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REGIONAL LIMITATIONS OF STOCK INDICES PREDICTION MODELS BASED ON MACROECONOMIC VARIABLES

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Abstract

Research purpose. Stocks as well as other securities are a crucial part of the financial market that helps to redistribute financial resources amongst market participants, which in a modern economy include not only professional stock players but also many common individuals seeking to increase their capital. Previous studies found a strong relationship between the macroeconomic variables and stock returns but often the explanatory power of those models seems to be limited in the applicable region. The aim of this article is to establish whether each region's stock indices have to be predicted based on a separate set of variables.

Design / Methodology / Approach. The article uses correlation–regression analysis method to confirm the initial hypothesis regarding regional limitations of such prediction models.

Findings. The same set of independent variables cannot be directly applied to different regions because although the chosen Y2B model did provide an accurate relationship between macroeconomic variables and stock indices in the United Kingdom, it failed to provide accurate (usable) results in other regions (Estonia, European Union, France, Germany, Latvia and Lithuania),

Originality / Value / Practical implications. The results are important in order to define the way that the smaller and less-researched economies should be examined because detailed researches of power economies such as the United States, the United Kingdom, China or Germany often cannot be directly applied outside the initial research region. Therefore, the need of separate studies for smaller regions such as Baltic States is confirmed.

Keywords: stock indices, macroeconomic variables, prediction, relationship, correlation – regression analysis.

JEL codes: G15; C53.

Introduction

Many authors (Ouma & Muriu, 2014, Gjerde & Sættem, 1999, Chen, 2008, Laichena & Obwogi, 2015, Larsson & Haq, 2016, Flannery & Protopapadakis, 2002, Wongbangpo & Sharma, 2002, Benaković & Posedel, 2010; N.-F. Chen et al., 1986, Cheung & Ng, 1998, Marcišauskienė & Cibulskienė, 2013) found a strong relationship between the macroeconomic variables and stock returns but often the explanatory power of results is limited both in their regional application. Furthermore, there is only a limited number of studies performed on the Baltic States, which leaves much to be desired in order to prevent possible financial loss because of the lack of predictive models available because most of the previous studies are focused on the United States, United Kingdom, Germany, Japan or other large markets as the size and short history of free market in the Baltic States both restricts the depth of the analysis of the relationship between the stock market and macroeconomic variables and might not be considered important enough to analyse, which only increases the demand for such study as the Baltic States, since the very first day of reclaiming their independence strived to integrate with the western world and their claims, have been best illustrated by joining the North Atlantic Treaty Organization (NATO), the European Union, Euro zone, the Organisation for Economic Co-operation and Development (OECD) and so on. Therefore, though economically insignificant, these markets carry the heavy weight of the transition from planned to free market economy.

This article aims to solve the problem whether there are regional limitations of stock indices prediction models based on macroeconomic variables. Research objects of this article are macroeconomic variables, stock returns and their relationship, because the aim of the paper is to test the ability of stock indices prediction models based on the same set of variables to explain the relationship between macroeconomic variables and stock indices in different regions and time periods.

Tasks:

1. Review scientific researches regarding the nature of relationship between macroeconomic variables and stock returns in order to identify the statistically important indicators and establish the initial hypothesis for further research.
2. Apply correlation and regression analysis methods to identify the limitations of selected set of variables by comparing the prediction power of created linear regressions in different countries.
3. Evaluate the need to the creation of region-specific stock indices prediction models for smaller economies.

The remainder of the article is organised as follows:

- Section 0 presents a brief background of previously attempted researches regarding the relationship of macroeconomic variables and stock indices in various regions.
- Section 0 Methodology provides the methodology used in the article;
- Section 0 presents the statistics of applied linear regression calculation;
- The final section provides the conclusions.

It is important to notice that the aim of this article is not to create a high-accuracy prediction model that would be suitable for different regions and different types of market indexes and to establish whether one model can be reused for different regions and or market indexes and the described relationship model is provided just to make an example of such limitations.

Literature review

The study on the relationship between macroeconomic variables and stock returns was begun in the middle of the past century and one of the most influential works regarding stock returns and their correlation with macroeconomic variables was written by Fama and Schwert (1977). In their study, the authors analysed the 1953–1971 period in which they discovered that the US government bonds and bills and private residential real estate were highly immune to expected inflation. Labour income showed little short-term relationship with either expected or unexpected inflation, but the most anomalous result was that common stock returns were negatively related to the expected component of the inflation rate and, probably, also to the unexpected component. A decade later, Chen et al. (1986) tested the multifactor model in the United States by using seven macroeconomic variables and found that consumer consumption and oil prices did not have significant impact on stock returns that is mostly influenced by industrial production, changes in risk premium and twists in the yield curve.

The scope of research has broadened and one of such examples is Cheung and Ng (1998) who focused their attention not only on the United States but also on Canada, Germany, Italy and Japan to investigate the relationship between stock prices and such macroeconomic variables as gross national product, money supply, consumption and oil prices by using Johansen co-integration technique. They established a mutual relationship between stock market prices and macroeconomic indicators. They found that index returns were typically related to transitory deviations from the long-run relationship and to changes in the macroeconomic indicators. Furthermore, the constraints implied by the co-integration results yielded some incremental information on stock return variation that is not already contained in dividend yields, interest rate spreads and future GNP (growth national product) growth rates.

Gjerde and Saettem (1999) examined the causal relation between stock returns and macroeconomic variables in Norway by using both global and local macroeconomic data. The results showed a positive linkage between oil price and real economic activity and stock returns, although the study failed to show

a significant relation between stock returns and inflation. They also stated that consistent with the US and Japanese findings, real interest rate changes affected both stock returns and inflation, and the stock market responded accurately to oil price changes; however, stock market showed a delayed response to changes in domestic real activity.

