

A Tree-Based Approach to Modelling Stock Exchange Index Returns in EU Countries

AB Ülkelerinde Borsa Getirilerinin Modellenmesinde Ağaca Dayalı Yaklaşım

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ABSTRACT

In this paper, we examine the stock exchange index returns for the panel of 27 EU countries in the last ten years. Our method of choice is a special kind of tree-models, namely model-based recursive partitioning (MOB). The MOB algorithm uses the generalized M-fluctuation test to examine the parameter stability for a given node. In this investigation, we attempt to explain the returns of the EU stock exchange indices with the help of gross domestic product, interest rates, and other financial and macroeconomic variables. The model-based recursive partitioning algorithm yields four terminal nodes pointing to GDP growth and rate of inflation as the splitting variables. During different inflation and GDP growth regimes, the observed explanatory variables impact the stock exchange index returns with varying intensity. The results are discussed and interpreted in light of the current economic situation.

Keywords: Model-based recursive partitioning, regression trees, stock returns, financial markets.

ÖZET

Bu çalışmada son yıl içinde 27 AB ülkesi için hisse senedi endeksi getirileri incelenmektedir. Yöntem, ağaç modellerinin özel bir şeklidir, yani yinelemeli bölünmeye dayanan modeldir (MOB). MOB algoritması, verilen düğüm için parametre istikrarını incelemek için genellenmiş M-dalgalanma testini kullanır. Bu çalışmada AB hisse senetlerinin endekslerinin getirileri; gayri safi yurt içi hasıla, faiz oranları ve diğer finansal ve makro ekonomik değişkenler yardımıyla incelenmeye çalışılmaktadır. Yinelemeli bölünmeye dayanan model algoritması, üleştirilen değişkenler olarak gayri safi yurt içi hasıla büyümesine ve enflasyon oranına işaret eden dört uç düğümü verir. Farklı enflasyon ve gayrisafi yurt içi hasıla düzenleri sırasında, gözlenen açıklayıcı değişkenler, hisse senedi endeksi getirilerini değişen yoğunluk ile etkiler. Sonuçlar, mevcut ekonomik durum ışığında yorumlanıp tartışılmaktadır.

Anahtar Kelimeler: Yinelemeli bölünmeye dayanan model, regresyon ağaçları, hisse senedi getirileri, finansal piyasalar

1. INTRODUCTION

There is a great deal of empirical literature on the macroeconomic factors influencing stock market indices. Several empirical analyses of stock market integrations revealed that the main economic variables such as real GDP, trade balances, exchange rates, interest rates, consumer price index, public debt and unemployment are significant in their relation to the indices of the stock market. Baele et al. (2004) investigated comovements between the stock markets in the new EU member states in the period from 2000 to 2007 and found empirical evidence that the stock markets of entrant countries in the EU area were more exposed to adverse comovements, volatility, and persistence after their accession. This result suggests that the flip side of financial-market integration is stronger cross-country shock propagation.

Drawing upon the methods used by the authors who have dealt with the relation of stock market indices, we analyzed the impact of several financial

and macroeconomic variables on the returns of stock market indices in the EU-27. In our empirical study, we used a special kind of tree-models, namely model-based recursive partitioning (MOB).

The paper is organized as follows. In chapter 2, we present the empirical literature on macro-economic and financial factors influencing the stock market indices. Chapter 3 describes the model-based recursive partitioning algorithm. Data specifications and empirical results can be found in chapter 4 and discussion in chapter 5. The implications of the empirical analysis are revisited in the conclusion.

2. OVERVIEW OF THE EMPIRICAL LITERATURE ON MACRO-ECONOMIC AND FINANCIAL FACTORS INFLUENCING STOCK MARKET INDICES

Baltzer et al. (2008) found that financial markets in the new member states are significantly less integrated than the EU financial markets and that they are more susceptible to euro market shocks after

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EU accession. Nevertheless, there is strong evidence that the process of integration is well under way and has accelerated since accession to the EU. Horská (2005) claims that the correlation between the US and European stock markets has increased over time, leaving less room for portfolio diversification. Another finding regards the macroeconomic consequences of stock-price development, undermined by the assumption of the positive wealth effect of rising stocks. In relation to GDP growth regimes, the prediction power of the stock index has proven itself rather limited.

