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Central Eastern and South Eastern European Markets Macro-Fundamental Analysis

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Abstract:
A type of fundamental analysis focusing on broad economic factors that affect the stock market as a whole or industry groups of securities, also known as the macro-fundamental analysis, is the practice of evaluating the overall performance of the economy, its impact on industry groups and finally down to specific companies in the industry groups. As such, macro-fundamental analysis is broadly accepted as a critical tool to analyze and potentially predict the stock price development There has been a lot written about the cointegration and causality links between the macroeconomic factors and stock indices of the Western European markets. On the contrary, not so much has been researched about these links when it comes to the European emerging markets. The aim of this paper is thus to examine such relationships in case of selected Central and South-Eastern European countries, collecting the latest data and using a broader sample of macroeconomic indicators. Our findings reveal several pairwise short-run causal impacts between studied macroeconomic indicators and stock indices. Moreover, according to our results, all CEE&SEE stock markets under consideration may potentially be in violation of market efficiency.

1 Introduction

A type of fundamental analysis focusing on broad economic factors that affect the stock market as a whole or industry groups of securities, also known as the macro-fundamental analysis, is the practice of evaluating the overall performance of the economy, its impact on industry groups and finally down to specific companies in the industry groups. As such, macro-fundamental analysis is broadly accepted as a critical tool to analyze and potentially predict the stock price development (Tay, 2010). It is an important tool for investors interested in international stock picking as it might help them to generate excess returns if any causal impact from macroeconomic indicators to stock market is identified (Markwat *et al.*, 2008). Underlying research may also be very relevant for policy makers as they might take into account possible impacts of financial markets on the macroeconomic development when imposing new regulatory measures or policies.

Given the fact that most of the research papers elaborating on the topic of cointegration and causality links between the macroeconomic factors and stock indices refer to the Western European markets, the primary motivation of this paper is to add to the current knowledge by examining such relationships in case of selected Central and South-Eastern European (CEE&SEE) countries, specifically addressing two hypotheses. The first hypothesis to be verified states that the macro-fundamental relationships hold on selected eight CEE&SEE markets. Employing the latest data from these still relatively unexplored economies and applying customary research methods in the field, the paper revises presumed relationships within the theory of macro-fundamental analysis, also using a longer time horizon and a broader sample of macroeconomic indicators. If any impacts are verified, it determines the causality and analyzes the inter-linkage of studied indices with respect to relevant benchmark from developed financial markets such as Standard & Poor's 500 in the US or Europe's leading blue-chip index EURO STOXX 50. In addition to that, the second hypothesis stating that CEE&SEE markets behave efficiently in terms of Efficient Market Hypothesis is tested, with the efficiency of studied markets based on Fama´s (1969) definition of informationally efficient markets being assessed and adequately interpreted.

The remainder of this work is organized as follows. Chapter 2 briefly reviews the Efficient Market Hypothesis theory and discusses the theoretical background on stock valuation methods with the focus on top-down approach of fundamental analysis, the so-called macro-fundamental analysis. Chapter 3 proceeds with analytical framework. It presents the data under consideration and the specifications tests used to identify and evaluate the cointegration and causality linkages between macro-fundamentals and financial markets. Finally, Chapter 4 summarizes and discusses the inferences, assesses all the information and arguments presented in the paper and on their basis formulates a conclusion. An idea for the future extensions of the research is also provided.

2 Theoretical Background

Efficient Market Hypothesis (EMH) implies that, when certain conditions are met, the financial markets are fully efficient in reflecting all new relevant stock market information into stock prices without any significant delay. In consequence, the stocks have proper fair value and it is not possible to gain any additional return by trading undervalued or overvalued equities or by holding a diversified portfolio (Fama, 1969). If the Efficient Market Hypothesis holds, then the stock prices should fully reflect all the available market information and should not be influenced by any other publicly unknown factors. If the opposite is true, then valuation approaches could represent a useful financial tool.

Analysts who question the validity of EMH typically consider four stock valuation methods: fundamental analysis, technical analysis, trading psychology analysis or their combinations (Musílek, 2011). The paper focuses on fundamental analysis from macroeconomic perspective by reviewing the presumed relationships between stock markets and macroeconomic indicators and deals primarily with the so called Top-Down or macro-to-micro method of evaluating financial information. If any cointegration or causality directed from macroeconomic indicators to stock market is revealed, the condition of market efficiency would be partially violated and investors could find the macro-fundamental analysis as a useful tool to evaluate or predict stock market performance. If a reverse dependence is revealed, policy makers or governments could take into account possible impacts of financial markets on the economy when implementing new regulation.

2.1 Presumed Macro-Fundamental Relationships

The paper sticks to the most common macroeconomic indicators as suggested by the relevant literature: Gross Domestic Product (GDP), inflation, various types of interest rates and money supply both used in a monetary policy, government budget impacted by a fiscal policy and trade balance with capital flows (Musílek, 2011).

Table 1 summarizes the macroeconomic indicators used and their expected impact on the stock price development.

Table 1: Summary of Presumed Macroeconomic Relationships

	Economic Indicator	Effect on Stock Price
Increase in	GDP	Increase
Increase in	Inflation	Decrease
Increase in	Money Supply	Increase
Increase in	Interest rate	Decrease
Increase in	Exchange rate	Ambiguous
Increase in	Budget deficit	Decrease
X	Shocks	Ambiguous

Source: Own elaboration

2.2 Literature review

The concept of market efficiency and theory of random walk were firstly mentioned by Bachelier (1900) and Kendall (1953) respectively. Later in 1969, Eugene Fama defined the theory and empirics of efficient market models. According to Fama (1969), the market is efficient when the prices fully reflect all the available information. To control for the effectiveness of markets, Fama (1969) applied three levels of security price tests with regards to the information subset of interest: weak form, semi-strong and strong form tests. All forms of tests showed results mostly in favour of EMH. Although there were found some stock market correlations (in weekly stock returns, buy-and-hold strategy or tendency towards excessive reversals of stock price) the evidence against EMH was not strong enough. Fama (1969) suggests that prices follow a random walk and thus we cannot reject the hypothesis of efficient markets.

EMH has both advocates and opponents. Jensen (1978) was fully confident with efficient markets theory saying that there does not exist any other economic proposition with so strong empirical evidence than EMH. Taking into account the condition that all investors are rational, Lucas (1978) also supports Fama´s definition of EMH. Afterwards, Fama and French (1988) found long-term significant serial correlation for weekly and monthly holding period returns proving that some returns can be predictable. Also Lo and MacKinlay (1988) rejected the random walk theory for weekly stock returns, however their evidence did not fully prove the inefficiency of stock price creation. In 1991, Fama published his revision of capital market efficiency where he admits that the strong version of efficient markets does not exist. Moreover, Fama (1991) states that estimating the market efficiency can be sometimes very ambiguous and stresses the need for joint-hypothesis testing when evaluating the level of efficiency.

According to Malkiel (2003) there exists some techniques that generate an excess return on stock deals as not all investors behave faultlessly. He admits that due to new sophisticated approaches of trading, stock markets might move even farther from being efficient. Shiller (2003) supports the behavioural finance view stating that, since investor’s decisions are affected by their thinking and expectations, efficient market theory can provide misleading explanations of some events such as market bubbles or booms, effectively suggesting that EMH does not hold in the real world.

If we consider the fact that markets might not be fully efficient, the stock market analysis approaches might represent a very useful tool to generate an extra profit. Ou and Penman (1989) analysed future company earnings by simulating a portfolio long in stocks with high Pr (the probability of future increase in accounting earnings) and short in stocks with low Pr. They managed to generate the annual return of 8.34 percent. Supportive evidence was provided by Holthausen and Larcker (1992) who found abnormal but lower returns as well. On the contrary, Greig (1992) re-examined the model of Ou and Penman (1989) and disproved their findings that portfolios of Pr stocks generate extra profit. Abarbanell and Bushee (1988) tested whether there is a possibility of additional return using fundamental analysis. Taking into account the micro-fundamentals such as selling expenses, tax rates, gross margins, inventory or sales productivity of a company, an abnormal 12-month average return of 13.2 percent was generated from their portfolios. The possibility of generating extra profit around the time when firms announce their earnings was confirmed as well. Those results are consistent with the findings of Lewellen (2004). Ahmed (2013) or Baresa *et al.* (2013) propose to include macro-fundamentals such as the level of inflation, interest rates, money supply, fiscal stability and exchange rate as a part of the approach. Oberlechner (2001) and Bettman *et al.* (2009) suggest that both technical and fundamental analyses can serve as powerful tools when applied jointly.

