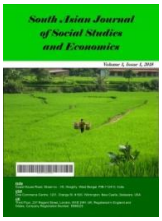

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Toda and Yamamoto Causality Test between US $ Exchange Rates and Stock Market Prices in Sri Lanka

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aim: The paper empirically analyzes the dynamic relationship between stock market and exchange rate in Sri Lanka.
Study Design: The long-run relationship between All Share Price Index and Sri Lankan Rupees - US Dollar (LKR/USD) exchange rate is tested using Johansen co-integration test, and the short-run dynamic causal relationship is tested using Granger's causality and Toda and Yamamoto [1] causality test.
Place and Duration of Study: The study use daily data from the 02nd of October 1998 to 07th of September 2018.
Results: The results show that there is no long-term equilibrium relationship between All Share Price Index and US Dollar-Sri Lankan Rupees exchange rate. According to Granger's causality and Toda-Yamamoto causality tests, the results indicate that there is a unidirectional causality running from All Share Price Index and US Dollar-Sri Lankan Rupees exchange rate in the short run.
Conclusion: The study concludes that stock market causes on Exchange rate in Sri Lankan economy in the short run, but not vice versa.

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Contribution: This study is useful for macroeconomic policymakers and financial managers to have a better understanding of the movements between among the variables. The better understanding of short-term movements of these two variables helps to make the more informed investment and financing decisions.

Keywords: Causality; exchange rate; granger causality; stock market; Toda-Yamamoto.

1. INTRODUCTION

A well-organized capital market with appropriate policy on international finance is a crucial and fundamental requirement for the achievement of economic development of a country. The capital market performance has a significant impact on an economy, so that absence of proper monitoring and understanding the behavior of the capital market may adversely impact the performance of the economy [2]. More attention has been paid on capital market development during last few decades. The earlier and recent economic crises in developed and developing countries indicate that financial market volatility has a significant adverse impact on the economy [3]. Due to the crises, many social and economic problems were arises such as unemployment, reduction in investment, negative economic growth and volatility in economic indicators [4]. Stock Exchange is considering one of the vital components of the capital market of an economy. The stock exchange has played an important role for economic boom and recession of a country. Volatility in economic growth trend arises followed by substantial changes in government and their economic policy decisions. Mutually agreed on macroeconomic policies, especially monetary and exchange policies, become effective on the stock market operations.

In addition to the financing of economic entities, the stock exchange plays a vital role in monitoring the healthy functioning of firms and their management, as well as helping to increase the growth rate of savings and investment and control inflation through the proper management of liquidity [3]. The stock markets in recent decades have played a significant share of the economic growth of countries. However, in some circumstances, such as weaknesses in laws, unsuitable regulations, unwanted government interference, unstable government policies and other related economic and political factors, the stock market has become an ineffective system for some countries.

Stock market developments and stock price indices have been accompanied by changes in the economy and its macroeconomic variables. The economic variables include interest rates, gross domestic product, investment risk, inflation rate, and exchange rate impact on the stock market development and its operations [5]. In some economic theories, the exchange rate is the most crucial variable in the financial sector of the economy. This variable has created changes in its stock price index with uncertainty. Also, the inverse relationship between the volatility of the stock price index and the uncertainty of the exchange rate may have occurred. Therefore, the existence of a two-way relationship between these two variables is not distant [6]. Due to the importance and interrelationship between the capital market and the foreign exchange market, there is a necessity of adopting appropriate long-term stable policies by the country's currency authorities. Therefore, this study indeed encourages policy makers and decision makers to make useful policies and effective decisions regarding monetary and capital market of an economy.