Financial integration is positively associated with real per capita GDP, educational level, banking sector development, monetary growth, credit growth, stock market development, the legislation of the country and government integrity (Horská 2005, Aizenman and Noy 2005). GDP growth presumes a rise of the industrial production index, employment growth, lower public debt and public deficit lowering, and the rise of trade. Industrial production affects stock returns positively, primarily through increasing the expected cash flow. The strongest feedback between FDI and manufacturing trade is based on the argument that larger inflows of FDI will lead to a higher volume of trade as well as other benefits such as increased rates of total factor productivity growth or higher output growth rates (Černý and Koblas 2008).

Country-specific factors (besides global factors such as information technology, financial innovation, greater trade interdependence and convergence of inflation rates to a low level) also played an important role in the degree of comovement among international financial markets. Those factors may be: exchange rate risk, market size, differences in economic policies and financial market regulations, as well as different transaction and information costs (Berben and Jansen 2005).

Horobet and Ilie (2007) pointed out that the theoretical links between exchange rates and stock prices are microeconomic and may be observed in both the short- and long-run. The exchange rate as an important explanatory variable has a significant negative impact on stock exchange indices. For interest rates the implications are similar. A reduction in interest rates reduces the costs of borrowing, which has a positive effect on the future expected returns for the firm (Berben and Jansen 2005, Pan et al. 2007). Also, an increase in interest rates would make stock transactions more costly. Investors would require a higher rate of return before investing. This will redu-

ce demand and lead to a price depreciation (Horobet and Ilie 2007, Knif et al. 2008, Poghossian 2008).

There is no consensus in theories and empirical evidence about the influence of inflation on stock exchange. The impact of inflation on stock exchange index volatility can be negative or positive depending on the current economic situation (Fisher 1930, Fama 1981, Baele et al. 2004). Fisher hypothesis about positive correlation between inflation and stock exchange volatility could be explained with the fact that the market rate of interest comprises the expected real rate of interest and expected inflation. This hypothesis, when applied to stock markets, postulates a positive one-to-one relation between stock returns and inflation (Knif et al. 2008, Mohammad and Abdelhak 2009).

3. MODEL-BASED RECURSIVE PARTITIONING

Our method of choice is a special kind of tree-models, namely model-based recursive partitioning (MOB) developed by Zeileis, Hothorn and Hornik (2008). The authors carry further the integration of parametric models into trees by providing a framework that embeds recursive partitioning into statistical model selection. After fitting a segmented parametric model, a tree is obtained for which every terminal node (leaf) is associated with its own model, often a linear regression. Our notation and description of this methodological approach is based on the paper by Zeileis, Hothorn and Hornik (2008).

We start with a parametric model $M(Y, \theta)$ and n observations (vectors) Y_1, Y_2, \dots, Y_n . The estimate of the k -dimensional parameter vector θ can be obtained by minimizing some objective function $\Psi(Y, \theta)$, i.e.

$$\hat{\theta} = \arg \min_{\theta \in \Theta} \sum_{i=1}^n \Psi(Y_i, \theta). \quad (1)$$

M-type estimators can be implemented in this way, including OLS and maximum likelihood. The idea behind the MOB approach is that while it is often not reasonable to assume the existence of a model that fits well on all observations, one may partition the data with respect to one or more variables to obtain locally well-fitting models. For l partitioning variables $Z_j \in Z_j, j = 1, 2, \dots, l$, we assume the existence of the partition

$$\{\mathbf{B}_b\}_{b=1, \dots, B} \quad (2)$$

of the space $Z = Z_1 \times Z_2 \times \dots \times Z_l$ consisting of B cells (segments) with the property that in each cell \mathbf{B}_b a local model $M(Y, \theta_b)$ holds. The segmented model is denoted by $M_B(Y, \{\theta_b\})$. Clas-

sification and regression trees are special cases of segmented models.

In case of several ($l > 1$) splitting variables, determining the optimal partition is complicated as the number of all possible partitions becomes too large for an exhaustive search. The authors therefore suggest a greedy forward search (where the objective function can be optimized locally in each step) to find a partition that is close to the optimal one. A single parametric model is assigned to each node.

The MOB algorithm uses the generalized M-fluctuation test to examine the parameter stability for a given node. The suggested algorithm is carried out in four steps: (i) the model is fitted to all observations in the current node by minimizing the objective function, (ii) the test for parameter instability is performed, (iii) in case of an existent parameter instability, the variable associated with the highest instability is chosen, (iv) the current node is split into daughter nodes and the procedure is repeated.