3 Macro-Fundamental Model

Based on presumed relations presented in the previous section, the following lines comprise the examination and evaluation of interlinkages between macroeconomic indicators and stock markets through cointegration and causality analysis. The analysis is focused on the selected Central and South-Eastern European markets (CEE & SEE) –Austria, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovenia. The selection of countries is straightforward. All countries under consideration (except for Austria) are former communist regimes that are quite homogenous and relatively open with similar social and economic policies in place.

3.1 Methodology

Several approaches are applied to find out the cointegration and causality relationships and to test whether the selected stock markets are efficient in terms of Efficient Market Hypothesis. In order to study the interlinkages among the variables, we imply the inferential statistics and compute simple correlation coefficients to check the linear relationships at first. Further, we verify the stationary properties of our time series and perform the Engel-Granger and Johansen cointegration tests. If any cointegration relationship is detected, we perform vector error correction model (VECM) to confirm the long-run equilibrium relationships. Moreover, Granger causality is employed to verify the short-run causalities between variables. Finally, with respect to the obtained results, we assess the efficiency of studied stock markets.

3.2 Data

Based on the macroeconomic theory presented earlier, the analysis uses the set of five macroeconomic indicators that are expected to affect financial markets: production index as a proxy to gross domestic product (PRODUC), exchange mid-rate of USD (FX), consumer price index as a proxy to inflation (CPI), money supply represented by monetary aggregates (M2/M4[1]) and 1-month interbank offered rate (IFR). In addition to these, we have chosen two exogenous stock market indices Standard&Poor´s 500 Index (SPX) and EURO STOXX 50 (SX5E) to check whether there is any incidence between benchmark from international developed financial environment and the selected CEE & SEE stock markets. To proxy for individual financial markets in Austria, Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovenia, the local stock market indices were chosen: ATX, SOFIX, CRObex, PX, BUX, WIG, BET, SBITOP, respectively.

Detailed description of selected CEE & SEE-8 stock market indices can be found in Table 2.

Table 2: Description of selected CEE & SEE-8 stock market indices

Ticker	Description	Ccy
ATX	C-W index[2] of the most heavily traded stocks on Vienna SE.	EUR
SOFIX	C-W, comprises the most liquid companies on the Bulgaria SE.	BGN
CRObex	C-W, designed to track price movements of Zagreb SE shares.	HRK
PX	Official index of the Prague SE which replaced and took over values of PX50 and PX-D indices.	CZK
BUX	C-W index adjusted for free float that tracks daily tracks large, actively traded shares on Budapest SE.	HUF
WIG	C-W index of 20 Polish stocks listed on main market that is taken as an underlying instrument for futures tranasactions on Warsaw	PLN
BET	C-W index of the 10 most liquid stocks listed on the Bucharest SE tier 1.	RON
SBITOP	Free-float and C-W Blue-Chip index of the most liquid shares at Ljubljana SE.	EUR
SPX	C-W index of 500 stocks representing all major industries, measures performance of the broad domestic economy.	USD
SX5E	Europe´s leading blue-chip index for the Eurozone, representing supersector leaders. Comprises 50 stocks from 12 Eurozone countries, licensed to financial institutions.	EUR

Source: Own elaboration based on Bloomberg

[1] The choice of monetary aggregates M2 vs. M4 is made based on data availability

[2] Capitalization-Weighted Index

Seasonally unadjusted values of industrial production indices are used for all studied countries as a proxy to GDP. Data representing CPI indices are not seasonally adjusted values YoY in percent. Money supply data are also not seasonally adjusted values in national currencies. The Eurozone money supply is used in case of Austria and Slovenia as these countries had adopted the euro throughout the research period and money supply data prior the euro adoption were not available. We use 1-month reference rates of selected markets in national currencies except for Slovenia, for which the 1-month SIT index was not available.

Our data cover the monthly observations over the period of 11 years from January 1995 to January 2015, ideally resulting into 252 observations per country. Some of the variables were not measured by individual countries in early 1990s so we have to account for this fact in the research. The total number of observations is presented in the descriptive statistics and fluctuate across countries. The Czech Republic’s analysis is performed over the whole period from January 1995 to January 2015. Hungarian analysis starts from August 1996 as there are no 1-month interbank offered rate data available prior to this date. Polish time series starts in December 1996 due to scarcity of the money supply data. So is the reason for Romania and Slovenia starting both in January 2007. Austria is analysed from January 1999 onwards, due to its euro adoption. We analyse Croatia and Bulgaria starting from January 2001 and February 2003, respectively due to 1-month interbank offered rate data unavailability.

All the variables are converted to natural logarithm, except for Bulgarian and Croatian money supply variable, which is analysed in levels, as it was proven to have better statistical properties for the purpose of cointegration analysis than its logarithm alternative. Brooks (2008) states that such adjustment is valid, claiming that when series are proven to be cointegrated in levels, they will also be cointegrated in log-levels.

The data is collected from Bloomberg Professional Platform, EUROSTAT or the respective countries’ statistical offices and central banks. We use Stata, E-Views and Gretl software to perform the analysis.

3.3 Descriptive Statistics

Simple correlation coefficient is used to measure the degree of linear relationship between selected macroeconomic variables and stock market indices. Table 3 shows correlation coefficients between stock market indices and chosen macroeconomic variables. Most of the coefficients show quite strong significant correlations, where the strongest interdependences with values around 90 percent are between SOFIX index and SX5E index, BET index and SX5E index, BUX index and production index and BUX index and money supply. On the contrary, almost no correlation is present between CRObex index and 1-month ZIBOR.

Table 3: Simple correlation coefficients

x/y	ATX	SOFIX	CRO	PX	BUX	WIG	BET	SBITOP
FX	-0.77	-0.32	-0.75	-0.81	-0.24	-0.71	-0.22	-0.47
CPI	0.16	0.45	0.19	-0.36	-0.60	-0.29	-0.32	0.47
PRODUC	0.67	0.21	0.69	0.81	**0.87**	0.70	0.33	0.60
IFR	-0.19	0.37	**-0.01**	-0.58	-0.70	-0.58	-0.43	N/A
M2/M4	0.63	-0.18	0.55	0.74	**0.88**	0.60	-0.14	-0.80
SPX	0.34	0.25	0.34	0.51	0.58	0.55	0.73	-0.15
SX5E	0.05	**0.90**	0.41	0.29	0.17	0.26	**0.87**	0.73

Source: Own elaboration

3.4 Properties of the Time Series

In order for the time series to be valid, the data set has to be stationary, meaning that its statistical properties such as mean, variance, autocorrelation structure etc. are time-invariant (i.e. constant over the time at which the time series is observed). (Brooks, 2008) Nevertheless, macroeconomic and financial data are usually found non-stationary, unit root $I(1)$ processes (Brooks, 2008; Engel and Granger, 1987; Barbic and Jurkic, 2011; Králik, 2012 etc.).

