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The relationship between macroeconomic variables and stock market indices: evidence from Central and Eastern European countries

Marie Ligocká[a*]

[a] Prague University of Economics and Business, Prague, Czechia

Abstract
The aim of the study was to investigate the relationship between selected macroeconomic variables and the values of representative stock market indices for Central and Eastern European countries in the period Q1 2004 – Q4 2021. The results, based on the Johansen cointegration test, revealed that the selected macroeconomic variables have an impact on the value of stock market indices on the long term. These results are attributed to the importance of the state of the macroeconomic environment for stable business activity. The reason for this is that macroeconomic stability provides better grounds for predicting the development of the market situation and fiscal and monetary policy. The application of VECM estimations and the Granger causality test indicate that the selected macroeconomic variables affect the values of European stock market indices on the long term rather than on the short term. These findings may reflect the expectations of subjects and/or the consequences of policy measures, whose the impacts can only be estimated and may manifest with a significant delay.

Keywords: macroeconomic variables, stock market indices, Europe, cointegration

Introduction

Stocks are equity securities, which are one of the most widespread investment instruments in capital markets. The achievement of profit is one of the motives for stock trading. Within this context, stock price prediction is an important issue, but a problematic one. Unlike bonds, stock prices are quoted in absolute terms and determining the theoretically correct share price and the future behaviour thereof is very challenging. The reasons for this include the unpredictability of future profits and dividend payments, which are therefore estimated and prone to being inaccurate. Additional complications include the inability to determine the maturity date of the share and the difficulty of calculating the appropriate discount rate due to the

[*] ✉ Marie Ligocká, Assistant Professor, Prague University of Economics and Business, Prague, Czechia; email: marie.ligocka@vse.cz.

characteristics of this security. Knowing the factors that affect stock prices is essential for forecasting stock prices (Veselá, 2019).

Research has shown that macroeconomic and microeconomic variables are among those variables that can affect stock prices. This article focuses on macroeconomic variables, which are essential for economic practice, because macroeconomic policy influences the behaviour of individual economic subjects, as well as the behaviour of financial markets. This information, is particularly important instock market fluctuations because it can help managers and investors better administer and diversify their portfolios (Barakat et al., 2016) and because at a time of stock market instability and stock market decline, significant investor losses can occur (Demir, 2019). Evidently, long-term investors often base their decision to invest in equities on the development of macroeconomic variables, as suggested by Bhuiyan and Chowdhury (2020).

Based on empirical research, it is clear that the importance of macroeconomic variables and their interconnectedness grows with the greater volatility and instability of stock markets (Beetsma & Giuliodori, 2012). Stock markets that are characterised by insufficient financial depth affect its interconnectedness with macroeconomic variables. Caporale et al. (2015) argue that countries in such a position have stock and credit markets that are generally underdeveloped. This lower degree of market integration and development may be the reason for the specific relationship between macroeconomic variables and stock markets (Pradhan et al., 2015a). Within this context, it seems crucial to support the development of stock markets because it can lead to increased capital raising for investment purposes, which in turn boosts economic growth (Pradhan et al., 2014).

Furthermore, Pradhan et al. (2014) argue that attracting foreign direct investment and promoting trade openness can facilitate further investment and easier ways to raise capital to support the stock market and bank activities, leading to increased economic activity. Due to the volatile macroeconomic situation, especially in less developed stock markets, developments are less predictable. Investing in these markets may therefore be riskier, so knowledge of the link between macroeconomic variables and the stock market is essential.

The markets of Central and Eastern Europe, which continue to undergo many political, structural, social and economic changes, can be included in this category, as stated by Zyznarska-Dworczak (2018). Deltuvaitė (2016) adds to this by pointing out the significant differences in areas such as the size of the markets and the level of development in Central and Eastern Europe, thereby stating that the level of stock market development significantly affects the degree of global and regional financial integration. As financial markets are well connected to regional and global financial centres, they facilitate better capital allocation and consumption smoothing, leading to less reliance on domestic savings for investment purposes. The financial integration of markets critically affects the functioning of any economy at the microeconomic and macroeconomic levels (Beck & Stanek, 2019). In addition, local markets, such as Central and Eastern European stock markets, may develop independently of the economic situation of large markets due to the limited interest in them (Przekota et al., 2019). Within this context, and as previously mentioned, the more complicated the predictability of stock market developments, in combination with the various forms of change (Zyznarska-Dworczak, 2018) and the specificity of CEE stock markets, the greater the impact on and the change in the relationship between the macroeconomic variables and the stock markets over time. Verifying the relationship between macroeconomic variables and stock indices (stock prices) in CEE countries is therefore desirable.

This article aims to investigate the relationship between selected macroeconomic variables and the values of representative stock market indices for Central and Eastern European countries in the period Q1 2004 – Q4 2021. By setting this aim, it should be possible to confirm or refute the formulated hypotheses, as defined based on the results from empirical literature. For the stated aim, the representative stock market indices of Central and Eastern Europe are: Sofix (Bulgaria), Crobex (Croatia), PX (Czechia), BUX (Hungary), WIG20 (Poland), BET (Romania), SAX (Slovakia), OMX Tallinn (Estonia), OMX Riga (Latvia) and OMX Vilnius (Lithuania); and the selected macroeconomic variables are: consumer price index (CPI), economic activity, as measured by gross domestic product (GDP), and money supply (M3).

The introduction, in which the issue of the relationship between various macroeconomic variables and stock markets (in CEE countries) is presented, is followed by the literature review, in which the findings from empirical literature and the defined hypotheses are presented. The methods for validating the hypotheses are subsequently proffered. The achieved results are then introduced, discussed and conclusions drawn. The application of the methods shows that the analysed macroeconomic variables rather affect the values of European stock market indices on the long term than on the short term.

1. Literature review

In empirical literature, many studies focus on the relationship between stock prices and macroeconomic variables. Anari and Kolari (2001) show that the impact of inflation is negative in the short term and positive on stock prices in the long term. Similar findings regarding the impact of inflation were also mentioned by Camilleri et al. (2019) and Keswani and Wadhwa (2022), who showed the importance of inflation and other macroeconomic variables on stock markets. Consistent with these findings are also those of Megaravalli and Sampagnaro (2018), who highlight the negative impact of inflation and the positive impact of the exchange rate on stock markets. However, the findings of Kwofie and Ansah (2018) about inflation are in contrast to the aforementioned, as are the findings of Rapach (2002) in contrast to those of Anari and Kolari (2001). Rapach (2002) shows that inflation does not erode the real long-term value of stocks. On the other hand, Apergis and Eleftheriou (2002) present empirical evidence that inflation, rather than nominal interest rate movements, affects stock prices. Bahloul et al. (2016) present similar results regarding the effect of interest rates and show that the conventional index return and changes in the money supply significantly impact Islamic index return in low and high volatility regimes in developing and emerging markets. Likewise, Gan et al. (2006) also determined the impact of money supply, as well as interest rates and real GDP, on the stock market. For example, Bahloul et al. (2016) suggest that money supply demonstrates a strong positive relationship with the SET Index on the long term. In contrast, the industrial production and consumer price indices show negative long-term relationships with the SET Index. Barakat et al. (2016), Forson and Janrattanagul (2013), Tripathi and Seth (2014), Hanousek and Filer (2000), Demir (2019), Dumitrescu and Horobet (2009), and Bhuiyan and Chowdhury (2020) also present conclusions that are consistent with Bahloul et al. (2016).

Many researchers have also investigated the relationship between stock prices and economic growth and showed its significant effect on the stock market. Like Gan et al. (2006), Hassapis and Kalyvitis (2001), Hondroyiannis and Papapetrou (2001), Christopoulos and Tsionas (2004), Hanousek and Filer (2000), Peiró (2016), and Calderón and Liu (2003) also draw the same conclusions regarding the relationship between real stock prices and economic growth. However, the results of Caporale et al. (2015) suggest that the stock and credit markets in countries lacking financial depth are still underdeveloped and that their contribution to economic growth is limited. Pradhan et al. (2015b) suggest there is a clear relationship between economic activity and the stock market by showing that there is a robust long-term economic relationship between economic growth, oil prices, stock market depth, the inflation rate, real effective exchange rate and real rate of interest. The findings of Marques et al. (2013) and Beetsma and Giuliodori (2012), Tripathi and Seth (2014), Barakat et al. (2016), Jareño and Negrut (2016), Demir (2019) and Van Nieuwerburgh et al. (2006) on the importance of macroeconomic variables are also consistent with the aforementioned.

In a similar vein, economic development, as reflected in the unemployment rate, and the impact thereof on stock markets, has been analysed, for example, by Pan (2018) and Sibande et al. (2019). Pan (2018) determined that the unemployment rate and stock market prices are cointegrated in all country groups. The findings of Sibande et al. (2019) support this by demonstrating time-varying causality.

Beyond the significance of the mentioned macroeconomic variables, the effect of the exchange rate on stock markets is well documented. This was shown by Pradhan et al. (2015b) and Abbas et al. (2019). Of the analysed variables, the exchange rate, interest rate, and terms of trade appear to be the most impactful macroeconomic variables. The impact of the exchange rate on the stock market is also presented by Bahmani-Oskooee and Saha (2016), who show that exchange rate changes can affect companies differently depending on whether they are exportoriented or use imported inputs. The various impacts of the exchange rate and other macroeconomic variables on stock markets in the analysed countries are also revealed by Dahir et al. (2017), Tsagkanos and Siriopoulos (2013) and Dumitrescu and Horobet (2009). Mouna and Anis (2016) confirm the impact of exchange rates in most of the surveyed countries. The findings of Suriani et al. (2015) are in contrast with Mouna and Anis (2016). They suggest that there is no relationship between the exchange rate and stock price, both variables being independent from one another.

