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Does stock market capitalization cause GDP? A causality study for Central and Eastern European countries

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Abstract
This paper analyses the relationship between stock market capitalization and real GDP in ten Central and Eastern European countries (CEECs) that joined the European Union in 2004 and 2007, with the objective of determining if the financial markets have played a role as a driver of the economic development in these countries or vice versa. The methodology is based on the application of three different measures of causality between the relevant variables, in order to determine the existence and the direction of causality. Using a cointegrated Vector Autoregressive model (VAR), the authors study the relationship between the relevant variables through the following tests: Granger causality test, Toda-Yamamoto approach and Frequency Domain approach. The results obtained suggest evidence of the existence of this relationship, in both directions, in a significant number of this group of countries, and especially in those there is a long-term relationship.

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Keywords Stock market development; economic growth; Granger causality; Toda-Yamamoto; Frequency Domain

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1. Introduction

The possibility of the financial sector affects and stimulates the real and productive sector of an economy, and its growth, generates a wide debate. As Levine (1997) points out, economic growth could be affected through the functions of financial markets by the channels of capital accumulation and technological innovation. Therefore, the analysis of the relationship between financial and economic variables arouses great interest in empirical literature (King and Levine, 1993; Levine and Zervos, 1998).

Among the different financial markets, the stock market is very relevant because of the the liquidity, the important capital inflows it channels and the useful source of information for investors (Wachtel, 2003). Stock market development could therefore potentially contribute to economic growth (Caporale et al., 2004; Caporale and Spagnolo, 2012; Levine and Zervos, 1996) and an economic policy objective in itself. The role of securities markets (including stock markets) in the financial system, and the role of banks generate debate around which side stimulates more economic growth, with two sides: *market based* and *bank based*.

In emerging Europe, the stock market is the most developed market segment (Iorgova and Ong, 2008). In this context, the transition economies, and in particular the Central and Eastern European countries (CEECs) integrated into the European Union (EU) in 2004 (Czech Republic, Hungary, Poland, Estonia, Latvia, Lithuania, Slovenia and Slovakia) and in 2007 (Bulgaria and Romania), could be an interesting case study. These former communist economies have had to develop an important transition process to become market economies. After the fall of the Berlin Wall, in 1989, and until the mid-1990s, most CEECs began to open their stock markets and resume stock market activity interrupted during the communist era. The emergence of different stock markets was closely related to privatization, where property rights were assigned to citizens. In Bulgaria, Romania, Slovakia, the Czech Republic among others, the stock market grew suddenly due to the mandatory mass listing inclusion of mass privatization programs. As expected, there were a lot of liquidity problems. In Poland and Hungary among others, an IPO (Initial Public Offering) process was followed; they were smaller in number and more likely to have some activity (Bonin and Wachtel, 2003). The three main countries in the Central and Eastern European region: Poland, Hungary and the Czech Republic have the most developed stock market, as well as relatively higher liquidity (Iorgova and Ong, 2008). In addition, foreign-held shares represent a substantial part of the total in these countries, especially in Hungary (Bonin and Wachtel, 2003).

The Ljubljana (Slovenia) stock exchange was the first to open its market in 1989, followed by Budapest (Hungary) in 1990; in 1991, Bratislava (Slovakia), Warsaw (Poland) and Bulgaria; in 1993, Prague (Czech Republic) and Vilnius (Lithuania); in 1995, Riga (Latvia) and Bucharest (Romania); and finally, Tallinn (Estonia) in 1996. This liberalisation process was subsequently encouraged by the process of European integration, generating a double expansive impulse. On the one hand, since the implementation of their transition, the CEECs have experienced significant rates of economic growth and convergence with the rest of the EU members and, on the other, their stock markets have been transformed (Annex 1), despite the fact that after the onset of the economic and financial crisis in 2008 they were affected in one way or another.

The aim of this paper is the analysis of the causal relationship between stock market capitalization to GDP (variable denoting stock market development) and real GDP (variable that measures economic growth) using a Vector Autoregressive model (VAR) in ten Central and Eastern European countries (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia). The analysis has been carried out with the highest number of observations available for each country, ranging from 1995 to 2017.

The main contribution of this paper is the use of the analysis of three different causality measures (Granger causality test, Frequency Domain approach and Toda-Yamamoto approach), for the study of the relationship between stock market development and economic growth of the CEECs, which has not been previously carried out in the empirical literature for all these countries. Other studies, such as Caporale and Spagnolo (2012) and Pece (2015), use a single method to study causality, making their results less robust. The results will show whether the stock market has played an important role in the economic growth of the CEECs. Logically, the stock market is expected to have made an important contribution to the economic growth of these countries. The result could be important for policymakers and regulators in order to facilitate this important issue.

This paper is structured as follows. Section 2 discusses the literature review. Section 3 explains the methodology and presents the data. In section 4, the empirical analysis is carried out and the results of the empirical model are presented. Finally, section 5 concludes the paper.

2. Literature Review

The relationship between economic growth and financial development has been a topic that is widely researched in economic debate. It is very important for policy makers the possible role of financial system for economic growth, and how the functions of financial system are linked to economic growth.

Goldsmith (1969) was one of the first authors to empirically demonstrate the implication between financial development and economic growth, using the value of assets intermediated as a percentage of GDP as a proxy for financial development. King and Levine (1993) found, using a sample of 80 countries from 1960 to 1989, that development of financial sector have a strong correlation with economic growth, the rate of physical capital accumulation and improvements in the efficiency of capital allocation. Furthermore, financial development is a good predictor of long-term growth; in countries with high levels of financial development, they found that economic growth tends to be relatively fast, specifically over the next 10 to 30 years.

There is a wide debate in the literature as to whether *bank-based* financial systems stimulate economic growth more than *market-based* financial systems and vice versa (Levine, 2002; Levine, 2005; Demirgüç-Kunt and Levine, 2001). On the other hand, there are authors who maintain that the two aspects of the financial system, *bank-based* and *market-based*, are complementary and both contribute to economic growth. Levine and Zervos (1998) suggested that at the same time, bank development and stock market development are good predictors of economic growth, capital accumulation and productivity growth, in a sample of 47 countries from 1976 until 1993.

In the context of intervened economies, any of the above disquisitions is useless because of government intervention, including financial areas. In particular, for financial markets, that implies a restriction on the mobilization of savings, investment and economic growth (McKinnon, 1973; Shaw, 1973). These authors developed the well-known *Hypothesis of Financial Liberalization* according to which the financial system must be liberalized and financing must be determined by the free play of the market[1]. This hypothesis was later criticized by the Asymmetric Information Theory (Stiglitz and Weiss, 1981) and fundamentally by King and Levine (1993) that manifested the existence of two ways by which causality exists between economic growth and the financial development of a country. On the one hand, a country with the financial development of its stock markets can stimulate and promote economic growth and this, in turn, will create greater demand for financial services. If, on the other hand, financial institutions respond effectively to that demand, economic change is assured. From this point of view, both financial development and economic growth are interdependent and their relationship generates causal feedback.

The relationship between stock market development and economic growth has been studied empirically by many authors. Levine and Zervos (1996) showed that stock market development is positively associated with long-run economic growth using data of 41 countries over the period 1976-1993 in cross-country instrumental variables estimation. Economic growth is measured by real per capita growth. Stock market development is measured by indicators of size, liquidity and risk diversification. In a later study, Levine and Zervos (1998), using cross-country data for 47 countries from 1976 to 1993, found that measures of stock market liquidity (turnover and value traded) and measures of banking development (bank credit) predict futures rates of economic growth, capital accumulation and productivity growth.

Mauro (2003) found a positive correlation between economic growth (measured by output growth) and stock returns (obtained as the difference between nominal stock returns and consumer price inflation) in five out of eight emerging countries and ten out of 17 advanced countries, with at least 20 observations and individual-countries regressions. Therefore, the result is stronger in developing countries. Caporale et al. (2004) obtained from a sample of seven countries (Argentina, Chile, Greece, Korea, Malaysia, Philippines and Portugal), over the period 1977-1998 and estimating a Vector Autoregressive model (VAR), evidence of a robust relationship between stock market development (measured by capitalization to GDP and the value of listed shares to GDP) and economic growth (measured by GDP in levels).

There is also a long list of empirical studies that focus on the analysis of the relationship between the stock market and economic growth in specific countries as for example Adamopoulos (2010) in Germany; Hondroyiannis et al. (2005) in Greece; Ndako (2010) in

[1] For an in-depth review of the Financial Liberalization Theory see Gemech and Struthers (2003).

South Africa; Marques et al. (2013) in Portugal; and in Asia, Pan and Mishra (2017) in China, and Ibrahim (2011) in Thailand.

The empirical evidence of the relationship between the stock market and economic growth for the CEECs is not entirely clarifying, perhaps because of the short time horizon of these countries in a market economy system. For example, Caporale and Spagnolo (2012) analysed the relationship between the volatility of stock returns (stock index differences) and economic growth in three CEECs countries (Czech Republic, Hungary and Poland) in a VAR-GARCH framework between 1996 and 2011. The results suggested that there is a one-way causality ranging from stock markets to growth at levels, and that this link becomes stronger after EU accession. Pece (2015) concluded that there is a two-way link between economic growth and stock performance (BET Index) in Romania in the period 2000-2013. In contrast, Caporale et al. (2015) suggested by estimating a dynamic panel model, stock market capitalization in the CEE-5 (Czech Republic, Hungary, Poland, Slovakia and Slovenia) has a positive and small effect on economic growth; and for Baltic countries, Bulgaria and Romania stock market capitalization has a positive but insignificant effect. The authors commented that in the CEE-5, the stock market expanded more rapidly due to privatisation and foreign investors. Despite this, the contribution of these markets is limited because they are relatively underdeveloped. Cojocaru et al. (2016) concluded for 10 CIS (Commonwealth of Independent States) and 15 European Union countries, that the efficiency of the financial system and competitiveness is more important than the amount of credits to the private sector provided by banks.