Flannery and Aris (2002) re-evaluated the effect of macro announcement series on the US stock returns. They found that three nominal factors (consumer price index [CPI], producer price index [PPI] and a Monetary Aggregate) and three real factors (balance of trade, housing starts, employment reports) seemed to affect stock returns but real GNP and industrial production did not seem to be related to stock returns. They used GARCH (generalized autoregressive conditional heteroscedasticity) model of daily equity returns, where realised returns and their conditional volatility depend on 17 macro series announcements.

Wongbangpo and Sharma (2002) investigated the relationship between stock prices and some macroeconomic factors (GNP, CPI, money supply, interest rate and exchange rate) in Indonesia, Malaysia, Philippines, Singapore and Thailand. The results suggested that stock prices were positively related to growth in output in the long run and in the short run, stock prices were found to be the functions of past and current values of macroeconomic variables, decent government economic or financial policies can yield considerable gains in stock market.

Ibrahim and Aziz (2003) investigated the relationship between stock prices and industrial production, money supply, consumer price index and exchange rate in Malaysia. They discovered that the relationship was the most obvious during long run. They also stated that CPI and industrial production had a positive effect, whereas money supply and exchange rate had a negative association.

Kandir (2008) investigated the role of macroeconomic factors in explaining Turkish stock returns. A macroeconomic factor model was used for the period that spans from July 1997 to June 2005. This study used data from all non-financial firms listed on the ISE (Istanbul Stock Exchange), although it was based on stock portfolios rather than on single stocks. A multiple regression model was designed to test the relationship between the stock portfolio returns and seven macroeconomic factors (growth rate of industrial production index, change in consumer price index, growth rate of narrowly defined money supply, change in exchange rate, interest rate, growth rate of international crude oil price and return on the MSCI World Equity Index). The study revealed that the exchange rate (tourism and foreign trade), interest rate (alternative investment options) and world market return (ISE movement towards global integration) seem to affect all of the portfolio returns, whereas inflation rate (results inconclusive) was significant only for 3 of the 12 inspected portfolios. On the other hand, industrial production (asks for debate about the well-functioning of Turkish financial markets), money supply and oil prices (despite Turkey being net importer) did not appear to have any significant effect on stock returns.

Chen (2008) investigated whether macroeconomic variables can predict recessions in the stock market of the United States by using the Markov-switching model to identify the recession periods in the stock market. The study suggested that amongst the macroeconomic variables that were considered, yield curve spreads and inflation rates were the most useful predictors of Bear Stock Markets according to in-sample and out-of-sample forecasting performances.

Humpe and Macmillan (2009) examined whether industrial production, CPI, money supply and long-term interest rates affected the stock markets in the United States and Japan. The data showed the US stock prices were positively related to industrial production (relation significant) and money supply (relation insignificant) and negatively related to both the consumer price index and a long-term interest rate (both factors significant) within single co-integrating vector. Japan seems to have had two vectors; in one, price was influenced positively by industrial production and negatively by the money supply, and in the second, industrial production was negatively influenced by the consumer price index and a long-term interest rate.

Benaković and Posedel (2010) analysed the returns on 14 stocks on Zagreb market during 2004–2009 in relationship with inflation, industrial production, interest rates, market index and oil prices as factors by investigating both the direction and strength of the relation between the change in factors and returns. The calculation results showed that the market index had the largest statistical significance for all stocks and a positive relation to returns. Interest rates, oil prices and industrial production also marked a positive relation to returns, whereas inflation had a negative influence. Furthermore, cross-sectional regression with the estimated sensitivities used as independent variables and returns in each month as dependent variables

was performed, which resulted in time series of risk premiums for each factor. The most important factor affecting stock prices was proved to be the market index, which had a positive risk premium. Inflation was also a statistically significant factor in 2004 and 2008, marking a negative risk premium in 2004 and a positive one in 2008. The remaining three factors were not significant. The authors stated that stock prices are greatly affected by investors' expectations, so they respond very quickly to any publicly disclosed information, for example, economic or political news. For that reason, they suggested that when analysing influences on stock prices, whenever it is possible, it would be better to use indicators that measure changes in expectations about future values of macroeconomic factors, for instance, changes in expected inflation or economic activity, instead of indicators measuring the changes in realisations of macroeconomic variables.

Laichena and Obwogi (2015) analysed the East African stock market that includes all the member countries of the East African Community (in this case Kenya, Uganda and Tanzania), which tend to make effort towards integration in numerous aspects including common currency during 2005–2014. This study sought to find out the effects of interest rate, inflation rate, exchange rate and gross domestic product (GDP) on stock returns. Descriptive analysis and panel data regression analysis were applied in the study, and it was found that interest rate had a negative impact, inflation rate that was also associated with the increase in money supply had a positive significant relationship, exchange rate (applied to USD) had an inverse significant relationship and GDP had a positive significant relationship with the East Africa stock market.

Peiró (2016) analysed the dependence of stock prices on macroeconomic variables in the three largest European economies: France, Germany and the United Kingdom. According to the author in the recent decades, industrial production and long-term interest rates were the important significant variables accounting for approximately one half of annual movements in stock prices. Both factors seem to be equally important, but a closer examination revealed that the weight of these factors had clearly moved from interest rates to production. This evidence is common to all three of these European countries and is in sharp contrast with the results for the United States.

Gilbert (2011) showed that there exists an empirical relation between stock returns on macroeconomic news announcement days and the future revisions of the released data but that this link differs across the business cycle. The author analysed news regarding nonfarm payroll, GDP and industrial production and stated that stock prices positively react to this news during expansion period and negatively during recession. Gilbert also noted that revisions matter and the investors care not only about initial macroeconomic announcements but also about the confirmations of such news. The results seem to be consistent with the predictions of rational expectations trading models around public announcements combined with well-established empirical results on the asymmetric interpretation of information across the business cycle.

