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The effect of selected macroeconomic factors on exchange rate volatility in Sri Lanka

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Abstract
This study intends to investigate the factors affecting exchange rate volatility of USD/LKR in Sri Lanka, in the period of January 2010 to December 2017, by using time series Vector Auto Regressive model and Pearson Correlation Coefficient. The study analyses the factors namely, Colombo share market movements, exports, imports, worker's remittances and tourist arrivals which affect the exchange rate volatility of Sri Lanka. The results of the study indicate that to estimate exchange rate volatility ARIMA (1, 0, 0,)-GARCH (1, 0) is the best fittest model and It implies exchange rate had AR and ARCH effect only. As well as positive coefficient of GARCH model indicated there is positive impact of a magnitude of a shock (spillover effect) for exchange rate. From the results of Correlation coefficient showed evident for negative insignificant relationship between exchange rate volatility and all economic factors. It implies that there is a like hood of increases in exchange rate volatility with decrease in above mentioned economic variables and that relations is statistically insignificant. According to final VAR model The Colombo Share Market Movements and Imports showed the significant impact on the exchange rate volatility. Even though Pearson correlation coefficient concluded all the economic factors (including Colombo Share Market Movement and Imports) using the study are negatively associate with exchange rate volatility, VAR model coefficient observed quite different result which is including Colombo Share Market Movement and Imports had positive significant relation. The main policy implication from the results of this study is that crucial to emphasize that the macroeconomic policies have to be implemented in order to stabilize and reduce the exchange rates volatility.

Keywords: exchange rate volatility, macroeconomic factors, VAR model, pearson correlation coefficient

1. Introduction
There are many factors affecting on exchange rate volatility. These factors can be economical, political, psychological and also short run or long run. Conventional economic theories explain there are significant contribution of monetary and non- monetary factors toward the determination of country's exchange rate. . Namely, prices of exports, prices of imports, inflation, interest rate, financial market and budget deficit of home country considered as monetary factors and economic growth, political changes are considered as non-monetary factors. All of these factors or few of them significantly contributes toward the determination exchange rate As well as it may be not any significant impact but may contribute the determinate the exchange rate (Herath, 2005.) [13]. The exchange rate and its direct and indirect impacts are widely addressed issue at present.

Exchange rate of USD/LKR of Sri Lanka has depreciated continuously, ignoring small appreciations experienced from time to time. These fluctuations of the exchange rate will lead to an instability and lack of confidence in the economy. Therefore, either increasing instability of international economies, it is highly important to attain a further understanding of the factors that affect the exchange rate volatility. Given the above mention background, this study seeks to answer the following research questions.

- What is the significant relationship between exchange rate volatility and economic factors?
- What are the significant impacts of selected economic factors to determine exchange rate volatility in Sri Lanka?

The whole study is based on secondary data. The secondary source was Central Bank of Sri Lanka (CBSL). Selected economic factors are Colombo Share Market Movements, Exports, Imports, Interest Rate, Worker's Remittances and Tourist Arrivals. These factors were selected according to past literature and theories of exchange rate. The results of present study could be utilized how the macroeconomic factors can be implemented in order of reduce the exchange rate volatility.

1.1 Objectives of the Study
The researcher's main objective of this study is to determine whether following economic factors namely, Colombo Share Market Movements, Exports, Imports, Interest Rate, Worker's Remittances and Tourist Arrivals affect to decide exchange rate volatility of US dollar of Sri Lanka. For fulfilling above main objective the following sub objectives are framed by the researcher.

- To develop a statistical model to estimate the exchange rate volatility.
- To identify linear relationship between exchange rate volatility and economic factors using Pearson Correlation Coefficient. (Colombo Share Market Movements, Exports, Imports, Interest Rate, Worker's Remittances and Tourist Arrivals).
- To identify significant factors and their directions which influenced on exchange rate volatility in Sri Lanka.

1.2 Economic Factors Influence on Exchange Rate.
1.2.1 Effect of Prices of Exports
If the domestic prices of the exports rise, the demand for

export products will be reduced. Hence for local currency will be lowered and it will lead to depreciate the local currency (Herath, 2005.) [13].

1.2.2 Effect of Prices of Imports
The prices of imports rise and there are local substitutes available in the local market, it will create situation where there is a greater demand for local product. Therefore, demand for local currency will appreciate against the foreign currency (Herath, 2005.) [13].