When mild regularity conditions hold, the estimate of the parameter vector θ can be obtained by solving first order conditions

$$\sum_{i=1}^n \psi(Y_i, \hat{\theta}) = 0, \quad (3)$$

where

$$\psi(Y, \theta) = \frac{\partial \Psi(Y, \theta)}{\partial \theta} \quad (4)$$

stands for the score function. For many interesting models one can use well-known algorithms for computing the estimate of θ , i.e. OLS estimation with QR decomposition in case of linear regression.

The next question to answer is whether the parameters of the fitted model are stable over the ordering implied by the partitioning variables or whether one could improve the fit by splitting the sample according to one of the variables Z_j . Parameter instability can be tested by checking if the scores $\hat{\psi}_i$ fluctuate randomly around their mean (which is 0) or if there are any systematic deviations from 0 over Z_j . For this purpose, we evaluate the empirical fluctuation process

$$W_j(t) = \hat{J}^{-\frac{1}{2}} n^{-\frac{1}{2}} \sum_{i=1}^{\lfloor nt \rfloor} \hat{\psi}_{\sigma(Z_j)}, \quad 0 \leq t \leq 1, \quad (5)$$

where \hat{J} is an estimate of the covariance matrix $\text{COV}(\psi(Y, \hat{\theta}))$, for example, $\hat{J} = \frac{1}{n} \sum_{i=1}^n \psi(Y_i, \hat{\theta}) \psi(Y_i, \hat{\theta})^T$, but one can also use HC (heteroskedasticity consistent)

or HAC (heteroskedasticity and autocorrelation consistent) estimators. $\sigma(Z_j)$ stands for the ordering permutation returning the antirank of observation Z_j in the vector $Z_j = (Z_{1j}, \dots, Z_{nj})^T$. $W_j(t)$ is therefore the partial sum process of the scores ordered by the variable Z_j and scaled by n (number of observations) and \hat{J} . According to the functional central limit theorem (Zeileis and Hornik 2007), this empirical fluctuation process converges to a Brownian bridge W^0 under the null hypothesis of parameter stability. One can derive a test statistic by computing $\lambda(W_j(\cdot))$, where λ is a scalar functional capturing the fluctuation of the empirical process. The corresponding limiting process is $\lambda(W^0(\cdot))$. This general framework for testing parameter instability was developed by Zeileis and Hornik (2007) and is called generalized M-fluctuation test.

For assessing a numerical variable Z_j , the instabilities can be captured with the help of the functional

$$\lambda_{\text{sup } M}(W_j) = \max_{i=\underline{i}, \dots, \bar{i}} \left(\frac{i}{n} \cdot \frac{n-i}{n} \right)^{-1} \left\| W_j \left(\frac{i}{n} \right) \right\|_2^2 \quad (6)$$

defined as the maximum of the squared L2 norm of the empirical fluctuation process scaled by its variance function. In this way we obtain the well-known supLM statistics of Andrews (1993) that represents the supremum of LM statistics against the alternative of a single change point which is shifted over the interval $[\underline{i}, \bar{i}]$. This interval is usually defined with some minimal segment size \underline{i} where $\bar{i} = n - \underline{i}$.

4. EMPIRICAL ANALYSIS

To arrive at appropriate specifications in the spirit of the theoretical suggestions we had to investigate the time series properties of the data. The following variables were employed in our empirical analysis as possible predictors for the returns of the EU-27 stock exchange indices (R): rate of inflation (INFL; expressed in %), gross domestic product (GDP; expressed in millions of EURO for the reference year of 2000), money market interest rate (IR; expressed in %), public debt (DEBT; expressed as % of GDP), unemployment rate (U, expressed in %) and real effective exchange rate (REER; expressed as index with CPI deflator and base year of 1999). Variable names are given in brackets. Quarterly data for the period from the fourth quarter of 2000 till the second quarter of 2010 were obtained from Eurostat, Yahoo Finance database, national central banks and SourceOECD database. Unfortunately, we were not able to obtain the data on monetary aggregates for all EU-27 countries. Plots of quarterly data on annual stock exchange index returns (denoted by R) are shown in Figure 1.

