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Research of the Causalities US Stock Market Returns and G-7 Countries' Stock Market Volatilities from Pre-Crisis to Post-Crisis of 2008

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Abstract

Within the scope of this paper, causalities of the US stock market returns and volatilities on stock market volatilities in Group of 7 (G-7) economies between 2000-2013 have been analysed with Granger causality tests. All volatilities are obtained from conditional variance of returns in stock exchange with GARCH (1,1) model (except Japan stock exchange volatility). Japanese stock exchange volatility is gained with ARCH (1) model because of its coefficients' significances. In our study, we found that the US stock market returns causes stock market volatilities in G-7 countries in the 2000-2013 period. However, stock market volatilities in G-7 countries' economies do not cause the US stock market returns in analysis period.

JEL classification numbers: G15, F37, C32, C58
Keywords: stock market volatilities, G-7 economies, Granger causality test.

1 Introduction

The Group of 7 (G-7) is a group consisting of Canada, France, Germany, Italy, Japan, the United Kingdom, and the USA. The USA has also retained the strongest economy since ending World War II. In recent years, developments in information and communication technologies have contributed to the global development of the world economy and these countries led the world economy.

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Notably after 2003 because of high liquidity, global investors turned towards relatively risky. The liquidity excess lasted with the Global Financial Crisis of 2008 and the crisis affected negatively the macroeconomic parameters of global markets (especially their stock markets).
The main purpose of this study is to reveal causalities between the US stock market returns and G-7 economies' stock market volatilities which are integrated into global markets.
In section 2 we present basic literature related to stock market returns and their volatilities. In section 3 we present and discuss the empirical results of causalities between the US stock market returns and stock market volatilities in G-7 economies. Section 4 we give conclusions.

2 Literature

Mandelbrot (1963) focuses on volatility clustering and suggests that high positive returns tend to be followed by high negative returns, and that low positive returns tend to be followed by low negative returns. After that Black (1976), Engle (1982) and Bollerslev (1986) studies volatility models by using capital markets. French et al. (1987) analyse the relationship between stock market returns and volatilities, and point to a negative relationship in-between. Hamao et al. (1990) evaluate the relationship between stock market volatilities in terms of how economies affect one another, and conclude that the US stock market volatilities affect the market volatilities in UK and Japan. Awartani and Corradi (2005) forecast S&P 500 index, volatility employing the GARCH model and asymmetric GARCH models. Caldara et al. (2012) analyse volatility risk on the basis of asset pricing models.
Bahmani-Oskooee and Sohrabian (1992) examine the relationship cointegration analysis between the effective exchange rate and the S&P 500 index using the Granger causality test and they find a short term relationship between the mentioned variables. Nasseh and Strauss (2000) suggest that the macroeconomic variables in developed European countries and Germany which is deemed the biggest economy in Europe affect the market prices in the countries analysed.
Chaudhuri and Smiles (2004) find that Australian stock market and Tokyo stock exchange are affected by the fluctuations in the US stock market. Bloom (2009) examines external factors of affecting volatilities in financial markets. Zakaria (2012) evaluates the volatility of the stock market and the volatility of macroeconomic variables in his work on the Malaysian Economy. Srinivasan and Kalaivani (2013) find the relationship between India, Malaysia, Hong Kong, Singapore, G. Korea, Taiwan, Japan, China and Indonesian Stock Exchange returns. Also they determine a dynamic interaction between the USA and UK stock exchanges and these Asian markets for the period January 2000 - January 2013.
Lee (2013) studies effects of US stock market volatilities on Asian markets, and finds that the US stock market affects stock market volatilities in Taiwan.

Similarly, Kayral (2016) forecast exchange rate volatilities and examine causalities with Granger causality tests between returns and volatilities. He finds that unidirectional causality is determined from returns to volatilities.
The aim of the research is to determine causalities between the returns of the US stock market which is deemed the strongest economy in global markets and on stock market volatilities in G-7 countries' economies.

3 Empirical Research

The aim of the research is to determine causalities between the returns of the US stock market which is deemed the strongest economy in global markets and on stock market volatilities in G-7 countries' economies.

3.1 Variables

The Global Financial Crisis of 2008 influenced numerous advanced and emerging market economies. Data pertaining to G-7 economies (including USA) before and after the crisis (between 2000-2013) were included in the study. The economies and their stock markets which are included in the study are listed in Table 1.

