Financial and Trade Integration of Selected EU Regions: Dynamic Correlation and Wavelet Approach[1]

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Abstract

We evaluate the process of financial and trade integration in 26 European Union (EU) countries over the period 1993 – 2012. We distinguish between "new" and "old" EU countries to compare the processes of financial and trade integration in the developed countries and formerly central-planned economies. We use classical and moving correlation, dynamic correlation, and wavelet co-spectrum. Classical and moving correlation shows the strong relation until 2008. Dynamic correlation confirms strong relation for long and business cycle frequencies. Specification via wavelet co-spectrum reveals that long frequencies are correlated in the period 2000 – 2009, business cycle frequencies in the period 1993 – 1994 and 2003 – 2004 and middle frequencies generally in the period 2008 – 2010. The process of financial integration was stronger in the old EU member countries while the process of trade integration in the new member countries.

Keywords: *financial integration, foreign trade, international financial markets, correlation analysis, wavelet co-spectrum*

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

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

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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. Moreover, the execution of the monetary policy, which is implemented through the financial system, should be efficient and functioning 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 case of negative macroeconomic shocks.

However, negative effects can be linked with this process. Some capital may hinder the economy without barriers for capital movement, especially the so-called “hot money”, which can be transferred from one country to another very quickly and without any restrictions and major expenses. Moreover, integration can lead to a higher specialisation of production and countries may become more vulnerable to asymmetric shock (see Krugman, 1993). Therefore, international supervisory cooperation becomes important in the light of globalisation in order to address the weaknesses of the international financial system.

Foreign trade is one of the most important factors fostering the financial integration. Lane and Milesi-Ferreti (2000) or Lane and Milesi-Ferreti (2003) specify two important linkages between trade and financial integration. Firstly, foreign trade evokes the corresponding financial transactions. Foreign direct investments (FDI) had a great impact on the external balance of the "new" EU member countries; trade deficits originating from the transformation process were compensated by investment inflows (i.e. by increasing financial integration). And 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 more prone to buy the shares of these companies (the “familiarity effect”).

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 do not focus on the causality between these processes. We aim to answer the questions whether the EU countries face the similar character and trends of financial and trade 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 (plus Cyprus and Malta) so far. By doing so, we can distinguish between the processes in these country groups 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, Latvia or Lithuania) 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 European countries. We divide these countries into three country groups: the country group EU-10 (new EU countries), EU-16 (old EU countries plus Cyprus and Malta) and EU-26. We use data for the period 1993 – 2012 in time and frequency varying perspectives. We use quantity-based measures of financial integration derived from the countries' international investment positions and the static, moving and dynamic correlation and the wavelet approach. The text is structured as follows. After an introduction we provide a literature review. Then, methods, data, countries, and financial and trade indicators are defined. In third section, we describe preliminary results, i.e. overview of indicators used for the analysis and the results of static correlation. The fourth section contains the core results of correlation analysis (moving and dynamic) of financial and trade integration processes. In section five, the wavelet analysis is performed to verify and specify previous results. Section six brings conclusions.

1. Literature Review

1.1. Financial and Trade Integration

The paper focuses on changes in both financial integration and trade integration. However, only few empirical papers examine both processes simultaneously. One of the first attempts to analyse financial integration processes using the foreign assets and liabilities is the study of Lane and Milesi-Ferretti (2001). Authors develop 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. Later on, Lane and Milesi-Ferretti (2003) focus on international balance sheets to examine the relation between foreign assets and liabilities and a set of various regressors (trade openness, GDP per capita, external liberalisation, financial depth etc.). They find that international trade and stock market capitalisation are the two most important variables influencing international balance sheets. This study is updated in Lane and Milesi-Ferretti (2008).

Kose, Prasad and Terrones (2006) analyse how the financial and trade integration influence the relationship between growth and volatility in both industrial and developing countries. They find that trade and financial integration weaken the negative relationship between growth and volatility. Countries that are more open to trade experience a less severe trade-off between growth and volatility. In case of financial integration, its effect on this relationship is somewhat less

important. Schiavo, Reyes and Fagiolo (2010) examine the patterns of international trade and financial integration by using complex network analysis and find that the international trade network (i.e. trade integration) is more densely connected than the international financial network (i.e. financial integration), while both types of network display a core-periphery structure. Moreover, high income countries are linked and create groups of tightly interconnected nodes. This could be the reason why financial crisis spread primarily among advanced countries and affected emerging markets later.