In a preliminary analysis, unit root tests were applied to all variables and three variables (GDP, public debt and real effective exchange rate) turned out to be I(1). Therefore, annual growth rate variables expressed as % changes were employed in our study and the suffix _GRW was added to variable names.

Next, we performed the model-based recursive partitioning algorithm. MOB yielded four terminal nodes (leaves) pointing to GDP growth and rate of inflation as the splitting variables. During different inflation and GDP growth regimes, the observed explanatory variables thus impact the stock exchange index returns with varying intensity. The models in the four terminal nodes are as follows:

- model 1 is determined by low inflation, i.e. annual rate of inflation less or equal to 1.36 %;
- model 2 is a high inflation model with annual rate of inflation over 4.44 %;
- model 3 is determined by a medium annual rate of inflation (between 1.36 % and 4.44 %) and by annual GDP growth less or equal to 3.29 %;
- model 4 comprises medium inflation (between 1.36 % and 4.44 %) and annual GDP growth above 3.29 %.

The given intervals for rate of inflation and GDP growth rate were determined by the MOB algorithm (i.e. with the test for parameter instability). Results are shown in Table 1 below.

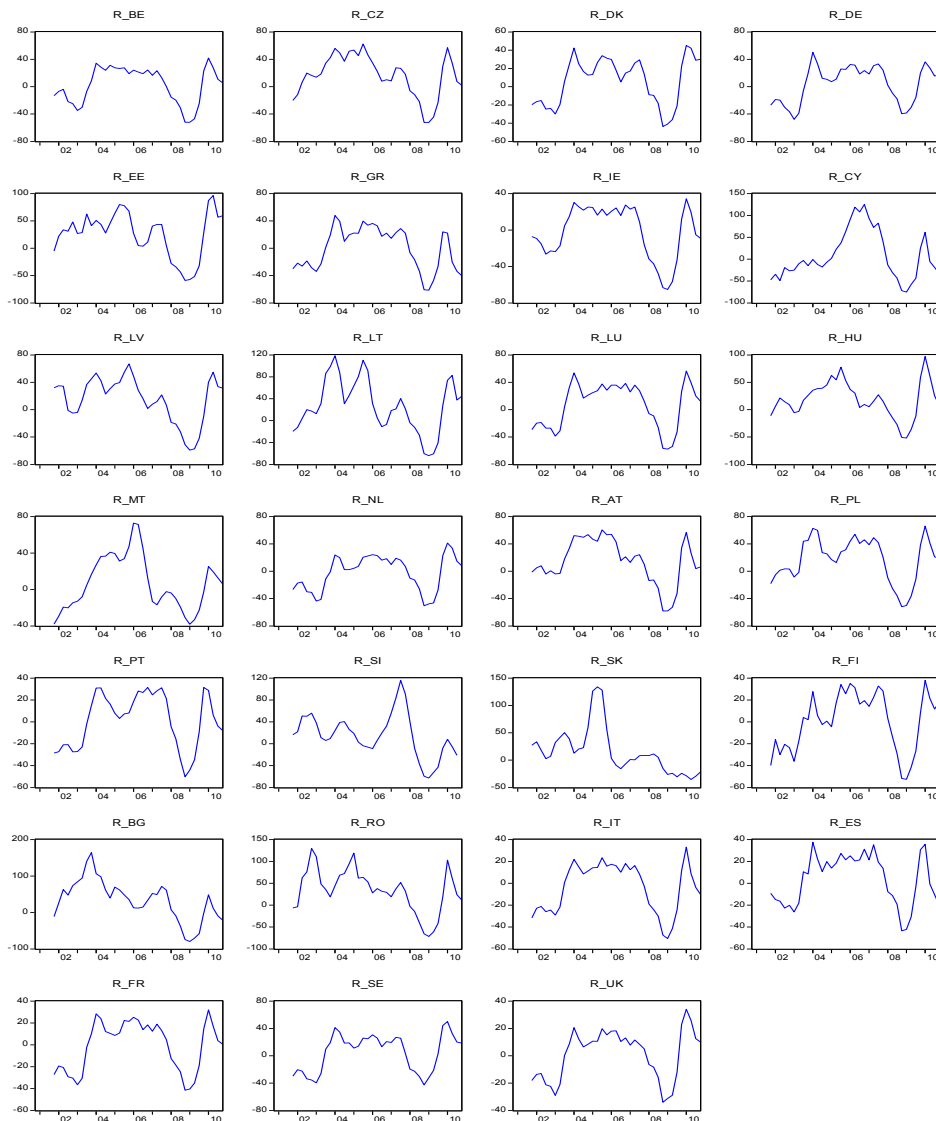


Figure 1: Stock Exchange Index Returns for EU-27 Countries

5. RESULTS AND DISCUSSION

Our analysis revealed a significant influence of the chosen explanatory variables on the stock exchange indices of the EU-27 countries. We can confirm the positive influence of GDP and unemployment. Interest rate and government debt, on the other hand, have a negative impact on stock exchange index returns. Similar results were obtained by Maysami et al. (2004) and Lin (2009).

Low inflation has a positive impact on the stock exchange index returns, while the influence of high inflation is significant only at the 10 % level. Medium level inflation (at the growth rate of GDP higher than 3.29 %) negatively influences stock index returns. As already mentioned, there is no consensus in theories and empirical evidence about the influence of inflation on stock exchange. The impact can be either negative or positive, depending on the current economic situation (Fisher 1930, Fama 1981, Baele et al. 2004).