The interaction between stock prices and macroeconomic variables, including exchange rates, was also investigated by Nasseh and Strauss (2000) and Huang et al. (2016). Nasseh and Strauss (2000) demonstrate that stock price levels are significantly related to industrial production, business surveys of manufacturing orders, short- and long-term interest rates and foreign stock prices. However, Huang et al. (2016) show that US stock markets respond positively to oil price rises and negatively to an appreciation of the USD against major currencies and interest rates.

As evidenced by the literature review and summary table in Annex 1, empirical studies focus on the impact of macroeconomic variables on different stock markets. The results of these studies have shown that those variables affecting stock markets (or vice versa) include: exchange rate, interest rate; inflation; economic growth; money supply; industrial production; foreign direct investment; and unemployment. According to empirical studies, the influence of individual variables differs geographically and over time. This allows us to formulate two hypotheses:

H1: Macroeconomic variables influence the value of stock indices over the long term;

H2: Macroeconomic variables influence the value of stock indices in the short term.

2. Data and methods

The research uses data covering the period Q1 2004 – Q4 2021 (2,880 observations), specifically quarterly data on the stock market indices of Central and Eastern European countries, namely: Sofix (Bulgaria), Crobex (Croatia), PX (Czechia), BUX (Hungary), WIG20 (Poland), BET (Romania), SAX (Slovak republic), OMX Tallinn (Estonia), OMX Riga (Latvia) and OMX Vilnius (Lithuania). SBITOP (Slovenia) could not be used due to the unavailability of sufficient time series. Albania was excluded because it is not a member of the EU and does not have a tradeable stock index. The choice to start the time series in 2004 was based on the desire to include the largest possible sample of European stock market index values and macroeconomic variables in the dataset. The choice to end the time series with Q4 2021 was based on the availability of macroeconomic data for the analysed countries. The values of the stock market indices were calculated as the average daily closing values for each quarter to incorporate the volatility of the market over the time series. The data were sourced from Yahoo Finance and the Stooq and Investing web portals.

The macroeconomic variables of interest were:

- *M3 monetary supply (in EUR millions, M3)*: M3 is used in accordance with Bahloul et al. (2016), Bhuiyan and Chowdhury (2020) and Hanousek and Filer (2000). The reason for doing so is that the M3 variable is the most stable for the development of GDP (compared to M1 and M2). Monetary overhang can significantly impact economic stability in the form of rising inflation or unemployment. Given the greater sensitivity of Central and Eastern European markets, monetary overhang could have more significant effects on economic stability and the stock markets.
- *Consumer Price Index (2005=100, CPI)*: the CPI was selected because the literature review revealed the impact it has on stock prices. Examples of relevant studies include Dumitrescu and Horobet (2009), Apegris and Eleftherious (2002) and Camilleri et al. (2019). Inflation: this is considered an essential variable. Kwofie and Ansah (2018) claim that inflation is in the interest of any government since it serves as a proxy for determining how well its economy is doing. At the same time, it is necessary to consider that a certain inflation rate is natural for the economic system. However, it is necessary to prevent the disproportionate growth of inflation (Qin & Wang, 2018).
- *Gross Domestic Product (at market prices in EUR million, GDP)*: the use of GDP is in accordance with the conclusions of Arestis et al. (2001), Marques et al. (2013) and Hondroyiannis and Papapetrou (2001), who demonstrate the influence of the variable on stock prices. The use of GDP is also consistent with the idea that there are increasing pressures on economic growth in times of globalisation and internationalisation. However, economies can be more susceptible to external factors and various problems that can disrupt stable economic growth on the long term.

Data on the macroeconomic variables were sourced from the databases of the OECD, Eurostat and IMF, as well as the Trading Economics web portal. Quarterly frequency data were used. All data were transformed into natural logarithms, in accordance with, for example, Anari and Kolari (2001), Rapach et al. (2016), Hassapis and Kalyvitis (2001) and Nasseh and Strauss (2000).

Based on the set aim, the two formulated hypotheses: H1: Macroeconomic variables (GDP, CPI, M3) influence the value of stock indices on the long term; and H2: Macroeconomic variables (GDP, CPI, M3) affect the value of stock indices in the short term, were tested for their validity.

2.1. Stationarity and correlation

The stationarity of the individual time series was verified by applying the Augmented Dickey-Fuller test (ADF). The Kwiatkowski-Phillips-Schmidt-Shin test (KPSS) was also subsequently applied due to some criticisms of the ADF test. For example, Paparoditis and Politis (2018) point out the limiting distribution of the extended Dickey-Fuller test, which, under the null hypothesis, is valid under a very general set of assumptions (beyond the linear AR (1) process). The KPSS test was therefore applied to detect the stationarity of the time series around the deterministic trend. The Chow test was subsequently applied to determine the structural breaks in the data. All these tests were used to verify the occurrence and possible removal of trends, cyclicity, and seasonality from the time series, which could distort the results of subsequent tests.

After verifying stationarity, the data could be used for further analysis. The following sections present the Pearson correlation coefficients between the selected variables. The correlation coefficient helps identify the dependence between the variables, i.e. how the selected variables are related to each other.

2.2. The long-term relationships between the variables

The Johansen cointegration test was applied to verify H1. This test determines whether there is long-term equilibrium in the relationship between the analysed variables. Its application is consistent with, for example, Anari and Kolari (2001), Barbić and Čondić-Jurkić (2011), Pradhan et al. (2015a) and Nasseh and Strauss (2000). The Johansen cointegration test is the standard model used to test the cointegration bond. It has its starting point in the vector autoregression of VAR, which can be expressed as a general m-dimensional VAR(p) model (Hjalmarsson & Österholm, 2007):

$$y_{it} = \mu + A_1 y_{i,t-1} + \ldots + A_p y_{i,t-p} + \varepsilon_{it} \quad (1)$$

where y_t represents the n x 1 vector of integrated variables of the first order, and the model constructed for the components $y_{1t} \sim I(1), \ldots, y_{mt} \sim I(1)$ has a possible EC model with the following form (Cipra, 2008; Hjalmarsson & Österholm, 2007):

$$\Delta y_{it} = \mu + \Pi y_{i,t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{i,t-i} + \varepsilon_{it} \text{ where } \Pi = \sum_{i=1}^{p} A_i - I \;\; a \;\; \Gamma_i = -\sum_{j=i+1}^{p} A_j \quad (2)$$

Supposing the coefficient matrix Π has reduced rank r < n, then, there is n x r matrices α and β, each with rank r, so that $\Pi = \alpha\beta' \textit{ and } \beta' y_t$ are stationary. The number of cointegrating relationships is represented by r, the index of the data cross-section by i, j = 1, …, with p indicating the number of factors in each cross-section. The basic elements of matrix α are known as the adjustment parameters in the EC model, and each column of matrix β is a cointegrating vector. For the number of cointegrating relationships, r is the maximum likelihood estimator of matrix β, the combination of y_{t-1}, where r is characterised by the largest canonical correlations of the parameter Δy_t and y_{t-1} after correction for lagged differences and deterministic variables (Hjalmarsson & Österholm, 2007). The trace test was applied as a likelihood ratio test. The mathematical expression of it is:

$$J_{trace} = 2\left(\ell\left(\hat{\beta}_n\right) - \ell\left(\hat{\beta}_r\right)\right) = -T\sum_{i=r+1}^{n}\ln(1-\hat{\lambda}_i) \approx T\sum_{i=r+1}^{n}\hat{\lambda}_i \qquad (3)$$

where T is the sample size and $\hat{\lambda}_i$ is the largest canonical correlation. The null hypothesis of trace statistics is r cointegration vectors against the alternative hypothesis n cointegration vectors, i.e. H_0: $H_{(r)}$ against $H_{(n)}$. The null hypothesis is rejected if J_{trace} is higher than the critical value. The testing is carried out gradually for r = 0, 1, …, m-1 (Cipra, 2008; Hjalmarsson & Österholm, 2007; Neusser, 2016).

On the other hand, the maximum eigenvalue tests the null hypothesis r cointegration vectors against the alternative hypothesis r + 1 cointegration vectors, i.e. H_0: $H_{(r)}$ versus $H_{(r+1)}$. The null hypothesis is rejected when J_{max} is higher than the corresponding critical value. J_{max} can be expressed as (Cipra, 2008; Hjalmarsson & Österholm, 2007; Neusser, 2016):

$$J_{max} = 2\left(\ell\left(\hat{\beta}_n\right) - \ell\left(\hat{\beta}_r\right)\right) = -T\ln(1-\hat{\lambda}_{r+1}) \approx T\,\hat{\lambda}_{r+1} \qquad (4)$$

2.3. The short-term relationships between the variables

According to Barbić and Čondić-Jurkić (2011), if the variables are non-stationary and cointegration vectors between the variables are found, VAR should be transformed into VECM:

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1\Delta y_{t-1} + \Gamma_2\Delta y_{t-2} + \ldots + \Gamma_{k-1}\Delta y_{t-(k-1)} + u_t \qquad (5)$$

where Π and Γ are 2x2 matrices, and k is the lag order. Through the VECM, the deviations from the long-term equilibrium are corrected gradually through a series of partial short-term adjustments (Anari & Kolari, 2001; Barbić & Čondić-Jurkić, 2011).

