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TODA-YAMAMOTO CAUSALITY BETWEEN E7 COUNTRIES STOCK MARKETS

Tekin Bilgehan | Department of Business Administration, Cankiri Karatekin University, Cankiri, Turkey; btekin@karatekin.edu.tr

Abstract: *In this study, the causal relationship between the fastest growing emerging countries (Emerging 7) stock markets is discussed. In the study, Turkey, India, Indonesia, China, Mexico, Brazil and the Russian stock market indexes is taken into causal relationship with each other. As analysis method Toda Yamamoto approach to Granger causality test was used. As a result of the study, it was concluded that the regional interaction between stock markets is more than intercontinental interaction.*

Keywords: *Stock markets, Causality, Toda Yamamoto Analysis, Emerging Countries*

JEL Classification: F21, F35, N20

INTRODUCTION

In recent years, international capital movements have increased. The relations between international capital markets are gaining more importance together with the world, which continues to unite rapidly. The process of globalization of international stock exchanges has been studied in depth by economists and other researchers, and it is concluded that stock markets are highly globalized in these researches (Menezes, 2013).

In this context, the integration of international capital markets in the financial literature continues to be widely explored and discussed. The integration of international capital markets has implications for both policy makers and investors. An examination of the integration of capital markets is important because it allows for effective portfolio diversification for international market investors. The basis of effective portfolio theory is based on diversification and dissemination and reduction of risk. At this point, in addition to diversity among economic sectors, geographic or regional diversifications are important for an effective portfolio.

Mutual relations between international exchanges also have an impact on asset allocation and risk management. In particular, the recent global financial crisis and its contagious impacts have revealed that joint movements and causal relations between international markets need to be further studied.

With developing technological infrastructure and computer systems, it is much easier to direct capital to international transfers and investments. Correlational, retrospective and delayed relationships are therefore also important for investors who prefer to gain earnings through portfolio diversification in international markets. Although it is important whether stock markets act together or at what level they are integrated into each other in different countries and the causality between the indices is important for policy makers and future predictors of understanding the dynamics of index returns.

However, the integration process of financial markets is difficult to measure as it has a dynamic structure. In the literature, various empirical methods are used to reveal such relations. In some of these studies, researchers conducted regressions of different sub-dimensions in order to obtain information on long-term changes in the dynamics of integration and causality of stock exchanges (Tudor, 2011). In this study, the world's fastest-growing emerging markets (E7) of Turkey, India, Indonesia, China, Mexico, Brazil and Russia causality of stock index was investigated. The Granger causality test was carried out with Toda Yamamoto procedure.

LITERATURE

With the rapid liberalization of financial markets in the world, stock market integration and correlations between countries are also realized rapidly. Since these developments are directly related to the finance field, the number of studies conducted in this direction also increases. In the literature, different sampling and analysis techniques are used to reveal the inter-country financial market relations.

Cheung & Mak (1992) examined the causal relationship between the two developed markets, US and Japan, using the weekly yields of the emerging Asia-Pacific markets for the period from 1977 to 1988 in their study. As a result of the study, it was determined that the US market affected the developing Asia-Pacific countries, with the exception of the relatively more covered markets such as Korea, Taiwan and Thailand. And also they found that the Japanese market is less important for Asia-Pasific stock markets.

Chowdhury (1994) investigated the relationship between the stock exchanges of four economies in Asia. The results showed that Hong Kong and Singapore stock markets had an important link between Japan and the United States.

Sharkasi, Ruskin and Crane (2005) examined the relationship between stock prices in Ireland, England, Portugal, USA, Brazil, Japan and Hong Kong stock exchanges. As a result of the study, they found evidence of the co-movements of the stock markets in Europe. There is also a co-movement between the US and Brazilian markets and the Japanese and Hong Kong markets. Finally, within the circle of influence, it was concluded that European markets influenced American continent markets and then American stock markets influenced Asian stock markets.

Beine, Capelle-Blancard & Raymond (2008) investigated the linear and nonlinear Granger causality between the French, German, Japanese, UK and US daily stock index yields from 1973 to 2003. They found two-way nonlinear causality as a result of the study, but stated that most of them could be explained by heteroskedasticity and structural fractures.

Gözbaşı (2010) examined the interaction between Borsa İstanbul and the stock markets of seven developing countries. The data range is the weekly data for the period December 1995-December 2008. Cointegration and causality analyzes were performed. The results show that there is a long-term relationship between the BIST and Brazil, India and Egyptian stock exchanges, and the interaction between the BIST and the Mexican and Hungarian stock exchanges in the short term.