3. Methodology and model specification

3.1 Data

The relevant variables used are stock market capitalization to GDP, as a proxy for stock market development, and real GDP (in chain- linked volumes) as a proxy for economic growth. Real GDP growth is a main objective for economic and political institutions and an objective in itself within the framework of economic policy, since the concept of GDP growth is often associated with a country's prosperity and well-being and is also used in virtually all empirical research as a fundamental variable in causal relationships. Stock market capitalization is a measure commonly used to quantify stock market size (as in Azam et al., 2016; Ake and Ognaligui, 2010).

The countries under study are: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. Market capitalization data for all countries are obtained from the World Bank (*World Development Indicators Database*) and Federal Reserve Bank of St. Louis (*FRED Economic Data*). Real GDP data are obtained from Eurostat (*Quarterly National Accounts Database*). The variables are defined in table 1. Table 2 specifies the frequency of the data, in the range from 1995 to 2017, depending on the data available for each country from the sources consulted. A temporal disaggregation of low frequency (annual) to high frequency (quarterly) is performed for the stock market capitalization through the method of Chow and Lin (1971), which finds the best unbiased linear estimator of the series used. The frequency of data for GDP is quarterly.

Table 1. Definition of variables

Variable	Definition
Market capitalization to GDP (CAP)	Total value of all shares traded on the stock market as a percentage of GDP Annual variable. It is transformed to quarterly by the method of Chow and Lin
Real GDP (GDP)	Chain-linked volumes, 2010=100 Seasonally and calendar adjusted data except for Slovakia (seasonally adjusted data, not calendar adjusted data) Quarterly variable

Table 2. Frequency of data

Country	GDP 2010=100 quarterly	CAP yearly	Range after transformations
Bulgaria	95:1 - 18:2	93 - 12	95:1 - 17:4
Czech Republic	96:1 - 18:2	93 - 12	96:1 - 12:4
Estonia	95:1 - 18:2	98 - 12	98:4 - 12:4
Latvia	95:1 - 18:2	96 - 12	96:4 - 12:4
Lithuania	95:1 - 18:2	96 - 12	96:4 - 12:4
Hungary	95:1 - 18:2	92 - 17	95:1 - 17:4
Poland	95:1 - 18:2	92 - 17	95:1 - 17:4
Romania	95:1 - 18:2	95 - 11	95:4 - 11:4
Slovenia	95:1 - 18:2	95 - 17	95:4 - 17:4
Slovakia	95:1 - 18:2	93 - 13	95:1 - 13:4

3.2 Methodology

To analyze the causality relationship between financial and economic variables in the model, we use three different causality measures: Granger, Frequency Domain and Toda-Yamamoto. Specifically, we seek to find evidence of the relationship between stock market capitalization to GDP with the real GDP, in both directions and for each country. The results of these three measures will be used to demonstrate a causality relationship in a robust manner.

The first causality approach is Granger causality. According to Granger (1969), X causes Y, if X's past values improve the estimate of Y, that simply by using Y's past values. It is therefore a concept that is based on predictability, that is, the ability of one variable to help predict another.

The null hypotheses in Granger causality tests are specified in each direction in the following form:

H_a: GDP $\not\rightarrow$ CAP
Real GDP does not cause Granger to market capitalization

H_b: CAP $\not\rightarrow$ GDP
Market capitalization does not cause Granger to real GDP

The rejection of the null hypothesis leads to the verification of the existence of this relationship between the variables involved.

The model to be specified and estimated is a Vector Autoregressive model VAR, as in Nguyen and Pham (2014). In the application to the variables, the VAR model would have the following form, where the variables are endogenous:

$$GDP_t = \mu_0 + \sum_{i=1}^{n} \alpha_i GDP_{t-i} + \sum_{i=1}^{n} \beta_i CAP_{t-i} + u_{1t} \ (1)$$

$$CAP_t = \delta_0 + \sum_{i=1}^{n} \lambda_i CAP_{t-i} + \sum_{i=1}^{n} \delta_i GDP_{t-i} + u_{2t} \ (2)$$

The second causality measure is the Frequency Domain approach. A spectral causality test is proposed (Breitung and Candelon, 2006), where causality relationships are broken down into the frequency spectrum that can be attributed to causality relationships in the short, medium and long-term. Therefore, this approach provides the temporal vision of causality. Tiwari et al. (2015) used specifically this methodology in India. Croux and Reusens (2013) found for the G-7 countries between 1991 and 2010, that slowly fluctuating components of the stock prices (components with a periodicity larger or equal to one year) have predictive power for the future GDP, while quickly fluctuating components do not have.

As Gomez-Gonzalez et al. (2015) indicated, the spectral function of each variable is estimated first, then, cycles are extracted using Fourier analysis. Finally, the co-movement between cycles is estimated by using the cross-spectral density function, and its related coherence measures. Breitung and Candelon (2006) explained that:

Let $Z_t = [x_t, y_t]'$ be a two-dimensional vector of time series observed a $t = 1, 2 \ldots T$, Z_t represents a finite-order VAR of the following type:

$$\Theta(L) Z_t = \varepsilon_t \ (3)$$

Where $\Theta(L) = I - \Theta_1 L - \cdots - \Theta_p L_p$ is a 2×2 lag polynomial with$L^k Z_t = Z_{t-k}$. The error vector ε_t is white noise with $E(\varepsilon_t) = 0$ and $E(\varepsilon_t \, \varepsilon_t') = \Sigma$ where Σ is positive. G is the lower triangular matrix of the Cholesky decomposition $G'G = \Sigma^{-1}$. The moving average representation of the system (which is assumed to be stationary) is:

$$Z_t = \phi(L)\varepsilon_t = \begin{bmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} = \psi(L)\eta_t \begin{bmatrix} \psi_{11}(L) & \psi_{12}(L) \\ \psi_{21}(L) & \psi_{22}(L) \end{bmatrix} \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \end{bmatrix} (4)$$

Where $\phi(L) = \Theta L^{-1}$ and $\psi(L) = \phi(L) G^{-1}$. The spectral density of x_t can be expressed:

$$f_x(\omega) = \frac{1}{2\Pi} \left\{ \left|\psi_{11}(e^{-i\omega})\right|^2 + \left|\psi_{12}(e^{-i\omega})\right|^2 \right\} (5)$$

Causality is defined as (Geweke, 1982; Hosoya, 1991):

$$M_{y\to x}(\omega) = \log\left[1 + \frac{|\psi_{12}(e^{-i\omega})|^2}{|\psi_{11}(e^{-i\omega})^2|}\right] (6)$$

If $|\psi_{12}(e^{-i\omega})| = 0$ means that and y does not cause a x in the frequency (ω). Therefore, to test that y does not cause a x in frequency (ω), the null hypothesis is:

$$H_0 = M_{y\to x}(\omega) = 0 \; (7)$$

The complete frequency range is from 0 to Π. The frequency ω is equal to 2Π/cycle duration (T), therefore values of ω near zero correspond to long-term cycles, while values of ω near Π correspond to short-term cycles.

And finally, we analyze Toda and Yamamoto approach (1995). These authors step forward with Granger causality approach and use the modified Wald test (MWALD), based on a VAR(k + d_{max}) model where k is the optimal order of system lags, and d_{max} is the maximum order of model integration. This approach includes an additional lag to take into account the non-stationarity of the time series, the number of additional lags is based on the order of integration of the time series. The VAR can be applied in non-stationary series. Saafi et al. (2016) used this approach to analyse causality between financial integration and economic growth for a group of 19 developing and developed countries, as well as Andersson et al. (2016) analysed causality between the banking sector and Chinese economic growth from the Toda-Yamamoto approach. Caporale et al. (2004) also used this approach when studying the relationship between stock market development and economic growth for Argentina, Chile, Greece, Korea, Malaysia, the Philippines and Portugal during the period 1977-1998 and estimating a Vector Autoregressive model (VAR).

In the application to the variables and in accordance with the approach of Toda and Yamamoto, the VAR model would have the following form:

$$GDP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} GDP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \alpha_{2j} GDP_{t-j} + \sum_{i=1}^{k} \beta_{1i} CAP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \beta_{2j} CAP_{t-j} + u_{2t} \; (8)$$

$$CAP_t = \delta_0 + \sum_{i=1}^{k} \delta_{1i} CAP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \delta_{2j} CAP_{t-j} + \sum_{i=1}^{k} \gamma_{1i} GDP_{t-i} + \sum_{j=k+1}^{k+d_{max}} \gamma_{2j} GDP_{t-j} + u_{1t} \; (9)$$

4. Empirical analysis and results

The first step for empirical study involves testing for unit root in time series. The series should not have a unit root for both Granger causality and Frequency Domain causality, i.e. they should be I(0) or stationary, whereas in the Toda-Yamamoto approach is not a necessary condition.

First of all, the time series are transformed into logarithms due its exponential behaviour. Then, the presence of unitary roots is analyzed by means of the Phillips-Perron test (1988) where the null hypothesis is the existence of a unit root, or I(1). The results indicate (presented in Annex 2) that market capitalization and GDP are I(1) in all countries. For Poland and Hungary, the stationarity of capitalization is also tested with the KPSS test (1992). For these countries, capitalization to GDP does not have a linear trend, so the results could be confusing applying a trend. The graph shows for these countries, that capitalization to GDP could be I(1). The KPSS test results show that capitalization to GDP is not stationary, that is why another test is used. Therefore, the series are differentiated to correct the presence of a unit root, as well as in first differences to verify that the order of integration is 1.