1.2.3 Effect of Interest Rate
Currencies with higher interest rates attract large number of investors seeking a better opportunities for their investment. This makes the currency more attractive as a form of investment and increases the demand for the currency. So that the short term interest rate are higher than relative to others there is tendency to an inflow of short term capital in to that country effort to take advantage of higher interest will lead to appreciate the domestic currency (Vidyavathi, Keerti, & Pooja, 2016) [26].

1.2.4 Effect of Share Market Movements
If the foreign investments are increased in share market. It makes more demand for domestic currency. Then it cause to appreciate the domestic currency. The opposite relationship exists for decreasing investments of share market, low investments tend to decrease exchange rates (Herath, 2005.) [13].

1.2.5 Effect of Worker's Remittances
If worker's remittances inflows increased, it makes supply of foreign currency and increase the demand for domestic currency. It will lead to appreciate the domestic currency against the foreign currency (Rajakaruna, 2017) [21].

1.2.6 Effect of Tourist Arrivals
The increment of tourist arrivals, will create supply of foreign currency and increase demand for domestic currency. It will lead to appreciate the domestic currency (Tang, Sriboonchitta, Ramos, & Wong, 2016) [24].

2. Literature Review
2.1 Share Market Movements
Lee-Lee & Hui-Boon, (2007) [17] examined the factors; money supply, income, interest rate, inflation, trade balance, stock market of exchange rate volatility form the macroeconomic perspective for four neighboring ASEAN economies namely, Malaysia, Indonesia Thailand and Singapore. The study covered the sample period for four economies within the flexible exchange rate period. The researchers used the Exponential generalized autoregressive conditional heteroscedasticity (E-GARCH) models to generate a measure of exchange rate volatility. The co-integration and VAR models used to find relationship. Researchers found four economies have had significant impact of stock market on exchange rate volatility as well as the findings indicated that the significant common set factor influenced the exchange rate volatility is only generate from stock market. Hence, capital market seems to play a significant influenced to exchange rate volatility in all the economies examined.

2.2 Exports
Aftab, Abbas, & Nawaz Kayani, (2012) [2] investigated the impact of exchange rate volatility at sectoral level on the exports trade of Pakistan. Quarterly data regarding research were collected over the period 2003 to 2010, the bound testing approach was used to study the relationship between sectoral exports and exchange rate volatility, while ADF and Phillips Parron (PP) tests were used to test the unit root of series and GARCH was used to study exchange rate volatility. The results showed that exports are negatively influenced by exchange rate volatility and relative prices (Aqeel & Nishat, (2006.) [4] and Doganlar, (2002) [7] also indicated same result of five Asian Countries namely, Turkey, South Korea, Malaysia, Indonesia and Pakistan.
Ekanayake & Chatrna, (2010) [9] conducted a study to investigate effect of exchange rate volatility on Sri Lankan exports to its major partners. The study utilized sectoral data covered quarterly data from 1980Q01 to 2007Q04.The researchers used the GARCH models to generate a measure of exchange rate volatility. The co-integration and error correction models used to find relationship. The researchers identified in the short run exchange rate volatility has a significant negative impact on exports of Sri Lanka and there existed a long run equilibrium relationship between real exports and real foreign economic activity, real exchange rate and real exchange rate volatility.

2.3 Imports
Quang My & Sayim, (2016) [20] examined the impact of macroeconomic factors (foreign direct investment, inflation, public debt, imports and gross domestic product) on the foreign exchange rates between United States and four big emerging countries; India, Mexico, Brazil and China for the period of 2005 to 2014. The study used enter and stepwise multiple regression methods to investigate the impact of economic factors significantly predict and influence the exchange rates between USD/CNY, USD/INR, USD/ Brazilian Real and USD/Mexican Pesos. Researchers found imports had negative correlation with USD/CNY and USD/ Brazilian Real and positive correlation with USD/INR, USD/ Mexican Pesos.
Akhter & Faruqui, (2015) [3] analyzed how macroeconomic variables namely, exports, remittances, total reserves and total imports influence on exchange rate in Bangladesh. Researchers used correlation and regression analysis. The study found imports impact on exchange rate negatively. According to above studies researcher came following conclusion, that is imports influenced on exchange rate is various by country to country.

