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GRANGER CAUSALITY BETWEEN STOCK MARKET AND MACROECONOMIC INDICATORS: EVIDENCE FROM GERMANY

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Abstract

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The aim of this paper is to investigate informational efficiency of the stock market in Germany. Granger causality between the stock market and the selected macroeconomic variables is investigated by bivariate analysis using Toda-Yamamoto (1995) approach. This study focuses on monthly data from January 1999 to September 2015, and the stock market is represented by blue chip stock market index DAX. Investigated macroeconomic indicators include industrial production, inflation, money supply, interest rate, trade balance and exchange rate. Stock market Granger-causes industrial production and interest rate, and is therefore leading indicator of these variables. Between money supply and stock prices is Granger causality in both directions. Other variables seem to be independent on development of the stock market. We do not find any violation of Efficient market hypothesis which indicates that the stock market in Germany is informational efficient.

Keywords: Granger causality, Efficient market hypothesis, DAX, stock market, macroeconomic indicators, Germany

INTRODUCTION

One of the main characteristic of the capitalistic economy is business cycle. A lot of researches have been conducted about this topic trying to understand its nature. We are able to predict business cycle to some extend using leading economic indicators which tend to rise and fall in advance of the rest of the economy. On the other hand, stock market is assumed to be forward-looking predictor of future profitability. It is often considered as leading indicator and can be used for predicting economy. But stock prices remain unpredictable, according to Efficient market hypothesis (EMH).

Efficient market hypothesis means that stock prices already contain all available information and we can distinguish among weak, semi-strong and strong EMH. These three versions have different meaning of the phrase “all available information”. Weak form of the EMH takes into account only common publicly available information about market, past prices, trading volume, etc. The semi-strong form of the EMH adds some fundamental data about company, such as information about product, management, balance sheet, etc. The last form of the EMH called strong contains all the data already mentioned plus information available only to insiders (Bodie *et al.* 2011).

When we study causal relations between stock prices and macroeconomic indicators, it tells us a lot about informational efficiency of the given market. We usually address only the weak EMH. We can dismiss hypothesis about the weak EMH if we are able to find one-directional Granger causality stemming from macroeconomic variables to stock prices. In this case, stock market participants would be able to adopt trading strategy that gives them more than average returns over long term period. In other words, it means that in current stock prices are not fully reflected all relevant information contained in given macroeconomic indicator.

If we find that stock market performance can be used for predicting macroeconomic variables or presence of bi-directional Granger causality, it is the sign that market is efficient. In case of independent time series no relationship should be observed and this behavior does not disrupt market efficiency. It just means that selected macroeconomic variable does not contain any useful information about stock market.

But we expect to observe the stock market returns as a leading indicator of the most macroeconomic variables. According to Ikoku (2010) there exist at least four theoretical approaches supporting hypothesis that stock market is the leading indicator of economic activity: stock prices are aggregators of expectations, there are the cost of raising equity capital and also the effect of the financial accelerator and the wealth effect.

Stock prices are often explained by dividend discount model. This valuation method is based on theory that stock is worth the sum of all of its future dividend payments, discounted back to their present value. Investor is therefore considered as forward looking person. If stock prices depend on expected dividends and dividends depend on the profitability of firms, then stock prices should contain investor's expectations about future economic performance.

The second theoretical reason is based on a simple assumption that rising equity prices lowering cost of equity for firms. This process reduces the weighted average cost of capital and lead to more optimal capital structure of the company, increase of investments, etc., resulting in increased future economic activity.

The financial accelerator is another theory suggesting stock market to be leading indicator of economic activity. The principle of this effect is very simple. Households and firms hold in their balance sheet some financial assets for example stocks. If stock prices are rising, it also improves creditworthiness of these subjects. As a result, they can borrow and spend more which increases future economic activity. This process can theoretically work in both directions (Bernanke *et al.* 1996).

The last mentioned theory is the wealth effect. The wealth effect is the change in spending that accompanies a change in perceived wealth and is usually positive. It is important to point out that in case of stock market the wealth effect depends strongly on stock ownership in a country. Generally, in Europe stock ownership rates are lower than in U.S. and thus wealth effect is also lower in European countries (Paiella 2007).