Secondly, the presence of cointegration is studied (Annex 3). For there to be cointegration, there must be I(d) of order d in the variables. Cointegration indicates the existence of long-term relationships between the different variables of the model. Cointegration exists when given two (or more) non stationary series; there is a linear combination between them that is stationary. The Johansen method (1995) has been used to verify cointegration. We show that there are cointegration ratios (1-1) between the two variables for Bulgaria, Hungary, Latvia, Romania, Slovakia and Slovenia, whereas does not exist in Czech Republic, Estonia, Lithuania and Poland.

The second step, once the stationarity and cointegration of the series have been analysed, is studying causality from the different approaches.

For Granger causality, the models established in equations (1) and (2) are estimated with an unrestricted VAR if the series do not cointegrate. If they cointegrate, it is estimated with an Error Correction Model (ECM). Once the model has been estimated, Granger causality test is carried out from them. Granger causality is sensitive to the number of lags included, and they have been selected by using Akaike Information Criteria (AIC) and Schwartz Information Criteria (SIC). The selected VAR models are shown extensively in Annex 4 and summarised in Table 3. For Granger casusality, the optimum lag is obtained with the series in differences, and for Toda-Yamamoto approach it is not necessary.

Table 3. Optimum VAR lag

Country	For Granger causality	For Toda-Yamamoto approach	Country	For Granger causality	For Toda-Yamamoto approach
Bulgaria	6	6	Lithuania	1	2
Czech Republic	5	6	Poland	1	2
Estonia	5	5	Romania	2	2
Hungary	2	2	Slovakia	2	2
Latvia	3	3	Slovenia	2	2

Granger causality results are shown in table 4. The results reveal Granger causality from real GDP to stock market capitalization in Bulgaria, Estonia and Slovenia. In the opposite direction, the results reveal Granger causality from market capitalization to real GDP in six countries: Bulgaria, Czech Republic, Latvia, Lithuania, Poland and Slovakia.

Table 4. Granger Causality Test

Country		GDP does not cause CAP	CAP does not cause GDP
Bulgaria	Chi-sq	71.54587	32.67190
	Lags	6	6
	Prob	0.0000*	0.0000*
Czech Republic	Chi-sq	2.214748	25.55086
	Lags	5	5
	Prob	0.8187	0.0001*
Estonia	Chi-sq	13.50423	2.799691
	Lags	5	5
	Prob	0.0191**	0.7308
Hungary	Chi-sq	0.093006	4.429123
	Lags	2	2
	Prob	0.9546	0.1092
Latvia	Chi-sq	1.173336	8.990155
	Lags	3	3
	Prob	0.7594	0.0294**
Lithuania	Chi-sq	0.031587	10.11122
	Lags	1	1
	Prob	0.8589	0.0015*
Poland	Chi-sq	0.152508	6.843598
	Lags	1	1
	Prob	0.6962	0.0089*
Romania	Chi-sq	0.831612	0.049580
	Lags	2	2
	Prob	0.6598	0.9755
Slovakia	Chi-sq	0.380414	10.84742
	Lags	2	2
	Prob	0.8268	0.0044*
Slovenia	Chi-sq	7.481536	1.439342
	Lags	2	2
	Prob	0.0237**	0.4869

Note
*, **, *** show that the null hypothesis is rejected with a significance level of 1%, 5%, 10% respectively

The causality from the Frequency Domain approach is represented in table 5, where in the abscissa axis the frequency (ω) is represented, which is equal to 2Π/cycle duration (T). The probability is shown on the ordinate axis. Transforming the previous function with respect to time would remain:

$$\text{Cycle duration (T)} = \frac{2\Pi}{\omega} \quad (10)$$

Therefore, ω close to zero values correspond to long-term cycles, while close to Π correspond to short-term cycles. For example if ω=2.4, time=2.244; that would be approximately the short-term limit. For the interpretation of results, short-term is considered less than two years; medium-term, between two and five years; and long-term, from five years. In table 5, the countries shown are those where the angular frequency ω is significant (at a significance level of 5%) and their correspondence in years. Annex 5 shows the results in graphs form.

Table 5. Causality from the Frequency Domain approach

	GDP does not cause CAP		CAP does not cause GDP	
	Angular frequency (ω)	Time range (years)	Angular frequency (ω)	Time range (years)
Bulgaria	0.0827 to 0.3307 0.6614 to 1.4881 2.0668 to 3.0589	76.0005 - 19.0000 9.5000 - 4.2222 3.0400 - 2.0541	1.1574 to 1.4054 1.8188 to 1.9015 2.8109 to 3.0589	5.4286 - 4.4706 3.4545 - 3.3043 2.2353 - 2.0541
Czech Republic			0.6614 to 0.9094	9.4998 - 6.9092
Estonia	0.5610 to 2.1318 3.0294	11.200 - 2.9474 2.0741		
Hungary	0.2762 to 0.7595 0.8976 to 1.2428 2.6237 to 2.8999	22.750 - 8.2727 7.0000 - 5.0556 2.3947 - 2.1667	0.0690 to 0.8286	91.0000 - 7.5833
Latvia			0.0982 to 0.2945	63.9999 - 21.3334
Lithuania	0.7854 to 0.9817	8.0000 - 6.4000	0.0982	63.9999
Slovakia			0.0785 to 0.5498 1.8850 to 2.5918	79.9998 - 11.4286 3.3333 - 2.4242
Slovenia	0.6426 to 1.2852	9.7778 - 4.8889	0.4284 to 1.4994 2.9274 to 3.0702	14.6666 - 4.1905 2.1463 - 2.0465

For the causal relationship of real GDP to stock market capitalization the evidence is in the medium and long-term for Bulgaria, Estonia and Hungary; and for the medium-term in Lithuania and Slovenia. For the causal relationship of stock market capitalization to real GDP, it is evident in the medium-term in Bulgaria and Czech Republic. In Hungary, Slovakia and Slovenia it is evident in the medium and long-term; and in Latvia and Lithuania in the long-term. Comparing with Granger causality, these results are similar in Bulgaria (GDP to CAP, and CAP to GDP); Estonia and Slovenia (GDP to CAP); and Czech Republic, Latvia, Lithuania and Slovakia (CAP to GDP).

For causality from the Toda-Yamamoto approach, we estimate the VAR models established in equations (8) and (9) and causality tests are performed from them. We employ Akaike Information Criteria (AIC) and Schwartz Information Criteria (SIC) to find the optimal number of lags (table 3 and annex 4).

Table 6. Causality from the Toda-Yamamoto approach

Country		GDP does not cause CAP	CAP does not cause GDP
Bulgaria	Chi-sq	72.07504	31.20633
	Lags	6	6
	Prob	0.0000*	0.0000*
Czech Republic	Chi-sq	2.934159	26.74237
	Lags	6	6
	Prob	0.8171	0.0002*
Estonia	Chi-sq	11.29194	5.126207
	Lags	5	5
	Prob	0.0459**	0.4007
Hungary	Chi-sq	0.075906	3.343927
	Lags	2	2
	Prob	0.9628	0.1879
Latvia	Chi-sq	1.201362	2.076302
	Lags	3	3
	Prob	0.5632	0.9176
Lithuania	Chi-sq	0.195098	6.241992
	Lags	2	2
	Prob	0.9071	0.0441**
Poland	Chi-sq	0.462088	6.507404
	Lags	2	2
	Prob	0.7937	0.0386**
Romania	Chi-sq	0.950735	2.908125
	Lags	2	2
	Prob	0.6217	0.2336
Slovakia	Chi-sq	1.164178	10.27040
	Lags	2	2
	Prob	0.5587	0.0059*
Slovenia	Chi-sq	6.392230	1.337711
	Lags	2	2
	Prob	0.0409**	0.5123

Note
*, **, *** show that the null hypothesis is rejected with a significance level of 1%, 5%, 10% respectively

The results of causality from Toda-Yamamoto approach are shown in table 6. The results reveal causality from real GDP to stock market capitalization in Bulgaria, Estonia and Slovenia. In the opposite direction, stock market capitalization causes to real GDP in five countries: Bulgaria, Czech Republic, Lithuania, Poland and Slovakia.

According to the results, there is evidence of bi-directional causality in all three approaches and in both directions in a considerable number of countries (table 7). Except in Bulgaria, the countries where causal relationships existed joined in 2004. In the three most developed countries there are causal relationships from stock market capitalization to economic growth: in Poland and Czech Republic from Toda-Yamamoto approach and Granger causality; in Czech Republic and Hungary from the Frequency Domain approach. Also noteworthy is the case of Estonia, Lithuania and Latvia, that are countries with a common pattern (comprise the Baltic Republics). In Lithuania and Latvia, Granger causality is from stock market capitalization to real GDP, whereas in Estonia Granger causality is from real GDP to stock market capitalization, similar to Toda-Yamamoto approach. For these countries causality from the Toda-Yamamoto approach exists too, from stock market capitalization to real GDP in Lithuania, and from real GDP to stock market capitalization in

Estonia. In Bulgaria, causality exist in all directions and approaches, whereas in Romania has no causal relationship.