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, Papaioannou and Peydro (2010) investigate the 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. 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. Schiavo (2008) investigates the relation between trade integration, financial integration and the correlation of business cycles in the euro area in the context of the Optimum Currency Area theory. He finds that monetary integration positively affects capital market integration, which in turn affects the economic system and results in closer trade and business cycles synchronization.

Aviat and Coeurdacier (2007) explore the complementarity between bilateral trade in goods and bilateral asset holdings in a simultaneous gravity equations framework. According to the authors, trade in goods and trade in assets are closely related. They find an effect of trade on financial asset holdings and vice versa; however, the impact of asset holdings on trade in goods is smaller. Kučerová (2009) confirms the same results for European countries 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 (not causality) and its character between two processes – financial and trade integration – in the EU-26 member countries and also separately in the EU-16 and EU-10 countries. Considering individual country groups is an innovative approach with respect to the above mentioned studies.

1.2. Common Features

The key question of analysis of common features is how to quantify the degree of synchronisation and how to analyse the evolution of such a synchronisation in time. Traditionally, the analysis of co-movement measurement was performed in the time domain. The basic approach is a correlation analysis and its modification such as moving correlation.

The great attention paid in literature to the co-movement research arises from the optimum currency area theory (Darvas and Szapáry, 2008). Consequent methodological approaches have proceeded to use of spectral and cross spectral analysis for the past several decades. This allows a detailed study of the co-movement of time series (Iacobucci and Noullez, 2005). Thus, the analysis of co-movement can be based on the dynamic correlation and phase shift methods, coherency or squared coherency. Croux, Forni and Reichlin (2001) provide the theoretical background with a practical application on business cycles in Europe and the USA. Fidrmuc, Ikeda and Iwatsubo (2012) use dynamic correlation to estimate the determinants of output co-movements among OECD countries. Kučerová and Poměnková (2013) assess the relationship between financial and trade integration in the new EU member countries using the classical, moving and finally dynamic correlation. In another paper, Poměnková and Kučerová (2014) identify a strong relation between financial and trade integration in the pre-crisis period (before 2008) in all EU countries compared to period after 2008 using a wavelet approach. Methods developed in time-frequency domain provide the interconnection of both time and frequency domain, such as a wavelet analysis (Yogo, 2008, Fidrmuc, Korhonen and Poměnková, 2014). This method allows us to use 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 wavelet power spectrum, wavelet cross-spectrum and to wavelet coherence and significance tests by Jiang and Mahadevan (2011). An advantage of the wavelet analysis is that it captures the features of non-stationary 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, Forni and Reichlin (2001) as measurement of co-movements between two time series. 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 – a co-spectrum (the real part of the cross-spectrum),
Sy, *Sz* – the individual spectra of time series *y* and *z* for frequencies ω.

Integrating the eq. (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 $\omega_1 = 0$, $\omega_2 = \pi$ the integration is done over the whole defined frequency range and thus the dynamic correlation coefficient corresponds to the classical correlation coefficient (Fidrmuc, Ikeda and Iwatsubo, 2012).

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

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

where

a – the time position (time shift),
b – 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 of the time and frequency structure of time series (Jiang and Mahadevan, 2011). For the analysis of the relation between two time series in the time-scale domain, a cross-spectral measurement 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 $S_{CWTj}(a, b)$ is calculated according to the formula (2) 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 or Fidrmuc, Korhonen and Poměnková, 2014).

2.2. Data and Countries

We use yearly data 1993 – 2012 from the International Monetary Fund International Financial Statistics (IMF IFS) database, a category the international investment position (IMF, 2014a). Incomplete data for some countries and some

years are 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).