A series with no deterministic component which has a stationary, invertible ARMA representation after differencing d times, is said to be integrated of order d, denoted I(d). (Engel and Granger, 1987)

Hence the series needs to be differentiated once in order to get $I(0)$ stationary process. However, there exists a unique case called *cointegration* when the stochastic trends in two time series of the same order are cancelled out, if we regress one series on another (Gujarati, 2014). If the variables of two time series are integrated of the same order and there exists a linear combination of them, the regression equation is balanced, cointegration exists and the error term between the variables is stationary over time. (Gujarati, 2014; Hubana, 2013)

The order of integration in our data sample is investigated using Kwiatkowski–Phillips–Schmidt–Shin (KPSS) stationarity test. KPSS test is derived based on the model below and tests the null hypothesis $H_0\colon \sigma_e^2 = 0$ that y_t is stationary against its alternative $H_1\colon \sigma_e^2 \neq 0$ (presence of unit root). (Kwiatkowski et al., 1992)

$$\boldsymbol{y_t = \beta' D_t + \mu_t + u_t} \qquad (1.1)$$
$$\mu_t = \mu_{t-1} + \varepsilon_t; \quad \varepsilon_t \sim WN(0, \sigma_e^2)$$

, where $\mathrm{D_t}$ contains deterministic components and $\mathrm{u_t}$ is $I(0)$

As our results, using the Newey–West covariance matrix estimator with Barlett kernel and the automatic bandwidth selection, provide an evidence that most of the series are integrated of the same order $I(1)$ at 1% significance level, the Engel-Granger and Johansen cointegration tests are performed in the following section. In cases where $I(1)$ property of data was confirmed on 10% significance level, an Augmented Dicker Fuller complementary unit root test (ADF) was applied to confirm the findings. The optimal number of lags for ADF test is selected using Akaike Information Criteria (AIC): $\mathrm{AIC} = \log\left|\widehat{\sum}\right| + \frac{2\mathrm{k}}{\mathrm{T}}$, where $\widehat{\sum}$ is a variance-covariance matrix of residuals, k is number of coefficients in the equation, T is number of observations. The overview of critical values and detailed results of the KPSS and ADF tests can be found in the Appendix.

3.5 Cointegration and Causality Analysis

In order to check whether there are any long-run or short-run interlinkages between selected stock markets and macro-fundamental variables, the univariate cointegration and causality analyses are performed.

If two series x_t and y_t are both $I(1)$, then they *are said to be cointegrated, if there exists a parameter α such that* $u_t = y_t - \alpha x_t$ *is a stationary process.* (Sørensen, 2005)

The Engle-Granger and Johansen cointegration methods are applied to determine the long-run interrelations. If stable and strong long-run cointegration is present, then the variables have similar movement tendencies over a long time period and converge towards mutual equilibrium. Further, the Granger causality test is carried out to examine the short-run lead-lag relations. Based on the obtained results, the efficiency of selected stock markets is reviewed. If any cointegration or causal impact from macroeconomic indicators to stock market indices is revealed, then movements of studied variables are not independent and therefore do not follow the random walk. Consequently, if past values of one variable can be used to predict future performance of other variable such as stock, the hypothesis of market efficiency is partially violated. (Fama, 1969; Granger, 1986; Heilmann, 2010)

3.5.1 Engel-Granger Test

The Engel-Granger (EG) procedure allows to test the bilateral cointegration relationship using single equation model with one endogenous and one exogenous variable. Table 4 shows detailed results of EG procedure. Selected stock indices (dependent variable *y*) are presented in the first column, appropriate macroeconomic indicators (independent variable *x*) are shown in the first row. The highlighted pairs of variables are found to be cointegrated. There should be weak long-run relationship among BUX index and FX rate; BET index and production index, and strong long-run interlinkage between CRObex index and SX5E index.Other pairs of variables did not satisfy the EG cointegration rule. In cases where cointegration is found, the vector error-correction model is estimated.

Table 4: Engle-Granger Cointegration test results

y/x	FX	M2	PRODUC	CPI
ATX	NNN, No, (1)[a] 0.84[b]; 0.92[c]; 0.73[d]	NNN, No, (1)[a] 0.84[b]; 0,33[c]; 0,80[d]	NNN, No,(12)[a] 0.84[b]; 0.62[c]; 0.82[d]	N/A
SOFIX	NNN, No, (1)[a] 0.13[b]; 0.53[c]; 0.83[d]	NNN, No,(3)[a] 0.22[b]; 0.32[c]; 0.52[d]	NNN, No,(0)[a] 0.13[b]; 0.11[c]; 0.53[d]	NNN, No,(3)[a] 0.13[b]; 0.37[c]; 0.34[c]
CRO	NNN, No,(10)[a] 0.63 [b]; 0.92[c] ;	NNN, No, (2)[a] 0.49[b]; 0.85[c]; 0.49[d]	NNN, No,(12)[a] 0.63[b]; 0.63[c]; 0.56 [d]	NNN, No, (4) [a] 0.63[b]; 0.75[c]; 0.49 [d]
PX	NNN, No,(0)[a] 0.77[b]; 0.88[c]; 0.68[d]	NNN, No, (1)[a] 0.77 [b]; 0.79 [c]; 0.65	NNN, No,(12)[a] 0.77 [b]; 0.58 [c] ; 0.58	NNN, No,(0)[a] 0.77 [b]; 0.25 [c]; 0.89
BUX	NNR, Yes**, (1) [a] 0.25 [b]; 0.55 [c];	NNN, No,(3)[a] 0.25 [b]; 0.80 [c]; 0.17	NNN, No,(12)[a] 0.25 [b]; 0.31 [c]; 0.19 [d]	NNN, No,(2)[a] 0.25 [b]; 0.26 [c]; 0.47
WIG	NNN, No,(3)[a] 0.57 [b]; 0.55 [c]; 0.21	NNN, No,(0)[a] 0.57 [b]; 0.16 [c]; 0.76	NNN, No,(12)[a] 0.57 [b]; 0.66[c]; 0.62 [d]	NNN, No,(0)[a] 0.57 [b]; 0.43 [c]; 0.69
BET	NNN, No,(5)[a]	NR/, N/A, (4) [a]	NNR, Yes**, (12) [a]	NNN, No, (1)[a]

y/x	FX	M2	PRODUC	CPI
	0.15 [b]; 0.27 [c]; 0.45	~~0.15 [b]; 0.06 [c]; N/A~~	0.15 [b]; 0.49 [c]; 0.07 [d]	0.15 [b]; 0.95 [c]; 0.59
SBITOP	NNN, No, (3)[a] 0.65 [b]; 0.25 [c]; 0.60	NNN, No, (3)[a] 0.65 [b]; 0.15 [c]; 0.74	NNN, No,(0)[a] 0.65 [b]; 0.47 [c]; 0.69 [d]	NNN, No, (3)[a] 0.65[b]; 0.38 [c]; 0.69 [d]

y/x	IFR	SPX	SX5E
ATX	~~NR/, N/A, (1)[a] 0.84[b]; 0.06[c]; N/A~~	NNN, No, (1)[a] 0.84[b]; 0.66[c]; 0.94[d]	NNN,No, (2)[a] 0.84[b]; 0.70[c]; 0.96[d]
SOFIX	NNN, No,(3)[a] 0.13[b]; 0.85[c]; 0.36[d]	NNN, No,(0)[a] 0.13[b]; 0.77[c]; 0.69[d]	NNN,No, (2)[a] 0.13[b]; 0.39[c]; 0.13[d]
CRO	~~NR/, N/A, (1)[a] 0.63 [b]; 0.04 [c]; N/A~~	NNN, No, (8) [a] 0.63 [b]; 0.42 [c]; 0.87 [d]	NNR, Yes, (0) [a] 0.63 [b]; 0.47 [c]; 0.02 [d]
PX	NNN, No,(0)[a] 0.77 [b]; 0.69 [c]; 0.64 [d]	NNN, No, (1)[a] 0.77 [b]; 0.34 [c]; 0.87 [d]	NNN, No,(0)[a] 0.77 [b]; 0.33 [c]; 0.93 [d]
BUX	NNN, No,(3)[a] 0.25 [b]; 0.63 [c]; 0.35 [d]	NNN, No,(3)[a] 0.25 [b]; 0.54 [c]; 0.55 [d]	NNN, No,(0)[a] 0.25 [b]; 0.15 [c]; 0.84 [d]
WIG	NNN, No,(0)[a] 0.57 [b]; 0.11 [c]; 0.75 [d]	NNN, No,(0)[a] 0.57 [b]; 0.48 [c]; 0.88 [d]	NNN, No,(0)[a] 0.57 [b]; 0.22 [c]; 0.80 [d]
BET	NNN, No, (1)[a] 0.15 [b]; 0.84 [c]; 0.26 [d]	NNN, No,(0)[a] 0.15 [b]; 0.37 [c]; 0.28 [d]	NNN, No,(0)[a] 0.15 [b]; 0.29 [c]; 0.39 [d]
SBITOP	N/A	NNN, No, (4)[a] 0.65 [b]; 0.37 [c]; 0.67 [d]	NNN, No, (3)[a] 0.65 [b]; 0.29 [c]; 0.14 [d]