The analysis of the short-term causality of the relationship between the stock market indices and macroeconomic variables was performed using the Granger test. The Granger test is used to identify whether one time series can predict the future values of another, i.e. whether past values of macroeconomic variables can be used to predict the future value of stock indices. The causal model in the mathematical equation is in accordance with Granger (1969):

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{q}\beta_{1i}\Delta Y_{t-i} + \sum_{i=1}^{q}\beta_{2i}\Delta X_{t-i} + \varepsilon_{1t} \qquad (6)$$

$$\Delta X_t = \varphi_0 + \sum_{i=1}^{r}\varphi_{1i}\Delta X_{t-i} + \sum_{i=1}^{r}\varphi_{2i}\Delta Y_{t-i} + \varepsilon_{2t} \qquad (7)$$

where Y_t and X_t represent stock market indices and macroeconomic variables respectively, coefficient t symbolises the time period, and ε_{1t} and ε_{2t} are uncorrelated stationary random variables. The objective of this test is to reject H_0: $\beta_{21} = \beta_{22} = ... = \beta_{2q} = 0$. This hypothesis implies that macroeconomic variables do not Granger-cause the value of the stock market index. Similarly, failing to reject H_0: $\varphi_{11} = \varphi_{12} = ... = \varphi_{1r} = 0$ suggests that the stock market index does not Granger-cause macroeconomic variables. The VECM and Granger causality test were therefore used to verify H2.

3. Results and discussion

This section presents the results of the empirical testing of the relationships between the selected macroeconomic variables and the basic stock market indices of Central and Eastern European countries. The subsections present the results of the descriptive statistics and correlations, address the long-term relationships between the variables, and the testing of the short-term relationships between the variables.

3.1. Descriptive statistics and correlations

The descriptive statistics are provided at the beginning (see Annex 2). As the values for skewness and kurtosis show, the majority of time series are not normally distributed. Jarque-Bera statistics also emphasize this. They show that normal distribution data can only be observed for LogCPI and LogM3 in Croatia, the Czech Republic and Hungary, LogCPI in Estonia and Romania, LogGDP and LogM3 in Latvia, LogCPI and LogM3 in Hungary, and LogM3 in Poland. In the case of the other time series, the existence of Leptokurtic distribution is assumed. According to the values of the standard deviations, it was found that the volatility of the stock indices was high in all monitored countries, with the exception of Poland. In the case of Poland, the greatest volatility was seen in the LogGDP indicator. The least volatility was found for LogCPI in most of the monitored countries, with the exception of Latvia (least volatility for LogGDP) and Poland (least volatility for LogIndex). A more detailed view of the volatility of the logarithmic returns of the analysed stock indices (see Annex 3) shows the significant impact on stock returns from Q2 2007 of the global financial crisis. In some ways, the euro area debt crisis and the associated credibility of the financial markets may also have contributed to greater market volatility. At the end of 2019, the stock markets of not only the monitored countries were negatively affected by the incipient coronavirus. However, this effect was short-lived and the value of stock indices began to rise again. This positive effect has been linked to the financial preferences of the populations, which may be related to their response to rising inflation and concerns about the devaluation of their funds.

Upward trends in GDP are evident in all the monitored countries. However, certain fluctuations in GDP development are apparent in individual countries (see Annex 4), especially in 2008 and 2020. These impacts vary from country to country, depending on their specific situation. For illustration purposes, the situations encountered by some analysed countries are given. Latvia faced a relatively large current account deficit in 2007 and 2008 due to rapidly rising indebtedness. This was because foreign capital was not used for investment in production, but directed towards the real estate market, goods for export were mostly low-value, value-added goods, and Latvian industry is dependent on imports of large volumes of semi-finished products. These facts and the high inflation rate affected the Latvian economy even more significantly as the global financial and economic crisis began to bite. Due to high public debt, Hungary faced economic problems as early as 2007. However, due to a subsequent increase in taxes and the reduction of government spending to reduce the budget deficit, the country entered recession, thereby significantly affecting and deepening the subsequent manifestation of the financial crisis. In the case of the Czech economy, the downturn was mainly due to a decline in demand from foreign entities. As a result, the crisis significantly impacted the country's openness towards world economies in terms of goods and capital flows (as reflected in a significant decrease in foreign direct investment). The effect of different coronavirus measures in other countries has also been felt to varying degrees across industrial sectors and, therefore, on GDP.

A closer look at the development of the CPI (see Annex 5) and the inflation rate also reveals problems in the monitored economies, such as deflation or failure to meet the inflation target. In the period under review, the highest inflation rate was seen in Bulgaria between 2007 and 2008 (caused by rising oil and food prices due to drought and flood damage). The country actually experienced deflation in 2014 (a decline in commodity prices greater than in the euro area). The highest inflation rate in the Czech Republic was recorded in 2008 (the causes were multiple: increases in regulated rents, housing services prices, energy prices, excise duties on cigarettes and tobacco, the introduction of environmental taxes, and an increased VAT rate to 9%), while the lowest rate was in 2015 (caused by a significant reduction in fuel prices). The highest inflation rate in Croatia was recorded in 2008 (caused by rising energy and food prices due to geopolitical conflicts), with deflation reported in 2016 (caused by declining transport costs due to persistently low energy prices). Hungary recorded its highest inflation rate in 2007 (caused by higher food and fuel prices), with the lowest rate in 2013 (caused by lower prices for energy, electronics and some foodstuffs).

The highest inflation rate in Latvia was recorded in 2008 (caused by rising textile, education and energy prices). In contrast, the highest deflation rate was recorded in 2010 (the decline in consumer goods prices was caused by low demand and crises in various sectors of the economy). In the case of Estonia, the highest inflation rate was recorded in 2008 (mainly caused by the impact of energy prices), with deflation recorded in 2020 (caused by rising energy and food prices). The highest inflation rate recorded in Slovakia was in 2004 (caused by price deregulation of selected commodities such as gas and electricity and the introduction of a single VAT rate). In contrast, deflation was recorded in 2016 (caused by the impact of free rail transport for students and pensioners and the reduction of the VAT rate on certain foodstuffs). In the case of Romania, the highest inflation rate was recorded in 2004 (caused by problems in the economic transformation of the country), with the country even struggling with deflation in 2016 (caused by falling prices for energy and consumer goods). Poland recorded its highest inflation rate in 2021 (caused by increasing prices for foodstuffs, electricity, gas and other fuels). In contrast, deflation was recorded in 2015 (caused by falling world energy commodity prices, which were reflected in other commodity prices). In Lithuania, the highest inflation rate was recorded in 2008 (caused by rising prices for foodstuffs, soft drinks, housing and energy), with deflation recorded in 2015 (caused by lower prices for housing and some goods and services).

In the case of the M3 variable, gradual growth is evident (see Annex 6), which is typical of converging economies. Generally, the amount of money in circulation adapts flexibly to the economy's needs. This means that changes in the money supply are a response to corporate demand for credit, the optimism or pessimism of households and the needs to finance real estate purchases. Changes in the money supply reflect the economic decisions of entities which, in turn, are a reflection of the central bank's activities, i.e. through the instruments it has at its disposal to influence the industrial and financial sectors in their countries.

The above completes the presentation of the descriptive statistics and the trends in the developments of the monitored macroeconomic variables. The stationarity of the individual time series was subsequently tested. The ADF test was applied first. It was found that all the time series were stationary at 1% and 5% (see Annex 7). Because logarithmic changes of the monitored quantities were used for the subsequent analysis, the logarithmic time series were also tested. The assumption of stationarity at level I(0), which corresponds to I(1) in the case of logarithmic time series, was met for the entire time series. The subsequent application of the KPSS test showed that the LM-statistic values were lower than the critical value in all cases. It can therefore be argued that the time series are stationary around the deterministic trend (see Annex 7).

In most cases, it was impossible to reject the null hypothesis based on the KPSS test, even at the 10% significance level. After applying the ADF and KPSS tests, the Chow test was used to determine the possible structural breaks in the data. The results of the Chow test showed that significant structural breaks in the data occurred in the case of the Sofix, Crobex, PX, WIG20 and SAX indices (see Annex 8). This could be linked to specific economic policy measures. For example, in the case of the WIG20 index, the reduction in the key interest rate from November 2008, the (in)stability of the banking system, and the relative closedness of the Polish economy may have manifested (Velculescu, 2009).

The correlation coefficients between the value of the stock market indices and the selected macroeconomic variables were then calculated (see Annex 9). The results indicate a positive linear relationship between GDP and the logarithmic change of the European stock market indices, specifically BUX, WIG20, BET and SAX. The reasons for the positive correlation could reflect the specific economic policies of the individual countries. Poland was the only European country to avoid a recession associated with the financial and economic crisis, which could be connected to certain structural factors. In Hungary, GDP growth in 2021, the highest since 1995, could have some impact.

Furthermore, in Q1 2014, for example, the year-on-year growth of Hungary and Poland was the highest in the EU. The fact that, before the financial crisis, Slovakia was one of the fastest-growing economies, mainly due to the development of foreign trade, could have an impact. The positive correlation between GDP and BET could be related, among other things, to Romania's economic performance before the pandemic; the GDP per capita increased by about half of the OECD average and the percentage of the population at risk of poverty fell sharply.

On the other hand, in the case of the LogM3 variable, the existence of both positive and negative correlations is evident. Negative correlation coefficients were found between the PX and WIG20 indices and M3, whereas a positive correlation was found between the SAX index and M3. The existing linear relationship could reflect the specific situation regarding the monetary policy. For example, in the case of the Czech Republic, this could be, among other things, a response to the exceptional use of foreign exchange interventions (end of 2013). In Poland, factors such as the change of the required minimum reserves in 2010, the reduction of the base interest rate in 2015, and other factors could manifest. In Slovakia, this could be the introduction of non-standard monetary policy instruments in connection with the financial crisis (e.g. NIRP), harmonisation of the monetary policy instruments of the National Bank of Slovakia and the European Central Bank, foreign exchange interventions in 2005, and other factors. The other correlation coefficients were not statistically significant; therefore, it can be assumed that the linear relationship between the variables was not very strong.