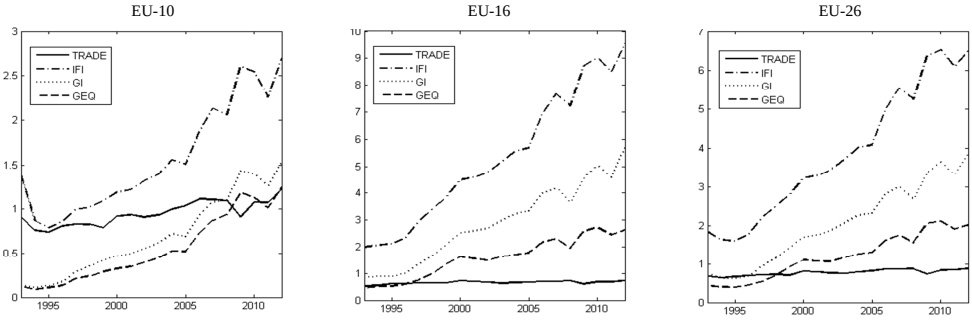
Each indicator (see below) is calculated for 26 representative EU countries (EU-26). Luxembourg is dropped from the sample by reason of an extremely high level of financial integration. To separate and compare the processes of financial and trade integration in the developed countries and formerly central-planned economies, which underwent the transformation process after 1989, we divided the EU countries into two subsamples: EU-16 (Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Malta, Netherlands, Portugal, Spain, Sweden, and the United Kingdom) and EU-10 (Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia). Therefore, Malta and Cyprus are treated as „old" EU member countries (EU-16) even though these two countries entered the EU in 2004 together with „new" EU member countries.

2.3. Indicators

Indicators used in our analysis are derived from the international investment position and defined in Lane and Milesi-Ferretti (2003).

F i g u r e 1

Time Trend of TRADE, IFI, GI and GEQ for EU-10 (a), EU-16 (b) and EU-26 (c)



Source: IMF (2014a; 2014b); Lane and Milesi-Ferretti (2007).

Foreign assets include several categories: 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. In this context, IFI is the broadest and GEQ is the narrowest definition of cross-border capital movement (or financial integration), i.e. IFI encompasses both GI and GEQ indicators and GI encompasses GEQ indicator. Therefore, we are able to study different types (or more exactly stages) of financial integration using these three indicators.

Following Figure 1 represents input time series calculated as averages for respective country groups according to the formulas written in the table 1 with respect to available data described in the section „Data and Countries".

T a b l e 1

Indicators Description

Indicator	Short Notation	How to Calculate
TRADE	Indicator of trade integration	$TRADE_{it} = \frac{(EX_{it} + IM_{it})}{GDP_{it}}$ 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.
IFI	Quantity-based measure of financial integration	$IFI_{it} = \frac{(FA_{it} + FL_{it})}{GDP_{it}}$ 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, GDP_{it} is the nominal GDP of country i in time t.
GI	Investment-based measure of financial integration	$GI_{it} = \frac{(FDIA_{it} + FDIL_{it} + PEQA_{it} + PEQL_{it} + PDEA_{it} + PDEL_{it})}{GDP_{it}}$ $FDIA_{it}$ is the stock of foreign direct investment assets of country i abroad, $FDIL_{it}$ is the stock of foreign direct investment liabilities 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.
GEQ	Equity-based measure of financial integration	$GEQ_{it} = \frac{(FDIA_{it} + FDIL_{it} + PEQA_{it} + PEQL_{it})}{GDP_{it}}$

Source: Lane and Milesi-Ferretti (2003).

3. Preliminary Results

3.1. Indicators Overview

In all country groups, there is an overall growing tendency of the trade integration process in 1993 – 2012 (see Figure 1a – c). The financial crisis caused a short drop in the level of all indicators. However, the growing trend was shortly

renewed in most cases. The level of the overall *IFI* indicator together with the average growth rate is substantially higher in the EU-16 countries than in the EU-10 countries. The level of the *IFI* indicator in the EU-16 countries increased in 2009 and 2010, then decreased in 2011 and finally increased in 2012. In the EU-10 countries, the situation was only slightly different: *IFI* increased in 2009, decreased in 2010 and 2011 and then increased in 2012. 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 investors from the EU-16 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.