2.4 Interest Rate
Fraz & Fatima, (2016) [11] found developing country, Brazil had positive impact on exchange rate and there was a unidirectional causal relationship present between the exchange rate and interest rate. There is a strong unidirectional causal relationship present between the interest rate and exchange rate for the developing country India. While there is a moderate and negative correlation has been found between the exchange rate and interest rate of United Kingdom and there was a unidirectional causal relationship present between the interest rate and exchange rate for the country UK. On the other hand, Japan is the only

developed country which showed the strong and positive correlation between the exchange rate and interest rate in this study.

Rehman *et al*., (2010) [22] investigated the relationship between inflation, interest rates and exchange rate, data of interest rate, inflation and exchange rate between Pakistan rupee and British pound of the last fifteen years (1994-2009) on monthly basis analyzed. A multiple regression model was applied to check relationship. Negative and significant relationship was found between interest rate and exchange rate. Researchers concluded inflation and interest rate differential are the most important tool to determine the exchange rate in the Pakistani market scenario if it is compared with Pound.

Rajakaruna, (2017) [21], ashok & Vikram, (2016) [5], Quang My & Sayim, (2016) [20] Khera & Singh, (2015) [15], Geke, (2015) [12], Bouraoui & Phisuthtiwatcharavong, (2015) [6] and Mirchandani, (2013) [18] also found evidence for a negative and significant effect for interest rate on exchange rate of some developing countries.

2.5 Worker's Remittances

Rajakaruna, (2017) [21] examined the factors affecting exchange rate fluctuation in Sri Lanka. The factors was inflation, interest rate ,terms of trade, net foreign purchase, official intervention and remittances and multiple regression model and VAR used with monthly data ,for the period 200 to 2010. The result found there was a strong positive relationship between the nominal exchange rate (USD/LKR) and remittances, correlation was 0.87. But according to VAR result exchange rate and remittances exist a negative relationship. Akhter & Faruqui, (2015) [3] also found same result. Jayasuriya & Perera, (2016) [14] had found worker's remittances had a predictive ability in determining the present values of USD/LKR exchange rate.

***Source*:** Created by Researcher

Fig 1: Conceptual Frame Work of the Study.

3. Methodology

3.1 Research Design

The time series data are used in current study. The study is based on secondary data. Researcher intend to collect monthly data in recent past. (2010-2017). the dependent variable which was exchange rate volatility of USD/LKR derived from monthly average exchange rate. Independent variables are Colombo share market movements represented by ASPI, exports, imports, interest rate represented by average weighted lending rate, worker's remittances and tourist arrivals. They were selected by concerned about Sri Lankan economic situation and availability of monthly data as well as according to previous related studies.

3.2 Methods of Analyses

In this study a three-step procedure is taken. First, univariate analyses which presented descriptive analysis and variance estimates that are conditional on past exchange rate changes are obtained from an ARCH/GARCH model for returns of the exchange rate. In the second step, Bivariate analysis, which presented Pearson Correlation Coefficient and the last step is Multivariate analysis which employed a time series VAR model is employed to identify the nature of the dynamic relationship between the conditional volatility estimates (obtained from the ARCH procedure) and the economic factors. Data was analyzed using e views 8.1.

3.2.1 Univariate Analyses

Descriptive statistics Analyses

Descriptive statistics present the summary measurements such as mean which is average value of the series (measure of central tendency), maximum and minimum values of variables used in this study together with their standard deviation which measure how far observations are from the sample average (measure statistical dispersion). As well as kurtosis and skewness which measure of shape (peak or flatness) of the distribution and Jarque-Bera (JB) test which is goodness of fit measure of departure from normality (Kumar, 2013) [16].

Volatility Models

The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) Model

Bollerslev (1986) enhanced the ARCH model in to GARCH that allows the errors of variance to depend on its own lags and lags of the squared errors (Dritsaki, 2018) [8]. Abdalla, (2012) [1] mentioned GARCH model has only three parameters that allows for an infinite number of squared errors to influence the conditional volatility. The conditional variance determined through GARCH is a weighted average of past squared residuals. The weight decline gradually but never reach zero. The GARCH (p, q) model can be written as follows.

$$\sigma_t^2 = \omega + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-1}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-1}^2$$

Where p is the number of lagged σ_t^2 conditional volatility and q is the number of lagged ε^2 terms. ω is the standard notation for GARCH constant. α is the GARCH error coefficient. β is the GARCH coefficient. The assumptions of ARCH is also related to GARCH model too. (Dritsaki, (2018) [8] ,Omari *et al*., (2017) [19] and Abdalla, (2012) [1].