3.2. The long-term relationships between the variables

The Johansen cointegration test was applied for the examination of the long-term relationships between the variables. To start with, it was necessary to identify the optimal lag length. According to the Akaike & Hannan-Quinn information criterion, the optimal lag length is one quarter. The Johansen cointegration test was then applied using a time series. The outputs were in the form of trace statistics and maximum eigenvalues. The results (see Annex 10) show that four cointegration vectors exist for all the stock indices, with the exception of the SAX index. Therefore, on the long term, changes in inflation, GDP and M3 have affected the selected European stock indices. These findings are consistent with Apergis and Eleftheriou (2002), Peiró (2016) and Tripathi and Seth (2014). In the case of the SAX index, the results obtained with trace statistics differ, so the maximum eigenvalues differ. Since the maximum eigenvalue proves the existence of only two cointegration vectors, the result of this statistic was used. The results also suggest that the negative link between the CPI and the value of the stock indices is real, which is consistent with Megaravalli and Sampagnaro (2018). The countries under the magnifying glass had problems with overshooting their inflation target. Measures to support the reduction of inflation may have had a negative impact on the stock markets. At the same time, a higher inflation rate means an increase in the costs of living and borrowing money, and a related reduction in dividends (Megaravalli & Sampagnaro, 2018). It was only in the case of the CPI and the SAX index that a positive relationship was detected. The positive effect of inflation is also evident in Anari and Kolari (2001). Several years of deflation in Slovakia and its impact on the country's economy may be reflected in these results.

A predominant positive effect was found in the macroeconomic variable GDP and the value of stock indices. The results are consistent with, for example, Hondroyiannis and Papapetrou (2001) and - Dumitrescu and Horobet (2009). At the same time, this could be related to the influence of many variables on the value of stock indices. The reason may be, for example, the development of the financial markets, as the causal relationship may be sensitive to the level of financial development and the way financial markets are regulated due to different levels of regulation and control in other countries, as reported by Yildirim et al. (2013). Economic policy development in the individual countries may also be an important factor, with the financial crisis and COVID-19 measures manifesting themselves with different intensity in the countries. Investments can support country-level economic expansion. The development of household consumption may be affected by consumer sentiment and better employment. The negative relationship between GDP and stock index values was only found in the case of two models, SAX and Sofix. This phenomenon could be related to the fact that the stock market in Slovakia, which is among the smallest in the world, and the Bulgarian stock market, which is the youngest in the CEE countries, need stimulation through more significant economic growth.

The relationship between M3 and the value of stock market indices is also evident. This is in accordance with Forson and Janrattanagul (2013) and Tripathi and Seth (2014). In the case of M3, the findings are ambiguous; in the case of some models, the effect on the stock indices is negative (PX, OMX Tallinn, WIG20, BET), whereas, in other cases, it is positive (Sofix, Crobex, OMX Vilnius, OMX Riga, BUX, SAX). The reason for these differences is that the central banks of individual countries use their instruments differently, depending on the economic situation. The degree of transparency of policies and expectations regarding government and central bank actions in individual countries may also play a role.

3.3. The short-term relationships between the variables

VECM estimations supplemented the long-term relationship between the variables investigated by using the Johansen cointegration test to analyse the short-term dynamics between the selected macroeconomic variables and the value of European stock market indices. As at least one cointegration relationship was found by using the Johansen cointegration test (see Annex 10), a VECM model was therefore created for each analysed European stock market index. According to the VECM estimations (see Annex 11), the error correction parameter CointEq1 coefficients are statistically significant for four of the models (Crobex, OMX Tallinn, WIG 20 and BET). In the case of two models, Crobex and OMX Tallinn, the error correction coefficient had a clear negative value. This means that a positive development in the macroeconomic variables should have a negative effect on the stock index.

Conversely, in the case of two models, namely WIG 20 and BET, a positive development in the macroeconomic variables should have a positive effect. At the same time, it is clear that the most deviations from the long-term equilibrium (which are corrected in the following period) are clarified based on the compiled model; in the case of OMX Tallinn at 40.52%, while the least in the case of the BET model, namely 2.8%. Based on the results, it is clear that the variables CPI and M3 cause certain deviations in the Crobex index. For the OMX Tallinn index, it is M3, and for the WIG20 index, it is GDP. The results could be affected by the extent of the demand for investment instruments and investment strategies, the intensity of the impact of the change in the macroeconomic variable on the economy itself and the stock markets, the power with which the stock market perceives the importance of the variables, and the current state of the economy and possible influence on the decision-making of shareholders (Ahmed, 2008).

Subsequently, an analysis of the short-term causality of the relationship between the stock indices and macroeconomic variables was also performed by using Granger causality. In this case, it must be assumed that causality, in terms of Granger, cannot be identified as a relationship that determines that the cause can result in a consequence (Osińska, 2011). As seen from the results (see Annex 12), causality in terms of Granger was only detected in the case of the OMX Tallinn stock index and the M3 variable and between the CPI and the OMX Vilnius stock index. Instead, the causality in the opposite direction, going from the value of stock market indices to the macroeconomic variables, prevailed. This was specifically the case for the value of the OMX Riga, OMX Vilnius, BET and SAX indices in relation to GDP. Likewise, there is also causality in the opposite direction for the value of the OMX Vilnius, WIG20 and SAX indices in relation to M3.

Conclusions

The aim of the study was to investigate the relationship between selected macroeconomic variables and the values of representative stock market indices for Central and Eastern European countries in the period Q1 2004 – Q4 2021. The set aim made it possible to verify the set hypotheses: H1 - Macroeconomic variables influence the value of stock indices on the long term; and H2 - Macroeconomic variables influence the value of stock indices in the short term.

The descriptive statistics were first presented. This was followed by the calculation of the correlation coefficients between the values of stock market indices and the selected macroeconomic variables. The results indicate a positive linear relationship between GDP and the European stock market indices, specifically for the BUX, WIG20, BET and SAX indices. Both positive and negative correlations were found between M3 and some of the selected stock indices (PX, WIG20, SAX).

Johansen's cointegration test was applied to verify hypothesis H1. The result revealed the existence of cointegration between stock indices and the selected macroeconomic indicators, thereby confirming hypothesis H1. These findings are consistent with empirical literature, for example, Anari and Kolari (2001), Hondroyiannis and Papapetrou (2001), Dumitrescu and Horobet (2009) and Forson and Janrattanagul (2013). The reasons for the effects on the value of stock indices were linked to more factors simultaneously, for example, different economic policies and central bank measures in individual countries, the level of integration of financial markets, the impact of crises, and consumer sentiment.

VECM estimates and Granger causality were used to verify hypothesis H2. The results showed sporadic short-term deviations from the long-term equilibrium. The differences between the two results are clear. This may be related to the different principles of the two methods. As mentioned above, causality in terms of Granger, cannot be identified as a relationship that determines that the cause can result in a consequence (Osińska, 2011). However, due to the minimal relationships between the variables in the short term, hypothesis H2 was rejected. Sporadic short-term deviations may have been related to less expected interventions by the Central Bank or the government. These findings may reflect the expectations of subjects and/or the consequences of policy measures, the impacts of which may manifest themselves with a significant delay and can only be estimated. Other reasons could be a lack of depth and stability in the financial and credit markets.

According to Zyznarska-Dworczak (2018), CEE markets are still undergoing many political, structural, social and economic changes. These changes may also significantly impact the development of stock markets and the variables that affect them. Given the long-term causality between the variables, the interconnectedness of the applied economic policy and stock markets is evident. As a result, according to Pradhan (2015a), transparent and appropriate monetary and government policies could support the development of stock markets, which could be associated with further economic growth. The development of financial markets can also contribute to less reliance on domestic savings for investment purposes (Beck & Stanek, 2019). However, the results are limited due to the characteristics of the Central and Eastern European markets, as mentioned above. Given the many ongoing changes in these markets, the relationships between macroeconomic variables and stock indices are therefore expected to evolve. This creates space for future research on the topic.

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Annex 1. Overview of statistically significant macroeconomic variables in relation to stock prices

Author(s)	**Country**	**Statistically significant variables**
Abbas et al. (2019)	China	exchange rate, interest rate, terms of trade
Anari & Kolari (2001)	USA, Canada United Kingdom, France, Germany, Japan	inflation
Apergis & Eleftheriou (2002)	Greece	inflation
Arestis et al. (2001)	Germany, USA, Japan, United Kingdom, France	economic growth
Bahloul et al. (2016)	developed market indices (Australia, Canada, France, Germany, Japan, Netherlands, Spain, Switzerland, UK and USA) and ten emerging markets indices (Chile, China, Czech Republic, India, Korea, Malaysia, Mexico, Russia, South Africa and Thailand	inflation rate, short-term interest rate, the slope of the yield curve, money supply
Bahmani-Oskooee & Saha (2016)	Brazil, Canada, Chile, Indonesia, Japan, Korea, Malaysia, Mexico, United Kingdom	exchange rates
Barakat et al. (2016)	Egypt, Tunisia	consumer price index, exchange rate, money supply, interest rate
Beetsma & Giuliodori (2012)	USA	federal funds rate, real per capita GDP growth rate, inflation rate
Bhuiyan & Chowdhury (2020)	USA, Canada	industrial production, money supply, long-term interest rate, different sector indices
Calderón & Liu (2003)	109 developing and industrial countries	economic growth
Camilleri et al. (2019)	Belgium, France, Germany, Netherlands, Portugal	inflation, industrial production
Caporale et al. (2015)	Bulgaria, Czech Republic, Estonia, Hungary, Latvia Lithuania, Poland, Romania, Slovakia, Slovenia	x
Dahir et al. (2017)	Brazil, Russia, India, China, South Africa	exchange rates
Demir (2019)	Turkey	economic growth, domestic currency, portfolio investment, foreign direct investments, interest rate, crude oil prices, money supply, consumer price index, interest rate
Forson & Janrattanagul (2013)	Thailand	interest rates, industrial production index
Gan et al. (2006)	New Zealand	interest rate, money supply and real GDP
Hanousek & Filer (2000)	Visegrad group	money supply, industrial production, inflation
Hassapis & Kalyvitis (2001)	USA	economic growth
Hondroyiannis & Papapetrou (2001)	Greece	economic growth, foreign stock market changes
Dumitrescu& Horobet (2009)	Romania	gross domestic product, consumer price index, money supply, interest rates, real exchange rates
Huang et al. (2016)	USA	oil price shocks, interest rates
Christopoulos & Tsionas (2004)	Colombia, Paraguay, Peru, Mexico, Ecuador, Honduras, Kenya, Thailand, Dominican Republic, Jamaica	economic growth
Jareño & Negrut (2016)	USA	gross domestic product, industrial production index, unemployment rate, long-term interest rates
Keswani & Wadhwab (2022)	India	economic growth, inflation, disposable income, foreign institutional investor, youth unemployment rate