The empirical evidence is not always that clear as the theory. The relationship between various macroeconomic indicators and stock market performance has been examined in many studies. Most of these studies focused on developed markets, especially on the United States. Stock market as a leading indicator of real economic activity was confirmed in studies from Fama (1981, 1990), Campbell (1989), Lee (1992), Comincioli (1996), Otoo (1999), Foresti (2007) and many others. On the other hand, Binswanger (2000) claimed that stocks are not leading indicator of economic activity in U.S. since the stock market boom in early 1980s.

For other developed countries considerably fewer studies are available with more inconsistent results, e.g. Pearce (1983), Thorton (1993), Choi *et al.* (1999), Aylward and Glen (2000) or Stock and Watson (2003). Confirmation of stock market as leading indicator is more frequent in these studies, but it is not strictly dominant opinion for all developed countries.

Mookerjee (1987), Pearce and Roley (1983) and Taamouti (2015) examined relationship between stock market returns and money supply. They found M1 and M2 variables to be significant indicators of stock market returns. Thorton (1993) studied situation in UK and found money supply to be lagging behind stock market performance, and Serletis (1993) investigated money supply in U.S. and supported efficient market hypothesis. Also exchange rate or value of trade balance can have an impact on stock prices, e.g. Bahmani-Oskooee and Sohrabian (1992) or Morley and Pentecost (2000).

Noteworthy is study by Habibullah *et al.* (2000) which examined relationship between interest rate, price level, national income, money supply and real effective exchange rate applying Toda-Yamamoto long-run Granger causality test. According to their results interest rate and money supply lead stock prices and stock prices leads the rest of the variables.

The main goal of this study is to answer the question how stock market reflects economic conditions in Germany. Generally, stock market performance should be leading indicator of real economy and this relationship also helps us to determine the informational efficiency of the market. This is very important information for macroeconomic policy makers. To achieve this, we use Toda-Yamamoto (1995) methodology for testing Granger causality on monthly data from January 1999 to September 2015.

We are searching for two the most important outcomes of this study. When we prove that stock market is leading indicator of given macroeconomic variable then the Efficient market hypothesis is not violated. We are able to predict development of this macroeconomic variable using information from stock market. This can help to policy makers to improve implementation of their macroeconomic policy.

The second outcome is the exact opposite situation. Stock market is lagging behind given indicator and this indicator can be used for predicting future stock prices. In this case the Efficient market hypothesis is violated. This means that financial resources are not allocated effectively and utility is not maximized. The third situation is also possible when no causal relation is found or there is causality in both directions.

MATERIALS AND METHODS

This study follows the Toda and Yamamoto (1995) procedure to test for Granger causality and applies analysis on monthly data from January 1999 to September 2015. We examine bivariate relationship between stock market returns in Germany and the selected macroeconomic indicators such as industrial production, inflation, money supply, interest rate, trade balance and exchange rate.

Stock market prices in Germany are measured by blue chip stock market index DAX consisting of the 30 major German companies trading on the Frankfurt Stock Exchange. This index includes for example companies such as Siemens, BMW, Adidas or Allianz. It is a total return index and the equities use free float shares in the index calculation.

In the following Tab. I are listed all investigated variables. First column shows variable name and second column abbreviations for particular variable used in this study. There are also units of all variables and source of the data. Subsequent analysis uses natural logarithms of the data except the variable representing interest rate.

The most common measure of the output of the economy is gross domestic product (GDP). This variable contains total production of goods and services in given economy. In general term, it is easier for the company to increase its sales when GDP is growing, which is also good for the price of its stocks. One of the popular alternatives is industrial production which is more narrowly focused on the manufacturing side of the economy. Industrial production measures the output of industrial establishments in the mining and quarrying industry, manufacturing and public utilities. Production is based on the volume of the output. This variable is used as alternative instead of real GDP, because real GDP is not reported monthly.

The rest of the indicators are related to monetary sector. As an indicator of inflation we choose the index of consumer prices. Inflation is the rate at which the level of prices rises. Many countries believe that stable low positive inflation is the best for the economic health and it is often very important part of the macroeconomic policy.

Next variable is money supply represented by M1. It is the most liquid components of the money supply, as it contains cash and assets that can quickly be converted to currency. Money supply is often considered as leading indicator, because monetary policy can be implemented and observed pretty quickly, but its effect can take several months to become visible.

Interest rates are key determinants of business investment expenditures. When they are low, it is more attractive to invest and borrow money. Variable contains data about 10-year government bond yields. This indicator has been selected because of availability of the data for the whole observed period, and it is good approximation of the development of the interest rate in economy.