Table 7. Summary of results

		Granger	Toda- Yamamoto	Frequency Domain	Cointegration
Bulgaria	CAP to GDP	*	*	Medium-term	*
	GDP to CAP	*	*	Medium and long-term	
Czech Republic	CAP to GDP	*	*	Medium-term	
	GDP to CAP				
Estonia	CAP to GDP				
	GDP to CAP	*	*	Medium and long-term	
Hungary	CAP to GDP			Medium and long-term	*
	GDP to CAP			Medium and long-term	
Latvia	CAP to GDP	*		Long-term	*
	GDP to CAP				
Lithuania	CAP to GDP	*	*	Long-term	
	GDP to CAP			Medium-term	
Poland	CAP to GDP	*	*		
	GDP to CAP				
Romania	CAP to GDP				*
	GDP to CAP				
Slovakia	CAP to GDP	*	*	Medium and long-term	*
	GDP to CAP				
Slovenia	CAP to GDP			Medium and long-term	*
	GDP to CAP	*	*	Medium-term	

The causality analysis from Frequency Domain approach shows the significance in a time horizon (medium and long-term), and especially in those countries where there is cointegration, i.e. a long-term relationship between the variables: Bulgaria, Hungary, Latvia, Slovakia and Slovenia. Hungary is one of the countries with the most developed stock market, as well as the largest foreign ownership of shares (Bonin and Watchel, 2003).

Therefore, the importance of stock market size in the early stages of transition for these emerging countries (CEECs), and how stock market development could catalyse economic growth should be considered, since there is a link between this variables, in accordance with Caporale and Spagnolo (2012) and Pece (2015) for CEECs; but also for other developing countries, such as Asian countries (Azam et al., 2016) and African countries (Ndako, 2010). It would be interesting to delve into other aspects to better understand this relationship that is being studied. Some of these aspects could be other economic and legal issues that influence market capitalization: the protection of shareholders and the size of the assets of institutional investors (Claessens et al., 2000).

5. Conclusions

The aim of this paper is to study the link between economic growth and stock market in ten Central and Eastern European (CEECs) countries ranging from 1995 to 2017, which joined the European Union in 2004 (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia) and 2007 (Bulgaria and Romania). We investigate this relationship through the study of three different approaches of causality (Granger, Frequency Domain and Toda-Yamamoto).

These former communist economies have developed an important transition process to become market economies. Therefore, we intent to analyze the direction of causality and we try to demonstrate if stock markets could be a catalyst for economic growth in these countries. The variables involved in the model are: stock market capitalization to GDP, as a variable indicative of stock market development, and as an economic variable, real GDP in chain-linked volumes. We empirically study whether variables that denote stock market development cause economic growth, and whether variables that denote economic growth cause stock market development. The results behind the different causality approaches show support for the relationship between stock market development and GDP growth, with a two-way causality link. This relationship more robust exists in those countries where there is a long-term relationship (cointegration): in Bulgaria, Hungary, Latvia, Slovakia and Slovenia.

Therefore, the potential contribution of stock market development to economic growth must be taken into consideration in these countries. In this context, policymakers should encourage stock market development as a potential way to economic growth, where there is a transfer of resources from the financial to the productive sector; as well as undertake legal reforms to increase transparency and efficiency in these markets.

The European Stock Exchanges Federation (2014) proposes an Action Plan for European Capital Markets. It suggests more financing for businesses through capital markets, which will help Europe achieve more and better levels of innovation, mobilisation of savings, distribution of wealth, risk management and job creation. It also suggests actions by policy makers and regulators to reduce the costs of financing through the stock market and to be able to provide capital and profitability to all companies, especially those most affected by the crisis: SMEs.

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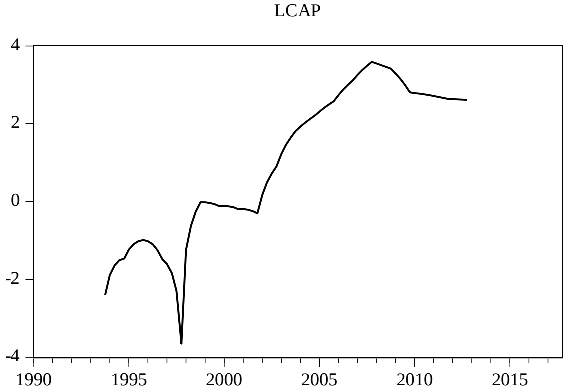
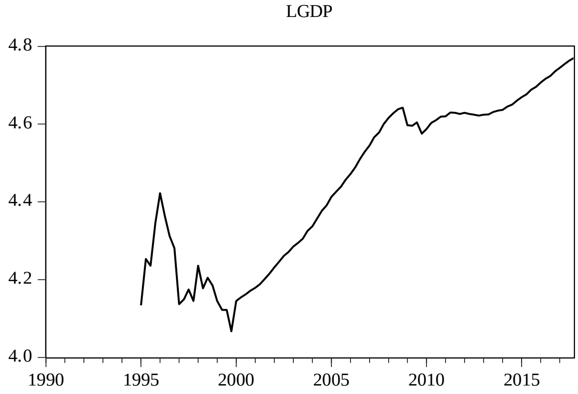
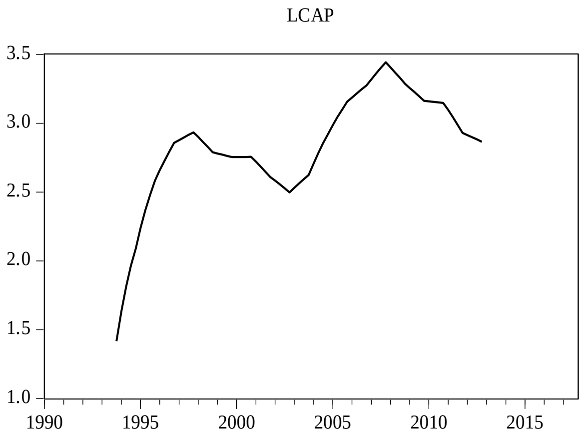
Annex 1: country graphs