Kwofie & Ansah (2018)	Ghana	inflation
Marques et al. (2013)	Portugal	economic growth
Megaravalli & Sampagnaro (2018)	India, China and Japan	exchange rates, inflation
Mouna & Anis (2016)	Germany, the USA, Greece, the UK, France, Spain, Italy, and China	exchange rate, the interest rates
Nasseh & Strauss (2000)	France, Italy, Netherlands, Switzerland, United Kingdom, Germany	industrial production, short- and long-term interest rates, short-term interest rates
Pan (2018)	30 advanced countries, 11 developing and emerging countries	unemployment rate
Peiró (2016)	France, Germany, United Kingdom	production, interest rates
Pradhan et al. (2014)	ASEAN countries	banking sector development, per capita economic growth, foreign direct investment, trade openness, inflation rate, government consumption expenditure
Pradhan et al. (2015a)	OECD countries	economic growth, inflation
Pradhan et al. (2015b)	G-20 countries	economic growth, oil prices, stock market depth, real effective exchange rate, inflation rate, the real rate of interest
Rapach (2002)	Australia, Austria, Belgium, Canada, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Spain United Kingdom, United States	permanent inflation shocks
Sibande et al. (2019)	United Kingdom	unemployment
Suriani et al. (2015)	Pakistan	x
Tripathi & Seth (2014)	India	money supply
Tsagkanos & Siriopoulos (2013)	EU, USA	exchange rates
Van Nieuwerburgh et al. (2006)	Belgium	economic growth

Source: authors' representation

Annex 2. Descriptive statistics

Bulgaria

Variable	LogIndex	LogCPI	LogGDP	LogM3
Mean	4.7342	0.7491	1.7725	1.5478
Median	2.0863	0.5784	2.1011	1.2435
Maximum	259.6870	5.0840	7.1757	9.1207
Minimum	-79.2792	-1.4764	-7.4712	-8.7661
Std. Dev.	34.5930	1.2372	2.7268	2.6284
Skewness	5.5079	0.9671	-0.7334	-0.5348
Kurtosis	43.3379	4.1888	3.9128	7.6762
Jarque-Bera	5172.647*	15.2497*	8.8299**	68.0760*
Probability	0.0000	0.0004	0.0120	0.0000

Croatia

Variable	LogIndex	LogCPI	LogGDP	LogM3
Mean	0.8210	0.4786	0.8416	1.6051
Median	1.4334	0.4252	1.2996	1.6191
Maximum	27.7904	2.8397	7.6242	8.6943

Minimum	-55.1966	-1.5793	-18.1192	-3.3108
Std. Dev.	12.6692	0.9467	3.1488	2.5648
Skewness	-1.3840	-0.0866	-3.0449	0.4081
Kurtosis	7.8074	2.5703	20.5894	2.9123
Jarque-Bera	91.0387*	0.6348	1024.998*	1.9941
Probability	0.0000	0.7280	0.0000	0.3689

Estonia

Variable	**LogIndex**	**LogCPI**	**LogGDP**	**LogM3**
Mean	2.4965	0.8907	1.7283	2.8285
Median	2.1676	0.9563	2.3879	2.4780
Maximum	39.7696	4.6307	7.9016	13.553
Minimum	-53.9533	-1.4918	-7.7447	-12.4412
Std. Dev.	13.5007	1.2059	2.9709	3.7879
Skewness	-0.6197	0.3497	-1.0895	-0.0302
Kurtosis	6.8816	3.0802	4.5348	6.9169
Jarque-Bera	49.1179*	1.4667	21.0157*	45.4000*
Probability	0.0000	0.4802	0.0000	0.0000

Lithuania

Variable	**LogIndex**	**LogCPI**	**LogGDP**	**LogM3**
Mean	2.0981	0.8055	1.7095	3.0086
Median	3.0684	0.6715	1.8962	2.4596
Maximum	54.3025	3.9059	6.4993	21.2478
Minimum	-58.1911	-0.7519	-12.8739	-4.5218
Std. Dev.	13.7814	1.0274	2.7745	4.0378
Skewness	-0.5172	0.9531	-2.3716	1.5448
Kurtosis	9.3006	3.8727	12.7567	7.5330
Jarque-Bera	120.6073*	13.0047*	348.1744*	89.0295*
Probability	0.0000	0.0015	0.0000	0.0000

Latvia

Variable	**LogIndex**	**LogCPI**	**LogGDP**	**LogM3**
Mean	1.8446	1.5894	0.8898	2.4640
Median	3.5096	1.7059	1.0142	2.2032
Maximum	30.1274	8.1491	5.5310	11.4401
Minimum	-35.5029	-16.1562	-1.9316	-4.8367
Std. Dev.	11.5563	3.7634	1.4144	3.4547
Skewness	-0.6810	-1.7218	0.4781	0.4312
Kurtosis	4.6361	9.7171	3.5200	2.8312
Jarque-Bera	13.4087*	168.5637*	3.5059	2.2848
Probability	0.0012	0.0000	0.1732	0.3190

Hungary

Variable	**LogIndex**	**LogCPI**	**LogGDP**	**LogM3**
Median	4.8364	0.7243	1.2455	2.2472
Maximum	32.4764	3.6880	9.7151	10.9974
Minimum	-43.2666	-1.2232	-16.7878	-5.1252
Std. Dev.	12.9875	1.0176	3.9246	2.9818
Skewness	-0.8722	0.3103	-2.1997	0.2786
Kurtosis	5.2886	2.8368	10.4210	3.5380
Jarque-Bera	24.4980*	1.2184	220.1822*	1.7748
Probability	0.0000	0.5437	0.0000	0.4117

Poland

Variable	LogIndex	LogCPI	LogGDP	LogM3
Mean	0.6057	1.6326	0.3545	2.4824
Median	0.5012	1.9489	1.0040	2.5425
Maximum	2.8112	11.2900	20.8510	6.9858
Minimum	-0.6405	-15.1622	-35.1521	-0.9610
Std. Dev.	0.7758	4.1245	10.3734	1.7550
Skewness	0.6545	-1.7198	-0.8486	0.1602
Kurtosis	3.0162	8.5008	4.5619	2.4149
Jarque-Bera	5.0705***	124.5202*	15.7390*	1.3161
Probability	0.0792	0.0000	0.0003	0.5178

Romania

Variable	LogIndex	LogCPI	LogGDP	LogM3
Mean	2.0850	1.0084	2.1327	3.2425
Median	3.9361	1.0631	2.2898	2.6197
Maximum	36.6402	3.3492	10.6831	15.6987
Minimum	-42.2840	-1.6995	-17.8981	-4.5279
Std. Dev.	14.4937	1.0330	4.4282	3.8427
Skewness	-0.7866	-0.1888	-1.7310	1.0527
Kurtosis	4.5672	2.6710	9.6790	4.8098
Jarque-Bera	14.5901*	0.7421	167.4264*	22.8042*
Probability	0.0006	0.6900	0.0000	0.0000