Measurement of Exchange Rate Return

The estimation of exchange rate log return is based on previous studies. According to Talwar & Bhat, (2018) [23] Dritsaki, (2018) [8] ,Omari *et al*., (2017) [19], Epaphra, (2017) [10] and Abdalla, (2012) [1] mentioned as in most of empirical finance literature, the variable to be modelled is percentage

monthly exchange rate return which is the first difference of the natural logarithm of the exchange rate and the equation can written as follows.

$$ex_r = 100 \times \log\left(\frac{E_t}{E_{t-1}}\right)$$

Where, ex_r is the monthly percentage return to the exchange rate and E_t and E_{t-1} denote the exchange rate at the current day and previous day, respectively.

Conditional Mean Equation

According to Omari *et al*.,(2017) [19] and Abdalla, (2012) [1] conditional mean equation which might be an AR process, moving average (MA) process or a combination of AR and MA processes. The Autocorrelation Function (ACF) and Partial Autocorrelation (PACF) are used to determine the order of ARMA (p, q) models. For an example ARMA (1, 1) process the conditional mean equation can write as follows.

$$Y_t = \sum_{i=1}^{p} \alpha_i Y_{t-i} + \varepsilon_t + \sum_{j=1}^{q} \beta_j \varepsilon_{t-j}$$

Where, Y_t is a time series being modeled. In this study, the mean equation is modified to include appropriate AR term to control for autocorrelation in the data. After obtaining conditional mean equation the next steps were to test following tests.

Testing for Heteroscedasticity

Most important issue before applying the ARCH/GARCH methodology is to first examine the residuals of the exchange rate returns series for evidence of heteroscedasticity (Abdalla, 2012) [1]. To test for heteroscedasticity, the ARCH LM test is applied and also used the squared residuals of autocorrelation function. To developed ARCH/GARCH model there should be ARCH effect of conditional mean equation. The null hypothesis is,

Null Hypothesis: There is no ARCH effect.

The computed ARCH (LM) statistics that greater than the critical values at 5 per percent significant level then null hypothesis will be rejected or if the probability value (p-value) is lower than 0.05 then null hypothesis will be rejected.

Testing for Autocorrelation

In here, researcher used two methods to test autocorrelation. Which were Q statistics and serial correlation test. The existence of serial correlation among residuals is a necessary pre requisite for apply ARCH/GARCH models.

Null hypothesis: There is no serial correlation.

The p-value of the test is less than 0.05, the null hypothesis of no serial correlation is rejected and it can be concluded that there might be serial correlation.

Testing for Normality

Normality test is employed with Jarque and Bera test. The probability was more than 0.05 thus the data was normally distributed and do not reject null hypothesis. The null hypothesis is as follows.

Null hypothesis: The residuals are normally distributed.

In-Sample Model Comparison Criteria/Lag Length Criteria

The study has applied three information criteria namely Akaike information criteria (AIC), Schwarz information criteria (SC) and Hannan-Quinn information criteria (HQC) for model comparison. The model which gives lowest value of these criteria were selected. As well as Lag length is usually determined using above three main methods, which are considered to be the classical procedures for determining the lag length. The lag is lapse of time (Epaphra, 2017) [10].

Testing for Stationary

Many economic data are non-stationary data. Therefore researcher has to convert those non stationary data in to stationary data (Rajakaruna, 2017) [21]. A series is said to be stationary if the mean and auto covariance's of the series do not depend on time (Venkatesan & Ponnamma, 2017) [25]. The unit root test is carried out to test whether the series are stationary or not. The ADF and PP method were conducted to check the stationary and random walk of the variables. ADF and PP tests can be specified with intercept, and also intercept with trend. Hence study is used these two specification. The null hypothesis can written as follows,

Null hypothesis: The series has a unit root.

The null hypothesis is rejected if the value of probability is less than 0.05 for the test statistic computed. The series has no unit roots implies a stationary time series.

