (Figures 5a-7a) with respect to the frequency range 0.001-0.6 we can observe the higher level of correlation of *TRADE* and *PEQ* for al country groups than with indicators *FDI*, *PDE*. On the other hand, the dependence between *TRADE* and *PEQ* represented by the dynamic correlation curve in EU16 shows the decreasing tendency in the whole frequency range (0;1) compared to curves for the other two indicators. In EU10 and EU26 the same dynamic correlation curve (*TRADE* and *PEQ*) indicates a little bit higher volatility (than in EU16). The dependency between *TRADE* and *PEQ* behaves similarly to dependency between *TRADE* and *IFI, GI, GEQ* in EU16. In all three country groups (Figures 5a-7a), there is the high correlation of all indicators with the indicator *TRADE* in long cycles and economic cycles. This fact comes from the level of the dynamic correlation curves with respect to the frequency range 0.001-0.33; the correlation is varying between 0.6 and 0.98.

The dynamic correlation curves with respect to the frequency range 0.65-0.85 which corresponds to short cycles show different results with respect to the region and indicator. Thus, in EU10 (Figures 5a) curves show a significant dependency for all indicators, only the case of very short cycles (0.9-1 frequencies) is insignificant for *PEQ*. The results of dynamic correlation curves in EU16 (Figure 6a) show the most different tendency across frequencies 0.5-1 (i.e. short and very short cycles). In the case of EU26 (Figure 7a), the dependence for *PDE* and *FDI* behaves similarly (the results are statistically significant), while the *PEQ* and *TRADE* dynamic correlation curves show a similar decreasing tendency of dependency across frequencies, from significant to insignificant values.

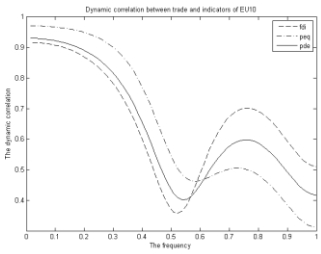

Figure 5a Dynamic correlation curves EU10

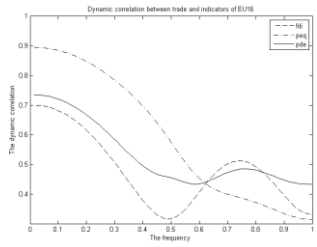

Figure 6a Dynamic correlation curves EU16

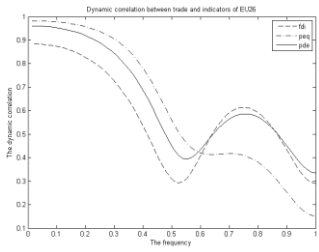

Figure 7a Dynamic correlation curves EU26

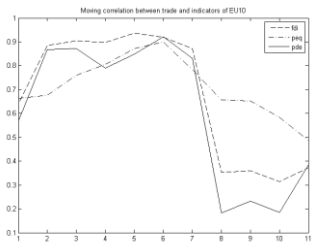

Figure 5b Moving correlation curves EU10

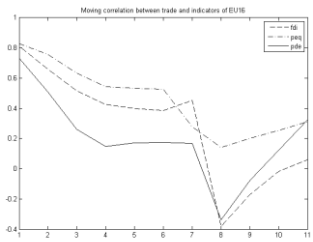

Figure 6b Moving correlation curves EU16

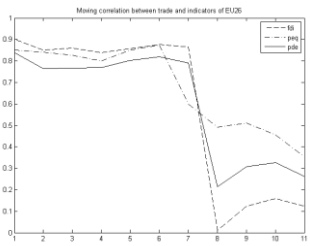

Figure 7b Moving correlation curves EU26

Source: authors' calculations

The situation for *FDI, PEQ, PDE* indicators is different to the *IFI, GI, GEQ* indicators also in the moving correlation curves. There is no such similarity in the curve tendency. But all cases confirm the structural break in 2008.