Note: p-values for the EG test are based on MacKinnon (1996) criterion. Constant term and trend were included in the regression as standard t-test confirmed the statistical significance of both in each regression. NNN – N as not rejection of H0, R as rejection of H0 for the variables in the same order as in bcd
No means no cointegration, Yes implies presence of cointegration
areports the lag value chosen by Gretl on the basis AIC (Akaike information criterion)
breports the p-value for the dependent variable y
creports p-value for the independent variable x
dreports the p-value for residuals $\hat{u}_t$
**indicates 10% significance level
Source: Author´s computation based on downloaded data using Gretl/E-Views

Crossed cells in Table 4 represent the cases where ADF test showed that independent variable x_t is not $I(1)$, thus the non-stationary property of variables x_t is violated. However as stated by Brooks (2008) or Harris and Sollis (2003), ADF test sometimes tends to over reject the null hypothesis especially in small finite samples or in the event of structural break presence. Bahmani-Oskooee (1998), Brooks (2008) and Nisha (2015) suggest the KPSS unit root test as a robust alternative to ADF test. Based on the KPSS results, all selected variables are $I(1)$. Nevertheless, with respect to the ADF test performed within EG analysis, we will take any possible cointegration relationships between BET index and money supply, ATX index and 1-month VIBOR and CRObex index and 1-month ZIBOR with discretion, so that any spurious conclusions are prevented.

3.5.2 Johansen Test

The following lines proceed with the Johansen cointegration test. As opposed to EG procedure, Johansen test allows the identification of more than one interrelation (if it is present) in the entire system of variables and thus it is more widely applicable (Brooks, 2008). However, the method can also be used to estimate the pairwise long-run cointegration by formulating the Vector Autoregressive (VAR) model for each pair of variables. (Johansen, 1991). Results of the Johansen cointegration test for pairs of variables are summarized in Table 5. Studied stock indices are presented in the first column, possible cointegration links are shown in the first row.

Table 5: Johansen cointegration test results

Country	Stock Index (SI)	SI-FX	SI-M2/4	SI-PROD	SI-CPI	SI-IFR	SI-SPX	SI-SX5E
Austria	**ATX**	No	No	Yes	N/A	No	No	No
Bulgaria	**SOFIX**	No	No	No	No	No	No	No
Croatia	**CRObex**	No	Yes	Yes	No	No	Yes**	No
Czech Republic	**PX**	No	Yes	No	Yes	Yes	No	No
Hungary	**BUX**	No	Yes	No	No	No	No	No
Poland	**WIG**	No	Yes	Yes	No	No	No	No
Romania	**BET**	No	No	Yes**	No	No	No	No
Slovenia	**SBITOP**	No	No	No	No	N/A	No	Yes

Note: **indicates 10% significance level based on MacKinnon-Haug-Michelis (1999) p-values
Source: Author´s computations based on downloaded data set using Gretl/E-Views

As we are always testing the cointegration relationship between pairs of variables, there are only two possible vector ranks *r*. *Rank 0*, indicating there is no cointegration relationship between variables and *Rank 1*, referring to one cointegration vector between variables. If we reject the null hypothesis of *Rank 0* e.g. at 10% significance level, we can conclude there is one cointegrating vector present.

When compared to EG test results, Johansen test confirmed the cointegration relationship between production index and stock index in Romania (at 10% significance level), newly we got significant cointegration interlinkage between production index and stock market in Austria, Croatia and Poland; between money supply and stock index in Croatia, Czech Republic, Hungary and Poland; between exogenous indices and stock market indices in Croatia (S&P 50) and Slovenia

(Eurostoxx 500); and between Prague stock market index and 1-month Pribor rate and Prague stock market index and inflation.

Table 6 shows detailed results of λTrace and λMax statistics for pairs of variables where cointegration was found. It is not unusual that trace and max statistics sometimes yield conflicting results. In such cases, the trace statistics outcome is preferred as it tends to have more power in small sample sizes than max test. (Juselius, 2005; Lütkepohl *et al.*, 2000)

Table 6: Detailed results of Johansen test for cointegrated pairs of variables

Cointegration link	Rank	λTrace	p-value	λMax	p-value
ATX-PROD	**rank 0**	**2**	**0.0387**	23.89	0.010
	rank 1	2	0.8924	2.862	0.892
CRO-M4	**rank 0**	**2**	**0.040**	22.77	0.016
	rank 1	3	0.763	3.856	0.763
CRO-PROD	**rank 0**	**6**	**0.000**	65.15	0.000
	rank 1	4	0.74	4.012	0.74
CRO-SPX**	**rank 0**	**2**	**0.098***	19.38	0.050
	rank 1	4	0.737	4.038	0.737
PX-M2	**rank 0**	**2**	**0.041**	23.43	0.012
	rank 1	3	0.859	3.144	0.859
PX-CPI	**rank 0**	**2**	**0.031**	19.27	0.051
	rank 1	8	0.239	8.161	0.239
PX-IFR	**rank 0**	**3**	**0.006**	27.20	0.003
	rank 1	5	0.555	5.289	0.555
BUX-M2	**rank 0**	**2**	**0.017**	20.57	0.034
	rank 1	9	0.18	9.001	0.18
WIG-M2	**rank 0**	**3**	**0.001**	35.04	0.000
	rank 1	4	0.732	4.072	0.732
WIG-PROD	**rank 0**	**3**	**0.003**	28.02	0.002
	rank 1	6	0.400	6.492	0.400
BET-PROD**	**rank 0**	2	**0.077***	14.33	0.232
	rank 1	9	0.127	9.998	0.127
SBITOP-SX5E	**rank 0**	**2**	**0.020**	25.79	0.005
	rank 1	3	0.865	3.099	0.865

Note: Optimal number of lags was selected based on SC lag selection criteria using unrestricted VAR model. **indicates 10% significance level based on MacKinnon-Haug-Michelis (1999) p-values
Source: Author´s computation based on downloaded data set using Gretl/E-Views

Table 7 shows detailed results of Johansen cointegration test with λTrace and λMax statistics for all tested pairs of variables. Crossed cells mark the pairs of variables where we reject the null hypothesis for rank 0 and also for rank 1. Apparently, the Johansen test is not able to determine the presence of cointegration in these cases as we both reject and confirm the presence of interlinkage. The reason for such inconsistency could be explained by so-called fractional cointegration which is based on a more general definition of cointegration with specific requirements for the order of integration of used variables (Lasak, 2005). However, the examination of such assumption is out of the scope of this paper.