Larsson and Haq (2016) investigated the short- and long-run relationship between the S&P500 and macroeconomic indicators (personal spending, initial jobless claims, money supply, building permits, Michigan Consumers Sentiment index and the ISM (Institute for Supply Management) manufacturing index) during 2000–2016 using the autoregressive distributed lags model (ARDL). The study stated that all indicators except personal spending were significant in the long-run on the one-percent level, in at least one time regime. All indicators had significant results also in the short run except the money supply, depending on which time period was under investigation. They concluded that indicators had different characteristics depending on the current dynamics of the stock market, economic state and other related markets. Moreover, it was noted that the development of the variable was more important than its value at specific data point.

Boreika and Pilinkus (2009) applied correlation method to identify the statistical relationship between macroeconomic variables and stock market (OMX Vilnius). They stated that inflation caused by increasing oil and food prices had a negative effect on consumer consumption that had a negative effect on business expansion and that real estate market was the first one to be hit by global financial crisis because of restrictions on house loans and higher interest rates. They observed a strong relationship amongst GDP, money supply, unemployment, personal consumption and construction price index and stock market prices.

Bareikienė and Sūdžius (2011) aimed to evaluate the impact of financial crisis of 2007–2008 on the Lithuanian stock market because after this crunch, lots of investors started to doubt about the reliability of stock market. The data of 2003–2010 were analysed and the study showed that the global crisis made the biggest impact on OMX Vilnius during 2008 when the GDP started to shrink, which shows that stock markets are more volatile than the common macroeconomic variables. Real GDP, inflation and interest rate were considered. The study also found that decrease and increase periods had similar total changes to the stock prices, but the decrease periods were longer; therefore, the investors had more time to sell their stocks and buy obligations.

Koncevičienė and Janickaitė (2011) investigated the effect of macroeconomic factors in 2002–2011 on the stock returns of NASDAQ OMX Vilnius companies from different sectors (food production, beverages, gas, electricity, pharmaceutical, telecommunications, paper, personal goods, consumer products, retail, construction, transportation, chemicals, oil, banking and financial services). Industrial production, CPI, interest rates, money supply, inflation, exchange rates (LTL/USD, LTL/RUB) and European Brent oil prices were considered. The study also showed how cyclical stocks were more sensitive to changes in macroeconomic variables than defensive ones; oil price shocks had a stronger effect on sectors heavily dependent on oil; currency changes had a stronger influence on stock returns of sectors producing goods mainly for export. Moreover, studies showed that macroeconomic factors differently affect stock returns of different sectors and the impact depends on peculiarity of the country.

Marcišauskienė and Cibulskienė (2013) aimed to identify which macroeconomic indicators were influencing the Baltic stock prices by using multinomial regression model. They investigated the relationship between the macroeconomic indicators of the Baltic States and the OMX index by using the data for the first quarters of 2000–2012. The authors have identified a strong and direct relationship between OMXV and M1, OMXV and FDI (foreign direct investments); a moderate and direct relationship between OMXV and PPI (producer price index), OMXV and GDP per capita; a strong and direct relationship between OMXR and M1; and moderate and direct relationship between OMXR and GPD per capita. The OMXR relationship with HCPI (harmonized consumer price index), FDI and PPI was direct but weak. The multinomial regression model of Baltic Stock Exchanges indexes and macroeconomic variables of the analysed period indicated that both OMXV and OMXR indexes were affected by their previous values as well as GDP per capita and unemployment rate that also had a negative effect on both indexes. The OMXT index was affected by its previous value as well, but it was also affected by M1, government debt that had a negative effect on the OMXT.

Rudzkis and Valkavičienė (2014) examined the dependencies of individual sectoral stock price indices of OMX Baltic security market on macroeconomic indicators by constructing regression models with quarterly time series of 2000–2011. The authors concluded that OMX Baltic securities market was significantly impacted by dollar/euro exchange rate and gold and oil prices. Econometric analysis of OMX Baltic security market also proved the hypothesis that the set of macroeconomic regressors vary considerably depending on the individual sector's price indices, especially in the case of small open economy with immature stock markets. According to the authors, the linear regression models have a fairly high level of precision and provide additional opportunities for investors who are shaping their portfolio taking into account the macroeconomic forecasts but because of the shortness of the available time series, the influence of several factors on the models was not reflected, and the models should be expanded and updated in view of the new data accumulated by including not only macroeconomic indicators as factors that affect sectoral indices but also the statistical data of the respective economic activities, and in case of longer time series, one should apply a generalised least squares method.

Alexakis et al. (2016) examined the emerging stock market contagion during the Global Financial crisis and the Euro zone Sovereign Debt Crisis. They focused on the three emerging Baltic markets and developed European markets, proxied by the EUROSTOXX50 stock index. They explored asymmetric dynamic conditional correlation dynamics across stable and crisis periods. The study showed that Latvia and Lithuania were affected during global crisis and Estonia was mainly affected only by Euro zone crisis. The authors tend to believe that the results could be attributed to financial and macroeconomic characteristics of the Baltic countries before and after the turmoil periods and the introduction time of the Euro as a national currency.

Ouma and Muriu (2014) analysed the impact of the macroeconomic variables on stock returns in Kenya during the period 2003–2013 using the arbitrage pricing theory (APT) and capital asset pricing model (CAPM) framework for monthly data. The ordinary least square (OLS) technique was applied to test the validity of the model and the relative importance of different variables that may have an impact on the stock returns. The analysis found that there existed a significant relation between stock market returns and money supply, exchange rates and inflation, whereas interest rates was not important in determining long rung run returns in the NSE (national stock exchange).

Jareño and Negrut (2016) in their study analysed relationship between the US stock market and GDP, CPI, industrial production index, the unemployment rate and long-term interest rates from which all factors except CPI showed significant relationships with the stock market. They claimed that the stock market can be conceived as a leading indicator of the real economy, because the market index tends to advance the behaviour of the economic cycle through a period of 6–12 months.