The stock market has become increasingly as one of the prominent indicators for the overall macroeconomic operation, and the US Dollar-Sri Lankan Rupees exchange rate is an important policy tool for maintaining national economic security and financial stability in Sri Lankan open economic environment. Therefore, an in-depth study of the dynamic relationship between the stock market and the foreign exchange market will not only help to deepen understanding of the relationship between financial markets, but also prevent policy risks such as financial risks and financial market reforms. Further, finding the dynamic relationship between the two variables also provides a theoretical basis for investors to control asset portfolio risk and government decision-making authorities to formulate macroeconomic regulation and control policies. Therefore, this paper investigates the daily data of All Share Price Index of Colombo Stock Exchange and Sri Lankan Rupees - US Dollar (LKR/USD) exchange from 02nd of October 1998 to 07th of September 2018, and uses the Granger's causality and Toda and Yamamoto [1] causality test to examine the dynamic

relationship between LKR/USD exchange rate and stock market returns in Sri Lanka.

2. LITERATURE REVIEW

Over thirty years there are many studies conducted about the relationship between foreign exchange rate and stock market movements. The exchange rate and stock market index are considered as important factors to evaluate the movement and strength of an economy. Usually, the relationship between these two variables is explained in two theoretical approaches. The first theoretical approach is the flow-oriented theory and the second one is the portfolio balance theory [7]. The first theory suggests that the changes in the exchange rate impacts on stock market performance. The exchange rate is determined by the current account balance. Meanwhile, the current account balance of an economy depends on its international trade balance. The exchange rate impacts on the international competitiveness of local firms listed in the stock market of an economy. Therefore, fluctuation in the exchange rate of an economy has impacted the level of import, export, and income of companies and their performance in the market. Consequently, it impacts on international trade balance and current account balance. Then, this performance reflects in the stock market as changes in their share price and market index as a whole. Therefore, the flow-oriented theory suggests that changes in exchange rate impacts on stock market performance [8].

The portfolio balance theory suggests that the stock market performance causes changes in exchange rate. This theory is established based on international capital flows prospect. This prospect states that the investors rebalance their portfolio of investment based on their performance in the domestic capital market. Likewise, international investors willing to invest in the domestic capital market when they perceive that the domestic capital market performs well. As a result, the demand for domestic currency increases as international fund flow and strengthen the domestic currency. Therefore, the theory suggests that changes in the capital market cause a change in the exchange rate [8].

Although the above mentioned two theoretical assumptions have clearly stated the theoretical relationship between stock price volatility and exchange rate changes, the conclusion obtained are not consistent with the empirical findings. Aggarwal [9] finds a significant positive correlation between the Dollar exchange rate and the US stock price. However, the study of Soenen and Hennigar [10] reveals that the relationship between the two variables is significantly negative. Mao and Kao [11] argue that currency appreciation would have a negative impact on the stock market for export-led countries, but it would have a positive effect on import-led national stock markets.

Early studies focused on developed markets and did not consider the non-stationarity of time series data leading to statistical regression inference problems. Bahmani-Oskooee and Sohrabian [12] used co-integration and Granger causality tests for the first time to study the relationship between exchange rate and stock price, and find that there is no long-term co-integration relationship between the two variables, but there is a two-way short-term causal relationship be present. Ajayi and Mougoué [13] have studied the relationship between the two markets in eight developed countries and find that there is a two-way causal relationship present between the foreign exchange market and the stock market. Abdalla and Murinde [14] have studied four emerging markets in Asia and find that there is only one-way causality between exchange rate and stock price.

Based on Asian data, to determine the appropriate Granger relations between stock prices and exchange rates, Granger, Huangb and Yang [15] use unit root and co-integration models. The study finds that exchange rates lead stock prices in South Korea whereas in the Philippines the stock market lags foreign exchange markets. Further, this study finds a strong feedback relationship between these two variables in Hong Kong, Malaysia, Singapore, Thailand, and Taiwan.

The study of Nieh and Lee [16] find that there is no long-term relationship between stock price and exchange rate, but there is a short-term relationship exist in G-7 countries. Tabak [17] study the Brazilian market and concludes that there is no long-term relationship between the two variables, but there is a linear causal relationship between the stock market and the foreign exchange market and a nonlinear causal relationship exist between the foreign exchange market and the stock market.