Slovakia

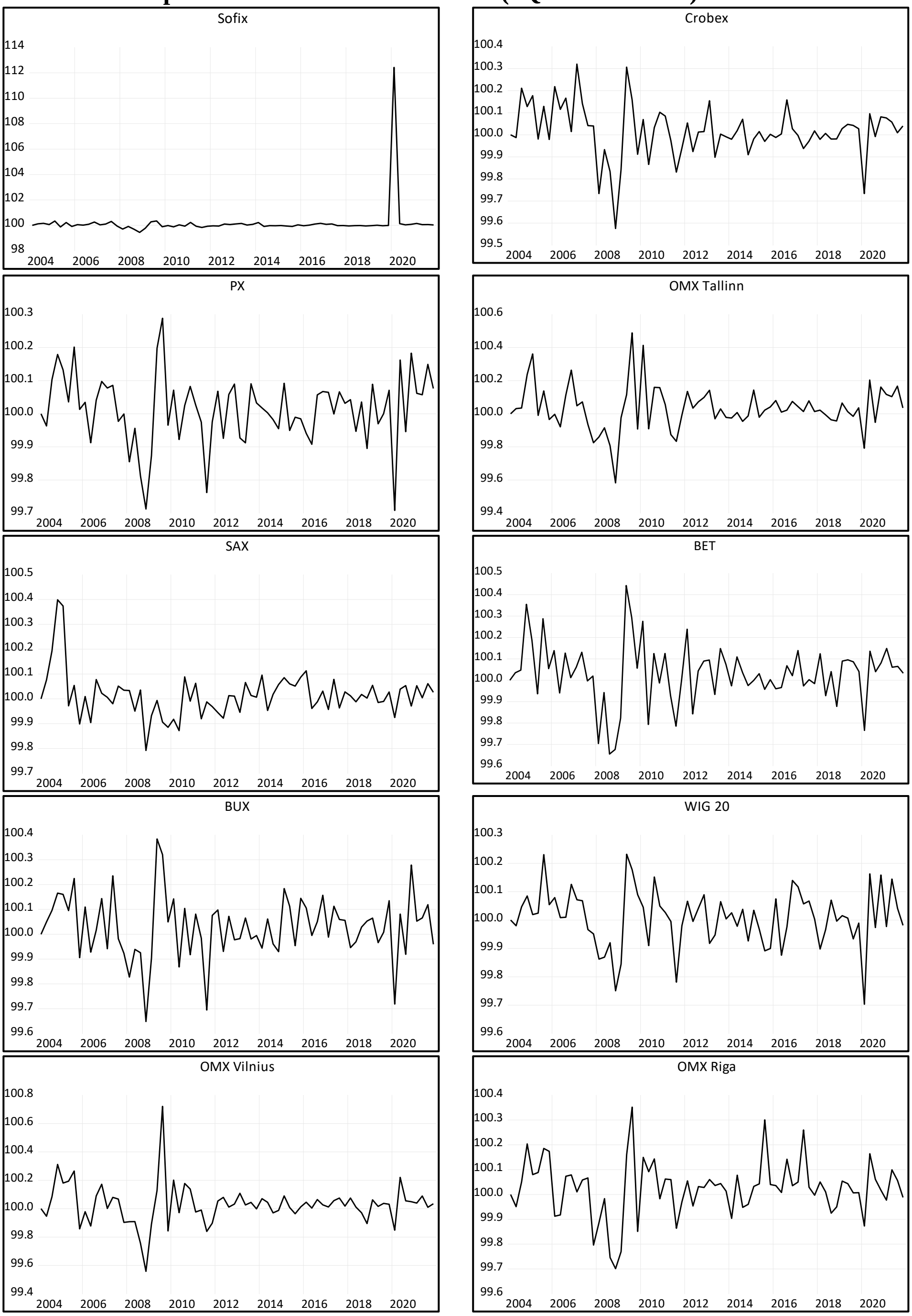
Variable	LogIndex	LogCPI	LogGDP	LogM3
Mean	1.1013	0.5144	1.5478	1.9908
Median	1.1875	0.3956	1.2435	1.6142
Maximum	33.5603	2.7260	9.1207	11.4256
Minimum	-23.2840	-0.7258	-8.7661	-2.2835
Std. Dev.	8.5202	0.6915	2.6284	2.1673
Skewness	0.9758	0.9482	-0.5348	1.3688
Kurtosis	7.2174	3.8083	7.6762	7.1325
Jarque-Bera	63.8890*	12.5741*	68.0760*	72.6948*
Probability	0.0000	0.0018	0.0000	0.0000

Czechia

Variable	LogIndex	LogCPI	LogGDP	LogM3
Mean	0.7728	0.5454	1.4099	1.7966
Median	2.6189	0.4870	1.5342	1.4551
Maximum	25.3279	3.1109	9.5948	6.4544
Minimum	-34.5293	-0.9790	-13.6472	-2.1663
Std. Dev.	10.9171	0.7800	3.2439	1.8624
Skewness	-0.9586	0.5536	-1.8606	0.4238
Kurtosis	4.9268	3.5675	9.8678	3.1101
Jarque-Bera	21.8585*	4.5799	180.5012*	2.1612
Probability	0.0000	0.1012	0.0000	0.3393

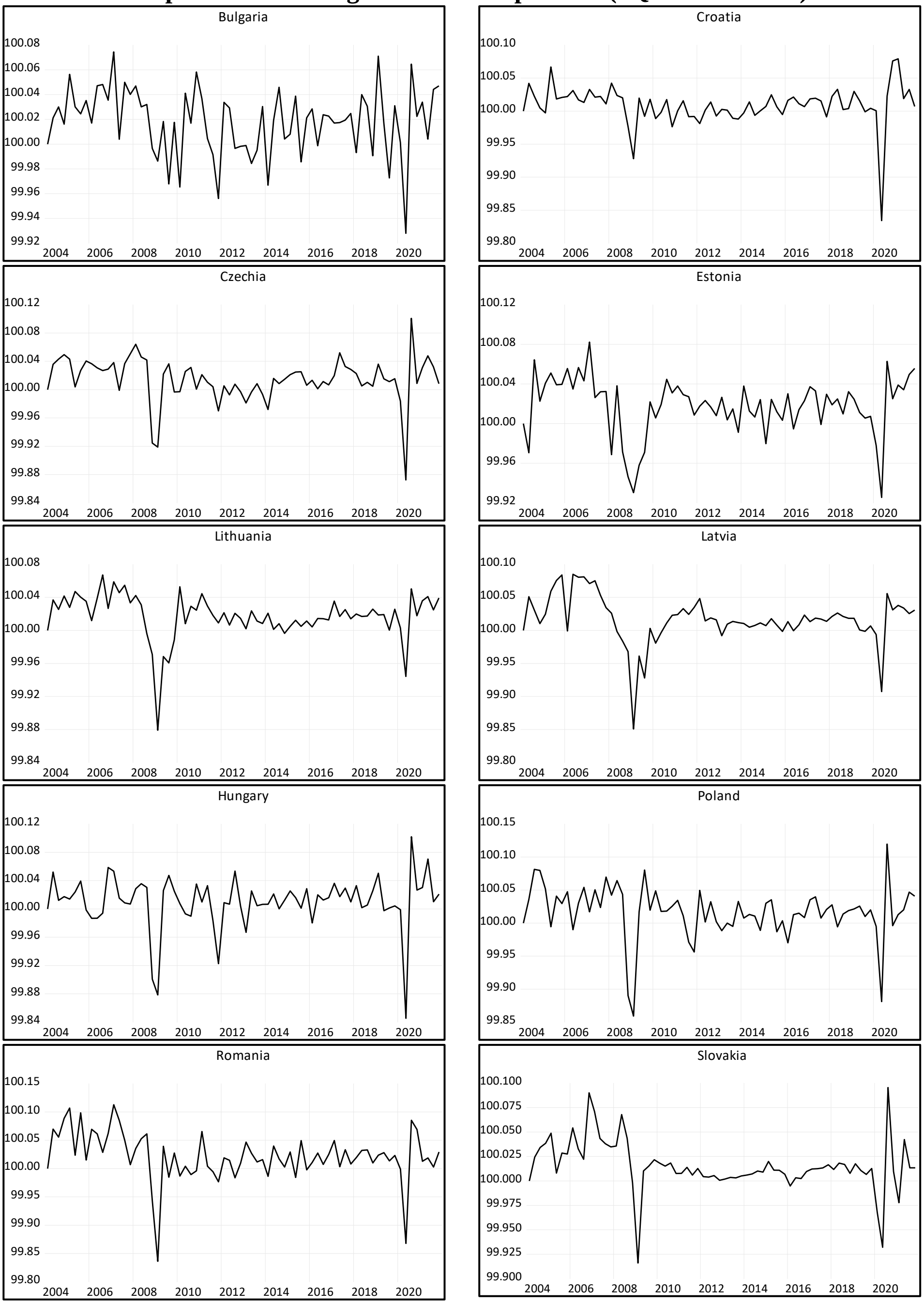
Source: author's calculation. Note: *, ** and *** denote significance at the 1%, 5% and 10% levels

Annex 3. Development trends of stock markets (1Q2004 = 100 %)