It should be noted that different authors used a wide variety of different calculation methods in order to establish the relationship between the macroeconomic variables and stock indices:

- APT (Ouma & Muriu, 2014), which is a multi-factor asset pricing model based on the idea that the asset's returns can be predicted using the linear relationship between the asset's expected return and a number of macroeconomic variables that capture systematic risk;
- CAPM (Ouma & Muriu, 2014), which is a model that describes the relationship between systematic risk and expected return for assets, particularly stocks;
- OLS (Ouma & Muriu, 2014), which is a type of linear least squares method for estimating the unknown parameters in a linear regression mode;
- Multivariate VAR (Gjerde & Sættem, 1999) approach and its co-integrated representation by VECM (Adam & Tweneboah, 2008);
- Markov-switching multifractal (MSM) (Chen, 2008), which is a model of asset returns that incorporates stochastic volatility components of heterogeneous durations;
- Descriptive analysis (Laichena & Obwogi, 2015), which uses brief descriptive coefficients that summarise a given data set that can be either a representation of the entire or a sample of a population;
- Panel data regression analysis (Laichena & Obwogi, 2015), which is widely used in econometrics to analyse two-dimensional (typically cross sectional and longitudinal) panel data;
- ARDL (Larsson & Haq, 2016) co-integration technique is preferable when dealing with variables that are integrated of different orders, I(0), I(1) or combination of the both, and robust when there is a single long-run relationship between the underlying variables in a small sample size;
- GARCH model (Flannery & Protopapadakis, 2002) of daily equity returns, which is based on the ARCH model by adding the lagged conditional variance term;
- Granger causality test (Wongbangpo & Sharma, 2002), which is a statistical hypothesis test for determining whether one time series is useful in forecasting another;
- Multifactor model (Benaković & Posedel, 2010; Chen et al., 1986), which is a financial model that uses multiple factors in its calculations to explain market phenomena and/or equilibrium asset prices;
- Johansen and Juselius co-integration test (Cheung & Ng, 1998), which makes it possible to estimate all co-integrating vectors when there are more than two variables;
- General correlation–regression analysis methods (Marcišauskienė & Cibulskienė, 2013).

In regards of the objectivity of this research, the difference in the macroeconomic variables that had impact on the stock indices can be explained because of different calculation methods used in the previous

researches, which is why in order to establish the regional limitation of the prediction models, the same set of variables for different countries should be examined in same calculation model.

Methodology

This study aims to define the presence or absence of the regional limitations of stock indices prediction models; therefore, the most important task is to identify the relationship between the independent (macroeconomic) and dependent (stock indices) variables, which is achieved by performing correlation–regression analysis. It should be noted that other methods may or may not be affected by regional limitations, but in case of regional limitations present in the accuracy of regression equations based on same set of variables in different regions, the possibility of general regional limitations should be considered.

The expression of linear regression is written as follows:

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_i x_i + \varepsilon, \qquad (1)$$

where y_i is the dependent variable, β_0 is the population Y intercept, β_1 is the population slope coefficient, x_i is the independent variable, ε is the random error component.

The dependent variables are the stock indices that represent the companies with highest capitalisation in each of the analysed regions:

- Estonia, Latvia and Lithuania – OMX is the only stock market index for these countries (OMX Tallinn, OMX Riga, OMX Vilnius, respectively);
- European Union – EURO STOXX 50 is made up of 50 of the largest and most liquid Eurozone stocks;
- France – CAC 40 is a benchmark French stock market index that represents the 40 most significant values amongst the 100 highest market caps on the Euronext Paris;
- Germany – DAX is a blue-chip stock market index consisting of the 30 major German companies traded on the Frankfurt Stock Exchange;
- United Kingdom – FTSE 100 is a share index of the 100 companies listed on the London Stock Exchange with the highest market capitalisation.

The selection of market indices is limited because Baltic States have only one option, but this restriction would only provide additional argumentation to the fact that a prediction model designed for a specific region (and / or index) should not be used outside its initial purpose limits.

For the best possible result in order to determine the presence of regional limitations, they must be found amongst similar countries, and according to current political situation, the European Union and its members are the best candidates for such research because of their inner dependability (main trade partners, political and economic integration, geographical distance, mostly single currency, etc.). The specific regions were chosen because of their size (3 biggest economies of the European Union [France, Germany and the United Kingdom] and the Union itself) and the less-researched region of the Baltic States, which consists of Estonia, Latvia and Lithuania.

The independent (macroeconomic) variables and assumption for their impact on this model are

- GDP is a most widely used macroeconomic variable to display the changes in the economy though because the Baltic states are facing the decline in population as opposed to the increase in population in the United Kingdom, Germany, France or the European Union; in general, the sum value is supposed to be less objective than per capita values but it has to be noted that GDP and GDP values of the European Union can be considered misleading in this calculation especially considering the increase in the number of the member countries most of which have lower than average GDP values. It is assumed that the growth of GDP has a positive effect on stock indices;

- Long-term government bonds are one of the safest investing options and are characterised by low returns; therefore, the increase in their returns shows the increased risk that adds to the economic uncertainty and should have negative effect on the stock returns;
- Unemployment statistics can be considered both way, as the lowering unemployment ratio shows the economic growth of the country and, therefore, companies can sell their production and services more easily; however after reaching specific point, the unemployment becomes problem for company profits because they face higher competition when hiring workers, which in low unemployment rate environment have more bargaining power; therefore, it is assumed that increase in unemployment will have a positive effect on stock indices;
- Labour cost is related to the second effect of the decrease in unemployment ratio and directly affects production costs, which in theory should decrease the profits and, therefore, lower the growth of stock indices; therefore, it is assumed that the increase in labour cost will have a negative effect on stock indices;
- Industrial production shows the value of goods produced and should have a positive effect on the income of commercial entities, therefore, adding to the growth (positive effect) of stock indices, although it must be noted that industrial production does not account for the provided services.
- PPI indicates the changes in producers' costs of their production output, and although it is linked to the labour cost, it is affected by material prices, taxes and so on as well; therefore, it should play a significant role in the final balance sheets and have a negative effect on stock indices;
- CPI measures the changes in the price level of market basket of consumer goods and services purchased by households and indicates the higher income per unit for the commercial entities, although it does not provide information regarding the volume of goods and services purchased but it is assumed that the positive effect due to larger expenditure will outweigh the limited purchasing power.