Table 1: Model-Based Recursive Partitioning Results

Model 1: INFL ≤ 1.36 % 193 observations				
Variable	Estimate	Std. Error	t-value	p-value
INFL	5.4228	2.5037	2.1659	0.0318
IR	-5.0522	1.3665	-3.6971	0.0003
GDP_GRW	3.8646	0.6188	6.2450	0.0000
DEBT_GRW	-0.0086	0.1381	-0.0621	0.9506
U	7.7675	1.4163	5.4842	0.0000
REER_GRW	1.3311	0.6023	2.2100	0.0285
R ²	0.4746	F-statistic (p-value)		0.0000
Model 2: INFL > 4.44 % 174 observations				
Variable	Estimate	Std. Error	t-value	p-value
INFL	2.1104	1.2719	1.6593	0.0992
IR	-1.9686	1.1761	-1.6738	0.0963
GDP_GRW	5.4848	0.9243	5.9342	0.0000
DEBT_GRW	0.1327	0.2326	0.5706	0.5691
U	7.0258	1.1360	6.1845	0.0000
REER_GRW	0.7748	0.5353	1.4473	0.1499
R ²	0.4095	F-statistic (p-value)		0.0000
Model 3: 1.36 % < INFL ≤ 4.44 % and GDP_GRW ≤ 3.29 % 346 observations				
Variable	Estimate	Std. Error	t-value	p-value
INFL	-0.6076	1.6628	-0.3654	0.7150
IR	-9.1899	0.9402	-9.7749	0.0000
GDP_GRW	6.1664	0.5683	10.8501	0.0000
DEBT_GRW	0.0391	0.1575	0.2483	0.8040
U	4.4274	0.7594	5.8299	0.0000
REER_GRW	0.9897	0.3353	2.9517	0.0034
R ²	0.5227	F-statistic (p-value)		0.0000
Model 4: 1.36 % < INFL ≤ 4.44 % and GDP_GRW > 3.29 % 232 observations				
Variable	Estimate	Std. Error	t-value	p-value
INFL	-6.5318	2.9017	-2.2511	0.0255
IR	-10.1392	2.4186	-4.1921	0.0000
GDP_GRW	-1.4594	1.6655	-0.8763	0.3819
DEBT_GRW	-0.6595	0.3277	-2.0124	0.0455
U	1.3293	1.0907	1.2188	0.2243
REER_GRW	-1.2135	0.6356	-1.9092	0.0577
R ²	0.1699	F-statistic (p-value)		0.0000

The strong GDP growth in the EU-27 countries, especially in the period from 2004 to 2008 (together with a growth in capital inflow, trade balances and industrial production), significantly influenced the stock exchange dynamics (Adam and Tweneboah 2009, Babetskii et al. 2007). According to our empirical analysis, the impact of GDP growth on stock returns is positive, except in the case of high GDP growth and medium inflation rate, where the influence is not significant. The strongest impact of GDP is seen in the regime of medium inflation rate. The majority of studies have confirmed that the dynamics of stock exchange index returns are procyclical with respect to economic growth. Periods of economic growth and strong demand for a country's exports have a positive effect on the domestic, corporate and household sectors and on stock exchange index returns (Borio et al. 2001).