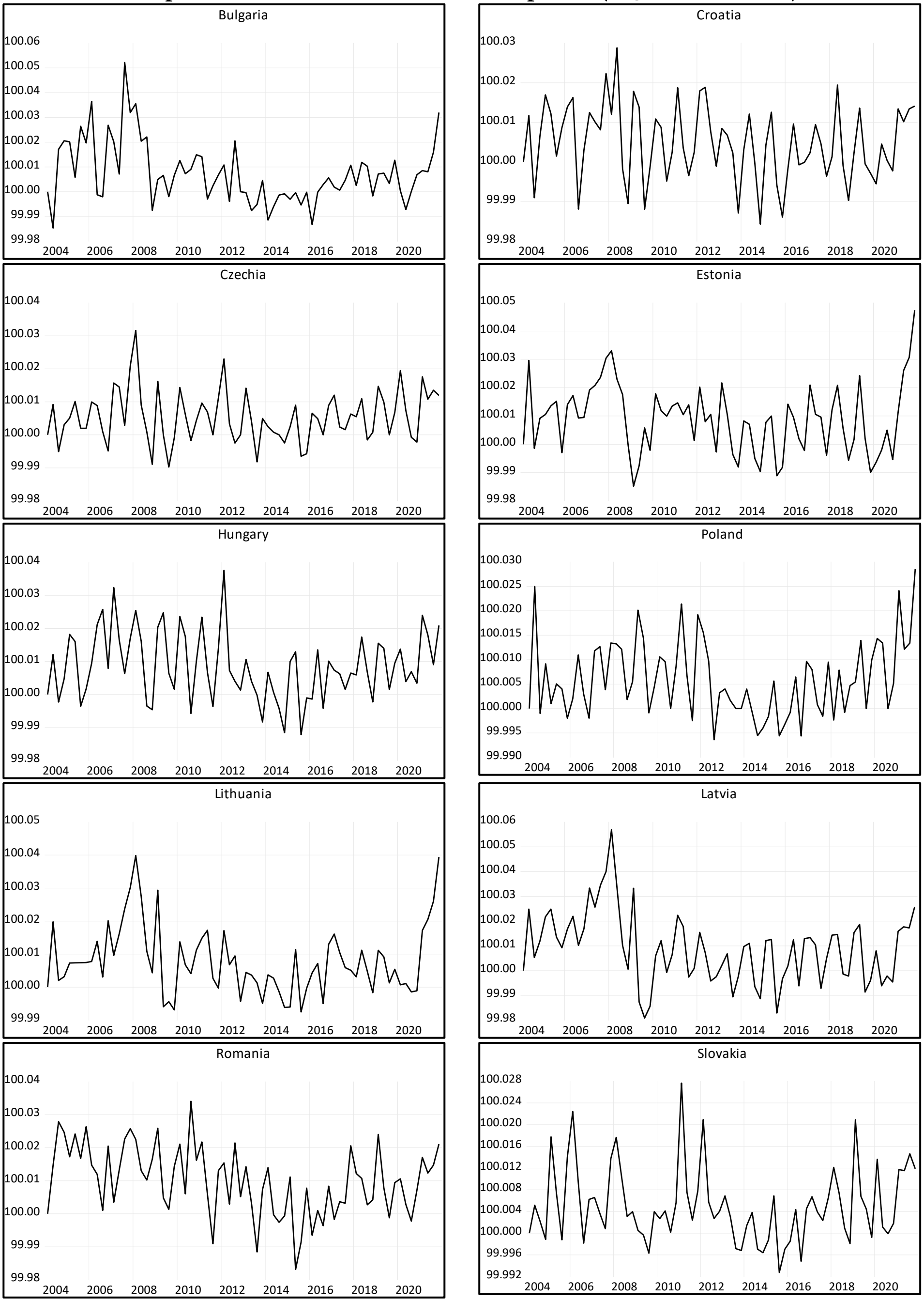
Source: author's calculation

Annex 4. Development trends of gross domestic product (1Q2004 = 100 %)



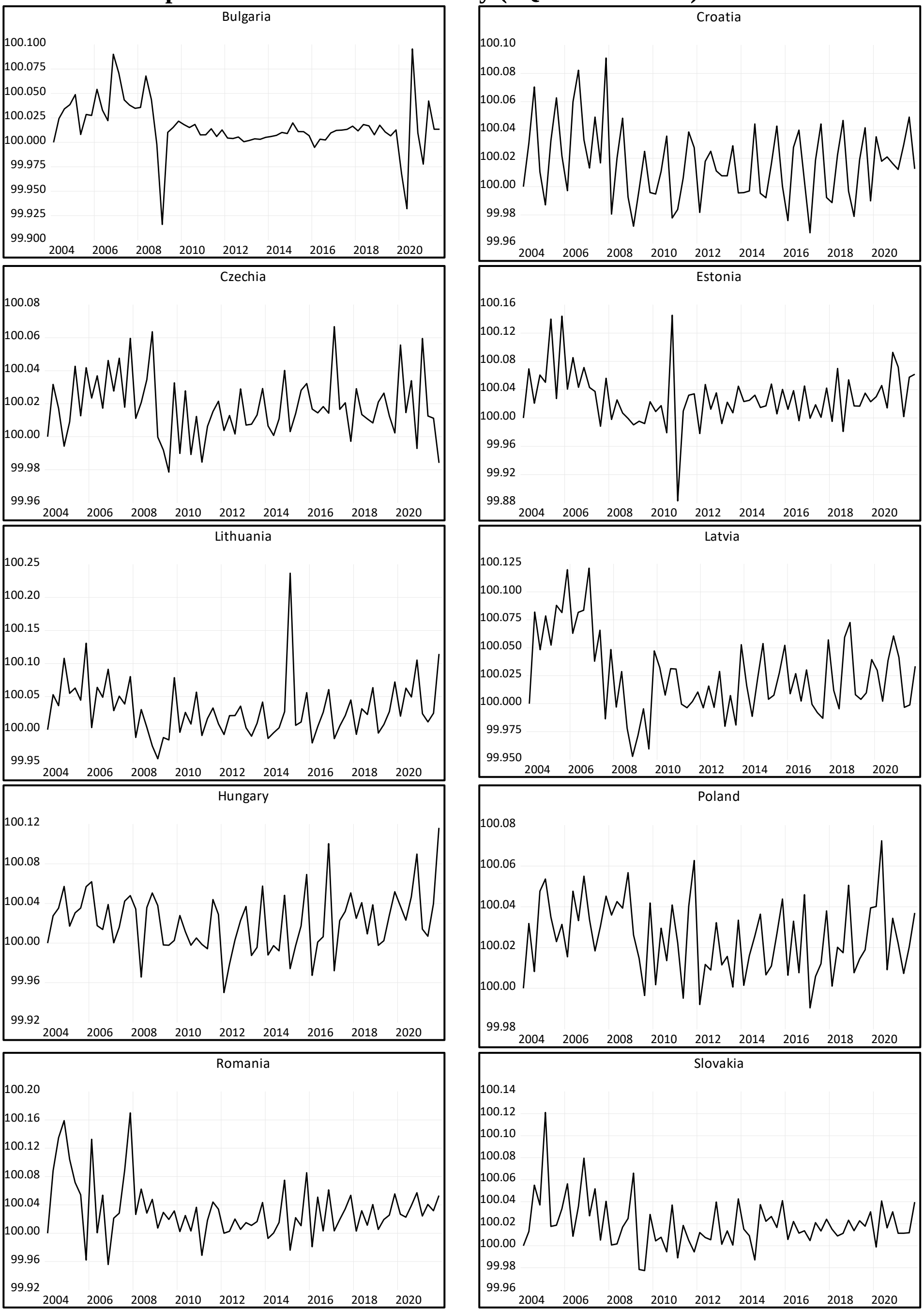
Source: author's calculation

Annex 5. Development trends of consumer index prices (1Q2004 = 100 %)



Source: author's calculation

Annex 6. Development trends of broad money (1Q2004 = 100 %)



Source: author's calculation

Annex 7. Results of unit root tests

Augmented Dickey–Fuller test (ADF)

Country	LogIndex	LogCPI	LogGDP	LogM3
Bulgaria	-7.4795*	-3.1956**	-8.4069*	-6.3799*
Croatia	-6.4530*	-11.7205*	-6.3185*	-9.2062*
Czechia	-7.1518*	-4.0772*	-7.0987*	-4.7509*
Estonia	-6.8904*	-4.6891*	-5.6244*	-9.9685*
Hungary	-8.0217*	-3.6326*	-7.8410*	-4.8821*
Latvia	-6.3156*	-3.4804**	-3.1907**	-5.1828*
Lithuania	-6.5462*	-4.3693*	-4.9636*	-7.5518*
Poland	-7.0530*	-4.5561*	-7.0265*	-8.5686*
Romania	-7.1310*	-5.7657*	-6.8908*	-7.1754*
Slovakia	-3.8748*	-3.7211*	-6.3799*	-8.1237*
Test critical values:			1% level	-3.5270
			5% level	-2.9035
			10% level	-2.5892

Source: author's calculation. Note: *, ** and *** denote significance at the 1 %, 5 %, and 10 % levels. In the table, there are t-Statistic values.

Kwiatkowski–Phillips–Schmidt–Shin test (KPSS)

Country	LogIndex	LogCPI	LogGDP	LogM3
Bulgaria	0.2695***	0.4500**	0.2608***	0.5905*
Croatia	0.1339***	0.3493**	0.1593***	0.4530**
Czechia	0.1131***	0.1327***	0.2352***	0.1810***
Estonia	0.0572***	0.1956***	0.0800***	0.2346***
Hungary	0.0736***	0.3531**	0.1363***	0.3388***
Latvia	0.1054***	0.4074**	0.1421***	0.3208***
Lithuania	0.0513***	0.1985***	0.1169***	0.2179***
Poland	0.0810***	0.2861**	0.2375***	0.4376**
Romania	0.0677***	0.5991*	0.3965***	0.4675**
Slovakia	0.1453***	0.1907***	0.5905*	0.4608**
Asymptotic critical values:			1% level	0.7390
			5% level	0.4630
			10% level	0.3470

Source: author's calculation. Note: *, ** and *** denote significance at the 1%, 5% and 10% levels. In the table, there are LM-Statistic values.

Annex 8. Result of Chow test for structural breaks

Variable	Break Date	F-statistic	p-value
Sofix c CPI	2019Q4	7.0779*	0.0016
Sofix c GDP	2019Q4	5.1685*	0.0082
Sofix c M3	2019Q4	8.0627*	0.0007
Crobex c CPI	2007Q4	5.6663*	0.0053
Crobex c GDP	2007Q4	5.8875*	0.0044
Crobex c M3	2007Q4	4.7339**	0.0119
PX c CPI	2007Q2	1.9077	0.1564
PX c GDP	2007Q2	1.1960	0.3088
PX c M3	2007Q2	3.6376**	0.0316
OMX Tallin c CPI	2007Q2	1.2292	0.2990
OMX Tallin c GDP	2007Q2	0.8109	0.4488
OMX Tallin c M3	2007Q2	1.7982	0.1735
BUX c CPI	2007Q2, 2019Q4	1.5510	0.1980

BUX c GDP	2007Q2, 2019Q4	1.6544	0.1714
BUX c M3	2007Q2, 2019Q4	1.0546	0.3861
OMX Riga c CPI	2007Q3	2.2666	0.1115
OMX Riga c GDP	2007Q3	0.2668	0.7666
OMX Riga c M3	2007Q3	0.8738	0.4220
OMX Vilnius c CPI	2007Q3	0.5962	0.5538
OMX Vilnius c GDP	2007Q3	0.5962	0.5538
OMX Vilnius c M3	2007Q3	0.6808	0.5096
WIG 20 c CPI	2007Q2	2.1969	0.1191
WIG 20 c GDP	2007Q2	1.1636	0.3186
WIG 20 c M3	2007Q2	3.7721**	0.0280
BET c CPI	2007Q4	1.6451	0.2007
BET c GDP	2007Q4	1.0319	0.3619
BET c M3	2007Q4	2.9396	0.0597
SAX c CPI	2008Q3	3.3732**	0.0402
SAX c GDP	2008Q3	1.3151	0.2753
SAX c M3	2008Q3	2.9100***	0.0614

Source: author's calculation. Note: *, ** and *** denote significance at the 1%, 5% and 10% levels. The values used are logarithmic changes of the analysed quantities.