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 EU-10 countries (0.95) than in the EU-16 countries (0.66), i.e. the EU-10 countries can be regarded as more open. However, the growing trend is a bit faster and less volatile in the EU-16 countries than in the EU-10 countries. The drop of the trade indicator in 2001 – 2003 in the EU-16 countries was not caused by the drop of the overall level of trade in the EU-16 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 EU-16 while the EU-10 countries suffered from a serious decrease of this indicator during 2007 – 2009. The highest rate of trade openness in 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).

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 step is focused on the calculation of classical (static) correlation coefficients in 1993 – 2012 for EU-10, EU-16 and EU-26 (Table 2). The second step follows the dynamic correlations calculation according to eq. (1) for $\omega_1 = 0$, $\omega_2 = \pi$ which confirms results given by the classical correlation coefficient.

Table 2 shows a significant positive dependence (zero p-value for all coefficients) between trade and financial integration indicators measured by static correlation. It is clear that the level of correlation between *TRADE* and financial

integration indicators is higher in the EU-10 countries than in the EU-16 countries. It is a result of the growing trend of trade and financial integration of the EU-10 countries during and after the transformation process and almost constant trend of trade integration in the EU-16 countries during the analysed time period.

T a b l e 2

Correlation Coefficients between TRADE and All Indicators of Financial Integration

	EU-10			EU-16			EU-26		
	TRADE	**IFI**	**GI**	**TRADE**	**IFI**	**GI**	**TRADE**	**IFI**	**GI**
IFI	0.83			0.61			0.813		
GI	0.82	0.97		0.64	0.99		0.83	0.99	
GEQ	0.82	0.98	0.99	0.66	0.98	0.99	0.81	0.99	0.99

Source: Own calculation.

4. Moving and Dynamic Correlation Results

However, the static correlation gives us information just about a strong positive linear relation between trade and all other indicators. Unfortunately, this information is insufficient and does not provide a deep view of the structure of dependence between trade and financial integration. To solve this problem, we apply moving and dynamic correlation. The moving correlation 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. The results can provide a quick view of the evolution of correlation with respect to the time and can reveal a „structural" break which can occur.

The second approach proceeds to calculation in a frequency domain and is called the dynamic correlation. The idea of the 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 results 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. 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 (8 years) and 0.33 (6 quarters).

4.1. Moving Correlation

When computing the moving correlation (Table 3), 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.).

In Table 3, we can see the statistically significant dependence for the EU-10 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 Figure 2a). Correlation coefficients for the EU-16 countries presented in the Table 3 indicate the insignificancy of most of the values except for periods till 2003 (*GI*) and till 2004 (*GEQ*). We can see a substantial decline in the level of moving correlation for all variables after period 1999 – 2008 (Figure 2b) as in case of the EU-10 countries. It is worth noting that the correlation coefficients dropped from positive to negative values immediately after 2008 (moreover the results are insignificant). This situation occurs only in case of EU-16 data. In other words, the process of financial and trade integration within the EU-16 countries (unlike the EU-10 countries) was seriously disrupted by the crisis.