Table 7: Detailed results of Johansen test for all pairs of variables

Rank	Y/X	FX	M2	PROD	CPI	IFR	SPX	SX5E
rank 0	ATX	7.74 (0.98)[a] 5.29 (0.98)[b]	19.51 (0.25)[a] 16.79 (0.12)[b]	26.76 (0.04)[a] 23.89 (0.01)[b]	N/A	23.01 (0.11)[a] 20.25 (0.04)[b]	13.51 (0.69)[a] 8.02 (0.82)[b]	8.97 (0.96)[a] 7.04 (0.89)[b]
rank 1		2.45 (0.94)[a] 2.45 (0.94)[b]	2.72 (0.91)[a] 2.72 (0.91)[b]	2.86 (0.89)[a] 2.86 (0.89)[b]	N/A	2.76 (0.90)[a] 2.76 (0.90)[b]	5.49 (0.53)[a] 5.49 (0.53)[b]	1.93 (0.97)[a] 1.93 (0.97)[b]
rank 0	SOFIX	14.94 (0.58)[a] 12.29(0.39)[b]	27.84 (0.00)[a] 16.14 (0.14)[b]	21.46 (0.16)[a] 13.39 (0.29)[b]	22.32 (0.13)[a] 16.93(0.11)[b]	35.88 (0.01)[a] 23.99 (0.00)[b]	18.68 (0.30)[a] 11.49(0.46)[b]	20.49 (0.20)[a] 16.33(0.13)[b]
rank 1		2.65 (0.92)[a] 2.65 (0.92)[b]	11.69 (0.06)[a] 11.69 (0.06)[b]	8.07 (0.25)[a] 8.07 (0.25)[b]	5.39 (0.54)[a] 5.39 (0.54)[b]	11.88 (0.06)[a] 11.88 (0.06)[b]	7.19 (0.33)[a] 7.19 (0.33)[b]	4.16 (0.72)[a] 4.16 (0.72)[b]
rank 0	CRO	11.07 (0.87)[a] 7.73 (0.85)[b]	26.63 (0.04)[a] 22.77 (0.02)[b]	69.17 (0.00)[a] 65.15 (0.00)[b]	14.79 (0.59)[a] 10.28(0.59)[b]	20.71 (0.19)[a] 16.89 (0.11)[b]	23.42 (0.09)[a] 19.38(0.05)[b]	17.79 (0.36)[a] 14.65(0.86)[b]
rank 1		3.34 (0.83)[a] 3.34 (0.83)[b]	3.86 (0.76)[a] 3.86 (0.76)[b]	4.01 (0.74)[a] 4.01 (0.74)[b]	4.51 (0.67)[a] 4.51 (0.67)[b]	3.82 (0.77)[a] 3.82 (0.77)[b]	4.04 (0.74)[a] 4.04 (0.74)[b]	3.15 (0.86)[a] 3.15 (0.86)[b]
rank 0	PX	9.78 (0.93)[a] 7.24 (0.88)[b]	26.58 (0.04)[a] 23.43 (0.01)[b]	22.21 (0.13)[a] 18.39 (0.07)[b]	27.43 (0.03)[a] 19.27(0.05)[b]	32.49 (0.01)[a] 27.21 (0.00)[b]	10.04 (0.92)[a] 8.32 (0.79)[b]	11.31 (0.86)[a] 8.19 (0.80)[b]
rank 1		2.54 (0.93)[a] 2.54 (0.93)[b]	3.14 (0.86)[a] 3.14 (0.86)[b]	3.82 (0.77)[a] 3.82 (0.77)[b]	8.16 (0.24)[a] 8.16 (0.24)[b]	5.29 (0.56)[a] 5.29 (0.56)[b]	1.72 (0.98)[a] 1.72 (0.98)[b]	3.11 (0.86)[a] 3.11 (0.86)[b]
rank 0	BUX	19.31 (0.26)[a] 16.12(0.14)[b]	29.58 (0.02)[a] 20.58 (0.03)[b]	20.38 (0.21)[a] 13.38 (0.29)[b]	17.99 (0.35)[a] 10.93(0.52)[b]	12.33 (0.79)[a] 9.09 (0.72)[b]	12.55 (0.77)[a] 11.34(0.48)[b]	15.74 (0.51)[a] 12.39(0.38)[b]
rank 1		3.19 (0.85)[a] 3.19 (0.85)[b]	9.00 (0.18)[a] 9.00 (0.18)[b]	7.00 (0.34)[a] 7.00 (0.34)[b]	7.06 (0.34)[a] 7.06 (0.34)[b]	3.24 (0.85)[a] 3.24 (0.85)[b]	1.21 (0.99)[a] 1.21 (0.99)[b]	3.35 (0.83)[a] 3.35 (0.83)[b]
rank 0	WIG	15.53 (0.53)[a] 10.49(0.57)[b]	39.12 (0.00)[a] 35.05 (0.00)[b]	34.52 (0.00)[a] 28.02 (0.00)[b]	15.25 (0.55)[a] 8.72 (0.75)[b]	28.41 (0.02)[a] 15.87 (0.15)[b]	7.49 (0.98)[a] 6.24 (0.95)[b]	13.35 (0.71)[a] 8.24 (0.79)[b]
rank 1		5.04 (0.59)[a] 5.04 (0.59)[b]	4.07 (0.73)[a] 4.07 (0.73)[b]	6.49 (0.40)[a] 6.49 (0.40)[b]	6.53 (0.39)[a] 6.53 (0.39)[b]	12.54 (0.05)[a] 12.54 (0.05)[b]	1.25 (0.99)[a] 1.25 (0.99)[b]	5.11 (0.58)[a] 5.11 (0.58)[b]
rank 0	BET	21.13 (0.17)[a] 11.80(0.43)[b]	27.77 (0.03)[a] 17.04 (0.10)[b]	24.34 (0.08)[a] 14.34 (0.23)[b]	14.65 (0.60)[a] 7.95 (0.83)[b]	19.93 (0.23)[a] 13.63 (0.28)[b]	16.44 (0.46)[a] 10.66(0.56)[b]	13.39 (0.71)[a] 8.09 (0.81)[b]
rank 1		9.33 (0.16)[a] 9.33 (0.16)[b]	10.74 (0.09)[a] 10.74 (0.09)[b]	9.99(0.13)[a] 9.99(0.13)[b]	6.70 (0.38)[a] 6.70 (0.38)[b]	6.30 (0.42)[a] 6.30 (0.42)[b]	5.78 (0.49)[a] 5.78 (0.49)[b]	5.29 (0.56)[a] 5.29 (0.56)[b]
rank 0	SBIT	13.59 (0.69)[a] 10.13(0.61)[b]	51.72 (0.00)[a] 39.69 (0.00)[b]	14.87(0.59)[a] 11.60(0.45)[b]	11.07 (0.87)[a] 7.97 (0.82)[b]	N/A	17.48 (0.38)[a] 13.29(0.31)[b]	28.89 (0.02)[a] 25.79(0.01)[b]

Rank	Y/X	FX	M2	PROD	CPI	IFR	SPX	SX5E
rank 1		3.46 (0.82)[a] 3.46 (0.82)[b]	12.03 (0.06)[a] 12.03 (0.06)[b]	3.27(0.84)[a] 3.27(0.84)[b]	3.09 (0.86)[a] 3.09 (0.86)[b]	N/A	4.18 (0.72)[a] 4.18 (0.72)[b]	3.09 (0.87)[a] 3.09 (0.87)[b]

Note: [a] denotes trace statistics, [b] denotes max statistics; p-values based on MacKinnon-Haug-Michelis (1999) are displayed in parenthesis
Source: Author´s computation based on downloaded data using Gretl/E-Views

As EG test and Johansen test did not always lead to the same results, the vector error correction model (VECM) is applied in the following section to prevent any misspecifications of results and to sufficiently confirm the long-run cointegration relationships. (Nisha, 2015)

3.5.3 Vector Error Correction Model

Based on Brooks (2008), a restricted VAR model with cointegration restrictions built into the specification, the so-called vector error (equilibrium) correction model, can be represented by the following equation:

$$\Delta \boldsymbol{y}_t = \boldsymbol{\beta}_1 \Delta \boldsymbol{x}_t + \boldsymbol{\beta}_2 (\boldsymbol{y}_{t-1} - \boldsymbol{\gamma} \boldsymbol{x}_{t-1}) + \boldsymbol{u}_t \quad (1.2)$$

The most important part of the model is the error correction (EC) term $y_{t-1} - \gamma x_{t-1}$ and the coefficient β_2 that represents the gradual adjustment of the system back to the long-run equilibrium. Coefficient β_1 describes the short-run dynamics in the system.

Table 8 presents the results of VEC model for pairs of variables where cointegration could be expected. Optimal number of lags was selected based on Schwarz criterion as in the case of Johansen test. All variables in the model are endogenous. The set of stock indices (dependent variable *y*) is presented in the first column, selected macroeconomic indicators (independent variable *x*) are shown in the first row.