In addition to the above studies of the direct relationship between stock prices and exchange

rates, some recent literature has indirectly studied the relationship between the two variables by introducing some exogenous variables. Kim [18] examines based on asset pricing model using monthly data finds that there is a long-term equilibrium relationship exists between US stock price and industrial production index, real exchange rate, interest rate and inflation. Further, he finds that the stock price is positively correlated with industrial production index, and the other three factors are negatively correlated.

Phylaktis and Ravazzolo [8] use the co-integration methodology and multivariate Granger causality tests to study the long-run and short-run dynamics between stock prices and exchange rates. They use monthly data to study five emerging markets in Asia and conclude that there is a positive correlation exist between the stock market and the foreign exchange market.

Pan, Fok and Liu [19] examine dynamic linkages between exchange rates and stock prices in seven East Asian countries during the period January 1988 to October 1998. The study period is divided into two sub-periods, such as before and during the Asian financial crisis and use Granger causality tests, a Variance Decomposition Analysis, and an Impulse Response Analysis. The study finds that exchange rates cause stock prices during the before the crisis period for Hong Kong, Japan, Malaysia, and Thailand. The equity market causes the foreign exchange market for Hong Kong, Korea, and Singapore.

For the first time, Kanas [20] uses the bivariate EGARCH model and daily data to study the nonlinear relationship between the stock market and the foreign exchange market in six industrial countries including the US, the UK, Japan, Germany, France and Canada. It finds that there is a volatility spillover effect from the stock market to the foreign exchange market for all countries except Germany. Further, he concludes that the international financial markets have become progressively integrated.

Caporale, Pittis and Spagnolo [21] study the causal relationship between stock prices and exchange rates volatility in four East Asian countries based on daily data. They use BEKK representation adopted GARCH model. The study finds that stock prices causes exchange rates negatively in Japan and South Korea and positively cause in Indonesia and Thailand during the pre-crisis sample period.

Yang and Doong [22] use the VAR and bivariate EGARCH model to find the relationship between stock and foreign exchange markets in the G-7 national market. They use the data set which consists of weekly closing exchange rates and stock market indices during the period from 01/05/1979 to 01/01/1999. The study finds that there is no significant long-run relationship between stock prices and exchange rates. Further, the evidence shows that movements of stock prices will affect future exchange rate movements, but changes in exchange rates have a less direct impact on future changes of stock prices.

3. RESEARCH METHODOLOGY

This study intends to examine the dynamic relationship between stock market and exchange rate in Sri Lanka. It uses daily observation of data (five days in a week) from 02nd of October 1998 to 07th of September 2018. After adjust the national holidays of the country, the sample of this study includes 1034 observations in total. The All Share Price Index (ASPI) is used as a proxy for represent stock market movement. The Sri Lankan Rupees per US dollar is used as a proxy for the exchange rate. The relevant data are obtained from Thomson Reuters Eikon online database. Finally, all time series data are transformed into natural logarithm form for the statistical purpose [23].

The time series variables must be stationary in order to obtain meaningful results in most time series statistical analysis. The mean and variance of a stationary time series variables do not change over time [24]. Granger and Newbold [25] have shown that even though the studies with non-stationary time series data the results having high R^2 and significant t statistic values, the estimated factors and results are not economically meaningful. Therefore, studies associated with time series data, it is necessary to test the stationary of the series to avoid incorrect interpretations and inferences. Therefore, the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPPS) test statistics are used to determine the stationary of data.

If the variables become stationary after convert into the same order of deference, i.e. both variables are integrated of order one; then it is to be tested for the existence of a co-integration relationship between the variables [26]. The co-integration test is done among the variables

using the Johansen [27] co-integration tests. Since, Johansen co-integration is sensitive to the lag length the Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) are used to determine the appropriate lag length. The Johansen [27] co-integration tests is performed to test the existence of the long-term relationship between the variables. If there is any evidence for the existence of any long-run relationship between the variables, then need to perform the VECM to test the causal relationship between the variables in the long run. If not, then need to test for the existence of the short-term causal relationship between the variables.