T a b l e 3

Correlation Coefficients between Trade and All Indicators: Moving Correlation

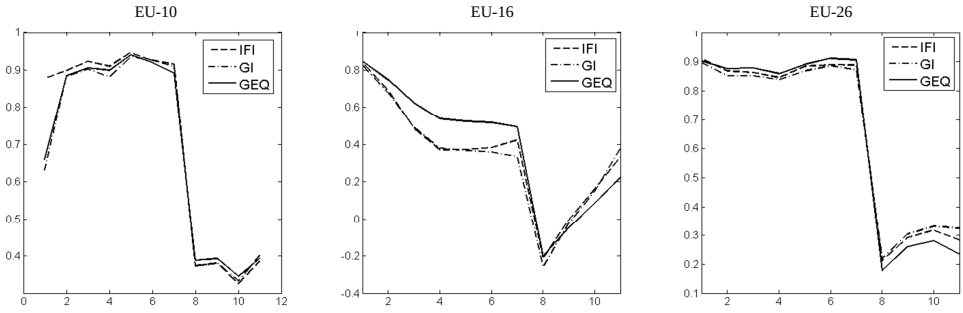
	1993 – 2002	**1994 – 2003**	**1995 – 2004**	**1996 – 2005**	**1997 – 2006**	**1998 – 2007**	**1999 – 2008**	**2000 – 2009**	**2001 – 2010**	**2002 – 2011**	**2003 – 2012**
	1	2	3	4	5	6	7	8	9	10	11
	Correlation coefficient, EU-10										
IFI	0.88 ***	0.90 ***	0.92 ***	0.91 ***	0.95 ***	0.93 ***	0.92 ***	0.37	0.38	0.33	0.39
GI	0.63 **	0.88 ***	0.90 ***	0.88 ***	0.94 ***	0.923 ***	0.91 ***	0.37	0.38	0.33	0.40
GEQ	0.66 **	0.89 ***	0.91 ***	0.90 ***	0.94 ***	0.92 ***	0.89 ***	0.39	0.39	0.35	0.39
	Correlation coefficient, EU-16										
IFI	0.84 ***	0.69 **	0.49	0.37	0.37	0.38	0.42	–0.21	–0.01	0.16	0.33
GI	0.83 ***	0.68 **	0.49	0.38	0.37	0.36	0.33	–0.26	–0.02	0.15	0.38
GEQ	0.85 ***	0.75 ***	0.62 *	0.54	0.52	0.52	0.49	–0.21	–0.05	0.09	0.22
	Correlation coefficient, EU-26										
IFI	0.91 ***	0.87 ***	0.86 ***	0.85 ***	0.88 ***	0.89 ***	0.89 ***	0.21	0.29	0.32	0.28
GI	0.90 ***	0.85 ***	0.85 ***	0.84 ***	0.87 ***	0.89 ***	0.87 ***	0.22	0.30	0.33	0.33
GEQ	0.90 ***	0.88 ***	0.88 ***	0.86 ***	0.89 ***	0.91 ***	0.91 ***	0.18	0.26	0.28	0.24

Note: Statistically significant dependence at 1% (***), 5% (**), 10% (*).

Source: Own calculation**.**

F i g u r e 2

Moving Correlation for EU-10 (a), EU-16 (b) and EU-26 (c)



Source: Own calculation.

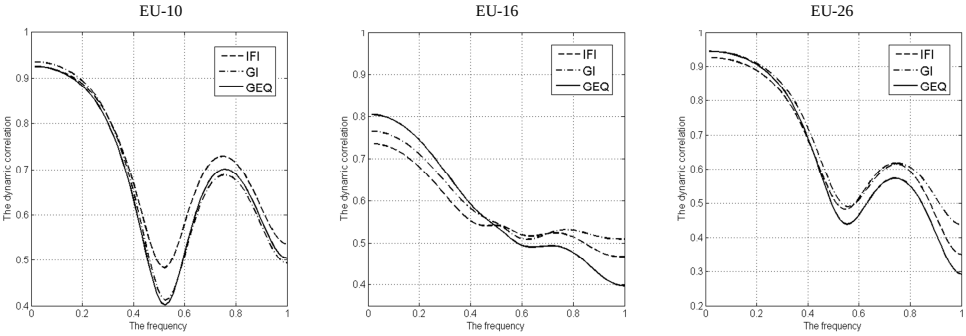
In Table 3 and Figure 2c, the results of moving correlation for the EU-26 countries are presented. Similarly to the results for the EU-10 countries, we can also see the statistically significant dependence for the EU-26 data till the year 2008 as well as a considerable drop in the level of moving correlation after 2008. The level and trend of correlation of the main financial integration coefficients of the EU-26 countries is similar during the analysed time period.

4.2. Dynamic Correlation

In the following step, we provide a detailed view of the structure of correlation via the dynamic correlation (eq. (1)). We present the development of dynamic correlation between *TRADE* and the selected indicators in relation to different frequencies in Figure 3a – c (*IFI, GI, GEQ*).