Unemployment has a positive impact on stock exchange index returns, with the exception of the medium inflation and high GDP growth regime where the influence is insignificant. Our results are partially in line with Boyd et al. (2001) who argue that on average an announcement of rising unemployment is good news for stocks during economic expansions and bad news during economic contractions. Therefore, most of the time stock prices increase on news of rising unemployment. Boyd et al. (2001) also provide an explanation for this phenomenon involving two types of information relevant for valuing stock returns that is incorporated into unemployment rate, namely information about future interest rates and about future corporate earnings and dividends. An increase in unemployment typically signals a decline in interest rates, which is positive for stock returns, as well as a decline in future corporate earnings and dividends, which has a negative connotation.

Interest rate has always a negative impact on stock exchange index returns, with marginal significance in the regime of high inflation and the strongest influence in the regime of medium inflation rate. Negative interest rates impact is in line with the theory that stock market returns are usually negatively correlated to interest rates. A rather high interest rate is typical for some New EU Member States due to insufficient national accumulation and credit supply potential (Baltzer et al. 2008). European financial markets (see: Erdogan 2009) have faced crucial structural and institutional adjustments, with the aim of accelerating financial integration in the money, credit, bond, and equity markets. These processes are also pushing the whole EU-27 region

towards further international financial integration increasing the impact of interest rate dynamics on stock exchange index returns.

Public debt growth has a significant negative impact in the regime of medium inflation rate and GDP growth higher than 3.29 %. Similar results were obtained by Presbitero (2010) and Muradoglu (2009). The accession of the candidate countries to the EU required the implementation of reforms that lead to further economic expansion. Implementing reforms that includes cutting government spending is a condition in the Lisbon Treaty. Probably the most important factors driving the acceleration of financial integration are related to the policy measures undertaken by the "new" and "marginal" member states in order to meet European financial standards, including the liberalization of capital accounts, as well as legal and institutional reforms (Christiansen and Rinaldo 2008, Poghossian 2008). The government debt provides us with clear evidence that reforms affecting budgetary discipline do not end after EU-27 integration.

Our results also confirmed the exchange rate as an important explanatory variable that has a significant impact on stock exchange indices. In the case of low inflation rate, the real exchange rate has a positive impact on stock exchange index returns, whereas the impact in the regime of medium inflation rate and high GDP growth is negative. The evidence of negative exchange rate impact was documented also by other authors (see: Berben and Jansen 2005, Horobet and Ilie 2007, Knif et al. 2008). However, the depreciation of exchange rates has adverse effects on exporters and importers. The difference in results depends on GDP structure and majority export or import economies. Exporters have an advantage over other countries' exporters and increase their sales and their stock prices go higher (see: Baele et al. 2004, Horobet and Ilie 2007, Stavarek 2010). While the EU-27 comprises importers and exporters, the depreciation of exchange rates can have a negative or a positive impact on the stock exchange returns. The evidence of a strong relationship between stock prices and exchange rates in the case of the EU-27 can also be explained by the fact that several economies partly depend on capital inflows and FDI. Some of them faced the high inflation rate, but the national currency value remained stable. The international competitiveness of several EU-27 economies has been boosted by productivity gains and real exchange rate appreciation (Onay 2007).

6. CONCLUSION

Our analysis confirmed that the financial system of the EU-27 countries is cyclically related to some macro economic variables. The strength of the relation depends on different GDP growth and inflation rate regimes. Andersen et al. (2004) argue that the equity markets react differently to the same news depending on the state of the economy, with bad news having a positive impact during expansions and the traditionally-expected negative impact during recessions.

Low inflation has a positive impact on the stock exchange index returns, while the impact of high inflation is not significant. There is a negative influence of medium level inflation at the growth rate of

GDP higher than 3.29 % on stock exchange index returns. Interest rate has always a negative impact on the stock exchange index returns, with marginal significance in the regime of high inflation and the strongest influence in the regime of medium inflation rate. The impact of GDP is positive, except in the case of high GDP growth regime and medium inflation rate – but the coefficient is not significant. Public debt growth has significant negative impact in the regime of medium inflation rate and GDP growth higher than 3.29 %. Unemployment has a positive effect on stock exchange index returns. In the case of low inflation rate, the real exchange rate has a positive impact on stock exchange index returns. In other inflation and GDP growth regimes, the impact is negative.

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