Table 8: VEC model results

y/x	FX	M2	PROD	CPI	IFR	SPX	SX5E
ATX			0,002[a]				
p-value			0,872[b]				
SOFIX							
p-value							
CRObex		0,001[a]	-0,018[a]			-0,021[a]	-0,018[a]
p-value		0,996[b]	0,215[b]			0,048[b]	0,064[b**]
PX		0,003[a]		-0,021 [a]	-0,023[a]		

y/x	FX	M2	PROD	CPI	IFR	SPX	SX5E
p-value		0,594[b]		0,001 [b]	0,042[b]		
BUX	-0,016[a]	-0,009[a]					
p-value	0,077[b**]	0,124[b]					
WIG		-0,023[a]	-0,063[a]				
p-value		0,185[b]	0,015[b]				
BET			-0,115[a]				
p-value			0,002[b]				
SBITOP							-0,004[a]
p-value							0,585[b]

Note: a reports the error-correction coefficient; b reports p-value of the error correction term
** indicates significance at 10% level
Source: Own elaboration based on downloaded data using Gretl/E-Views

A VEC model confirms the cointegration behaviour for pair of variables where the EC term in the equation has significantly negative value. In such cases, any diversion from the long-run equilibrium is continuously eliminated. Series that satisfy the long-run equilibrium rule are highlighted in Table 8. On the other hand, crossed cells represent the pairs of variables with statistically not significant EC term. In these cases the long-run interlinkage should not be taken into consideration as it is not stable and consistent.[3] The VEC model results confirm some of the cointegration that was found by EG and Johansen tests. The model verified a significant long-run equilibrium interaction between CRObex index and benchmark indices S&P 50, Eurostoxx 500; PX index and inflation; PX index and 1-month Pribor; BUX index and USD exchange rate; production index and stock indices in Poland (WIG) and Romania (BET). Therefore those pairs of variables have a common stochastic trend and converge to the long-run equilibrium.

Out of the scarce research on the long-run interactions between CEE & SEE stock markets and macroeconomic indicators, our results are consistent with Gurgul and Lach (2010) who also confirmed that Polish stock market index has an interconnection with industrial production, and no link with inflation rate in the long-run. Barbic and Jurkic (2011) employed similar methodology and found cointegration between inflation rate and Prague stock market index, which also supports our findings, although we find a difference in the choice of proxy for the inflation rate variable. The

[3] A significantly positive EC term would indicate a diverging behaviour of the series and thus no cointegration relationship. However, pairs of series under consideration do not have such features.

difference in proxies used could explain the fact that we have not found a long-run equilibrium between inflation and stock indices in Croatia, Hungary, Poland and Slovenia. But Barbic and Jurkic (2011) did not use the VEC model to sufficiently confirm the long-run interactions and did not specify the number of lags of variables used in the Johansen test, which is the most sensitive attribute of the analysis. Using Johansen test and M2 monetary aggregate, we come to the same results as Barbic and Jurkic (2011), who found cointegration between broader money supply (M3) and stock indices in Croatia, Czech Republic, Hungary and Poland. However, after performing VEC model to sufficiently confirm the findings, we find those cointegrations statistically insignificant in the long-run. The rest of the provided cointegration results are unique and cannot be compared to any past research.

3.5.4 Causality Analysis

The previous analysis revealed long-run equilibrium relationships between some of the analysed variables. However, there can also be some kind of short-run lead-lag linkage present between macroeconomic fundamentals and the selected stock indices. In the following section, a bivariate granger causality test is employed in order to test possible short-run links between studied variables.

Following Granger (1969, 1988), the VAR regression equations below are estimated for each pair of stock index (variable y_t) and macroeconomic variable (variable x_t):

$$\boldsymbol{y_t = \beta_0 + \sum_{j=1}^{n} \beta_{1j} y_{t-j} + \sum_{h=1}^{p} \beta_{2h} x_{t-P} + \varepsilon_{1t}} \quad (1.3)$$
$$\boldsymbol{x_t = \alpha_0 + \sum_{s=1}^{k} \alpha_{1s} x_{t-s} + \sum_{i=1}^{m} \alpha_{2i} y_{t-m} + \varepsilon_{2t}} \quad (1.4)$$

, where $\mathrm{y_{t-j}}$ and $\mathrm{y_{t-m}}$ define lag values of stock price index; $\mathrm{x_{t-p}}$ and $\mathrm{x_{t-s}}$ define lag values of each macroeconomic variable; $\varepsilon_{!t}$ and ε_{2t} are uncorrelated white noise vectors

In equation 1.9, we examine the null hypothesis H_0 whether all β_{2h} coefficients are equal to zero using a standard F-test, the so-called Wald test. The test follows a χ^2 distribution. The number of optimal lags chosen in the model is based on the Schwarz lag lenght criterion as in the previous cases. If at least one $\beta_{2h} \neq 0$, then we can say that variable X Granger causes variable Y. We interpret the equation 1.10 analogically. If at least one $\alpha_{2i} \neq 0$, then we can say that variable Y Granger causes variable X. If the causality is present in both directions, we speak about bidirectional causal relationship. As the precondition for ordinary Granger causality test is the stationarity of tested time series, we have to difference each series once to make it *I*(0). Engle and Granger (1987) add on that in cases where cointegration relationship was found, we have to re-parametrize the original version of granger causality test by including the equivalent error correction term.

Table 9 and Table 10 present the outcome of the Granger causality test. Results of Table 9 refer to the equation 1.10, where the impact of past values of stock index on current values of macroeconomic variable is analysed. Table 10 presents the results of the reverse analysis, i.e. whether macroeconomic variables granger cause any stock index. Table 10 refers to the equation 1.9.

Table 9: Causal impacts from stock index to macroeconomic indicator

y/x	ΔFX	ΔM2	ΔPROD	ΔCPI	ΔIFR	ΔSPX	ΔSX5E
ΔATX	0.50 (0.48)	0.07 (0.79)	8.87 (0.18)	1.54 (0.22)	7.84 (7.E-06)	1.58 (0.21)	0.23 (0.79)
ΔSOFIX	3.87 (0.02)	3.69** (0.06)	8.31 (0.0004)	1.05 (0.35)	1.13 (0.32)	4.04 (0.02)	3.34 (0.04)
ΔCRO	1.73 (0.19)	0.18 (0.69)	8.34 (0.004)	3.21** (0.07)	0.29 (0.59)	2.67 (0.26)	0.02 (0.89)
ΔPX	0.85 (0.36)	6.70 (0.04)	1.79 (0.12)	0.83 (0.36)	0.41 (0.52)	1.14 (0.29)	2.04 (0.15)
ΔBUX	0.25 (0.62)	3.80** (0.05)	2.09** (0.08)	1.59 (0.21)	4.77 (0.03)	0.10 (0.75)	0.35 (0.55)
ΔWIG	0.01 (0.92)	15.39 (0.0005)	13.27 (0.039)	0.78 (0.46)	0.89 (0.41)	0.01 (0.91)	1.31 (0.25)
ΔBET	3.51** (0.06)	0.03 (0.86)	13.40 (0.04)	0.09 (0.76)	0.65 (0.42)	7.39 (0.001)	3.32** (0.07)
ΔSBITOP	2.67 (0.11)	5.25 (0.02)	4.85 (0.03)	0.54 (0.47)	**N/A**	2.87** (0.09)	0.41 (0.52)

Note: F-statistics with p-value in parenthesis; ** denotes rejection of null hypothesis at 10% confidence level
Source: Author´s computations based on downloaded data using Gretl/E-Views

Table 10: Causal impacts from macroeconomic indicator to stock index

x/y	ΔATX	ΔSOFIX	ΔCRO	ΔPX	ΔBUX	ΔWIG	ΔBET	ΔSBITOP
ΔFX	1.08 (0.30)	0.52 (0.59)	0.64 (0.43)	4.07 (0.04)	0.03 (0.86)	1.18 (0.28)	0.83 (0.36)	4.49 (0.04)
ΔM2	0.0002 (0.98)	0.24 (0.63)	0.01 (0.90)	5.16** (0.08)	0.20 (0.65)	1.33 (0.51)	7.59 (0.007)	3.0E-05 (0.99)
ΔPROD	4.63 (0.59)	3.89 (0.02)	0.12 (0.73)	1.46 (0.20)	1.02 (0.39)	2.59 (0.86)	2.07 (0.91)	0.95 (0.33)

x/y	ΔATX	ΔSOFIX	ΔCRO	ΔPX	ΔBUX	ΔWIG	ΔBET	ΔSBITOP
ΔCPI	7.23 (0.007)	0.21 (0.81)	0.17 (0.68)	3.71** (0.054)	0.98 (0.32)	0.27 (0.76)	8.8E-07 (0.99)	0.03 (0.87)
ΔIFR	1.84 (0.12)	0.16 (0.85)	0.02 (0.88)	0.03 (0.87)	0.56 (0.45)	2.09 (0.12)	0.06 (0.81)	N/A
ΔSPX	2.36** (0.09)	1.61 (0.20)	13.54 (0.001)	1.05 (0.31)	3.74** (0.054)	0.17 (0.68)	0.17 (0.84)	4.83 (0.03)
ΔSX5E	2.56** (0.08)	1.39 (0.25)	12.89 (0.0003)	2.59 (0.11)	6.68 (0.01)	2.71 (0.101)	0.06 (0.80)	6.02 (0.01)