The last two variables are trade balance and exchange rate. Trade balance measures the difference between the exports and imports. Exchange rate is an obvious factor that affects the international competitiveness of a country. This variable represents an effective exchange rate which is a weighted average of the individual exchange rates of a particular country with its main trading partners. The bilateral exchange rates are weighted according to the importance of each partner

I: *Variables description*

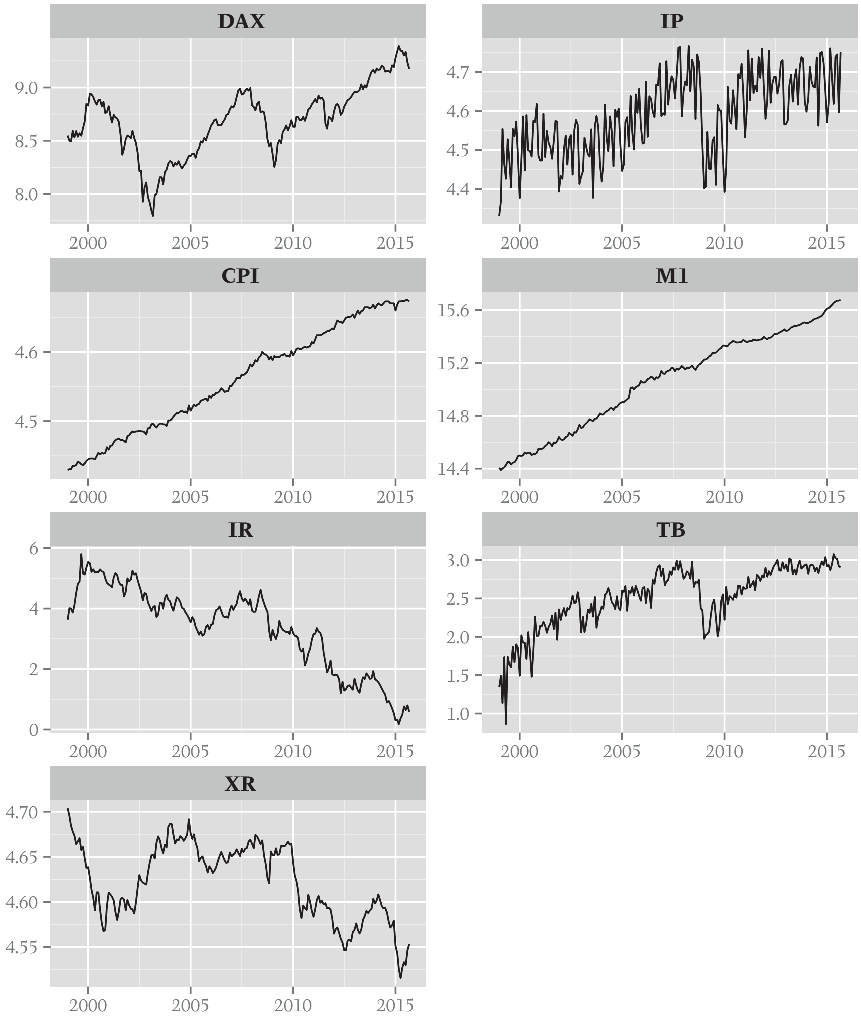
Variable	Label	Units	Source
DAX	DAX	Index	Bloomberg
Industrial Production	IP	Index	German Federal Statistical Office
Consumer Price Index	CPI	Index	German Federal Statistical Office
Money Supply	M1	Millions EUR	European Central Bank
Interest Rate	IR	Percentage	Bloomberg
Trade Balance	TB	Billions EUR	Deutsche Bundesbank
Exchange Rate	XR	Index	Bank for International Settlements

Source: www.bloomberg.com; www.destatis.de; www.ecb.europa.eu; www.bundesbank.de; www.bis.org

II: *Descriptive statistics*

Statistic	DAX	IP	CPI	M1	IR	TB	XR
Number of observations	201	201	201	201	201	201	201
Mean	8.690	4.587	4.560	15.065	3.358	2.505	4.622
Standard deviation	0.324	0.101	0.076	0.369	1.375	0.406	0.042
Minimum	7.793	4.331	4.430	14.390	0.180	0.863	4.515
Median	8.714	4.586	4.562	15.140	3.715	2.586	4.627
Maximum	9.390	4.766	4.675	15.676	5.800	3.077	4.704

Source: Based on author's data processing



1: *The data in levels*
Source: Based on author's data processing

country's share of trade with the reporting country. The real effective exchange rate is adjusted for inflation.