Table 1: The stock markets

Canada - TORONTO	Germany - DAX	France - SBF
Italy - MILANO	Japan - TOKYO	United Kingdom - FT
USA - S&P		

The stock market volatilities of G-7 economies and stock market returns of the USA as variables are analysed using dynamic models for 2000 -2013 period. All stock market data have been used from the Data Stream database, and the websites of countries' stock markets.

Table 2: Variables and Their Abbreviations

Country - Stock Exchange	**Stock Market Returns Abb.**	**Stock Market Volatilities Abb.**
Canada - TORONTO	SR_{Canada}	SRV_{Canada}
Germany - DAX	$SR_{Germany}$	$SRV_{Germany}$
France - SBF	SR_{France}	SRV_{France}
Italy - MILANO	SR_{Italy}	SRV_{Italy}
Japan - TOKYO	SR_{Japan}	SRV_{Japan}
United Kingdom - FT	SR_{UK}	SRV_{UK}
USA - S&P	SR_{USA}	SRV_{USA}

All variables are shown in Table 2.

3.2 Methodology

Before we put forward the results of the model we have composed, it is preferred to give general information about our methodology. Autoregressive conditional heteroscedasticity (ARCH) process is introduced by Engle (1982) to allow for past conditional variances in the current conditional variance equation is proposed. After that, Bollerslev (1986) reveals generalized autoregressive conditional heteroscedasticity (GARCH) process by using Maximum likelihood estimation. The GARCH model is derived from the path of the output with ARMA (p,q). The model is shown in equations 1, 2 and 3.

$$\varepsilon_t \mid \Psi_{t-1} \sim N(0, h_t) \tag{1}$$

$$h_t = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i h_{t-i} = \alpha_0 + A(L)\varepsilon_t^2 + B(L)h_t \tag{2}$$

$$\varepsilon_t = y_t - x_t' B \tag{3}$$

For the coefficients in the equations, it is necessary to provide the $p \geq 0$, $q > 0$, $\alpha_0 > 0$ $\alpha_i \geq 0$, $i = 1, 2, ..., q$ and $\beta_i \geq 0$ $i = 1, 2, ..., p$ constraints. In the case of p = 0, the model becomes the ARCH (p) process.

Granger causality tests are a test technique for revealing causality in time series. (Granger, 1969, pp. 431) The causality relationship between two variables is calculated from the regression models in the system of equations given below equations 4 and 5.

$$Y_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{i=1}^{n} \beta_i X_{t-i} + u_i \tag{4}$$

$$X_t = \alpha_0 + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \sum_{i=1}^{n} \beta_i X_{t-i} + u_i \tag{5}$$

A time series X is said to Granger-cause Y if it can be shown, usually through a series of t-tests and F-tests on lagged values of X (and with lagged values of Y also included), that those X values provide statistically significant information about future values of Y.

All volatilities are obtained from conditional variance of returns in stock exchange with GARCH (1,1) model (except Japan stock exchange volatility). In the scope of our study, the model (variance equation) representation is included in the equation 6.

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 h_{t-1} \tag{6}$$

If the coefficients $\alpha_0 > 0$, $\alpha_1 \geq 0$, $\beta_1 \geq 0$, $\alpha_1 + \beta_1 < 1$ are satisfied in the model and the coefficients are found to be significant using the maximum likelihood estimation method, then the model may be a good predictor.
Then we obtain volatilities, a number of Granger causalities are set in order to analyse the variables between the stock market volatilities ($SRV_{country}$) of G-7 countries and stock market returns of the USA (SR_{USA}) in accordance with the scope of this study.

3.3 Results

The results of the empirical study which demonstrates the causalities of USA stock returns and G-7 countries' stock market volatilities are shown in this section. The causalities between the variables in question are analysed with establishing separate models for each country. Stock returns are calculated with $return = \ln(\frac{P_t}{P_{t-1}})$ formula. Descriptive statistics of the stock market returns are given in Table 3.