The volatility of the dynamic correlation for all indicators show the higher variability in EU26 countries whereas the lowest one is in EU16 countries. The most volatile is dynamic correlation between *TRADE* and *PEQ* in EU26 the lowest volatile is dynamic correlation between *TRADE* and *IFI* in EU16. Denote the dynamic correlation between *TRADE* and *PEQ* in EU10, EU16 and EU26 indicate higher level of volatility compare to *FDI* and *PDE*.

Table 5. Variability of dynamic correlation

EU10	TRADE	IFI	GI	GEQ		TRADE	FDI	PEQ	PDE
TRADE	0%	2,008%	2,804%	2,671%	TRADE	0%	2,867%	5,507%	3,423%
IFI	2,008%	0%	0,169%	0,157%	FDI	2,867%	0%	3,279%	0,0745%
GI	2,804%	0,169%	0%	0,0002%	PEQ	5,507%	3,279%	0%	1,735%
GEQ	2,671%	0,157%	0,0002%	0%	PDE	3,423%	0,075%	1,735%	0%
EU16	**TRADE**	**IFI**	**GI**	**GEQ**		**TRADE**	**FDI**	**PEQ**	**PDE**
TRADE	0%	0,740%	0,844%	1,744%	TRADE	0%	1,453%	4,609%	1,117%
IFI	0,740%	0%	0,003%	0,021%	FDI	1,453%	0%	1,614%	0,367%
GI	0,844%	0,003%	0%	0,029%	PEQ	4,609%	1,614%	0%	0,635%
GEQ	1,744%	0,021%	0,029%	0%	PDE	1,117%	0,367%	0,635%	0%
EU26	**TRADE**	**IFI**	**GI**	**GEQ**		**TRADE**	**FDI**	**PEQ**	**PDE**
TRADE	0%	3,245%	3,053%	4,357%	TRADE	0%	3,899%	8,210%	4,488%
IFI	3,245%	0%	0,003%	0,005%	FDI	3,899%	0%	1,685%	0,133%
GI	3,053%	0,003%	0%	0,010%	PEQ	8,210%	1,685%	0%	0,751%
GEQ	4,357%	0,005%	0,010%	0%	PDE	4,488%	0,133%	0,751%	0%

Source: authors' calculations

Comparing the classical correlation results with the moving and dynamic correlation we can observe the influence of the financial crisis on the behaviour of the examined relationship. Especially the dynamic correlation curve provides information about comovement in some frequency range which can help us in additional analysis such as the analysis of sources of movements in the indicators. However, this analysis is out of the scope of this article.

5 Wavelet Analysis Confirmation

For the confirmation and specification of dynamic correlation results, we use the wavelet analysis. This approach allows us to evaluate the time and frequency character of input time series as well as their common features. All time-scale representations have been smoothed (averaged) along both the scale and time domain by the two scale samples (Jiang and Mahadevan, 2010). From the family of mother wavelet functions, we used the Morlet wavelet (Gencay et al., 2002). The results are described in Figures 8-10 below. We present charts for all indicators for EU10 (Figures 8a-f), EU16 (Figures 9a-f) and EU26 (Figures 10a-f).