Tab. II provides descriptive statistics of the comprised dataset and Fig. 1 shows the graphs of the data in levels. A visual inspection suggests that the variables in levels do not have constant mean. We can see that most of these variables show strong trend and probably are not stationary. In case of DAX, industrial production, CPI, money supply and trade balance there is present increasing trend. Conversely, interest rate and exchange rate show downward trend.

The first step in our analysis is to examine the time series properties of the data and find their order of integration. We have already checked the plots of each variable to show nature of the data. Then we use formal tests for presence of the unit root to determine the order of integration. The presence of unit root indicates that the data series is non-stationary. The most popular and widely used test for the unit root is Augmented Dickey–Fuller test (Dickey and Fuller 1979, Dickey and Fuller 1981). One of the alternatives is the Kwiatkowski-Phillips-Schmidt-Shin test also known simply as KPSS test (Kwiatkowski *et al.* 1992).

Then we have to create bivariate VAR models for data in levels and determine appropriate lag length p. For this purpose we base our choice of the lag on the Akaike information criterion (AIC):

$$AIC = 2k - 2ln(L)$$

Where L is the maximum value of the likelihood function for the model and k is the number of estimated parameters in model. The preferred model is the one with the minimum AIC value. Next step is to test presence of autocorrelation in our VAR models to make sure they are well specified. If we find autocorrelation, we try to increase lag length to deal with this problem.

For time series with the same order of integration, we can perform cointegration test. We use Johansen's methodology based on our previous VAR models to see possible presence of cointegration. This step provides us a possible cross-check on the validity of our results after Granger causality is examined. Because if two time series are cointegrated, then there must exist Granger causality between them in any direction or in both directions. But Granger causality can exists even between two not cointegrated time series.

Next step is to apply Toda-Yamamoto (1995) approach for testing Granger causality. This requires creating bivariate VAR models for data in levels with lag length $p+m$. Where p is number of lags found in previous analysis according to AIC, and m represents maximal order of integration of variables in the process.

$$Y_t = a_0 + \sum_{i=1}^{p+m} a_i Y_{t-i} + \sum_{i=1}^{p+m} b_i X_{t-i} + u_t$$

$$X_t = c_0 + \sum_{i=1}^{p+m} c_i X_{t-i} + \sum_{i=1}^{p+m} d_i Y_{t-i} + v_t$$

Then we can test Granger causality using Wald test for linear restriction but only for the first p lagged values. We test null hypothesis that X does not Granger-cause Y:

$$H_0 : \sum_{i=1}^{p} b_i = 0; H_1 : \sum_{i=1}^{p} b_i \neq 0$$

And also that Y does not Granger-cause X:

$$H_0 : \sum_{i=1}^{p} d_i = 0; H_1 : \sum_{i=1}^{p} d_i \neq 0$$

The Wald test statistics is asymptotically chi-square distributed under the null hypothesis. Rejection of this hypothesis supports the presence of Granger causality.

RESULTS

Unit root tests

For formal verification of our findings about non-stationarity of selected variables the Augmented Dickey-Fuller test and the KPSS test are used. The following Tab. III shows the results of the tests for presence of a unit root in levels and first differences. For every variable is shown test statistic and p-value from both tests. In case of Augmented Dickey-Fuller test the null hypothesis is non-stationarity and exactly the opposite for KPSS test where the null hypothesis states stationarity of the time series.

Obtained results confirm our assumptions. Augmented Dickey-Fuller test shows that all variables are non-stationary and are stationary at first differences on significance level 5 %. KPSS test gives us exactly the same results and confirmed our findings. According to these results, we can confidently state that our data series can be characterized as I(1).

Optimal lag selection

Now we have to estimate the appropriate lag length for the VAR models in levels. All VAR models contain constant. The appropriate lag is selected according to Akaike information criterion (AIC) for every model. Then it is necessary to check if our models are well specified, mainly we have to ensure that there is no serial correlation in the residuals. For this purpose is used Portmanteau test for serial correlation with null hypothesis of no autocorrelation in the residuals. In Tab. IV are results for this test.