Menezes (2013) examined the globalization process of stock exchanges in G7 countries with cointegration and Granger causality tests. The data covers the 36-year period starting from 1973. According to the results of the study, significant causal effects emerged. It has reached the evidence that the exchanges are closely related in the long term. He also stated that the US stock exchanges in general have an impact on the stock markets of other countries.

Benli (2014) has examined the long-term relationship between Emerging Countries and Turkey stock market. Long-term relationship was analyzed by Johansen cointegration test for December 30, 1994 to September 30, 2013 time period. According to the results obtained; Colombia and Turkey and Turkey and Mexican have a significant long-term relationship but there is no significant relationship between Turkey and other emerging countries.

Ellul (2015) examined the time-dependent correlation between the Malta Stock Exchange (MSE) index and major international stock markets. He used a MGARCH-DCC approach to measure the degree of MSE movement with other stock markets. The daily returns of six stock indexes were calculated and used to calculate the dynamic conditional correlations (DCCs) between markets. The results indicated that the local stock market was not driven by the same forces shaping foreign stock markets.

Akel (2015) conducted Granger causality test and Johansen cointegration analysis of Fragile Five (Brazil, Indonesia, South Africa, India and Turkey) countries using the stock market index in November 2000 and December 2013 with the weekly closing data. As a result, the existence of a short and long-term cointegration and causality relationship between the capital markets of these five countries was determined.

METHOD

The data on the variables used in the study were obtained from the websites of the stock market indices and from the Bloomberg and Yahoo Finance databases. The natural logarithmic values of the variables were used in the study. Toda Yamamoto causality analysis was used as the analysis method.

Toda-Yamamoto Approach Granger Causality Test

Conventional Granger causality tests in unrestricted VAR are based on the assumption that basic variables are in stationary or integrated at zero order. If the time series is not stationary, the stability condition of VAR is violated. In case of non-stationary time series, cointegration should be investigated and, if available, should be continued with vector error correction model (VECM) instead of unrestricted VAR. If the series is not integrated in the I(1) order or is integrated in different orders, the long-term relationship test cannot be performed. On the other hand, the use of unit root and cointegration may cause loss of power in series (Ghosh & Kanjilal, n.d.).

In addition, the use of difference values may cause loss of information. Toda and Yamamoto (1995) developed an approach to eliminate the problems observed in the traditional Granger causality test. They used a modified Wald test to limit the parameters of the VAR system's lag length k parameter to the parameters of VAR (k). In the Toda Yamamoto approach, the maximum integration level (dmax) of the variables is determined by the unit root test and then the optimum delay length (k) for the VAR model is increased by (dmax). Finally, Granger causality test is applied to VAR (k + dmax) model.

The TY approach does not cause the problem of information loss that we see in the difference process as it only requires VAR to be at the level values. Therefore, the TY approach is a long-term test. The Toda Yamamoto Approach Granger Causality test includes the estimation of the following models.

$$X_t = \alpha_\circ + \sum_{i=1}^{k+d\max} \alpha_2 X_{t-i} + \sum_{i=1}^{k+d\max} \alpha_3 Y_{t-i} + \eta_2$$

$$Y_t = \beta_\circ + \sum_{i=1}^{k+d\max} \beta_2 Y_{t-i} + \sum_{i=1}^{k+d\max} \beta_3 X_{t-i} + \eta_2$$

In equations, X_t and Y_t represent the variables examined. In models, each variable is regressed on each other with a number of delays from 1 to $k + d$max. η_1 and η_2 expresses error terms in equations. k shows the maximum number of delays and d the degree of integration of the variables.

Unit Root Test

The first step in time series analysis is to determine the degree of integration of each variable in the analysis. Augmented Dickey-Fuller (ADF) test is a commonly used test for this purpose. As mentioned above, it is not important whether the variables contain a unit root in the Toda-Yamamoto causality test. However, the unit root test is used to determine the maximum stationary degree (dmax). For a time series, the ADF test statistic is usually derived from the calculation of the following equation:

$$\Delta Y_t = \mu + \gamma Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \beta t + \omega_t$$

When μ is the drift term in the equation, t represents the time trend, and p is the maximum delay length. The equation is used to estimate whether $y = 0$. The ADF test statistic is calculated by dividing y 's estimate by the standard error. The cumulative distribution of ADF statistics is provided by Fuller (1976, 2009). If the calculated ADF statistic is less than the critical value in the Fuller table, Y 'is said to be stationary or zero integral (Bahmani-Oskooee, 1993). The unit root hypotheses were determined as shown below.