3.2.2 Bivariate Analysis

Bivariate Analysis present Pearson Correlation Coefficient which shows the linear relationship between two variables and is denoted by r. the Pearson correlation coefficient can take a range if values from +1 to -1.a value 0 indicates that there is no association between two variables. A greater than 0 indicates positive association and a value less than indicates a negative association (Vidyavathi *et al*., 2016) [26]. The formula of Pearson Correlation Coefficient can written as follows.

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2]\,[n\sum y^2 - (\sum y)^2]}}$$

3.2.3 Multivariate Analysis

Unrestricted Vector Auto Regression (VAR) Model

VAR model is used to model the dynamics and identify the casual relations among variables. According to Rajakaruna, (2017) [21] VAR model is a system of equation in which each variable is explained by its own lag and current value and lags of the other variables in the system. The VAR approach also provides an appropriate framework for making sectorial comparisons. The VAR approach allows the data to decide the shape of the impulse responses for different sectors. VAR (p) model, with p variables can be written as follows,

$$Y_t = A_0 + A_1 Y_{t-1} + \Lambda + A_m Y_{t-m} + \varepsilon_t$$

Where Y_t is an unrestricted VAR with m lags which is an $(n \times 1)$ vector of variables, A is an $(n \times n)$ matrices of parameters and ε_t is an $(n \times 1)$ vector of constant terms (Lee-Lee & Hui-Boon, 2007) [17]. Assumptions about the

error terms follows,

- The expected residuals are zero
- The error terms are not auto correlated

4. Result and Discussion

4.1 Univariate Statistics Analyses

4.1.1 Descriptive Statistics Analysis

Descriptive statistics of the all variables used in the study are important to understand the nature of the data under the study. Table 1. indicates the descriptive statistics for all variables in this study.

The ASPI, Interest rate, Imports and Exports have negative skewness (long left curve). Leptokurtic distribution are observed for ASPI, Imports and Exports. Platykuric distribution is observed for Interest Rate. As well as tourist arrivals and worker's remittances have positive skewness (long right tail) and platykuric. The JB statistic which is a test for normality, confirms that the null hypothesis of normality for the all independent variables not rejected at the 5% significant level except Colombo share market movements. Further, interest rate, imports, exports, tourist arrivals and worker's remittances followed normal distribution nor Colombo share market movements. USD/LKR have symmetric distribution and exchange rates are platykurtic. The JB statistic confirms that the null hypothesis of normality for the exchange rates of USD/LKR not rejected at the 5% significant level. Further, exchange rates of USD/LKR followed normal distribution.

Table 1: Descriptive Statistics of Independent Variables

	ASPI	Interest Rate	Imports	Exports	Tourist Arrivals	Worker's Remittances	USD/LKR Nominal Exchange Rate
Mean	6236.19	13.93271	1556.528	861.4495	117535.6	521.424	130.59
Median	6354.7	13.83	1577.075	865.5138	113368.5	543.15	130.82
Maximum	7798	17.41	2048.499	1070.104	244536	708.8	153.67
Minimum	3636.4	10.96	973.44	495.5104	35213	303	109.50
Std. Dev.	852.1139	1.711347	229.5593	106.6104	49655.22	96.7047	13.82
Skewness	-0.98493	-0.01983	-0.5795	-0.57067	0.431687	-0.53845	0.01
Kurtosis	4.056667	2.173255	3.279077	3.866332	2.355595	2.506591	1.96
Jarque-Bera	19.98755	2.740322	5.684659	8.212758	4.642685	5.612731	4.30
Probability	0.000046	0.254066	0.05829	0.016467	0.098142	0.060424	0.12

The results of the unit root test for exchange rate return shows the ADF test and PP were conducted on both the intercept and intercept and trend. It implies that exchange rate return is stationary at the level. As well as PP tests confirm that results. According to ADF and PP results the null hypothesis of a unit roots for all the time series are rejected at their level. Thus, the variables are stationary and integrated of same order.

According to the Q statistics is rejected for the exchange rate returns of USD/LKR in level form. The test statistics are statistically significant with p values not greater than 0.05, indicating that the returns are not white noise, indeed the monthly exchange ate returns exhibits a correlation. Researchers determine the form of the ARMA (p, q) which is Parameters p and q can be defined from partial autocorrelation coefficients and autocorrelation coefficient, respectively.