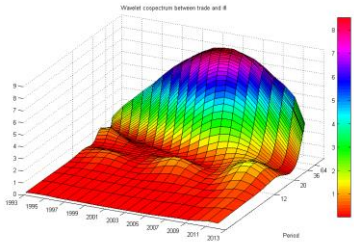

Figure 8a Wavelet co-spectrum EU10 between TRADE and IFI

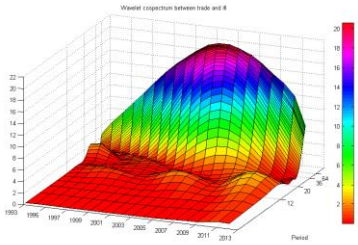

Figure 9a Wavelet co-spectrum EU16 between TRADE and IFI

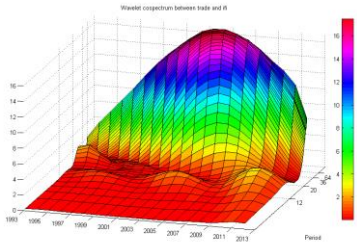

Figure 10a Wavelet co-spectrum EU26 between TRADE and IFI

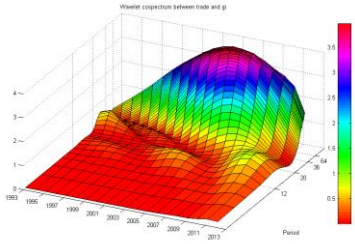

Figure 8b Wavelet co-spectrum EU10 between TRADE and GI

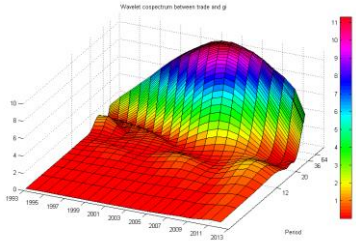

Figure 9b Wavelet co-spectrum EU16 between TRADE and GI

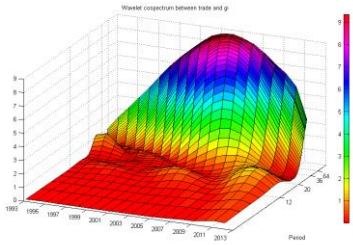

Figure 10b Wavelet co-spectrum EU26 between TRADE and GI

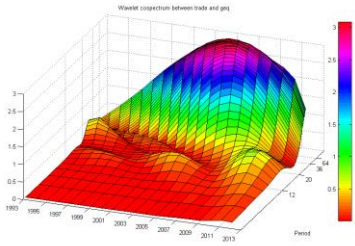

Figure 8c Wavelet co-spectrum EU10 between TRADE and GEQ

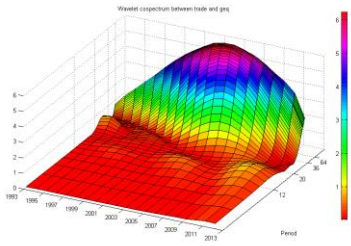

Figure 9c Wavelet co-spectrum EU16 between TRADE and GEQ

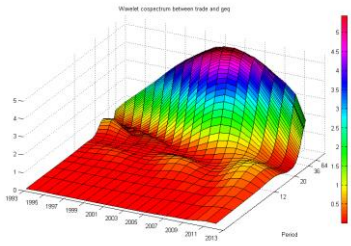

Figure 10c Wavelet co-spectrum EU26 between TRADE and GEQ

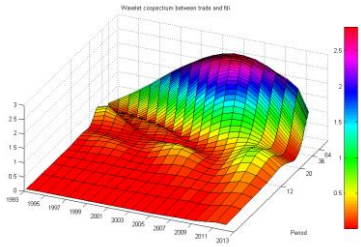

Figure 8d Wavelet co-spectrum EU10 between TRADE and FDI

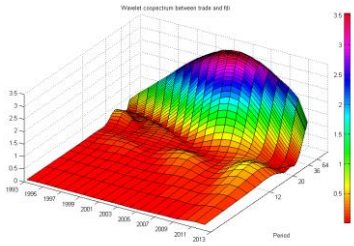

Figure 9d Wavelet co-spectrum EU16 between TRADE and FDI

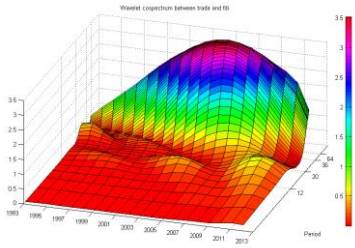

Figure 10d Wavelet co-spectrum EU26 between TRADE and FDI

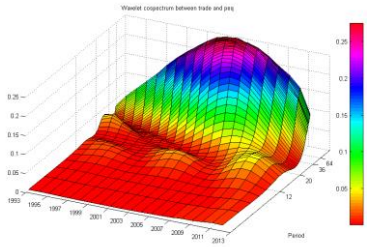

Figure 8e Wavelet co-spectrum EU10 between TRADE and PEQ

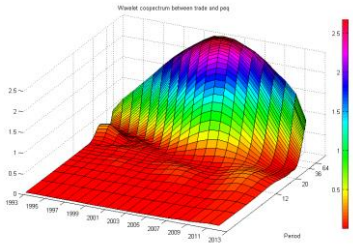

Figure 9e Wavelet co-spectrum EU16 between TRADE and PEQ

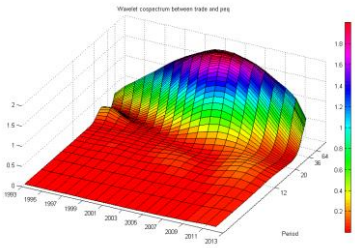

Figure 10e Wavelet co-spectrum EU26 between TRADE and PEQ

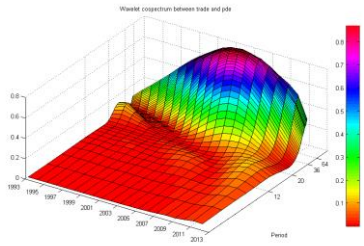

Figure 8f Wavelet co-spectrum EU10 between TRADE and PDE

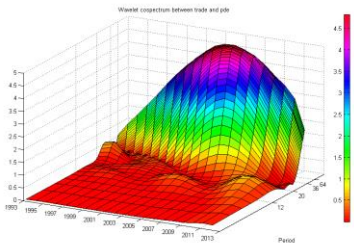

Figure 9f Wavelet co-spectrum EU16 between TRADE and PDE

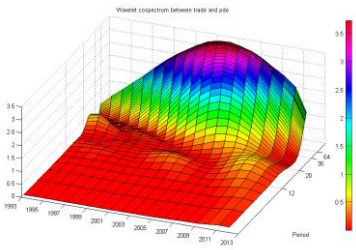

Figure 10f Wavelet co-spectrum EU26 between TRADE and PDE

Source: authors' calculations