F i g u r e 3

Dynamic Correlation for EU-10 (a), EU-16 (b) and EU-26 (c)



Source: Own calculation.

In case of dependencies between *TRADE* and the selected financial integration indicators (Figure 3a – c), we can see the volatility of the dynamic correlation curve, which varies with respect to the frequencies. Different frequencies also mean different lengths of cyclical components (i.e. the lower the frequency of inputs the longer the cyclical component).

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 (2nd paragraph of the section „Moving and dynamic correlation"); the correlation varies between 0.7 and 0.98. In case of EU-10 and EU-26 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. Under 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 EU-10 and EU-26 countries (the correlation is varying between 0.5 and 0.7).

Comparing charts for moving correlations for the *IFI, GI, GEQ* indicators (Figure 2a – c), we can observe the structural break in 2008. As far as the dependency between *TRADE* and *IFI, GI, GEQ* in EU-16 is concerned, there is a high correlation of all indicators with the indicator *TRADE* in long cycles and business cycles in all three country groups.

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 (as to the frequency range 0.65 – 0.85 which corresponds to short cycles) show different results with respect to the region and indicator (the highest dynamic correlation in the EU-10 countries and the lowest in the EU-16 countries).

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 co-movement in some frequency range which can help us to perform an additional analysis such as the analysis of sources of movements in the indicators. However, this analysis is beyond of the scope of this article.

5. Wavelet Analysis Confirmation

For the support and confirmation of dynamic correlation results, we use the wavelet analysis which allows us to evaluate the time and frequency character of input time series as well as their common features. In wavelet transform, the time resolution is intrinsically adjusted to the frequency with the window width narrowing when focusing on high frequencies while widening when assessing low frequencies. It enables a more flexible approach in time series analysis. When the interest is more focused on frequency resolution, then suitable approach is time-varying autoregressive transform (Klejmová, 2015). From the family of mother wavelet functions, we use the Morlet wavelet (Gençay, Selçuk and Whitcher, 2001). The decision for Morlet wave selection was motivated by literature which generally employs just this type of mother wave such Rua (2010), Berdiev and Chang (2015) or Aquiar-Conraria and Soares (2011). The results are described below; we present charts for all indicators for EU-10 (Figure 4a – 6a), EU-16 (Figure 4b – 6b) and EU-26 (Figure 4c – 6c).

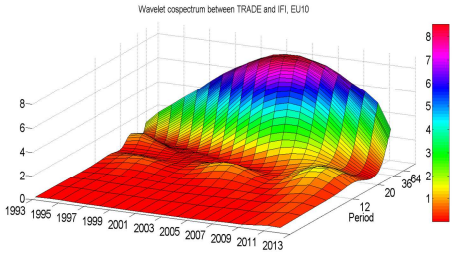
From the time-frequency perspectives, the co-movement between *TRADE* and all indicators measured by co-spectrum shows significant common features for long cycles (32 – 64 quarters); it occurs for both EU-16 and EU-26 in the same period (2000 – 2009). There are similar results in case of the EU-10 countries. The second area with common features (more/less weak) occurs in frequencies usually denoted as business cycle frequencies (between 18 and 32 quarters) in period 1993 – 1994 and partly in 1995 for all countries and indicators. In some cases – EU-16 (*IFI*) and EU-26 (*IFI*, *GI*, *GEQ*) in 2002 – 2003 – we can identify additional co-movement in business cycle frequencies. The last area with co-movement is examined in the middle cycles (12 – 20 quarters). In the EU-26 countries, the co-movement occurs in 2008 – 2010 for all three indicators. In the EU-16 countries, it occurs in the period 2008 – 2011 for *IFI* and in 2009 – 2010 for the other indicators. The EU-10 countries have different results for the three indicators; the co-movement is measured in 2008 – 2010 for *IFI*, in 2008 – 2011 for *GI* and in 2007 – 2011 for *GEQ*.

To sum it up, the dependence measured by the dynamic correlation was confirmed by the information obtained from the wavelet analysis. Comparing results from frequency domain and time-frequency domain, we can definitely confirm the existence of dependency and co-movement 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 co-movement between 18 – 30 quarters at the beginning of the time period (1993 – 1994) for all countries. Over time, we can find an additional business cycle co-movement between 12 – 20 quarters for all countries which occurs after the crisis in 2008 and ends mostly in 2010.