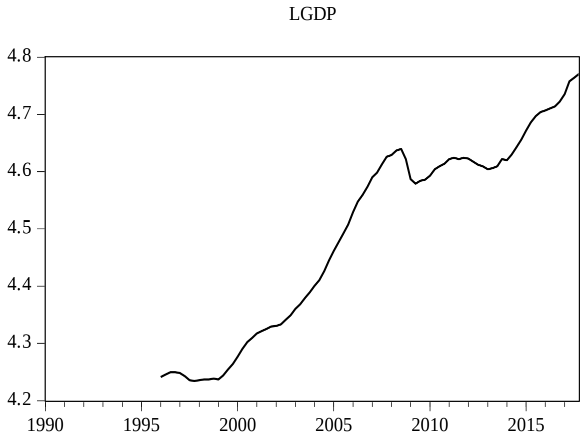
1.1 Bulgaria



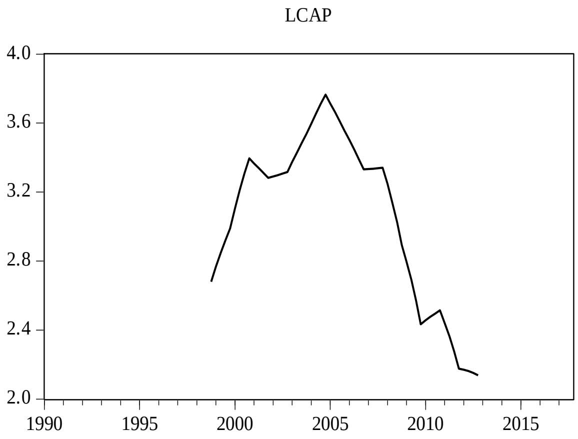


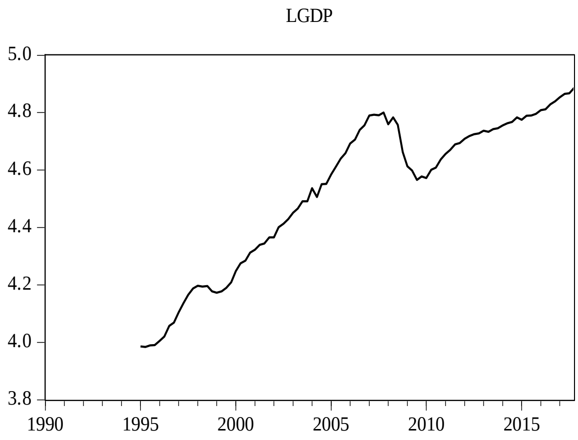
1.2 Czech Republic



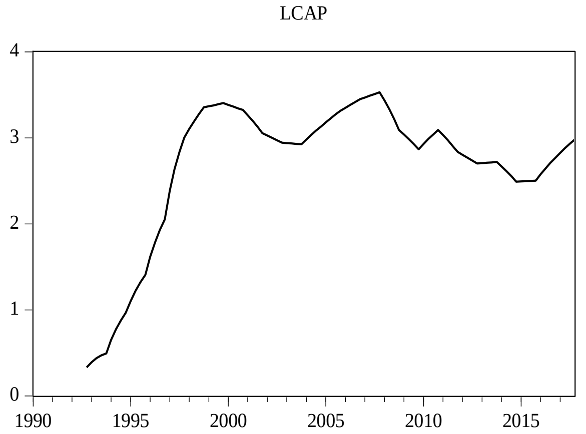


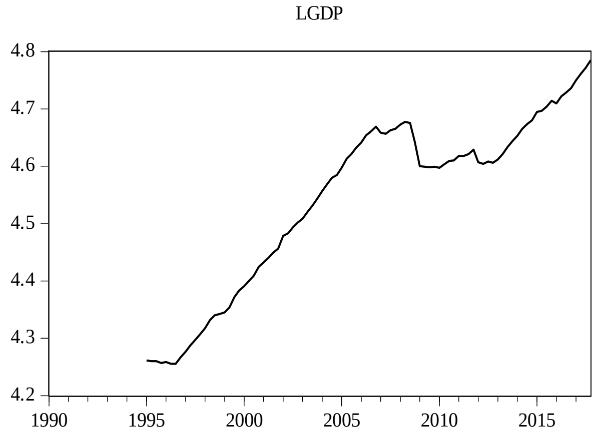
1.3 Estonia



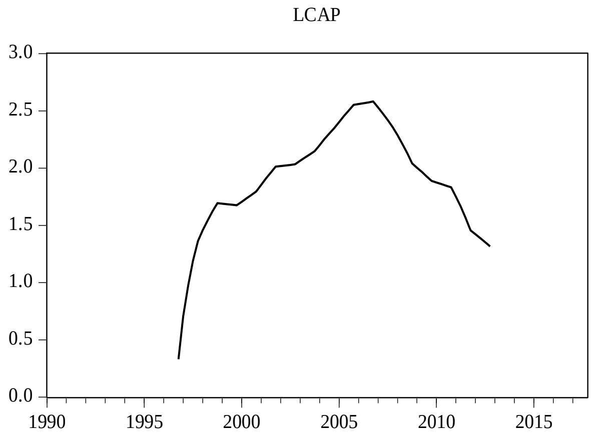


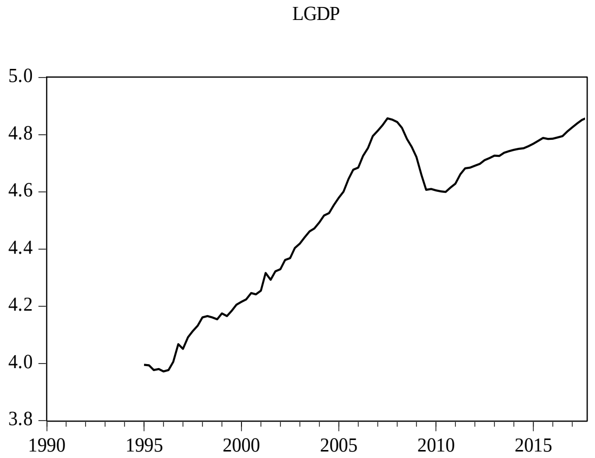
1.4 Hungary



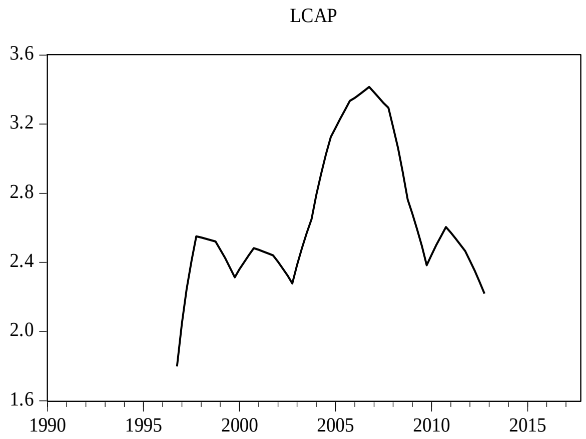


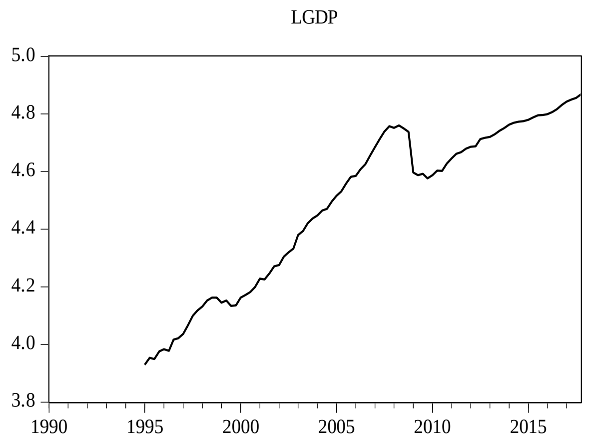
1.5 Latvia



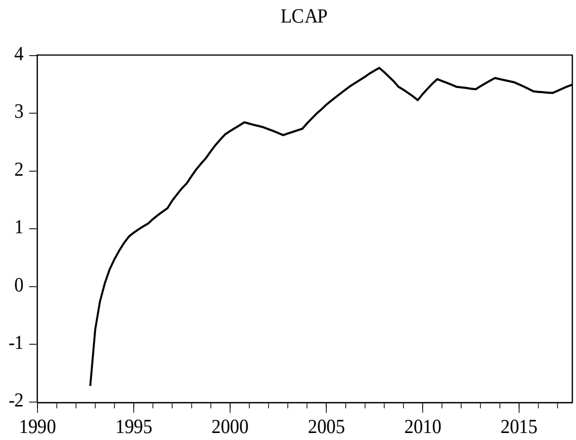


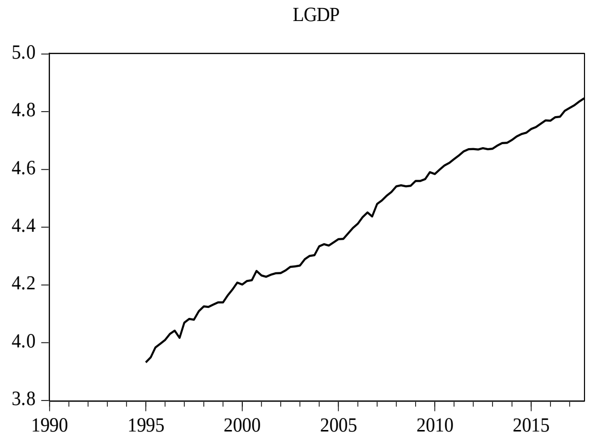
1.6 Lithuania



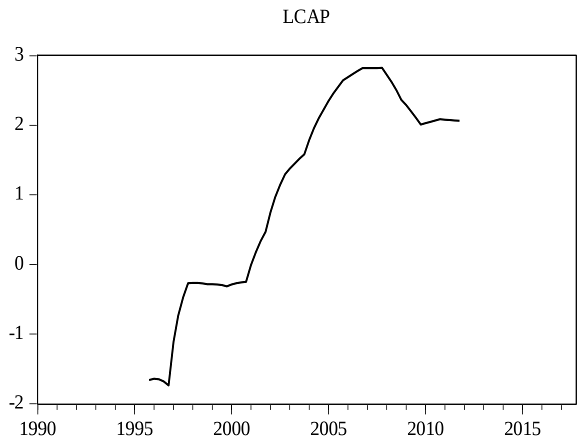


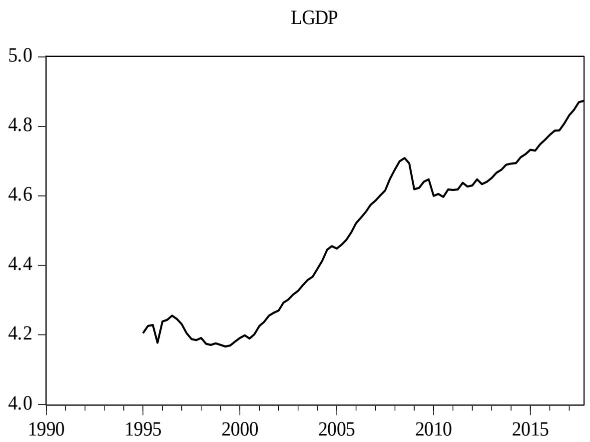
1.7 Poland



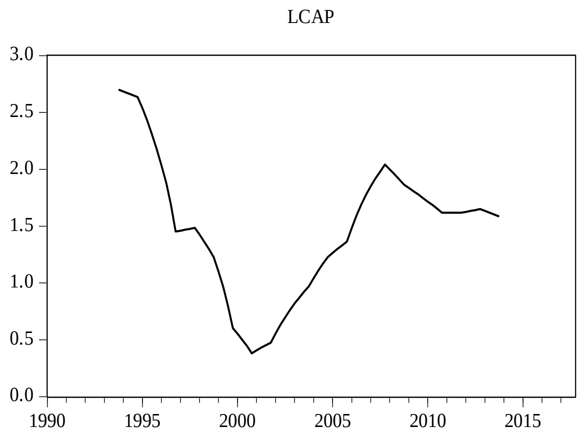


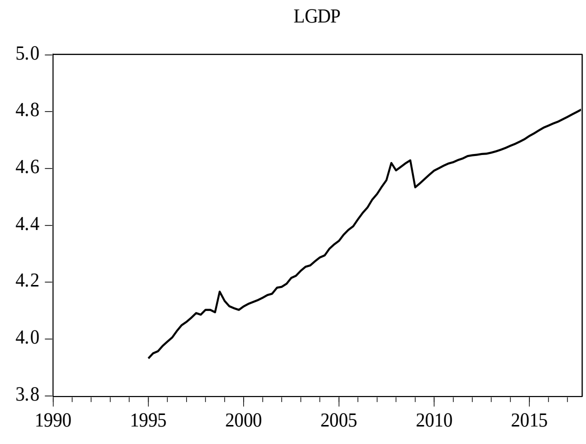
1.8 Romania



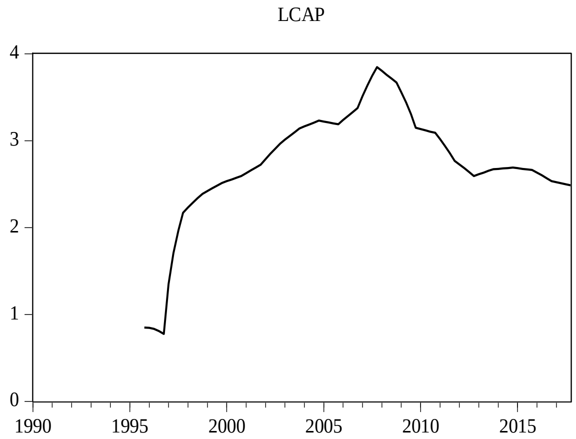


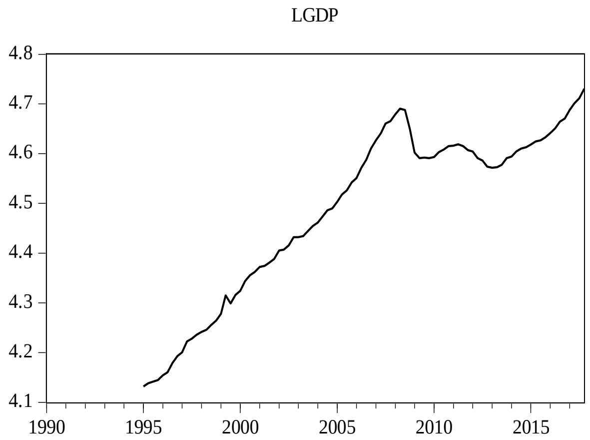
1.9 Slovakia





1.10 Slovenia





Annex 2: Unit root test (Phillips-Perron)

		t-Stat	Prob	Data	Unit root
Bulgaria	GDP	-2.150155	0.5110	Trend	
	CAP	-1.755856	0.7163	Trend	GDP: I(1)
	ΔPIB	-9.827242	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-8.436299	0.0000*	0 mean	
Czech Republic	GDP	-1.729401	0.7298	Trend	
	CAP	-3.195202	0.0932	Trend	GDP: I(1)
	ΔPIB	-2.948487	0.0036*	0 mean	CAP: I(1)
	ΔCAP	-3.906734	0.0002*	0 mean	
Estonia	GDP	-1.695813	0.7453	Trend	
	CAP	-0.216773	0.9298	Constant	GDP: I(1)
	ΔPIB	-6.447840	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-2.578064	0.0108**	0 mean	
Hungary	GDP	-1.308612	0.8796	Trend	
	CAP	-2.391948	0.3815	Trend	GDP: I(1)
	ΔPIB	-4.112357	0.0001*	0 mean	CAP: I(1)
	ΔCAP	-2.464738	0.0140**	0 mean	
Latvia	GDP	-1.410266	0.8516	Trend	
	CAP	-2.792841	0.2053	Trend	GDP: I(1)
	ΔPIB	-5.717847	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-5.660983	0.0000*	0 mean	
Lithuania	GDP	-1.631983	0.7726	Trend	
	CAP	-2.184319	0.2139	Constant	GDP: I(1)
	ΔPIB	-6.618819	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-3.470282	0.0008*	0 mean	
Poland	GDP	-2.947297	0.1530	Trend	
	CAP	-5.504325	0.0001*	Trend	GDP: I(1)
	ΔPIB	-7.807336	0.0000*	0 mean	CAP: I(0)*
	ΔCAP	-10.84034	0.0000*	Constant	
Czech Republic	GDP	-1.729401	0.7298	Trend	
	CAP	-3.195202	0.0932	Trend	GDP: I(1)
	ΔPIB	-2.948487	0.0036*	0 mean	CAP: I(1)
	ΔCAP	-3.906734	0.0002*	0 mean	
Romania	GDP	-1.806563	0.6936	Trend	
	CAP	-0.436846	0.9841	Trend	GDP: I(1)
	ΔPIB	-7.313172	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-3.235762	0.0016*	0 mean	
Slovakia	GDP	-1.627917	0.7743	Trend	
	CAP	-2.086407	0.2507	Constant	GDP: I(1)

	ΔPIB	-8.348053	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-2.490002	0.0132**	0 mean	
Slovenia	GDP	-1.534536	0.8104	Trend	
	CAP	-2.222784	0.4710	Trend	GDP: I(1)
	ΔPIB	-4.420164	0.0000*	0 mean	CAP: I(1)
	ΔCAP	-4.082828	0.0001*	0 mean	

*, **, *** shows that the null hypothesis is rejected with a significance level of 1%, 5%, 10%

KPSS Hungary		KPSS Poland	
LM-Stat.	0.242277	LM-Stat.	0.288845
1% level	0.216	1% level	0.216
5% level	0.146	5% level	0.146
10% level	0.119	10% level	0.119

Annex 3: Johansen cointegration test

Unrestricted Cointegration Rank Test (Trace)

	Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**	Coint.
Bulgaria	None *	0.415845	38.52359	15.49471	0.0000	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.053593	3.580341	3.841466	0.0585	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
Czech Republic	None	0.122275	11.68488	15.49471	0.1727	