From the time-frequency perspectives, the comovement between *TRADE* and all indicators measured by cospectrum shows significant common features for long cycles (64-32 quarters). It occurs for both EU16 and EU26 in the same period (2000-2009). EU10 showed, in general, similar results; just for *GI*, *GEQ* and *FDI* the time period with significant comovement is only slightly shorter (2001-2009).

The second area with common features (more or less week) occurs in frequencies usually denoted as business cycle frequencies (between 32 and 18 quarters) in period 1993-1994(1995) for all countries and indicators. In some cases – EU16 (*IFI*), EU26 (*IFI*, *GI*, *GEQ*) for 2002-2003 and EU16 (*FDI*) in 2003-2004 – we can identify additional comovement in business cycle frequencies.

The last area with comovement is examined in the middle cycles (20-12 quarters). In the EU26 countries, the comovement occurs in 2008-2010 for the *IFI*, *GI*, *GEQ*, and *PDE* indicators, also in 2008-2011 for the *FDI* indicators and in 2008-2009 for the *PEQ* indicator. In the EU16 countries, it occurs in the period 2008-2011 for *IFI,* for all others indicators it happened in 2009-2010. The EU10 countries have different results among indicators; 2008-2011 (*GI*), 2007-2011 (*GEQ*, *FDI*, *PEQ*), and 2009-2011 (*PDE*).

To sum it up, the dependence measured by the dynamic correlation was specified by the information obtained from the wavelet analysis. Comparing results from frequency domain (the dynamic correlation method) and time-frequency domain (the wavelet analysis), we can definitely confirm the existence of dependency and comovement for long cycles (over 32 quarters). Long cycles can be viewed as a time series trend, because the data have not been detrended. Moreover, we can observe the existence of a comovement between 30-18 quarters at the beginning of the time period (1993-1994) for all countries. Over time, we can also find an additional business cycle comovement between 20-12 quarters for all countries which occur generally after the crisis in 2008 and ended mostly in 2010.