Other authors have also considered variables such as currency exchange rate but the selected countries (except the United Kingdom) use the same currency (Euro) for almost the whole time period that was analysed (Germany, France, most of the European Union as a whole) or their currency was linked to the Euro before the country adopted the single currency (applicable to Estonia and Lithuania, not applicable to Latvia) and most of their trade (import and export) are made within the European Union, which makes the exchange rate a less-significant macroeconomic variable compared with others (not applicable to the United Kingdom, but the aim of this study is to apply the same variables as much as possible and the results show that the United Kingdom had the highest result accuracy despite the lack of exchange rate variable). Other possible variables such as oil prices are the same for all the countries and should be represented in the intercept values and variables such as tourism apply only to a smart part of each of these economies and were considered of less importance. Qualitative variables such as political regime and involvement in foreign conflicts are proven to have effect on the stock indices; however, most of the conflict involvement is similar amongst the countries because of their membership in NATO and the political regimes were more or less stable during the considered time period.

The data for the independent variables are provided by Eurostat (European Statistical Office).

Two correlation–regression models are applied:

- Year-to-year (Y2Y) model analyses the relationship between stock indices and macroeconomic variables by calculating the relationship of their growth rate (year-to-year value changes);
- Year-to-base (Y2B) model analyses the relationship between stock indices and macroeconomic variables by calculating the relationship of change in their value when compared to year 0 (2013).

The R-squared value (coefficient of determination) is the proportion of the variance in the dependent variable that is predictable from the independent variable(s) and is calculated using the formula

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}}, \qquad (2)$$

where SS_{res} is the residual sum of squares and SS_{tot} is the total sum of squares.

Because the models use relatively large number of independent variables when compared to the number of observations, the adjusted R-squared value is also considered:

$$\bar{R}^2 = 1 - (1 - R^2)\frac{n-1}{n-p-1}, \quad (3)$$

where R^2 is the R-squared value, n is the number of observations and p is the number of independent variables.

Results

First, the covariance calculations were applied using Microsoft Excel add-on 'Data Analysis – Covariance', which showed little to none of joint variability of two random variables amongst all the countries (several values were close to 0.6 but by the rule of the thumb, intercorrelation is present when the values are >0.8); therefore, the multicollinearity problem is absent.

According to the results shown in Table 1, the R-squared values when using Y2Y model are rather low amongst all the analysed countries, although it has to be noticed that the R-squared value of the United Kingdom is highest amongst all the analysed countries, but it is easily seen that such calculation model shows almost no relationship between macroeconomic variables and stock indices, at least on the acceptable level. The adjusted R-squared value shows even lower accuracy of the Y2Y model.

Table 1. Y2Y calculation model regression statistics (Source: author's compilation)

Regression Statistics	Estonia	European Union	France	Germany	Latvia	Lithuania	United Kingdom
Multiple R	0.68833	0.80339	0.84192	0.70969	0.69594	0.82062	0.85284
R-Squared	0.47379	0.64543	0.70883	0.50367	0.48434	0.67342	0.72733
Adjusted R-Squared	0.02276	0.23177	0.36913	−0.07539	−0.11727	0.29241	0.40921
Standard Error	0.35540	0.15334	0.14070	0.19401	0.32571	0.28957	0.10526
Observations	14	14	14	14	14	14	14

According to the results shown in

Table 2, the Y2B model is clearly more accurate than the Y2Y model as the R-squared value in each occasion is higher than the ones calculated using Y2Y model and the R-squared value of the United Kingdom and Germany is higher than 0.9 and their adjusted R-squared values are above 0.85, which is also a good result; however, the standard error in case of Germany is significantly higher than that in the case of the United Kingdom.

Table 2. Y2B calculation model regression statistics (Source: author's compilation)

Regression Statistics	Estonia	European Union	France	Germany	Latvia	Lithuania	United Kingdom
Multiple R	0.81170	0.90388	0.85169	0.96556	0.94656	0.92285	0.96589
R-Squared	0.65885	0.81700	0.72538	0.93231	0.89597	0.85166	0.93294
Adjusted R-Squared	0.36644	0.60350	0.40498	0.85334	0.77460	0.67859	0.85471
Standard Error	0.72137	0.12034	0.16428	0.25608	0.33165	0.41475	0.07651
Observations	14	14	14	14	14	14	14

Although Y2B calculation model provides higher accuracy results, it is worth mentioning that the Y2Y results of France and the United Kingdom, which have the highest R-squared values of Y2Y model, are higher than the values for Estonian stock indices calculated using Y2B model. Furthermore, it is obvious that changes in stock indices of the United Kingdom are most accurately represented despite the type of

model applied, which confirms the initial hypothesis of the need of specific set of variables for each country.

Table 3 shows the coefficients and p-values, and after their analysis, it is obvious that Y2Y model has very low prediction power as all except one, p-values are higher than 0.05, which means that factors are not significant, but it is worth noticing that the single p-value that is below 0.05 is the list of the UK variables.