III: *Unit root tests*

	Data in levels				Data in first differences			
	ADF test		KPSS test		ADF test		KPSS test	
Variable	**t-statistic**	**p-value**	**t-statistic**	**p-value**	**t-statistic**	**p-value**	**t-statistic**	**p-value**
DAX	–2.336	0.435	2.372	0.010	–4.984	0.010	0.099	0.100
IP	–2.831	0.228	3.186	0.010	–8.411	0.010	0.025	0.100
CPI	–1.819	0.652	5.121	0.010	–6.975	0.010	0.114	0.100
M1	–1.198	0.905	5.066	0.010	–4.072	0.010	0.129	0.100
IR	–3.277	0.077	4.288	0.010	–7.117	0.010	0.218	0.100
TB	–3.267	0.078	3.396	0.010	–8.029	0.010	0.098	0.100
XR	–1.942	0.600	1.942	0.010	–5.216	0.010	0.089	0.100

Source: Based on author's data processing

IV: *Lag selection and autocorrelation*

VAR model	Lags by AIC	test statistic	p-value
DAX vs. IP	15	49.728	0.064
DAX vs. CPI	13	54.634	0.131
DAX vs. M1	13	41.839	0.565
DAX vs. IR	2	80.686	0.697
DAX vs. TB	2	77.262	0.786
DAX vs. XR	2	102.357	0.141

Source: Based on author's data processing

We cannot reject the null hypothesis in any case. This means that there are no autocorrelation in the residuals and we do not have to adjust lags in our models. We can assume that our VARs are well specified and continue with subsequent analysis. We have also found optimal lag length marked as p for every model in this step.

Johansen's cointegration tests

The unit root tests presented earlier, suggest that all variables are characterized as integrated of order 1. We can therefore analyze cointegration between variables. In Tab. V are results for Johansen test between DAX and all macroeconomic variables. There are values of test statistics for every bivariate model and also appropriate critical values.

According to these results, possible cointegration occurs between DAX and industrial production. In this case, we can reject null hypothesis of no cointegrating vectors (r=0) on significance level 10 % and accept the alternative of one or more cointegrating vectors.

The presence of cointegration between stock market prices and selected macroeconomic variables provide firm evidence that there exists an interactive relation between them. If we discover some sort of this relationship in bivariate analysis, there inevitably exists a causal relationship at least in one direction.

Granger causality

The last step of our analysis is to create VAR models with $p+m$ lags and test Granger causality using Wald test for linear restrictions. Number of lags p we take from Tab. IV and increase it by 1 because all variables are I(1) like we know from Tab. III. Then we use Wald test for the first p lags and determine presence of Granger causality. The results of this analysis are in following Tab. VI.

We can reject the null hypothesis of no Granger causality from DAX to industrial production at the 1 % significance level. Next important relationship is between DAX and money supply. We found Granger causality in both directions at the 10 % significance level. The last case where we can reject the null hypothesis is Granger causality stemming from DAX to interest rate. This relationship is significant at the 1 % significance level. In all other cases we cannot reject the null hypothesis at the 10 % significance level and we are not able to find any evidence of Granger causality.

DISCUSSION

We found that stock index DAX Granger-causes industrial production and interest rates. In case of industrial production this finding was also supported by presence of cointegration. Statistically significant result also appeared between DAX and money supply, but in this case we found granger causality in both directions. Other variables do not exhibit any measurable relationship with stock prices in terms of Granger causality. This means that these time series are independent and the EMH is not violated. We can only say that selected macroeconomic variable probably does not contain any useful information about stock market.

Ikoku (2010) stated four theoretical reasons, why stock market should be leading economic indicator of the real economic activity. Our findings

V: *Johansen's cointegration tests*

	Values of test statistic						Critical values		
	IP	**CPI**	**M1**	**IR**	**TB**	**XR**	**10 %**	**5 %**	**1 %**
r ≤ 1	4.01	6.93	5.33	2.14	1.92	2.24	7.52	9.24	12.97
r = 0	15.05	11.76	11.43	9.38	10.76	11.47	13.75	15.67	20.20

Source: Based on author's data processing

VI: *Results of Granger causality*

Null hypothesis	test statistic	p-value
DAX do not Granger-cause IP	30.646	0.010
IP do not Granger-cause DAX	16.718	0.336
DAX do not Granger-cause CPI	17.106	0.195
CPI do not Granger-cause DAX	7.893	0.850
DAX do not Granger-cause M1	21.876	0.057
M1 do not Granger-cause DAX	20.514	0.083
DAX do not Granger-cause IR	9.388	0.009
IR do not Granger-cause DAX	0.102	0.950
DAX do not Granger-cause TB	2.267	0.322
TB do not Granger-cause DAX	0.446	0.800
DAX do not Granger-cause XR	1.713	0.425
XR do not Granger-cause DAX	2.445	0.295

Source: Based on author's data processing

did not violate this assumption but can support it only in two cases related to industrial production and interest rate. Inflation, money supply, trade balance and exchange rate cannot be predicted by stock market development because seem to be independent.