Because the wavelet analysis allows for the application on non-stationary data (Jiang and Mahadevan 2011) and with respect to the short samples, we did not provide the detrending of inputs. The detrending or usage of appropriate filter technique is possible, but the small samples do not guarantee the noising of results. We can assume the wavelet analysis applied on detrended data can provide better information about short cycles (under the level of 12 quarters), but in the case of 18 yearly observations we worry about the stability of results. Therefore, we skip this methodical step.

Conclusion

The aim of the article was to assess the relation between two types of economic integration – financial and trade – in the EU member country groups over the period 1993-2012. In our empirical analysis, we used the method of static, dynamic, and moving correlation to measure the degree of relation between financial and trade integration.

Empirical analysis in the time domain represented by static correlation showed a strong linear dependency between *TRADE* and the financial indicators for all countries. The moving correlation reveals the statistically significant dependence in the case of all countries till the year 2008 as well as a drop in the level of moving correlation after 2008 as results of the financial crisis. There is only one indicator – *PEQ* – which shows a significant dependence with trade after 2008; in this case, the drop in the level of correlation coefficients was not as large as in the case of the other indicators.

Additional analysis in frequency domain provides detailed information about the structure of dependence with respect to the frequency character of data. Thus, we can see a high dynamic correlation of all indicators in all countries for cycles of length from 20 years till 10 quarters (including business cycle frequencies of the length 32 to 18 quarters) and for short cycles of the length 3-2.5 quarters. In EU16, the dynamic correlation for the short cycles for the *FDI*, *PDE* and *PEQ*

indicators has a different curve tendency compared to the EU10 and EU26 countries. However, the curve tendency behaves similarly in the case of *IFI*, *GI*, and *GEQ*. In the whole range of frequency, *PEQ* is the only indicator with a decreasing tendency in EU16. This can be ascribed to the volatility of stock markets in the EU16 countries during the Internet bubble in 2000/2001 (and subsequent transfer of funds from equity to debt instruments) and the financial crisis in 2007/2008.

Wavelet analysis was used for the specification of dynamic correlation results. Via comparison both frequency and time-frequency domain results we can confirm the existence of dependency and comovement for long cycles (over 32 quarters). This finding can support the idea of a single currency (and a single monetary policy) in these countries because it is expected that it would be accompanied by common financial and trade integration processes, even if it is partly rejected by the decrease in the level of moving correlation after 2008. Furthermore, we can observe additional comovement areas. The first is in 1993-94, the second generally after the crisis in 2008 ended mostly in 2010. These results allow us to state that the economies analysed countries have reacted to the financial crisis in the same way as far as financial and trade integration processes are concerned.

We conclude that financial and trade integration has been deepening since 1993. However, both integration processes were broken by the world financial crises and the resulting fall of overall economic activity; the process of financial integration in 2008 and the process of trade integration in 2009. These results were proved by both moving and dynamic correlation approaches. The deepening integration trend was restored one year later in both cases. Especially in the EU16 countries, investors switched between equity and debt securities according to the current situation in financial markets. The situation was different in the EU10 countries where the major part of the financial account was formed by foreign direct investments (especially after 2005).

The process of financial integration was stronger in the EU16 countries compared to the EU10 countries. By contrast, the level of trade integration was higher in the EU10 countries than in the EU16 countries, i.e. the EU10 countries are thus more open economies. This finding confirms the fact that most of the EU10 countries are heavily dependent on their exports to other countries (especially other EU countries) and followed the line of more intense trade (than financial) cooperation. Therefore, the volume of trade with goods and services was higher than the volume of trade with financial assets (liabilities) in these countries. In the EU16 countries, the situation was opposite.

To sum up, the financial and trade integration processes are considerably interconnected, i.e. the more the countries trade the more financially integrated they are. Our empirical analysis confirms a strong relationship between the two main balance-of-payment components: the current account and

the financial account. We can also conclude, that the analysed country groups face approximately the same level of financial and trade integration and that the overall trends of these processes are similar. The financial crisis had an impact on the integration processes however, the long term trends are common for both the EU10 and EU16 countries.

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