Null Hypotheses: H_0:=0 (series contains a unit root)
Alternative Hypotheses: H_1:≠0 (series is stationary)

FINDINGS

Table 1 shows the ADF test results. According to the table the ADF test shows that the series contain unit roots and the first differences are stationary. All of the variables contain unit root I(1). Therefore, the maximum degree of integration for VAR (k + dmax) model is determined as dmax = 1.

Table 1: ADF Unit Root Test Results

SERIE	Period	Model	ADF test statistics at level	ADF test statistics at first difference	Integration order
BSE100 (India)	1990M1-2018M9	Intercept	1.235449	-9.812710 *	I(1)
BMV (Mexico)	1990M1-2018M9	Intercept	0.482980	-4.949963 *	I(1)
JSE (Indonesia)	1990M5-2018M9	Intercept	0.670528	-8962138 *	I(1)
SHCOMP (China)	1991M1-2018M9	Intercept	-1.860207	-6.862180 *	I(1)
BOVESPA (Brazil)	1993M4-2018M9	Intercept	-0.789079	-15.36353 *	I(1)
MOEX (Russia)	1997M10-2018M9	Intercept	-0.680382	-13.96712 *	I(1)
BIST100 (Turkey)	1990M1-2018M9	Intercept	0.327926	-6.492934 *	I(1)

Note: The maximum lag length in the ADF test is automatically determined by the Eviews program according to the Akaike Information Criteria.

* The hypothesis of H_0**: Series contains a unit root** is rejected at the 5% significance level.

The optimum delay length for the VAR (k + dmax) model was determined according to LR (sequential modified LR test statistic), FPE (final prediction error), AIC (Akaike information criterion), SC (Schwarz information criterion) and HQ (Hannan- Quinn information criterion) criteria. When the information criteria used to determine the delay lengths indicate different lag lengths, the method applied in general is to take into consideration the LR result (Akkaş & Sayılgan, 2015). The lag lengths in the study were determined by considering the FPE and ACI criteria. The LR criterion was taken into account when different criteria indicated different lag lengths. Table 2 shows the results of the TY causality analysis.

Table 2: TY Causality Results

Series	Casuality Direction	Series	df	Chi-Square	Prob.*
India	←	Turkey	2	7,444258	0,0242
Mexico	NONE	Turkey	1	0,694682 1,276894	0.4046 0,2585
Indonesia	←	Turkey	2	6.574477	0.0374
China	←	Turkey	2	6.543319	0.0379
Brazil	NONE	Turkey	2	0.379328 3.121881	0.8272 0.2099
Russia	→	Turkey	2	6.557483	0.0377
China	←	India	2	16,34109	0,0003

China	→	Indonesia	3	13,16410	0,0043
China	NONE	Mexico	1	0,438429 0,675726	0,5079 0,4111
India	←	Indonesia	3	29,89145	0,0000
India	←→	Mexico	3	12,61141 8,985283	0,0056** 0,0295***
Indonesia	←	Mexico	3	11,75191	0,0083
Brazil	←→	China	5	18,23497 13,24175	0,0027** 0,0212***
Brazil	→	India	2	6,625595	0,0364
Brazil	NONE	Indonesia	3	0,470822 5,138405	0,9253 0,1620
Brazil	←→	Mexico	7	18,66525 14,63184	0,0093** 0,0410***
Brazil	→	Russia	7	14,38554	0,0447
Russia	→	Mexico	7	15,21057	0,0334
Russia	→	Indonesia	2	11,07670	0,0039
Russia	←→	India	11	19,73834 23,76617	0,0491** 0,0138***
Russia	←	China	8	24,72340	0,0017

* 5% significance level. ** Dependent India, Brazil and Russia, *** Dependent Mexico, China and India

According to the Toda-Yamamoto causality test, the H_0 hypothesis that there is no causality from the BIST100 index to the Mexican (BMV) and Brazil (BOVESPA) indices is not rejected at 5% significance level. There is no causal relationship between these indices.