Table 2: Estimated Mean Equations

Model	Coeff				Model selection Criteria			Serial correlation LM test		ARCH test		JB test	
	C	P Value	AR	P Value	AIC	SC	HQC	Obs.R^2	P Value	Obs.R^2	P Value	JB	P Value
ARMA (1,0)	0.31	0.097 N/S	0.45	0.00*	2.79	2.85	2.82	5.91	0.052 **	3.675	0.055**	569.8	0.00*

- *and ** denotes statistically significant at 5% and 6% respectively.
- N/S denotes statistically insignificant at 5% and 6% significance level.

Table 2 provides the estimations of all mean models of exchange rate returns and the p values of the parameters (coefficients) together with the values of model selection criteria, as well as the results of autocorrelation test, heteroscedasticity and normality test. Exchange rate returns found ARIMA (1, 0, 0) or AR (1) (the model may be referred to base on the non-zero parameter) model as the best fitted mean equation. It implies exchange rate had AR process only. It indicates that the exchange rate returns is regressed on its own lagged values. As well as according to table 1 the coefficients are statistically significant (without constant) in 5% level of significant. The serial correlation results provide an evidence for rejecting the null hypothesis at the 6% significant level and indicated the existence of autocorrelation in residuals and the fitted model is adequate. The ARCH test results provide an evidence for rejecting the null hypothesis at the 6% significant level and indicated the existence of ARCH effect in residuals series in the mean equation. JB test results confirm that the null hypothesis of normality for the mean model is rejected at the 5% significant level, which means residuals of the model are not normally distributed.

The exchange rate returns that fulfill the conditions, where necessary to proceed volatility models which are existence of ARCH effect and serial correlation of the mean model, has gain to modelling ARCH/GARCH model.

Estimated Volatility Model

The parameters of estimated volatility model, the result of test of normality, conditional heteroscedasticity of the residuals and value of the log likelihood function and model selection criteria presented in table 3.

Table 3: Estimated Volatility Models

Volatility Model	Coeff.								Model Selection Criteria			Log likelihood		ARCH LM test		JB test
	Mean equation				Variance equation				AIC	SC	HQC					
	C	P	AR	P	Ω	P	α	P					Obs. R^2	P	JB	P
GARCH (1,0)	0.03	0.9	0.6	0.00 *	0.38	0.00 *	0.66	0.052 **	2.42	2.5	2.46	-109.73	0.027	0.86 N/S	361.19	0.00 *

- Ω and α Represent constant, ARCH term and GARCH term respectively.
- * and ** denotes statistically significant at 5% and 10% respectively.
- N/S denotes statistical insignificance at 5% and 10% significance level.

ARIMA (1, 0, 0,)-GARCH (1, 0) is best fittest model for exchange rate volatility. It implies exchange rates had ARCH effect only. It indicated there is positive impact of a magnitude of a shock (spillover effect) for exchange rates respectively. It can conclude there is positive impact on long term volatility for exchange rate. This result is quite different from Zakaria, (2013) for Malaysia Ringgit/ USD and Talwar & Bhat, (2018) [23] for INR/USD. As well as above mentioned models confirmed there are no additional ARCH effects and model is adequate. The estimated exchange rates volatility has long right curve (positive skewness) and exchange rate volatility is Leptokurtic. Thereby, exhibiting one of the important characteristic of financial time series data. As well as exchange rate volatility followed normal distribution.

Table 4: Results of Stationary Test for Dependent and Independent Variables

Variable	ADF				PP			
	Intercept		Intercept & Trend		Intercept		Intercept & Trend	
	Level (P)	1st dif (P)	Level (P)	1st dif (P)	Level (P)	1st dif (P)	Level (P)	1st dif (P)
Dependent variable								
USD_Ex_V	0.00*	-	0.00*	-	0.00*	-	0.00*	-
Independent variables								
LN_ASPI	0.0051*	-	0.0855***	0.00*	0.0059*	-	0.0777***	0.00*
LN_Interest rate	0.0000*	-	0.0000*	-	0.0000*	-	0.0000*	-
LN_Exports	0.0000*	-	0.0000*	-	0.0000*	-	0.0000*	-
LN_Imports	0.0988***	0.00*	0.1744	0.00*	0.0107*	-	0.0016*	-
LN_Tourist Arrivals	0.0001*	-	0.9998	0.0000*	0.1908	0.0001*	0.0007*	-
LN_WREM	0.00		0.3050	0.00*	0.1018	0.0001*	0.0001*	-

- (P) denotes Probability Value
- Optimal lag length as determined by SIC
- *, ** and ***denotes statistically stationary at 5%, 6% and 10% respectively.