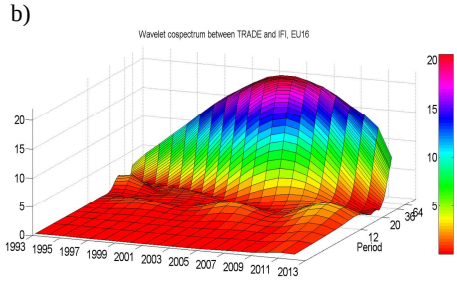
F i g u r e 4

Wavelet Co-spectrum EU-10 (a), EU-16 (b) and EU-26 (c) for TRADE and IFI

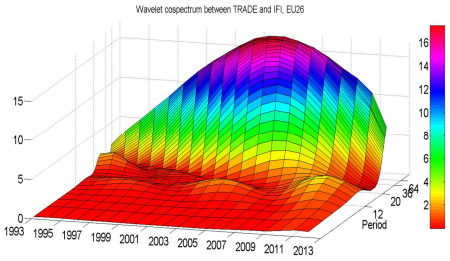
a)



b)



c)

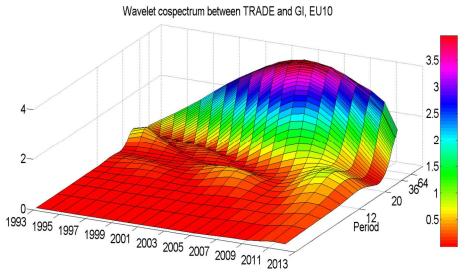


Source: Own calculation.

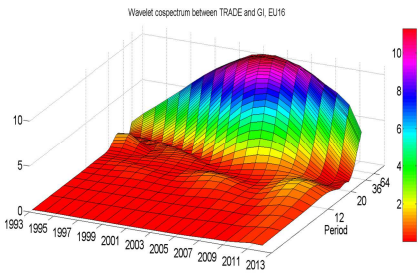
F i g u r e 5

Wavelet Co-spectrum EU-10 (a), EU-16 (b) and EU-26 (c) for TRADE and GI

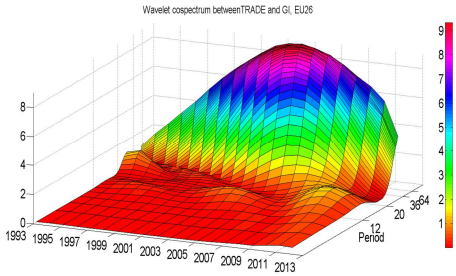
a)



b)



c)

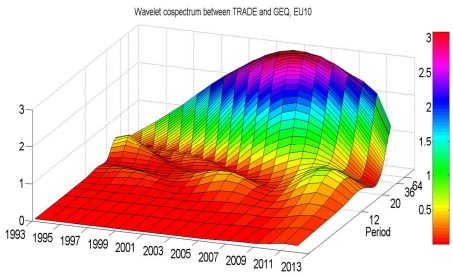


Source: Own calculation.

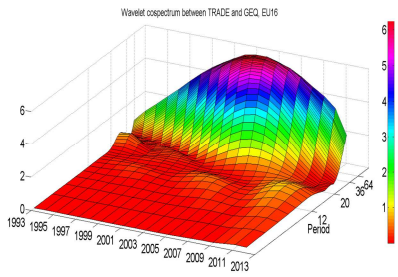
F i g u r e 6

Wavelet Co-spectrum EU-10 (a), EU-16 (b) and EU-26 (c) for TRADE and GEQ

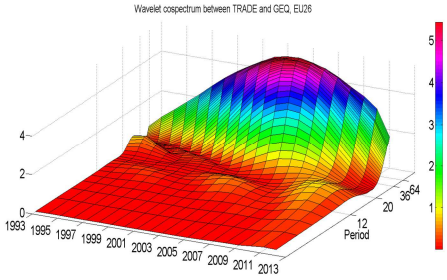
a)



b)



c)



Source: Own calculation.