Table 3: Stock Market Returns Descriptives

Variable	Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis	JB
SR_{Canada}	0.004	0.106	-0.186	0.044	-1.120	5.650	82.757
SR_{France}	0.001	0.102	-0.202	0.046	-1.114	5.473	76.157
$SR_{Germany}$	0.004	0.194	-0.293	0.064	-0.934	6.011	86.287
SR_{Italy}	-0.002	0.186	-0.186	0.058	-0.387	4.204	14.864
SR_{Japan}	-0.001	0.119	-0.226	0.053	-0.512	4.219	17.420
SR_{UK}	0.002	0.091	-0.144	0.042	-0.832	4.121	27.680
SR_{USA}	0.002	0.106	-0.186	0.046	-0.724	4.454	28.960

When the descriptive statistics are examined, it is seen that all countries' stock returns are skewed to the right. In all series, however, are shown more kurtosis than normal distribution. According to Jarque-Bera Test Statistics, stock market returns of G-7 economies do not have normal distribution.
Firstly, within the scope of the analysis, the volatilities of the variables are estimated. Stationarity of stock market returns of G-7 countries are assessed applying Augmented Dickey Fuller (ADF) and Phillips-Perron (P-P) Tests, and consequently level I (0) variables are determined to be stationarity. Results are given in Table 4.

Table 4: Stock Market Returns Stationarity

Variable	ADF (without trend)	ADF (with trend)	PP (without trend)	PP (with trend)
SR_{Canada}	-10.246*	-10.218*	-10.347*	-10.317*
SR_{France}	-9.895*	-9.906*	-9.865*	-9.868*
$SR_{Germany}$	-11.832*	-11.946*	-11.838*	-11.931*
SR_{Italy}	-12.036*	-12.003*	-12.105*	-12.072*
SR_{Japan}	-10.013*	-10.102*	-10.158*	-10.232*
SR_{UK}	-12.259*	-12.324*	-12.337*	-12.383*
SR_{USA}	-11.243*	-11.365*	-11.331*	-11.423*

*➔ statistical significance at the 1% level.

Notes: We applied ARCH-LM Test for stock returns to check heteroskedasticity. Variables are found appropriate to apply GARCH models to obtain volatilities.

The stock market volatilities are obtained by using the GARCH (1,1) model (except Japan Stock Exchange) for all analysis period. Model results are given in Table 5.

Table 5: GARCH (1,1) Models Results

Stock Exchange	**Mean Equation**		**Variance Equation**		
	AR (1)	MA (1)	α_0	α_1	β_1
Canada	0.704*	-0.568**	0.001	0.162**	0.758*
France	-0.577*	0.891*	0.001	0.065**	0.863*
Germany	-0.477	0.607***	0.001	0.179**	0.712*
Italy	-0.634**	0.751*	0.001	0.186***	0.722*
Japan	0.224**	-	0.002*	0.149**	-
United Kingdom	-0.980*	0.988*	0.000	0.172**	0.715*
USA	0.939*	-0.887*	0.001	0.214*	0.764*

* ➔ statistical significance at the 1% level. ** ➔ statistical significance at the 5% level. *** ➔ statistical significance at the 10% level.

Descriptive statistics related to the variables included in the analysis are presented in Table 6.

Table 6: Stock Market Volatilities Descriptives

Variable	**Mean**	**Max.**	**Min.**	**Std. Dev.**	**Skewness**	**Kurtosis**	**JB**
SRV_{Canada}	0.0018	0.0085	0.0018	0.0008	2.435	10.555	562.360
SRV_{France}	0.0022	0.0043	0.0013	0.0006	0.953	3.408	26.441
$SRV_{Germany}$	0.0044	0.0198	0.0020	0.0029	2.802	13.118	931.066
SRV_{Italy}	0.0034	0.0102	0.0015	0.0017	1.432	5.336	95.067
SRV_{Japan}	0.0027	0.0079	0.0023	0.0006	4.349	31.593	10.555
SRV_{UK}	0.0018	0.0067	0.0008	0.0009	2.017	8.370	313.867
SRV_{USA}	0.0022	0.0093	0.0005	0.0017	1.589	5.732	122.237

Stationarity of stock market volatilities of G-7 countries are also assessed applying ADF and Phillips-Perron Tests, and consequently level I (0) variables are determined to be stationarity and results are shown in Table 7.

Table 7: Stock Market Volatilities Stationarity

Variable	ADF (without trend)	ADF (with trend)	PP (without trend)	PP (with trend)
SRV_{Canada}	-3.646*	-3.746**	-3.206**	-3.306***
SRV_{France}	-2.789***	-3.211***	-2.719***	-3.185***
$SRV_{Germany}$	-3.743*	-3.917**	-3.738*	-3.927**
SRV_{Italy}	-4.195*	-4.238*	-4.155*	-4.199*
SRV_{Japan}	-11.089*	-11.146*	-11.100*	-11.104*
SRV_{UK}	-3.430**	-3.416***	-3.367**	-3.352***
SRV_{USA}	-2.998**	-3.346***	-2.998*	-3.347***

* ➔ statistical significance at the 1% level. ** ➔ statistical significance at the 5% level. *** ➔ statistical significance at the 10% level.