Note: F-test statistics with p-value in parenthesis; ** denotes rejection of null hypothesis at 10% confidence level
Source: Author´s computations based on downloaded data set using Gretl/E-Views

The highlighted cells in Table 9 and Table 10 show pairs of variables where some form of Granger causality is found. The results of Granger causality reveal that there is a short-run relation present between macroeconomic indicators and stock indices in all selected markets, indicating that all of the markets under consideration may partially violate Fama´s (1969) theory of efficient capital markets. (Granger, 1986)

The analysis showed a lead-lag relationship from stock market indices to: (a) money supply in case of Bulgaria, Hungary, Poland and Slovenia; (b) production index in case of Croatia, Hungary, Poland, Romania and Slovenia; (c) 1-month interbank offered rate in Austria and Hungary (d) indices S&P 500 and EUROXX 50 in Bulgaria and Romania; (e) USD exchange rate in Slovenia and Romania and (f) inflation in Croatia. Therefore, there is a possibility that past values of mentioned stock indices might be used as a predictor of some future macroeconomic conditions. Any causal impact from stock indices to macro-fundamental variables could be also taken into account by academicians, policy makers or governments when establishing new financial regulations or various policies. This kind of causal link denotes that the capital market is considered as a mirror for the economic activity (Bhattacharya, 2006).

Additionally, Granger causality reveals reverse causal impact directed from macroeconomic indicators to stock indices in all studied CEE & SEE markets except for Polish stock market. For the remaining countries, the following stock market inefficiencies are found: (a) indices representing developed financial environment S&P 50 and Euroxx 500 lead stock indices in Austria, Croatia, Hungary and Slovenia; (b) inflation and FX rate lead Prague stock market index; (c) FX rate is a leading indicator for Slovenian stock index; (d) money supply leads Romanian stock index and (e) inflation leads Austrian index. The 1-month interbank offered rate is the only variable whose past values do not affect any of the selected stock indices.

A stronger link, bidirectional causality, is found between S&P 500 and Slovenian stock index, production index and Bulgarian stock index and money supply and Czech market index. For these markets there is some form of mutual interdependence between macroeconomic development and the stock market present.

According to Fama´s definition of efficient markets (1969), we conclude that markets are not weakly efficient if a causal impact from macroeconomic indicator to stock market index is found. The reasoning for this inference is straightforward. When a causality link is present on the stock markets, then investors might predict or evaluate future stock index performance based on information about past values of particular macro-fundamentals and the theory of random walk is disputed. (Fama, 1969; Granger, 1986; Musilek, 2011)

Although using slightly diverse methods and different survey periods, our findings are in line with previous research papers. The results of short-run analysis between production index and stock markets in Poland, the Czech Republic and Hungary confirm conclusions of Sahin (2013). A short-run link between production index and stock markets in Poland and the Czech Republic was also affirmed by Samitas and Kenourgious (2007). However, our analysis differs in case of Hungary, where we find a causal impact between stock market and production index while Samitas and Kenourgious (2007) do not. Reported discrepancy could be explained by a difference in survey periods, with the recent recession having enormous impact on the results. Furthermore, likewise Sesar and Tomic (2015), we confirm a causal link in case of Croatian stock index and production index. The study of Barbic and Jurkic (2011) coincide with the outcome of performed causality test between stock indices in Croatia, Hungary, Poland and money supply or inflation. On the other hand, our analysis suggests no short-run impact of inflation on Slovenia stock index and causal impact from inflation to Czech stock market index. Again, the difference in selection of proxy variable for inflation might explain the discrepancy in results. The rest of provided causality results are unique.

3.6 Results Summary

The result of our research must be interpreted with caution. ADF unit root tests applied within the Engle-Granger analysis sometimes tend to wrongly indicate the stationary properties of the series. Based on incorrect ADF test conclusions, a researcher might find spurious cointegration between studied variables. This kind of biased deductions can occur either due to lack of power of ADF test in small finite samples, or due to presence of structural break over the studied period (Harris and Sollis, 2003). All applied methods are also extremely sensitive to the choice of lag length of variables used in the model. The outcome of research can significantly change if an inaccurate number of lags is included in the model (Hubana, 2013).

Data consistency within the examined period was also significantly influenced by the recent financial crisis. Many studies confirmed that the cointegration and causality relations on the stock markets can significantly differ in pre-crisis and post-crisis periods (Brahmasrene and Jiranyakul, 2007; Assidenou, 2010; Aghayev, 2012 etc.).

Bearing in mind the above-mentioned, our results show a long-run *cointegration linkage* between macroeconomic indicator and stock index, implying that cointegrated variables have common stochastic trend and converge to the mutual equilibrium. Such findings might be used to improve long-run forecast accuracy of country´s financial market or economic conditions (Lin, 2008). Short-run *causal linkage* found between selected macroeconomic indicators and stock indices suggests that either (i) past values of macro-fundamental predict future movements of stock index price or (ii) past values of stock indices might be used to forecast eventual economic conditions.

A summary of reported cointegration links and causal relations between the selected CEE & SEE stock exchanges and appropriate macro-fundamentals is presented in Table 11 and Table 12, respectively.

Table 11: Summary of the cointegration links identified

Country	Cointegration	FX	M2	PROD	CPI	IFR	SPX	SX5E
Austria	ATX							
Bulgaria	SOFIX							
Croatia	CRObex						◆·······◆	◆·······◆
Czech Republic	PX				◆·······◆	◆·······◆		
Hungary	BUX	◆·······◆						
Poland	WIG			◆·······◆				
Romania	BET			◆·······◆				
Slovenia	SBITOP							

Note: ◆·······◆ denotes cointegration link between variables
Source: Own elaboration

Table 12: Summary of the causality links identified

Country	Causality	FX	M2	PROD	CPI	IFR	SPX	SX5E
Austria	ATX				←----	→	←----	←----
Bulgaria	SOFIX	→	→	↔			→	→
Croatia	CRObex			→	→		←----	←----
Czech Republic	PX	←----	↔		←----			
Hungary	BUX		→	→		→	←----	←----
Poland	WIG		→	→				
Romania	BET	→	←----	→			→	→
Slovenia	SBITOP	←----	→	→			↔	←----

Note: → denotes causal impact from stock index to macro variable; ←-- denotes causal impact from macro-variable to stock index; ↔ denotes bi-directional causality
Source: Own elaboration

To conclude, the cointegration and causality analyses performed disclosed some form of market inefficiency in all studied CEE & SEE stock markets over the period studied. Such findings could serve as an indicator for investors, who are interested in international stock picking, as it might help them predict future economic or financial market conditions and generate excess returns (Markwat *et al.*, 2008). Moreover, our inferences might potentially be helpful for policy makers when analysing the impact of financial markets on the macroeconomic development and vice versa. However, it is important to mention that employed cointegration and causality tests serve to find a significant linkage between macro-fundamental indicators and stock markets, but do not provide any information about the sign of possible impacts or continuity of the linkage. Even though it would be very interesting to see the strength and signs of these relations, such analysis is out of the scope of current paper.

4 Conclusion

The paper examined the cointegration and causality links between macroeconomic factors and stock indices of selected Central and South-Eastern European countries, revising presumed relationships within the theory of macro-fundamental analysis. The paper contributes to current academic discussion by conducting the macro-fundamental analysis on a sample of eight CEE & SEE stock indices, collecting the latest data from these still relatively unexplored economies, broadening the sample of macroeconomic indicators and using a longer time horizon. The work also evaluates the efficiency of the studied CEE & SEE markets with respect to Fama´s (1969) definition of Efficient Market Hypothesis.