	At most 1	0.059303	3.729175	3.841466	0.0535	Trace test indicates no cointegration at the 0.05 level
Estonia	None	0.300130	24.15662	25.87211	0.0805	
	At most 1	0.110235	5.956712	12.51798	0.4658	Trace test indicates no cointegration at the 0.05 level
Hungary	None *	0.165872	16.33716	15.49471	0.0373	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.002193	0.195410	3.841466	0.6584	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
Latvia	None *	0.328658	30.02271	25.87211	0.0143	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.089443	5.715653	12.51798	0.4972	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
Lithuania	None	0.134755	11.54155	25.87211	0.8425	
	At most 1	0.040566	2.567500	12.51798	0.9235	Trace test indicates no cointegration at the 0.05 level
Poland	None	0.101458	9.525454	15.49471	0.3190	
	At most 1	4.60E-05	0.004098	3.841466	0.9477	Trace test indicates no cointegration at the 0.05 level
Romania	None *	0.216110	18.32941	15.49471	0.0182	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.050813	3.233264	3.841466	0.0722	Trace test indicates 1

						cointegrating eqn(s) at the 0.05 level
Slovakia	None	0.246419	25.12614	25.87211	0.0617	
	At most 1	0.059436	4.473116	12.51798	0.6730	Trace test indicates no cointegration at the 0.05 level
Slovenia	None *	0.173713	16.52914	15.49471	0.0348	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.001385	0.119189	3.841466	0.7299	Trace test indicates 1 cointegrating eqn(s) at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

	Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**	Coint.
Bulgaria	None *	0.415845	34.94325	14.26460	0.0000	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.053593	3.580341	3.841466	0.0585	Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
Czech Republic	None	0.122275	7.955705	14.26460	0.3832	
	At most 1	0.059303	3.729175	3.841466	0.0535	Max-eigenvalue test indicates no cointegration at the 0.05 level
Estonia	None	0.300130	18.19991	19.38704	0.0737	
	At most 1	0.110235	5.956712	12.51798	0.4658	Max-eigenvalue test indicates no cointegration at the 0.05 level
Hungary	None *	0.165872	16.14175	14.26460	0.0250	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.002193	0.195410	3.841466	0.6584	Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
Latvia	None *	0.328658	24.30706	19.38704	0.0088	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.089443	5.715653	12.51798	0.4972	Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
Lithuania	None	0.134755	8.974052	19.38704	0.7271	
	At most 1	0.040566	2.567500	12.51798	0.9235	Max-eigenvalue test indicates no cointegration at the 0.05 level
Poland	None	0.101458	9.521357	14.26460	0.2453	
	At most 1	4.60E-05	0.004098	3.841466	0.9477	Max-eigenvalue test indicates no cointegration at the 0.05 level
Romania	None *	0.216110	15.09614	14.26460	0.0369	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.050813	3.233264	3.841466	0.0722	Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
Slovakia	None *	0.246419	20.65303	19.38704	0.0326	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.059436	4.473116	12.51798	0.6730	Max-eigenvalue test

						indicates 1 cointegrating eqn(s) at the 0.05 level
Slovenia	None *	0.173713	16.40995	14.26460	0.0225	* denotes rejection of the hypothesis at the 0.05 level
	At most 1	0.001385	0.119189	3.841466	0.7299	Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level