Table 3. The coefficients and p-values of regression model for each country (Y2Y model) (Source: author's compilation)

	Estonia		European Union		France		Germany		Latvia		Lithuania		United Kingdom	
Factor	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value
Intercept	0.49	0.06	0.02	0.90	−0.04	0.78	0.30	0.21	0.20	0.28	0.40	0.19	0.14	0.31
Government bonds long			0.06	0.89	0.48	0.18	0.03	0.69	0.08	0.84	0.29	0.49	−0.33	0.22
GDP per capita	0.39	0.76	0.81	0.44	−0.18	0.83	0.11	0.92	0.20	0.94	0.90	0.51	0.80	0.15
Unemployment	0.58	0.25	0.57	0.47	1.11	0.27	1.03	0.25	0.41	0.61	0.68	0.18	0.76	0.09
Labour cost	0.37	0.87	7.44	0.09	3.65	0.10	−2.32	0.29	0.50	0.69	−0.14	0.93	−1.46	0.04
Industrial Prod	1.70	0.73	0.42	0.42	3.48	0.17	0.78	0.69	2.00	0.34	3.16	0.51	1.64	0.42
PPI	8.95	0.39	-0.73	0.86	−16.51	0.30	−1.14	0.84	1.38	0.86	0.97	0.83	−2.43	0.23
CPI	−14.53	0.18	-9.18	0.40	14.38	0.54	−4.95	0.82	−6.08	0.35	−14.46	0.18	−1.86	0.81

On the contrary, the p-values presented in Table 4 are almost ideal for the United Kingdom (except for the intercept value, which is 0.06, just slightly above 0.05); therefore, the model is suitable for the United Kingdom, although the p-values for other countries are well above 0.05 as in Y2Y model as well.

After checking the coefficients values in

Table 4, the conclusions regarding the predicted relationship nature of the macroeconomic variables and stock indices can be made, which state that in the case of the United Kingdom,

- As predicted, the growth of GDP (in this case GDP per capita) has a positive effect on the stock market indices;
- As predicted, the long-term government bonds return change have a negative effect on the stock market indices;
- The increase in unemployment seems to have a positive effect because of the higher bargaining power of the commercial entity;
- As predicted, the labour cost has a negative effect on the stock indices;
- As predicted, the industrial production has a positive effect on the stock indices;
- As predicted, the producer price index has a negative effect on the stock indices;
- As predicted, the consumer price index has a positive effect on the stock indices.

Table 4. The coefficients and p-values of regression model for each country (Y2B model) (Source: author's compilation)

	Estonia		European Union		France		Germany		Latvia		Lithuania		United Kingdom	
Factors	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value	*Coefficients*	p-Value
Intercept	1.12	0.11	0.26	0.33	0.35	0.14	−0.82	0.27	0.41	0.36	−0.39	0.63	0.17	0.06
LT government bonds			−0.49	0.26	−0.59	0.63	−0.22	0.88	0.90	0.06	0.03	0.95	−1.14	0.02

GDP per capita	−1.13	0.48	0.63	0.61	0.14	0.92	0.23	0.92	−1.36	0.36	0.78	0.54	0.99	0.03
Unemployment	−0.94	0.51	1.55	0.07	0.70	0.57	4.05	0.19	−1.63	0.21	0.44	0.79	0.80	0.02
Labour cost	−1.13	0.79	11.21	0.04	4.61	0.07	2.31	0.68	0.31	0.82	−5.27	0.04	−1.94	0.01
Industrial Prod	14.17	0.38	0.81	0.04	1.71	0.38	2.84	0.16	7.23	0.02	15.94	0.07	4.80	0.04
PPI	−17.90	0.40	4.30	0.42	0.26	0.98	−3.56	0.48	−2.12	0.79	−5.79	0.07	−4.62	0.01
CPI	16.01	0.43	−24.37	0.09	−11.32	0.33	22.22	0.14	3.05	0.65	5.01	0.46	6.01	0.02

When reviewing residuals in Y2Y model as shown in Table 5, it is hard to define the reasons for the spotted inaccuracies; therefore, it can only be mentioned that the biggest differences in the UK stock indices predictions are spotted before the financial crisis of 2007–2008 and after both the expansion of the European Union and the Brexit vote (1 year after the events) but the accuracy of these explanations might be dubious.

Table 5. Residuals based on Y2Y calculation model (top 2 [dark grey] and bottom 2 [light grey] values are highlighted) (Source: author's compilation)

Year	Estonia	European Union	France	Germany	Latvia	Lithuania	United Kingdom
2004	19.15%	4.50%	8.25%	−3.54%	36.04%	−1.75%	−1.25%
2005	30.71%	0.77%	7.49%	−6.64%	41.81%	31.46%	14.98%
2006	16.22%	13.08%	3.17%	13.36%	−5.52%	1.44%	−7.51%
2007	4.71%	−8.29%	−14.26%	3.31%	−4.04%	16.74%	−9.39%
2008	−25.82%	−8.77%	−9.19%	−24.96%	−21.46%	−16.33%	−7.96%
2009	2.07%	−5.29%	−10.18%	5.90%	5.80%	6.00%	2.78%
2010	21.50%	−2.50%	−8.87%	14.41%	−21.14%	10.17%	7.62%
2011	−47.68%	−18.84%	−8.62%	−2.34%	−25.24%	−44.21%	−1.58%
2012	40.58%	18.05%	14.57%	20.59%	−14.71%	20.01%	1.53%
2013	7.38%	9.90%	2.82%	3.36%	3.01%	−8.50%	−0.15%
2014	−41.26%	2.93%	3.68%	−4.18%	−24.47%	−17.82%	4.71%
2015	−0.76%	−11.76%	−8.63%	−25.27%	28.85%	−15.79%	−4.26%
2016	−19.56%	−3.76%	11.48%	7.02%	−3.82%	−0.27%	−7.49%
2017	−7.25%	9.97%	8.30%	−1.01%	4.88%	18.85%	7.98%

In order to display the difference in predicted and actual Y (change of stock indices) values more clearly, both the predicted and actual values are presented in Table 6.