Annex 9. Correlation coefficients between the value of stock market indices and selected macroeconomic variables

LogIndex	**LogCPI**	**LogGDP**	**LogM3**
Sofix	-0.0137	-0.0535	-0.1259
Crobex	0.1717	0.1036	0.1671
PX	-0.1296	0.1957	-0.3718*
OMX Tallinn	0.0431	0.1605	0.0562
BUX	0.0929	0.2647**	-0.0775
OMX Riga	-0.2386	0.1511	0.1020
OMX Vilnius	-0.1224	0.1240	0.1015
WIG20	-0.0488	0.2962**	-0.2354**
BET	0.0408	0.2516**	0.0707
SAX	-0.0434	0.2122***	0.3666*

Source: author's calculation. Note: *, ** and *** denote significance at the 1%, 5% and 10% levels.

Annex 10. Results of Johansen cointegration test

	r=0	**r ≤1**	**r ≤2**	**r ≤3**
logSofix/logCPI, logGDP, logM3				
Trace Statistics	125.9850*	69.6246*	35.1282*	10.3268*
Max-Eigen Statistics	56.3603*	34.4963*	24.8014*	10.3268*
logCrobex/ logCPI, logGDP, logM3				
Trace Statistics	158.6504*	85.0962*	38.8929*	14.7832*
Max-Eigen Statistics	73.5542*	46.2032*	24.1096*	14.7832*
logPX/ logCPI, logGDP, logM3				
Trace Statistics	135.1532*	69.2083*	34.2952*	11.2431*
Max-Eigen Statistics	65.9448*	34.9131*	23.0521*	11.2431*
logOMX Tallinn/ logCPI, logGDP, logM3				
Trace Statistics	106.4488*	61.5691*	31.9107*	11.8929*
Max-Eigen Statistics	44.8796*	29.6583*	20.0178*	11.8929*
logBUX/ logCPI, logGDP, logM3				
Trace Statistics	130.1300*	73.7258*	34.5035*	9.4063*
Max-Eigen Statistics	56.4041*	39.2222*	25.0972*	9.4063*
logOMX Riga/ logCPI, logGDP, logM3				
Trace Statistics	118.2889*	68.3566*	32.0514*	8.5486*

Max-Eigen Statistics	49.9322*	36.3051*	23.5027*	8.5486*
logOMX Vilnius/ logCPI, logGDP, logM3				
Trace Statistics	111.0839*	62.1802*	33.0822*	6.6640*
Max-Eigen Statistics	48.9037*	29.0979*	26.4181*	6.6640*
logWIG20/ logCPI, logGDP, logM3				
Trace Statistics	113.9543*	67.4051*	33.3680*	8.4274*
Max-Eigen Statistics	46.5491*	34.0371*	24.9405*	8.4274*
logBET/ logCPI, logGDP, logM3				
Trace Statistics	99.1272*	63.2777*	35.6615*	14.1121*
Max-Eigen Statistics	35.8495*	27.6161*	21.5493*	14.1121*
logSAX/ logCPI, logGDP, logM3				
Trace Statistics	106.8616*	52.2092*	25.6809*	12.0479*
Max-Eigen Statistics	54.6523*	26.5283*	13.6330	12.0479

Source: author's calculation. Note: *, ** and *** denote significance at the 1%, 5% and 10% levels.

Annex 11. Results of the Vector Error Correction Models

	Sofix	**Crobex**	**PX**	**OMX Tallinn**	**BUX**
CointEq1	-0.0756	-0.1849*	0.0804	-0.4052**	-0.1497
	(0.0556)	(0.0646)	(0.0540)	(0.1651)	(0.0805)
	[-1.3602]	[-2.8623]	[1.4893]	[-2.4534]	[-1.8581]
Index(-1)	-0.4124*	-0.2821**	-0.5825*	-0.2363***	-0.4175*
	(0.1151)	(0.1196)	(0.1286)	(0.1391)	(0.1167)
	[-3.5811]	[-2.3587]	[-4.5274]	[-1.6979	[-3.5763]
CPI(-1)	3.2704	7.0780*	-2.6677	-1.3404	3.0979***
	(4.1430)	(1.9321)	(2.0206)	(1.6548)	(1.5790)
	[0.7893]	[3.6634]	[-1.3202]	[-0.8100]	[1.9620]
GDP(-1)	3.9831**	0.3614	0.3407	-0.1338	0.01149
	(1.6676)	(0.4208)	(0.4133)	(0.5946)	(0.3540)
	[2.3884]	[0.8587]	[0.8243]	[-0.2251]	[0.0324]
M3(-1)	-3.0639	-1.1544**	-0.5641	0.6059***	-0.9510
	(2.3258)	(0.5120)	(0.63948)	(0.3555)	(0.6789)
	[-1.3173]	[-2.2547]	[-0.8821]	[1.7044]	[-1.4008]
R2	0.2795	0.3197	0.2626	0.4039	0.3193
Adj. R2	0.2223	0.2658	0.2041	0.3566	0.2652
F-statistics	4.8888	5.9238	4.4890	8.5399	5.9106

	OMX Riga	**OMX Vilnius**	**WIG20**	**BET**	**SAX**
CointEq1	-0.7819	-0.8088	0.2770*	0.0280*	-0.0127
	(0.1732)	(0.1879)	(0.0615)	(0.0084)	(0.0400)
	[-4.5130]	[-4.3038]	[4.5035]	[3.3160]	[-0.3192]
Index(-1)	0.1835	0.0855	-0.7608*	-0.5946*	-0.4840*
	(0.1412)	(0.1481)	(0.1176)	(0.1069)	(0.1048)
	[1.2991]	[0.5774]	[-6.4664]	[-5.5597]	[-4.6171]
CPI(-1)	3.2546	-0.9406	-2.3886	0.8766	-2.9614**
	(1.0746)	(1.8513)	(1.6345)	(1.6650)	(1.3124)
	[3.0285]	[-0.5081]	[-1.4613]	[0.5265]	[-2.2563]
GDP(-1)	0.1477	0.4272	0.9832*	0.7021	-0.4304
	(0.4043)	(0.6118)	(0.3491)	(0.4687)	(0.3863)
	[0.3653]	[0.6981]	[2.8162]	[1.4981]	[-1.1141]
M3(-1)	-0.1922	0.2211	-0.9978	-0.6063	0.0859
	(0.4519)	(0.3377)	(0.6196)	(0.4009)	(0.39208)
	[-0.4253]	[0.6548]	[-1.6103]	[-1.5124]	[0.21931]
R2	0.3571	0.3796	0.4061	0.3810	0.3400
Adj. R2	0.3061	0.3303	0.3590	0.3318	0.2876

F-statistics	7.0006	7.7103	8.6169	7.7559	6.49155

Source: author's calculation. Note: Standard errors are in round brackets, and t-statistics are in square brackets. All variables used in the VECM are first differenced. *, ** and *** denote significance at the 1%, 5% and 10% levels. The values used are logarithmic changes of the analysed quantities.

Annex 12. Results of Granger causality test

	F-Statistic	**Prob.**
Bulgaria		
logCPI → logSofix	0.1826	0.6705
logGDP → logSofix	0.2486	0.6197
logM3 → logSofix	0.7419	0.3921
Croatia		
logCPI → logCrobex	0.1059	0.7458
logGDP → logCrobex	0.1377	0.7117
logM3 → logCrobex	0.5520	0.4601
Czechia		
logCPI → logPX	0.2009	0.6554
logGDP → logPX	0.0230	0.8799
logM3 → logPX	0.0314	0.8598
Estonia		
logCPI → logOMX Tallinn	8.4091	0.0050
logGDP → logOMX Tallinn	0.6890	0.4094
logM3 → logOMX Tallinn	8.4355*	0.0050
Hungary		
logCPI → logBUX	0.8620	0.3565
logGDP → logBUX	0.0015	0.9689
logM3 → logBUX	0.0095	0.9223
Latvia		
logCPI → logOMX Riga	0.0102	0.9199
logGDP → logOMX Riga	0.0675	0.7957
logM3 → logOMX Riga	2.5077	0.1180
Lithuania		
logCPI → logOMX Vilnius	5.2099**	0.0256
logGDP → logOMX Vilnius	0.5449	0.4630
logM3 → logOMX Vilnius	0.1721	0.6796
Poland		
logCPI → logWIG20	0.1579	0.6923
logGDP → logWIG20	0.3226	0.5719
logM3 → logWIG20	0.0159	0.9000
Romania		
logCPI → logBET	0.2953	0.5886
logGDP → logBET	1.8869	0.1741
logM3 → logBET	0.3024	0.5842
Slovakia		
logCPI → logSAX	2.7448	0.1022
logGDP → logSAX	0.5466	0.4623
logM3 → logSAX	0.5921	0.4443

Source: author's calculation. Note: *, ** and *** denote significance at the 1%, 5% and 10% levels.