**MacKinnon-Haug-Michelis (1999) p-values

Annex 4: choice of optimum lag

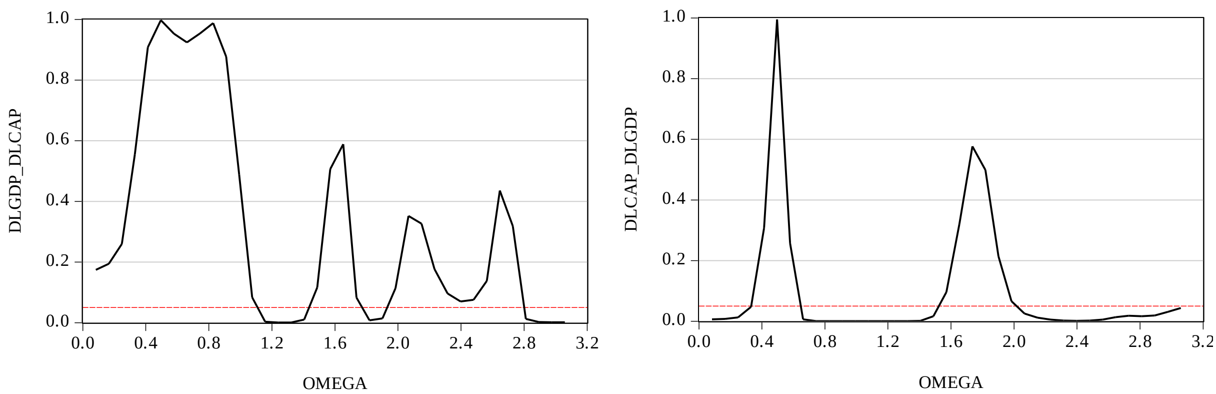
	For Granger causality				For Toda-Yamamoto approach			
Country	Lags	AIC	SIC	Optimum lag	Lags	AIC	SIC	Optimum lag
Bulgaria	0	2.029956	2.096310	6	0	2.029956	2.096310	6
	1	-3.476034	-3.276975		1	-3.476034	-3.276975	
	2	-3.524696	-3.19293		2	-3.524696	-3.19293	
	3	-3.49495	-3.030478		3	-3.49495	-3.030478	
	4	-3.644792	-3.047613		4	-3.644792	-3.047613	
	5	-3.849906	-3.120021		5	-3.849906	-3.120021	
	6	-4.260665*	-3.398074*		6	-4.260665*	-3.398074*	
Czech Republic	0	-10.68919	-10.61998	5	0	-1.584600	-1.515983	6
	1	-12.44974	-12.24212*		1	-10.53427	-10.32842	
	2	-12.45112	-12.10507		2	-12.46342	-12.12033*	
	3	-12.37935	-11.89489		3	-12.45363	-11.97331	
	4	-12.38626	-11.76338		4	-12.39544	-11.77789	
	5	-12.46018*	-11.69888		5	-12.39954	-11.64475	
	6	-12.41178	-11.51207		6	-12.50744*	-11.61541	
Estonia	0	-7.361876	-7.286118	5	0	0.558483	0.633531	5
	1	-8.222912	-7.995638*		1	-7.608509	-7.383365	
	2	-8.249934	-7.871145		2	-8.157498	-7.782259*	
	3	-8.183632	-7.653327		3	-8.204733	-7.679399	
	4	-8.147994	-7.466173		4	-8.204074	-7.528643	
	5	-8.265419*	-7.432082		5	-8.241189*	-7.415663	
	6				6	0.558483	0.633531	
Hungary	0	-0.887449	-0.829573	2	0	-0.887449	-0.829573	2
	1	-9.245142	-9.071512		1	-9.245142	-9.071512	
	2	-10.55862*	-10.26923*		2	-10.55862*	-10.26923*	
	3	-10.48195	-10.07681		3	-10.48195	-10.07681	
	4	-10.41018	-9.889287		4	-10.41018	-9.889287	
	5	-10.33481	-9.698163		5	-10.33481	-9.698163	
	6	-10.36675	-9.614352		6	-10.36675	-9.614352	
Latvia	0	0.381717	0.452142	3	0	0.381717	0.452142	3
	1	-8.807303	-8.596028		1	-8.807303	-8.596028	
	2	-9.603251	-9.251126*		2	-9.603251	-9.251126*	
	3	-9.607183*	-9.114208		3	-9.607183*	-9.114208	
	4	-9.507015	-8.87319		4	-9.507015	-8.87319	
	5	-9.425401	-8.650726		5	-9.425401	-8.650726	
	6	-9.388736	-8.473211		6	-9.388736	-8.473211	
Lithuania	0	-7.249286	-7.178236	1	0	0.366905	0.437330	2
	1	-8.276134*	-8.062985*		1	-7.282696	-7.071421	
	2	-8.155943	-7.800694		2	-8.241888*	-7.889763*	
	3	-8.039548	-7.5422		3	-8.127848	-7.634873	
	4	-8.273462	-7.634014		4	-8.016836	-7.383011	
	5	-8.199948	-7.418401		5	-8.234180	-7.459505	
	6	-8.07494	-7.151293		6	-8.170781	-7.255256	
Poland	0	-9.25284	-9.194555	1	0	0.340350	0.398227	2
	1	-10.44699*	-10.27214*		1	-9.362275	-9.188645	

	2	-10.41081	-10.11938		2	-10.33152*	-10.04214*	
	3	-10.35926	-9.951264		3	-10.30491	-9.899772	
	4	-10.2881	-9.763531		4	-10.24842	-9.727530	
	5	-10.23683	-9.59569		5	-10.19061	-9.553968	
	6	-10.15439	-9.396676		6	-10.12688	-9.374485	
Romania	0	0.929431	0.999856	2	0	0.929431	0.999856	2
	1	-7.414168	-7.202893		1	-7.414168	-7.202893	
	2	-8.391478*	-8.039353*		2	-8.391478*	-8.039353*	
	3	-8.299740	-7.806765		3	-8.299740	-7.806765	
	4	-8.236083	-7.602258		4	-8.236083	-7.602258	
	5	-8.215734	-7.441059		5	-8.215734	-7.441059	
	6	-8.156739	-7.241214		6	-8.156739	-7.241214	
Slovakia	0	0.392771	0.457527	2	0	0.392771	0.457527	2
	1	-7.73423	-7.53996		1	-7.73423	-7.53996	
	2	-8.656491*	-8.332708*		2	-8.656491*	-8.332708*	
	3	-8.575236	-8.121939		3	-8.575236	-8.121939	
	4	-8.469597	-7.886786		4	-8.469597	-7.886786	
	5	-8.403492	-7.691169		5	-8.403492	-7.691169	
	6	-8.439957	-7.59812		6	-8.439957	-7.59812	
Slovenia	0	-0.345122	-0.286	2	0	-0.345122	-0.286	2
	1	-9.338086	-9.160719		1	-9.338086	-9.160719	
	2	-10.46675*	-10.17114*		2	-10.46675*	-10.17114*	
	3	-10.41691	-10.00306		3	-10.41691	-10.00306	
	4	-10.3561	-9.824003		4	-10.3561	-9.824003	
	5	-10.38621	-9.73587		5	-10.38621	-9.73587	
	6	-10.40516	-9.636567		6	-10.40516	-9.636567	

Annex 5: Causality graphs from the Frequency Domain approach

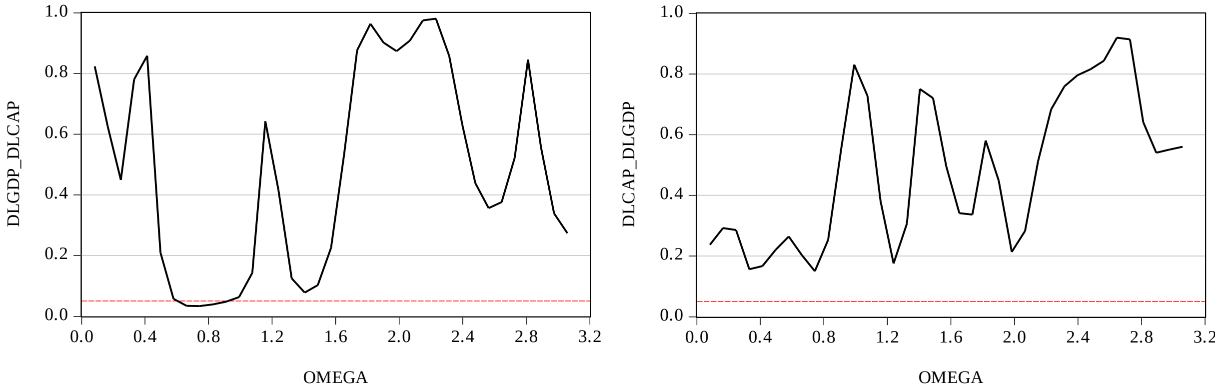
5.1 Bulgaria

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,35) | Selected lag: 12 | Exogenous variables: c



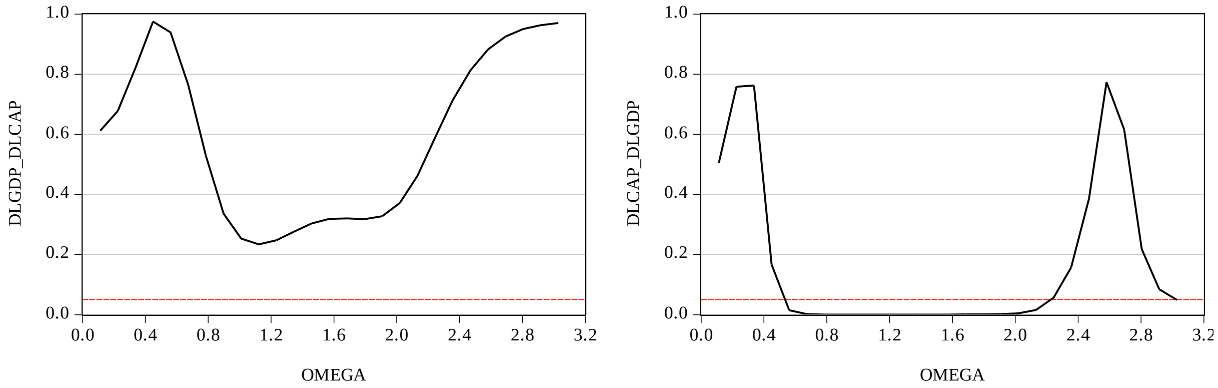
5.2 Czech Republic

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,19) | Selected lag: 16 | Exogenous variables: c