Table 6. Comparison of actual and predicted changes (based on Y2Y model) in stock indices (Source: author's compilation)

Year	Estonia		European Union		France		Germany		Latvia		Lithuania		United Kingdom	
	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual
2004	38%	57%	1%	5%	−1%	8%	8%	5%	7%	43 %	70%	68 %	12%	11%
2005	17%	48%	23%	24%	19%	26%	40%	33%	22%	64%	21%	53%	4%	19%
2006	13%	29%	0%	13%	10%	13%	6%	20%	2%	−3%	8%	10%	15%	8%
2007	−18%	−13%	−1%	−9%	1%	−13%	−2%	1%	−5%	−9%	−12%	4%	4%	−5%

2008	−37%	−63%	−32%	−41%	−30%	−39%	−12%	−37%	−33%	−54%	−49%	−65%	−21%	−29%
2009	45%	47%	29%	24%	36%	26%	23%	29%	−3%	3%	40%	46%	22%	25%
2010	51%	73%	9%	6%	16%	7%	12%	26 %	62%	41%	46%	56%	5%	13%
2011	24%	−24%	1%	−18%	−9%	−18%	−6%	−9%	20%	−6%	17%	−27%	−2%	−3%
2012	−2%	38%	−6%	12%	−1%	13%	0%	20%	21%	7%	−1%	19%	9%	10%
2013	4%	11%	2%	12%	9%	12%	16%	20%	13%	16%	27%	19%	4%	4%
2014	34%	−8%	8%	11%	7%	11%	19%	15%	13%	−11%	25%	7%	−1%	4%
2015	20%	19%	3%	−9%	5%	−4%	17%	−8%	17%	46%	23%	7%	−6%	−10%
2016	39%	20%	10%	6%	−4%	8%	11%	18%	27%	23%	15%	15%	24%	17%
2017	23%	15%	2%	12%	7%	15%	15%	14%	31%	36%	−2%	17%	−2%	6%

After reviewing the residuals in Table 7, it can be noted that the UK Y2B model shows significant relationship errors in four periods, which can be partially explained in this manner:

- 2004 – it is hard to summarise this year, but it is possible that the UK commercial entities and stockholders had negative opinion regarding the expansion of the European Union;
- 2005 – according to the macroeconomic variables, the stock indices should have grown by 10% less than they did (when comparing total growth to the base year of 2003), which probably can be linked to the formation of financial crisis because the commercial entities and stock holders were more optimistic than the macro variables should account for; therefore, additional variables that can predict financial bubbles should be included in models, although they are hard to acquire and such differences work in favour of the investors (growth larger than expected) and the upcoming problems can be addressed by reviewing past year data (if stocks grow up faster than the model predicts, it can signal the possibility of upcoming crisis), and it is also possible that the United Kingdom has changed its mind regarding the new EU members and they had a positive impact on the UK stock indices;
- 2010 – it seems that stock markets were more optimistic regarding the recovery from 2007–2008 financial crisis caused by the US subprime mortgages than the macroeconomic variables would predict;
- 2016 – it is obvious that macroeconomic variables did not fully account for the Brexit vote, which proves the need of including political regime/decisions variables to future prediction models.

In summary, the main reasons for the model's inaccuracy tend to be political events that are discussed in the research made by Larsson and Haq (2016) as well as the financial crisis. Although the sudden political changes can be hard to predict, the risk of sudden growth of financial bubbles can be seen when comparing the real and assumed growth of stock indices.

Table 7. Residuals based on Y2B calculation model (top 2 [dark grey] and bottom 2 [light grey] values are highlighted) (Source: author's compilation)

Year	Estonia	European Union	France	Germany	Latvia	Lithuania	United Kingdom
2004	−69%	−6%	2%	0%	−17%	−56%	−8%
2005	21%	−8%	−10%	−15%	32%	38%	10%
2006	95%	21%	16%	16%	−26%	16%	2%
2007	35%	−3%	4%	24%	30%	11%	−1%
2008	−113%	−1%	−5%	−41%	−37%	−17%	−4%
2009	−27%	4%	4%	−4%	19%	0%	−1%
2010	43%	−1%	−6%	16%	−5%	46%	5%

2011	−29%	−14%	−19%	2%	10%	−45%	−1%
2012	23%	6%	−2%	3%	−36%	7%	−3%
2013	27%	6%	9%	7%	8%	−2%	−2%
2014	15%	3%	12%	9%	13%	23%	5%
2015	−48%	−3%	−10%	−26%	−6%	−17%	2%
2016	−7%	−6%	−13%	3%	−3%	−4%	−8%
2017	33%	3%	17%	7%	18%	−1%	5%

In order to display the difference in predicted and actual Y (change in stock indices) values more clearly, both the predicted and actual values are presented in Table 8.

Table 8. Comparison of actual and calculated changes (based on Y2B model) in stock indices (Source: author's compilation)

Year	Estonia		European Union		France		Germany		Latvia		Lithuania		United Kingdom	
	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual	Predicted	Actual
2004	126%	57%	11%	5%	6%	8%	5%	5%	61%	43%	124%	68%	18%	11%
2005	112%	132%	38%	30%	46%	36%	55%	40%	103%	135%	119%	157%	21%	31%
2006	105%	200%	26%	47%	38%	54%	51%	67%	154%	127%	166%	182%	40%	41%
2007	125%	160%	37%	34%	29%	34%	44%	69%	77%	106%	183%	195%	35%	34%
2008	109%	−4%	−20%	−21%	−13%	−18%	48%	7%	31%	−6%	20%	3%	−1%	-5%
2009	69%	42%	−6%	−2%	−1%	3%	43%	38%	−22%	−3%	50%	50%	19%	18%
2010	101%	144%	5%	4%	16%	10%	58%	74%	41%	37%	89%	135%	28%	34%
2011	114%	86%	−1%	−15%	10%	−9%	57%	59%	19%	29%	117%	71%	30%	29%
2012	134%	157%	−10%	−5%	5%	3%	89%	92%	73%	37%	97%	104%	46%	43%
2013	159%	186%	0%	6%	6%	14%	122%	129%	51%	60%	144%	142%	50%	48%
2014	149%	164%	15%	18%	14%	27%	154%	163%	28%	42%	136%	159%	49%	54%
2015	263%	215%	10%	7%	32%	21%	168%	141%	112%	106%	196%	179%	37%	39%
2016	283%	277%	20%	14%	43%	31%	182%	184%	158%	155%	224%	220%	70%	62%
2017	302%	335%	24%	27%	33%	51%	218%	225%	228%	246%	275%	274%	67%	72%