If we assume that industrial production is the most important variable representing real economic activity, then we can confidently say that the stock market in Germany is leading indicator of real economic activity. By this statement, we can support most of the studies mentioned earlier. Binswanger (2000) claimed that since the boom in early 1980s stock market is not leading indicator of economic activity in United States. In case of Germany this is not true. From January 1999 to September 2015 we found clear Granger causality stemming from stock index DAX to industrial production. The stock market in Germany can still be considered as leading indicator of real economic activity.

Money supply measured by M1 is assumed to be significant indicator of stock market returns by, e.g. Mookerjee (1987), Pearce and Roley (1983) and Taamouti (2015). We can support this statement. Money supply and DAX seem to be related to each other, but we found Granger causality in both directions. That means we cannot predict stock market returns by money supply. All information contained in this indicator is implemented to stock prices very quickly, which supports the EMH.

The weak form of the EMH, which takes into account only common publicly available information about market, past prices, trading volume, etc., has important implications for policy makers. We did not find any violation of the EMH which implies an assumption that the stock market in Germany is effective. According to this result, policy makers should be able to conduct national macroeconomic policies without the risk of influencing stock prices and capital formation process. Moreover, we found that the stock market is a leading indicator of future economic activities which is very helpful for the formulation of the national macroeconomic policy.

Accurate forecasting of the economic growth is also inevitable for implementation of successful monetary policy. Using the forward looking asset prices could help to reveal information before it becomes incorporated into the other macroeconomic variables. However, policy makers need to be careful when trying to influence the economy through changes in macroeconomic variables.

Changes in money supply and interest rate may negatively influence the stock market and harm capital formation which would lead to further slowdown of the economy. Our results suggest tight connection between the stock market and money supply. In case of interest rate, the stock market could be regarded as a leading indicator of the interest rate, because we found one-directional Granger causality stemming from the stock market. One possible explanation of this relationship is that the Deutsche Bundesbank has a good level of credibility. When the Deutsche Bundesbank announces planned changes in the interest rate, investors incorporate this information into their investment decisions before the actual change in the interest rate occurs. But this issue definitely needs to be further investigated in order to verify this assumption.

To sum up our results and fulfillment of goals of this study, we can state that stock market in Germany measured by blue chips stock index DAX is leading indicator of industrial production and interest rate. In relation to the Efficient market hypothesis we did not find any violation of the EMH which implies assumption that the stock market in Germany is effective.

CONCLUSION

This paper tests Granger causality between German stock index DAX and selected macroeconomic indicators using Toda-Yamamoto (1995) approach. Analysis is focused on monthly data from January 1999 to September 2015 and investigates industrial production, inflation, money supply, interest rate, trade balance and exchange rates.

According to Johansen cointegration test, we found cointegration between DAX and industrial production in Germany. Our subsequent analysis validates this relationship and discovers that Granger causality stems from the stock index DAX to industrial production. According to this result, stock market can be considered as leading indicator of economic activity. It confirms our assumption based on theoretical and empirical evidence.

Bi-directional Granger causality emerged between stock market and money supply. This result does not violate efficient market hypothesis and confirms that market is efficient. There is some relationship between money supply and stocks but Granger causality exists in both directions. Money supply contains some important information relevant to stock market but investors are able to absorb it very quickly and reflect it to stock prices.

The last significant relationship with index DAX occurs in case of interest rate. According to our analysis, stock market represented by DAX Granger-causes interest rate. In other words, DAX is leading indicator for development of interest rates.

No macroeconomic indicator in our analysis is leading to stock market in terms of Granger causality. On the other hand, stock market plays the role of leading indicator in relation to industrial production and interest rate. According to our results, we can conclude that stock market in Germany is informational efficient and does not violate the EMH.

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