Because the wavelet analysis allows the application on non-stationary data (Jiang and Mahadevan, 2011) and with respect to the short samples, we do not provide the detrending of inputs. The detrending or the use of appropriate filter technique is possible, but the small samples do not guarantee the noising of results. We can assume that the wavelet analysis applied on detrended data can provide better information about short cycles (under the level of 12 quarters), but in case of our sample size 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 financial and trade integration in the EU member countries over the period 1993 – 2012. The financial and trade integration has been deepening since the beginning of the analysed time period. While the process of financial integration was stronger in the EU-16 countries, the level of trade integration was higher in the EU-10 countries. This result is not surprising because the EU-10 countries are more open economies heavily dependent on exports particularly to the EU countries. Thus, these countries followed the line of more intense trade cooperation within the whole European

Union. Both integration processes were temporarily broken by the world financial crises and the resulting fall of overall economic activity; the process of financial integration was damaged in 2008 and the process of trade integration in 2009. However, the overall trend of trade integration was more stable compared to the trend of financial integration.

Then, we focused on the calculation of both static and dynamic correlation coefficients. Empirical analysis via static correlation showed a strong linear dependency between trade and financial integration for EU-26. The moving correlation revealed the statistically significant dependence till 2008 as well as a drop in the level of moving correlation after 2008 as a result of the financial crisis. The process of financial and trade integration within the EU-16 countries was more influenced by the crisis (the EU-10 countries). Nevertheless, the overall trend was similar in all EU countries. This finding confirmed our previous conclusions that the EU countries were synchronised as far as financial and trade activities were concerned.

Additional analysis in frequency domain revealed high dynamic correlation of all indicators in all countries for long and medium cycles of the length from 18 quarters till 20 years (including business cycle frequencies of the length from 18 to 32 quarters) and for short cycles of the length 2.5 – 3 quarters and also the existence of a severe structural break in 2008. The comparison of all country groups from the dynamic correlation perspectives showed that the EU-16 countries achieved lower level of correlation of both processes compared to the EU-10 and EU-26 countries. The dynamic correlation curves of the EU-16 countries had lower volatility then the same curves of the EU-10 and EU-26 countries. At the same time, the dependency measured by the dynamic correlation for the EU-16 countries in low frequencies (short cycles) was slightly weaker. Under frequencies higher than 0.5 (to the *x*-axis ranges between 0.65 – 0.85), the dynamic correlation is higher particularly in the EU-10 countries (compared to EU-16 countries).

In the last step, we used the wavelet analysis which is ready to evaluate the time and frequency character of input time series as well as their common features in order to verify our previous results. The wavelet analysis confirmed the existence of the area with common features in the middle cycles (12 – 20 quarters) in 2008 – 2010 and in the business cycle frequencies (between 18 and 32 quarters) in period 1993 – 1994 and partly in 1995. In case of middle cycles, the co-movement in the EU-10 countries (compared to the EU-16 countries) was more evident using the GE and GEQ indicator after the crisis, i.e. there was a stronger co-movement of trade and foreign direct and portfolio investments. However, the analysis also showed additional area of co-movement, i.e. the existence of dependency and co-movement for long cycles (over 32 quarters) covering the period

2000 – 2009. These results detected the existence of strong dependency of the EU countries in the area of financial and trade cooperation and the significant role of future mutual cooperation of these countries.

These findings support the idea of a single currency in this group of 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. Our results conform to the results of Schiavo (2008), Aviat and Coeurdacier (2007), Kučerová (2009), Kučerová and Poměnková (2013) or Poměnková and Kučerová (2014). Furthermore, we can observe two important co-movement areas. The first was at the beginning of the analysed time period (1993 – 1994) when the EU-10 countries initiated the process of transformation from centrally planned to market economies. And the second was observed generally after the crisis in 2008 (ended mostly in 2010). These results allow us to state that the economies of analysed countries have reacted to the financial crisis in the same way as far as financial and trade integration processes are concerned. Again, this finding is certainly in favour of a common monetary policy in analysed countries.

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