After reviewing the residuals, it can be objectively stated that specific set of variables is accurate only for a certain region, in this case, the United Kingdom, and should be not used directly for other countries, for example, the biggest difference between predicted and actual change in the UK stock indices was 10% in 2005, whereas the smallest difference of the same model in Estonia was −7% in 2016 and the biggest one was −113% in 2008.

After analysing the values given in Figure 1, it should be noted that the lack of accurate results based on one model does not mean the inability of this set of variables to provide accurate prediction when using another model as it is shown in the figure, where the use of the same variables results in higher accuracy by Y2B model when compared to Y2Y model.

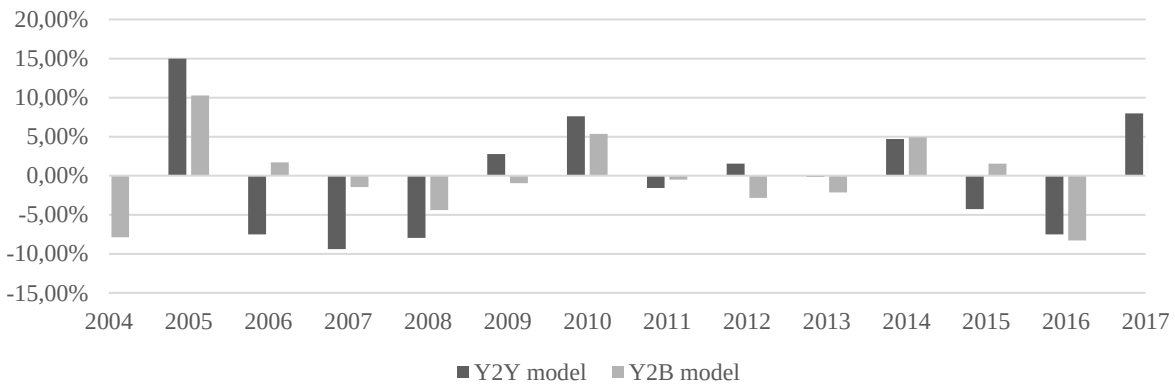

Fig. 1.The comparison of residuals between Y2Y and Y2B models for the United Kingdom (Source: authors' developed)

Furthermore, it is clear that political events might have a significant impact on the value of the dependent variable; therefore, they should be included in calculation models or at least considered if there is political uncertainty.

Conclusions

The literature study implies that the results of previous researches might have been inconsistent because of the narrowed scope of investigations because although most researchers have analysed similar macroeconomic variables, not all of them considered the impact of global trends or did hourly or daily observations on how speculations regarding the change in macroeconomic variables might have impacted the stock returns. This statement suggests that in order to establish an accurate prediction or explanatory model, it is important to apply as many initial variables as possible to refine the most significant ones and not just rely on several indicators that might prove to provide inconsistent or incorrect results. The studies were also limited to only few calculation models. It is worth to note that authors such as Gilbert (2011) have used somehow nonstandard methods of investigating the impact of economic publications as well as their revisions rather than only the factual variations in macroeconomic variables; Bali et al. (2014) examined the uncertainty effect; and Larsson and Haq (2016) also considered the impact of political regime.

The most influential and discussed macroeconomic variables were GDP, GDP per capita, CPI or inflation, PPI, long- and short-term interest rates, exchange rates, world market returns, industrial production, labour income, unemployment, oil prices, consumer consumption and few others. It is also frequently noted that stock returns depend not only on the value of macroeconomic variables at any data point but on their change as well as predictions regarding the change. Furthermore, the importance of global and regional factors on local markets is discussed, which implies that smaller or less-developed markets are dependent on leading economies, but small markets seldom influence the global trends.

The linear regression model agrees with the assumptions made based on the literature study and shows the negative effect of long-term government bonds, labour cost and producer price index, whilst the positive effect is driven by GDP growth, unemployment rate, industrial production and consumer price index.

In the practical part, it was also clearly established that the same set of independent variables cannot be directly applied to different regions because although the chosen Y2B model did provide an accurate relationship between macroeconomic variables and stock indices in the United Kingdom, it failed to provide accurate (usable) results in other regions (Estonia, European Union, France, Germany, Latvia and Lithuania), which fall in line with the claims of Alexakis et al. (2016); they mentioned that Latvia and Lithuania were affected during global crisis and Estonia was mainly affected only by Euro zone crisis, which clearly states that even countries of similar size, population and geographical location still have different economic trends and individual prediction models should be applied in order to get a clear picture of the future stock indices changes.

Although the calculations are based on the past values, the model presumably can be used for future calculations using predictions for macroeconomic variables, which only confirms the need for specific sets of variables for each region because applying incorrect method without acknowledging the consequences of such actions might lead to unfortunate results.

Further studies should focus their attention not only on macroeconomic variables but also on the market efficiency, media authority, differences in dominant political parties, the impact of global and regional macroeconomic and political situation because political and other qualitative factors might have significant effect on the stock returns.

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