The results of the unit root test for exchange rate volatilities and independent variables are given in above table 4 The ADF test and PP were conducted on both the intercept and intercept and trend. For estimating VAR researcher attempt to transform independent variables in natural log form. Because independent variables observed in variety of scales. Therefore, researcher indent to convert those variety of scale to same unit.

In summary, ADF test shows all independent and dependent variables are stationary in level with intercept. PP test confirms all dependent variables stationary in level with intercept and all dependent variables stationary in level with intercept and trend. Hence According to ADF and PP results the null hypothesis of a unit roots for all the time series are rejected at their level. Thus, the variables are stationary and integrated of same order. Hence, there is no need to run co-integration tests and researcher make VAR model (in level) to identify relationship between exchange rate volatility and above mentioned economic factors. Before Modelling VAR researcher attempt to analyze Pearson correlation coefficient in bivariate statistics analysis as follows.

4.2 Bivariate Statistics Analysis

Pearson Correlation Coefficients

Bivariate statistics analysis presents the correlation matrixes. Pearson correlation was used to analyze the level of association between exchange rate volatility and the macroeconomic variables. The results are presented in table 5 as follows.

Table 5: Correlation Matrix for Exchange Rate Volatility of USD/LKR

Probability	USD_EX_V	LN_ASPI	LN_EX	LN_IM	LN_IR	LN_TA	LN_WR
USD_EX_V	1.000						

LN_ASPI	-0.181	1.000					
	(0.081)	-----					
LN_EX	-0.116	0.464	1.000				
	(0.265)	(0.000)	-----				
LN_IM	0.018	0.437	0.577	1.000			
	(0.863)	(0.000)	(0.000)	-----			
LN_IR	0.029	-0.155	-0.044	-0.052	1.000		
	(0.785)	(0.137)	(0.672)	(0.622)	-----		
LN_TA	-0.099	0.400	0.552	0.545	-0.129	1.000	
	(0.341)	(0.000)	(0.000)	(0.000)	(0.214)	-----	
LN_WR	0.007	0.363	0.562	0.616	-0.019	0.847	1.000
	(0.944)	(0.000)	(0.000)	(0.000)	(0.854)	(0.000)	-----

- The numbers within parentheses shows probability values.

Results in table 5 indicating that the correlation between all independent variables (Logarithms of Colombo share market movements. exports, imports, interest rate, tourist arrivals and worker's remittances) with exchange rate volatility is not significantly different from zero at 5% significance level. The analysis of correlation between the all independent variables with exchange rate volatility has weak and negative relationship except imports and exchange rate volatility, worker's remittances and exchange rate volatility. The correlation between exchange rate volatility and all independent variable's correlations are insignificant at 5% significance level.

4.2 Multivariate Statistics Analysis

4.3.1 Determine Optimum Lag Length

The dependent variable is a function of its lagged values and the lagged values of other variables in the VAR model. Researchers had to observe maximum lag length. This is an empirical issue. Because if it is has too many lags it may be lose degree of freedom and statistically insignificant coefficients and multicollinearity. And the other hand if model has too few lags it is reason for specification errors. Therefore, researchers selected optimum lags using the information criterion AIC, SC and HQC.As well as for exchange rate volatility lag order was 1 as the lowest AIC criteria recorded.

4.3.2 VAR Model

The VAR model estimated by Ordinary least squares (OLS). The results of the analysis obtained the model coefficients and corresponding statistics and model summary statistics as shown in table 6 as follows.

Table 6: OLS Result for VAR of Exchange Rate Volatility

	Coefficient	Std. Error	t-Statistic	Prob.
USD_EX_V(-1)	0.234734	0.10293	2.280509	0.0251*
LN_ASPI(-1)	-4.20186	2.210531	-1.90084	0.0607**
LN_EXPORTS	-0.09133	2.2149	-0.04124	0.9672 N/S
LN_IMPORTS(-1)	3.774779	1.897672	1.989163	0.0499*
LN_IR(-1)	-2.1945	2.580047	-0.85057	0.3974 N/S
LN_TA(-1)	-1.18032	0.938646	-1.25747	0.212 N/S
LN_WREM(-1)	1.414352	2.212407	0.639282	0.5244 N/S
CONSTANT	20.98805	24.40803	0.859883	0.3923 N/S
R-squared	0.178408	AIC		4.277567
Adjusted R-squared	0.110747	SC		4.495425
Log likelihood	-190.907	HQC		4.365532
F-statistic	2.636803	Durbin-Watson stat		1.954071
Prob(F-statistic)	0.016257			

- * and ** shows significant at 5% and 10% significance level respectively.
- N/S shows insignificant at 5% and 10% significance level.