The H_0 hypothesis that there is no causality from the BIST100 index to the indices of India (BSE100), Indonesia (JSE) and China (SHCOMP) is rejected at 5% significance level. There is a one-way causality among these indices. On the other hand, the hypothesis H_0 which states that there is no causality from Russia (MOEX) index to BIST100 index was rejected at 5% significance level. Therefore, Turkey index affects the indexes of Indonesia and China but is affected by the Russian index.

When the relations between the other E7 countries are examined, it is seen that the Chinese index is a reason for the indices of Indonesia and Russia. The Indian index is a cause of the Chinese index. Thus, the Chinese index is influenced by the Indian index, which affects the indices of Indonesia and Russia.

India is influenced by the change in stock markets in Indonesia and Brazil. The change in the Indonesian stock market is also affected by Russia and Mexico. The

Russian stock exchange also affects the Mexican stock market. In the case of bilateral relations, it is seen that there is such a relationship between India-Mexico, Brazil-China, Brazil-Mexico and Russia-India.

Figure 1 shows the schematic representation of these relations. Rays show one-way relationships, while others show bidirectional relationships. The point to be considered here is that the number of periods studied in the causality relations is different for some countries. For example, while China is a cause of Turkey index and it is seen that Russia is a cause of China and Turkey is a cause of Russia.

However, the number of observations taken into consideration in the relationship between BIST100 and SHCOMP index is 333, while the number of observations in the relationship between MOEX and BIST 100 and SHCOMP indices is 253. This situation affects the results of the analysis. Therefore, BIST100 and SHCOMP index data were analyzed again for 253 periods and no causal relationship was found between these two indices (prob. 0, 0628). The same situation is also observed among other country indices. Hence, Figure 1 presents the results of all analyzes as a result of the aggregate.

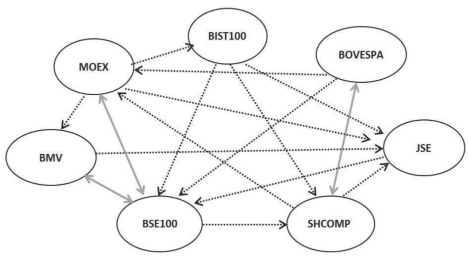

Figure 1: The direction of causality relations between E7 countries stock indices

When we look at the relations between India, Mexico, Turkey, it is observed that BIST100 affect the indices of BSE100. There is bidirectional causality between BSE100 and BMV indices. There is no problem in terms of these relations.

Likewise, the analysis made by the Chinese data, India, Mexico, Indonesia, Turkey has taken place. According to the figure Turkey and India affects China index. The Chinese index affects the Indonesian index. Considering Russia index, Turkey, Indonesia and Mexico are affected by Russian index. At the same time, we see that the Russian index is influenced by the Brazilian and Chinese indices and is in a two-way relationship with the Indian index.

CONCLUSION

As a result of the study, useful information was obtained for investors who wanted to perform arbitrage transactions in international stock markets. Causal relationships between the stock markets of the Far East countries which are listed in E7 and Turkey have been identified. There is also a causal relationship with Russia. This result can indicate that regional interaction between other stock markets and Turkey is more obvious according to the intercontinental interaction. On the other hand, when the relations between the stock exchanges of the other countries are examined, it is seen that the only stock exchange influenced by the Indonesian (JSE) stock exchange is the Indian stock exchange (BSE100). Furthermore the only stock exchange influenced by the Indian stock exchange is the Chinese stock exchange (SHCOMP). The Mexican stock exchange (BMV) is influenced by Russia (MOEX) while influencing Indonesia. Brazil (BOVESPA) is in mutual causality relationship with China stock exchange while affecting India and Russia. The Chinese stock exchange also affects Russia and Indonesia. No causal relationship was found between Brazil-Indonesia and China-Mexico.

According to the findings of this study, as the distance between geographical regions increases, it is observed that the causal relations weaken. At this point, the causality relationship between India and Indonesia stands out as the strongest relationship. As a result, investors who want to obtain arbitrage opportunities from international stock markets should look for intercontinental transactions and diversifying their portfolio. The results of this study have similar and different aspects in terms of the direction of relations with the results of the studies conducted by Gözbaşı (2010), Benli (2014), Dasgupta (2014) and Akel (2015). It also has a high level of similarity with the findings of the study by Jegadeeshwaran and Sangeetha (2018). The reason of the difference may be the effects of the time series covered by the series used and the index types selected for the analysis, as well as the differences of analysis methods. In future studies, testing of the findings of this study with different samples and analysis methods will make more consistent decisions for decision makers.

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