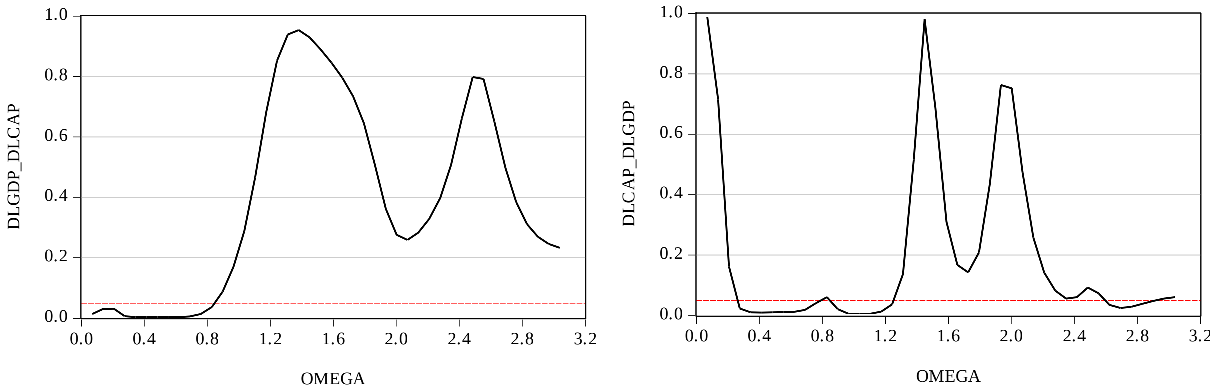
5.3 Estonia

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,35) | Selected lag: 7 | Exogenous variables: c



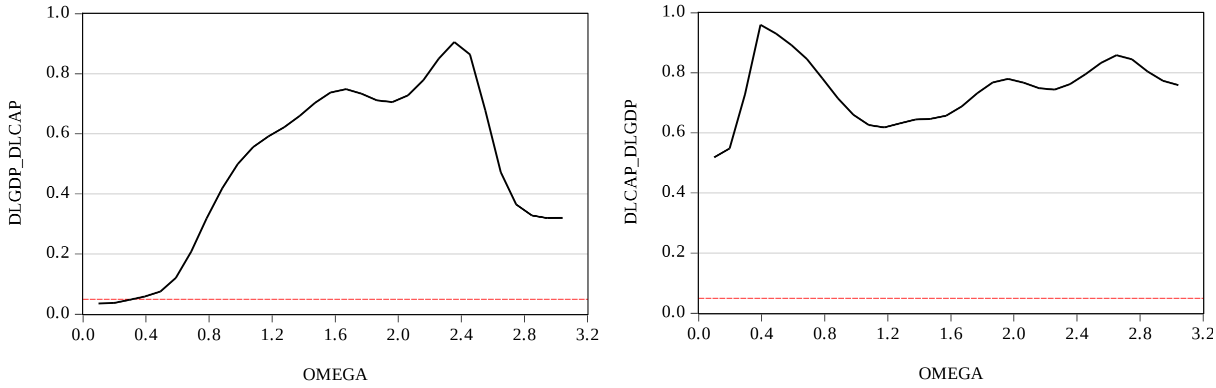
5.4 Hungary

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,54) | Selected lag: 12 | Exogenous variables: c



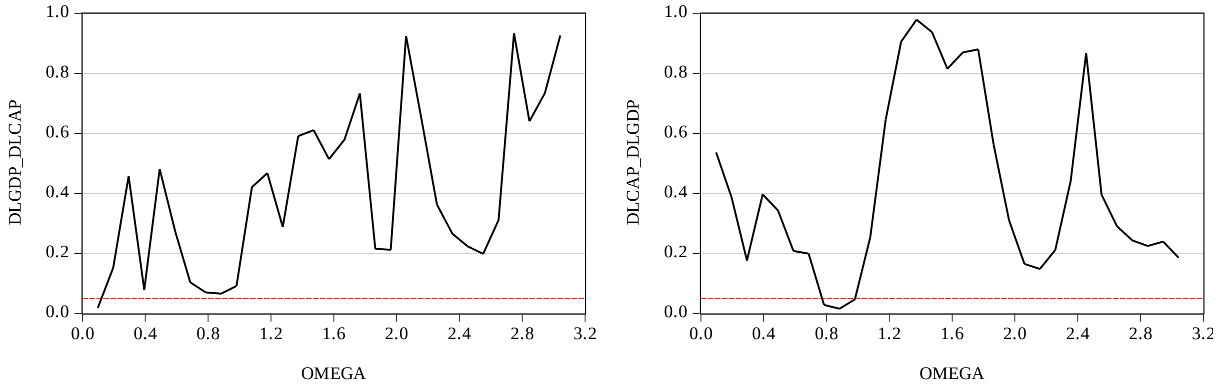
5.5 Latvia

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,37) | Selected lag: 9 | Exogenous variables: c



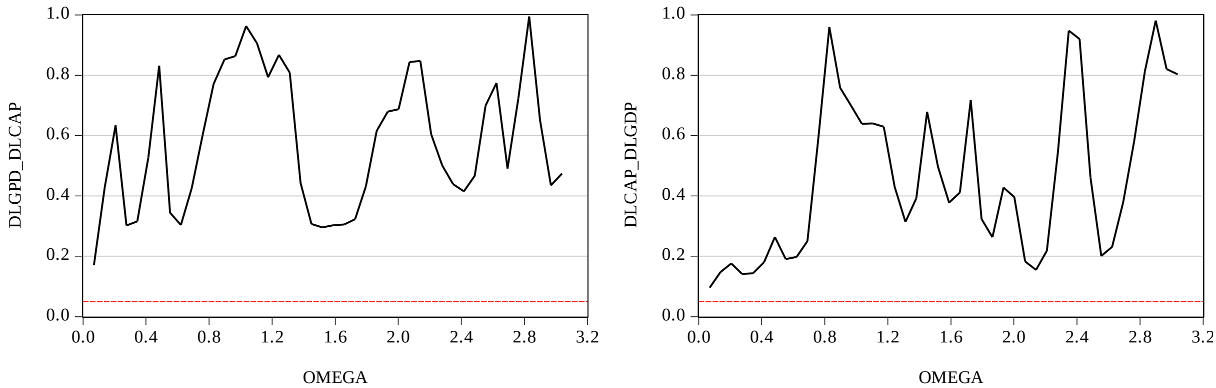
5. 6 Lithuania

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,10) | Selected lag: 18 | Exogenous variables: c



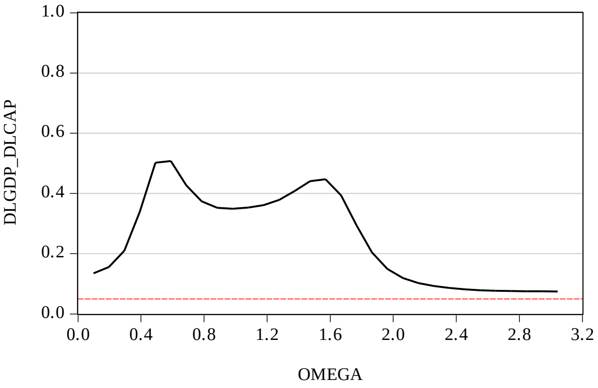
5.7 Poland

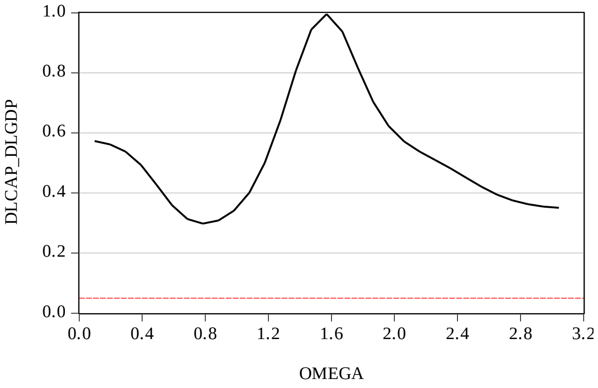
Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,12) | Selected lag: 26 | Exogenous variables: c



5.8 Romania

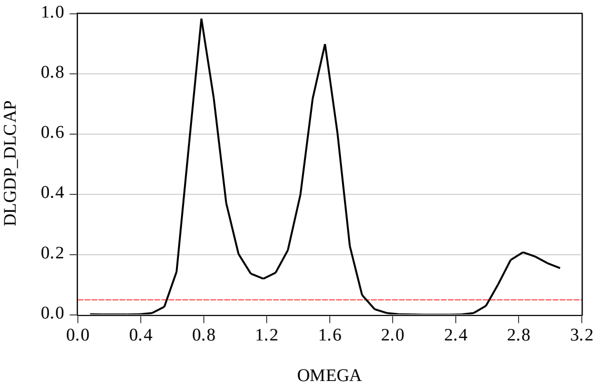
Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,46) | Selected lag: 6 | Exogenous variables: c

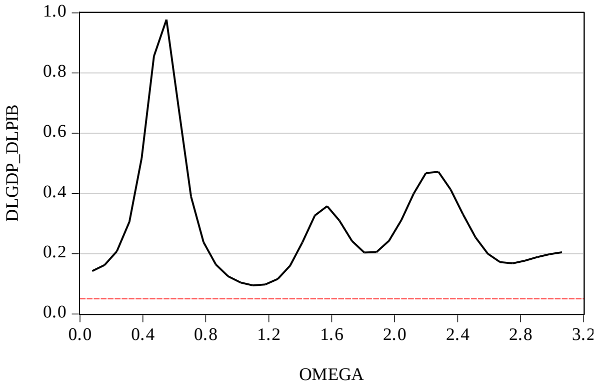




5.9 Slovakia

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,51) | Selected lag: 8 | Exogenous variables: c





5.10 Slovenia

Causality in the frequency domain | H0: There is not causality at frequency Omega | P-value D.F. (2,54) | Selected lag: 11 | Exogenous variables: c