The Granger causality test, which is widely used in the literature to examine the causal relationship among variables in the short-run. In order to perform the Granger causality test, the data series must be stationary even at their level or different levels. Even though many statistical analyses use the Pairwise Granger Causality tests, it has some statistical limitations. Consequently, Toda and Yamamoto [1] have introduced an improved model to assess the causal relationship among variables. Therefore, the Toda-Yamamoto causality test is then used to provide better explanations of the relationship between the variables. It is essential to determine the lag length (k) and the maximum order of integration (dmax) of the series to perform the Toda-Yamamato causality test. Once these two values have been determined, the Toda-Yamamato test can be performed by constructing Vector Autoregression (VAR) model of (k + dmax) size.

4. RESULTS AND DISCUSSION

In order to examine the dynamic relationship between the variables, it needs to make sure that the data series are stationary. For this, unit root test is performed by using the Augmented Dickey-Fuller and Phillips-Perron test statistics. This test statistics are used to test whether the time series variables contained a unit root. Table 1 shows the unit root test results for the unit root test., the unit root test result of the variables at the 1% level of significance reveals that both variables have unit root at their level, but these variables become stationary after convert to the 1st difference. Therefore, both data series are co-integrated of order one I(1).

Since both variables are co-integrated, it indicates the existence of a long-run relationship between the variables. Therefore, to test the existence of long-run relationship, the Johansen co‑integration test is applied which uses a trace test and a maximum Eigen value. The test result is given in Table 2. The result indicates that there is no integration equations in the given variables. Therefore, it suggests that there is no cointegrating relationship between the stock market and exchange rate in Sri Lanka. As such, the VECM (Vector Error Correction Model) cannot be applied to test the existence of the causal relationship between the variables in the long run.

In order to find the causal relationship in the short run among these variables, the Granger causality test is performed. The appropriate lag length should be determined before perform the Granger causality test. For this purpose Vector Auto-regression (VAR) model is used to find the optimal lag length. The VAR Lag Order Selection Criteria test result is given in Table 3. Based on the Sequential modified LR test statistic, Final prediction error, and Akaike information criterion, the optimal lag length is six (6). The Pairwise Granger Causality Tests is performed after convert the data at 1st level of difference and the test results is given in Table 4. The result reveals that the All Share Price Index (ASPI) causes on Exchange rate in Sri Lankan economy in the short run, but not vice versa. In addition, the relationship between the available data was investigated by Toda and Yamamoto [1] approach.

Table 1. Unit root test

		Augmented Dickey-Fuller test statistic	Phillips-Perron test statistic
ASPI	Level	-0.819031	-0.840170
	1st Difference	-24.31944*	-24.81708*
LKR/USD	Level	-0.093595	-0.180478
	1st Difference	-30.67018*	-30.83787*

** denotes rejection of the hypothesis at the 0.05 level*

Table 2. Co-integration test

Hypothesized No. of CE(s)	Trace Test				Maximum Eigenvalue Test			
	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.00531	7.632	15.49	0.505	0.0053	5.5090	14.2646	0.676
At most 1	0.00205	2.123	3.841	0.145	0.0020	2.1236	3.84146	0.145

Trace test indicates no co-integration at the 0.05 level

** denotes rejection of the hypothesis at the 0.05 level*

***MacKinnon-Haug-Michelis (1999) p-values*

Table 3. VAR lag order selection criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-6958.8	NA	2475.193	13.490	13.499	13.493
1	-6916.3	84.707	2297.338	13.415	13.443*	13.426*
2	-6910.5	11.503	2289.428	13.412	13.460	13.430
3	-6908.1	4.831	2296.396	13.415	13.482	13.440
4	-6904.2	7.615	2297.104	13.415	13.501	13.448
5	-6898.6	11.190	2289.748	13.412	13.517	13.452
6	-6890.9	15.139*	2273.54*	13.404*	13.529	13.452
7	-6886.9	7.877	2273.558	13.405	13.548	13.459
8	-6886.7	0.472	2290.190	13.412	13.575	13.474