The results can be summarized as in equation;

$$\mathrm{USD}_{EX_V} = 0.234734\,\mathrm{USD}_{EX_{V(-1)}} - 4.20186\,\mathrm{LN}_{ASPI(-1)} - 0.09133\,\mathrm{LN}_{EX(-1)} + 3.774779\,\mathrm{LN}_{IM(-1)} - 1.18032\mathrm{LN}_{TA(-1)} - 2.19451\mathrm{LN}_{IR(-1)} + 1.414352\ \mathrm{LN}_{WREM(-1)} + 20.98805$$

From the findings in table 6 above, the value of adjusted R square was 0.1107,an indication 11.07% of the variations in exchange rate volatility were caused by Colombo share market movements, exports, imports, interest rate, tourist arrivals, worker's remittances. Another 88.93% may come from other factors were not included in this study. Also, the results revealed that there was a quite weak relationship between selected economic variables and the exchange rate volatility of as shown by the correlation coefficient (R) equal to 0.1784.

According to estimated exchange rate volatility model Durbin-Watson statistic is 1.95 and it is very close to 2. It implies this model is so far free from serial correlation. The Colombo share market movements and imports shows the significant relation to the dependent variable which is exchange rate volatility at 5%and 10% significant level respectively. Another four variables show that there are insignificant coefficients for the dependent variable which is exchange rate volatility.

The Colombo Share Market Movements and Imports showed the significant impact on the exchange rate volatility. According to fitted VAR model indicated 1% appreciation of the imports is likely to increase exchange rate volatility of USD by 3.7747%. As well as for 1% increase of Colombo Share Market Movements, exchange rate volatility of USD is reduced by 4.2018%.

5. Conclusions and Recommendations

This study analyses the factors namely, Colombo share market movements, exports, imports, worker's remittances and tourist arrivals which affect the exchange rate volatility of Sri Lanka for the period of January 2010 to December 2017. The results of the study indicate that to estimate exchange rate volatility ARIMA (1, 0, 0,)-GARCH (1, 0) is the best fittest model and It implies exchange rate had AR and ARCH effect only. As well as positive coefficient of GARCH model indicated there is positive impact of a magnitude of a shock (spillover effect) for exchange rate and it can conclude there is positive impact on long term volatility for exchange rate. From the results of Correlation coefficient showed evident for linear relationship between exchange rate volatility and all economic factors namely, Colombo share market movement, exports and tourist arrivals have negative insignificant relationship. It implies that there is a like hood of increases in exchange rate volatility with decrease in above mentioned economic variables and that relations is statistically insignificant.

According to final VAR model The Colombo Share Market Movements and Imports showed the significant impact on the exchange rate volatility. This results is consistent with

an earlier study by Lee-Lee & Hui-Boon, (2007) [17] who also found stock market has significant impact on exchange rate volatility of the four countries namely, Malaysia, Indonesia, Thailand and Singapore. Colombo Share Market Movements negatively and Imports positively effect on exchange rate volatility. This is in line with past theories and literature. Even though Pearson correlation coefficient concluded all the economic factors (including Colombo Share Market Movement and Imports) using the study are negatively associate with exchange rate volatility, VAR model coefficient observed quite different result which is including Colombo Share Market Movement and Imports had positive significant relation.

The main policy implication from the results of this study is that crucial to emphasize that the macroeconomic policies have to be implemented in order to stabilize and reduce the exchange rates volatilities similarly government can make a stable political and financial condition in the country. The study was not exhaustive of the macroeconomic variables affecting exchange rates in Sri Lanka and this study recommends that further studies be conducted to incorporate other variables like Public Debt, Unemployment Rate, Income Levels, Gross Domestic Product, Political Stability and Economic Performance.

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