The simple correlation statistics indicated co-movements among some of the macroeconomic factors and stock indices. To affirm the inferential linkages, the Engle-Granger and Johansen tests were performed to test the long-run cointegrations. A vector error correction model was used to sufficiently confirm the cointegration findings. Furthermore, the Granger causality test was employed to assess the short-run interlinkages. We identified common long-run trend tendencies between (a) CRObex index and S&P 500/Euroxx 50;(b) PX index and inflation; (c) PX index and 1-month pribor; (d) BUX index and USD exchange rate; (e) production index and stock indices in Poland (WIG) and Romania (BET). We also found short-run lead-lag relationship from stock market indices to macroeconomic fundamentals, and vice versa, for all studied markets. Stock market indices lead (a) money supply in case of Bulgaria, Hungary, Poland and Slovenia; (b) production index in case of Croatia, Hungary, Poland, Romania and Slovenia; (c) 1-month interbank offered rate in Austria and Hungary; (d) indices S&P 500 and Euroxx 50 in Bulgaria and Romania; (e) USD exchange rate in Slovenia and Romania and (f) inflation in Croatia. This kind of causal link indicates there is a possibility that past values of mentioned stock indices might be useful when predicting future macroeconomic conditions.

Finally, we have also identified that certain macroeconomic indicators lead stock indices in the markets under consideration, supporting the existence of market inefficiencies, e.g.: (a) indices representing developed financial environment S&P 500 and Euroxx 50 lead stock indices in Austria, Croatia, Hungary and Slovenia; (b) inflation and FX rate lead Prague stock market index; (c) FX rate is a leading indicator for Slovene stock index; (d) money supply leads Romanian stock index and (e) inflation leads Austrian index. The interdependence between stock markets and macroeconomic performance, the so-called bidirectional causality, was found between S&P 500 and Slovene stock index, production index and Bulgarian stock index and money supply and Czech stock market index.

To sum up, our inferences suggest there seem to exist certain cointegration and causality links between some macro-fundamental factors and stock indices in all studied CEE & SEE markets. Our sample results also indicate that all the mentioned stock markets may potentially be in violation of Efficient Market Hypothesis. Although in line with the existing literature, the findings of our research must be interpreted with caution. The reason is that our data sample includes the period of the recent financial crisis which represents a structural break that has undoubtedly had an effect on the results. It is also important to mention that cointegration and causality tests employed serve to find a significant linkage between macro-fundamental indicators and stock markets, but do not provide much information about the sign and intensity of possible impacts. A useful tool to find out the direction and strength of confirmed relationships could be the impulse response function analysis. However, this kind of analysis is beyond the scope of the current paper.

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Appendix

KPSS stationarity test critical values

KPSS Critical Values level		
10%	**5%**	**1%**
0.119	0.146	0.216

KPSS Critical Values 1st diff		
10%	**5%**	**1%**
0.347	0.463	0.739

KPSS stationarity test results

Variable	**Time Period (mm/yy)**	**KPSS in levels**	**KPSS in 1st diff**
		Test statistic (trend and intercept)	**Test statistic (intercept)**
		Austria	
ATX	1/1999-12/2015	0.311	0.155
FX	1/1999-12/2015	0.322	0.155
M2	1/1999-12/2015	0.364 (11)	0.455 (7)*
CPI	1/1999-12/2015	0.066 (10)	-
PRODUC	1/1999-12/2015	0.292 (8)	0.299 (51)
VIB	1/1999-12/2015	0.198 (11)*	0.112 (9)
		Bulgaria	
SOFIX	2/2003-12/2015	0.161 (10)*	0.208 (7)
FX	2/2003-12/2015	0.294 (9)	0.277 (3)
M2	2/2003-12/2015	0.2163 (10)	0.096 (5)
CPI	2/2003-12/2015	0.198 (9)*	0.142 (7)
PRODUC	2/2003-12/2015	0.130 (9)**	0.027 (4)
SOBR	2/2003-12/2015	0.347 (10)	0.720 (5)
		Croatia	
CRO	1/2001-12/2015	0.309 (10)	0.222 (7)
FX	1/2001-12/2015	0.386 (10)	0.459 (3)
M4	1/2001-12/2015	0.343 (10)	0.272 (3)
CPI	1/2001-12/2015	0.208 (10)*	0.077 (1)
PRODUC	1/2001-12/2015	0.415 (9)	0.255 (28)
ZIBOR	1/2001-12/2015	0.249 (10)	0.066 (13)
		Czech Republic	
PX	1/1995-12/2015	0.246 (12)	0.104 (5)
FX	1/1995-12/2015	0.233 (12)	0.175 (2)
M2	1/1995-12/2015	0.380 (11)	0.530 (4)
CPI	1/1995-12/2015	0.147 (11)*	0.036 (5)

Variable	Time Period (mm/yy)	KPSS in levels	KPSS in 1st diff
		Test statistic (trend and intercept)	Test statistic (intercept)
PRODUC	1/1995-12/2015	0.243 (10)	0.069 (27)
PRIB	1/1995-12/2015	0.180 (12)*	0.147 (8)
Hungary			
BUX	8/1996-12/2015	0.285 (11)	0.140 (3)
FX	8/1996-12/2015	0.228 (11)	0.163 (1)
M2	8/1996-12/2015	0.298 (11)	0.108 (5)
CPI	8/1996-12/2015	0.163 (11)*	0.058 (3)
PRODUC	8/1996-12/2015	0.397 (11)	0.261 (15)
BUBOR	8/1996-12/2015	0.188 (11)*	0.168 (8)
Poland			
WIG	12/1996-12/2015	0.164 (11)*	0.087 (1)
FX	12/1996-12/2015	0.242 (11)	0.112 (3)
M2	12/1996-12/2015	0.128 (11)*	0.531 (7)
CPI	12/1996-12/2015	0.183 (11)*	0.080 (5)
PRODUC	12/1996-12/2015	0.231 (10)	0.097 (30)
WIBOR	12/1996-12/2015	0.224 (11)	0.054 (9)
Romania			
BET	1/2007-12/2015	0.169 (8)*	0.142 (6)
FX	1/2007-12/2015	0.137 (4)**	0.052 (4)
M2	1/2007-12/2015	0.2157 (8)	0.488 (6)
CPI	1/2007-12/2015	0.216 (8)	0.198 (10)
PRODUC	1/2007-12/2015	0.220 (7)	0.047 (8)
BUBR	1/2007-12/2015	0.199(8)*	0.391 (38)*
Slovenia[4]			
SBITOP	1/2007-12/2015	0.240 (9)	0.135 (6)
FX	1/2007-12/2015	0.141 (4)**	0.140 (4)
M2	1/2007-12/2015	0.160 (8)*	0.495 (5)
CPI	1/2007-12/2015	0.121 (10)**	0.093 (8)
PRODUC	1/2007-12/2015	0.163 (8)*	0.094 (5)
Exogenous Indices			
SPX	1/1995-12/2015	0.152 (12)*	0.189 (6)
SX5E	1/1995-12/2015	0.207 (12)*	0.252 (5)

Note: Bandwith automatically selected by Newey-West is presented in parenthesis. * indicates 5% significance level, ** indicates 10% significance level.
Source: Own elaboration based on data set using Gretl/E-Views

[4] Slovenia 1-month interbank offered rate SITI is not included in the analysis due to unavailability of the data throughout the studied period.

Unit root ADF test results

	Time Period (mm/yy)	ADF in levels	ADF in 1st diff
		p-value for Z(t)	p-value for Z(t)
Bulgaria			
PRODUC	2/2003-12/2015	0.1061	6.048e-023
Romania			
FX	1/2007-12/2015	0.272	1.973e-014
Slovenia			
FX	1/2007-12/2015	0.2465	3.054e-015
CPI	1/2007-12/2015	0.3797	2.042e-015

Note: The ADF test is based on the equation $\Delta Y_t = \delta Y_{t-1} + u_t$ and tests the null hypothesis $H_0: \delta = 0$ that series is non-stationary against its alternative $H_1: \delta \neq 0$ (series is $I(0)$). (Dickey and Fuller, 1979)
Source: Own elaboration based on data set using Gretl/E-Views

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