Notes: We applied ARCH-LM Test for stock returns to check heteroskedasticity. Variables are found appropriate to apply GARCH models to obtain volatilities.

Before the causalities are composed, the relations between the variables are determined. As shown in Table 8, it is found that the correlation coefficient between US stock returns and G-7 economies' stock market volatilities which are included in the analysis are bigger than -0.5 and smaller than 0.5.

Table 8: Correlations

Variable	**SRV_{Canada}**	**SRV_{France}**	**$SRV_{Germany}$**	**SRV_{Italy}**	**SRV_{Japan}**	**SRV_{UK}**	**SRV_{USA}**
SR_{USA}	-0.196	-0.046	0.082	0.052	-0.232	-0.114	-0.007

In this case, it may be predicated that there cannot be any multicollinearity between parameters.

The correlation coefficient between US stock returns and G-7 economies' stock market volatilities is found negative in five countries, but it is found positive other two countries. Therefore, Granger causality test results in question are as presented in Table 9.

Table 9: Granger Causality Test Results

Null Hypothesis:	**F-Statistic**
SRV_{Canada} does not Granger Cause SR_{USA}	1.66066
SR_{USA} does not Granger Cause SRV_{Canada}	7.82042*
SRV_{France} does not Granger Cause SR_{USA}	0.65494
SR_{USA} does not Granger Cause SRV_{France}	13.9463*
$SRV_{Germany}$ does not Granger Cause SR_{USA}	0.53968
SR_{USA} does not Granger Cause $SRV_{Germany}$	8.60218*
SRV_{Italy} does not Granger Cause SR_{USA}	0.99996
SR_{USA} does not Granger Cause SRV_{Italy}	12.2511*
SRV_{Japan} does not Granger Cause SR_{USA}	1.88619
SR_{USA} does not Granger Cause SRV_{Japan}	7.62461*
SRV_{UK} does not Granger Cause SR_{USA}	0.03375
SR_{USA} does not Granger Cause SRV_{UK}	11.0995*
SRV_{USA}does not Granger Cause SR_{USA}	0.39134
SR_{USA} does not Granger Cause SRV_{USA}	10.6413*

*➔ Statistical significance at the 1% level.

We examined in our analysis

$$SRV_{county,t} = \alpha_0 + \sum_{i=1}^{n} \alpha_i SRV_{county,t-i} + \sum_{i=1}^{n} \beta_i SR_{USA,t-i} + u_i$$ and

$$SR_{USA,t} = \alpha_0 + \sum_{i=1}^{n} \alpha_i SR_{USA,t-i} + \sum_{i=1}^{n} \beta_i SRV_{county,t-i} + u_i$$ equations. Causalities are analysed using F test statistics, the US market returns have significant influence on stock market volatilities in G-7 economies (the causality direction is from the US market returns to stock market volatilities). The results suggest that the US

stock market returns causes stock market volatilities in G-7 countries in the 2000-2013 period. However, stock market volatilities in G-7 countries' economies do not cause the US stock market returns in analysis period.

5 Conclusion

As a reasonable result of mutual interaction throughout history, financial crises, remarkably those arising in strong economies have spread into other countries in a short span of time. In this regard, even if the Global Financial Crisis of 2008 did not last as long time as the Great Depression of 1929 did, it affected many advanced and emerging market economies as a great number of economies are integrated into the system.

Within the framework of a number of studies which include stock market returns and volatilities, various econometric methods are employed (regression analysis, the Granger Causality Test, the vector autoregression model, vector error correction model etc.). These studies examine the relationship between the variables in question and other variables and volatilities. A certain number of studies, on the other hand, have taken the causalities of global markets across countries into consideration, and included the variables from various countries in the analysis process. The results obtained differ from country to country and according to the term in question.

Within the framework of the study, we examined causalities between the US stock market returns and G-7 economies' stock market volatilities in 2000-2013 period (including Global Financial Crisis of 2008) thence the USA is considered to be the strongest link of the system. In our study, we applied Granger Causality Tests and we found that the US stock market returns causes G-7 countries' stock market volatilities. Subsequent to our study, other studies focusing on the factors affecting macroeconomic variable volatilities other than stock market volatilities can be carried out. Moreover, it is foreseen that similar models for the countries which are not included in this paper can be set within the framework of other studies.

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