** indicates lag order selected by the criterion*
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Table 4. Pairwise granger causality tests

Null Hypothesis:	F-Statistic	Prob.
Exchange Rate does not Granger Cause ASPI	1.52765	0.1657
ASPI does not Granger Cause Exchange Rate	2.28574	0.0338*

** denotes rejection of the hypothesis at the 0.05 level*

In order to perform the Toda and Yamamoto [1] test, it needs to determine the appropriate lag length (p) with the help of the VAR model. Then, the maximum degree of smoothing (dmax) is added to the lag length (p). In this case, the relevant VAR model can be written in the equations as follows.

$$ASPI_t = \propto_0 + \sum_{i=1}^{p+d_{max}} \propto_1 ASPI_{t-1} + \sum_{i=1}^{p+d_{max}} \propto_2 EX_{t-1} + \mu_{yt} \quad (Equation - 1)$$

$$EX_t = \beta_0 + \sum_{i=1}^{p+d_{max}} \beta_1 EX_{t-1} + \sum_{i=1}^{p+d_{max}} \beta_2 ASPI_{t-1} + \mu_{xt} \quad (Equation - 2)$$

According to the results obtained from the VAR model is shown in Table 4, it was found that the optimal lag is 6. Therefore, it has been decided that the number of "p" lag is 6. As a result of the unit root tests obtained in Table 2, it is seen that the ASPI and Exchange Rate are integrated at I (1). In this way, it is decided that the highest degree of integration of the series (dmax) is 1. Therefore, the Toda-Yamamoto causality analysis requires for adjusted VAR model is p + dmax is 7. The results obtained Toda-Yamamoto causality analysis are reported in Table 5.

The Toda-Yamamoto causality analysis result is given in Table 5. The table provided Chi‑square statistic and probability values with respect to the null hypothesis of non‑causality. The test result reveals that the null hypothesis that the All Share Price Index does not cause the exchange rate is rejected, while the Exchange rate does not cause ASPI is not rejected at 5% significate level. Therefore, it suggests that there is one-way causal relationship from All Share Price Index to Exchange Rate in Sri Lanka. This empirical result is consistent with the findings of Pan, Fok and Liu [19], Kanas [20], Caporale, Pittis and Spagnolo [21] and Yang and Doong [22] in other markets.

Table 5. Toda‑Yamamoto causality test

Null Hypothesis:	F-Statistic	df	Prob.
Exchange Rate does not Granger Cause ASPI	8.897473	6	0.1794
ASPI does not Granger Cause Exchange Rate	15.06208	6	0.0198*

** denotes rejection of the hypothesis at the 0.05 level*

5. CONCLUSION

This study examines the dynamic relationship between stock market and exchange rate in Sri Lanka using daily data from the 02nd of October 1998 to 07th of September 2018. The unit root test shows that both data series are cointegrated of order one, I (1). Johansen co-integration test reveals that there is no long-term equilibrium relationship between and stock price and exchange. The Granger's causality test the Toda and Yamamoto causality test are used to examine the causal relationship between the stock market and Exchange rate. The Toda and Yamamoto Causality Test reveals that stock market price of Sri Lanka causes on Sri Lankan Rupees - US Dollar (LKR/USD) exchange rate in the short run, but in the reverse order. This study is useful for macroeconomic policymakers and financial managers to have a better understanding about the movements between the Stock market and exchange rate in Sri Lanka. Better understanding of movements of these two variables helps to make the more informed investment and financing decisions.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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