Statistical Properties of Exchange Rate Behavior: Evidence from Sri Lanka

S. Mathusha
Postgraduate Institute of Science
University of Peradeniya
mathusiva92@gmail.com

INTRODUCTION

The exchange rate plays a significant role in a country's trade and economy. Because exchange rate movements affect sales and profit forecasts, capital budgeting plans, the value of international investments and stock market performances. COVID - 19 has been rapidly spreading across the world and taking thousands of lives. Apart from the health consequences of COVID - 19, it has caused global financial unrest and the collapse of stock markets and exchange rate fluctuations in many countries around the world. Sri Lankan rupee also began to depreciate against major currencies from the first week of March 2020. Especially, it depreciated against the US dollar and reached LKR 198.46 as of 30 May 2021 (Central Bank of Sri Lanka, 2021). This was identified as one of the highest depreciation in its history. The depreciation of the rupee increases the country's expenditure on imports and burden on foreign debt.

However, knowledge about the statistical properties of daily exchange rate changes has important economic implications on international trade, the balance of payments and capital flows, international asset portfolios and the pricing options of foreign currencies. In particular, the empirical behavior of exchange rates is important for various reasons. First, the time-series behavior of exchange rates has implications on market efficiency which has received far more attention in the financial literature. Second, the distributional property of exchange rates determines the riskiness of the foreign exchange market and the validity of statistical inference in empirical work. Third, the statistical behavior of the exchange rate provides insight into the nature of the process governing exchange rate determination (Sivarajasingham and Thattil , 2015).

Several studies have been published dealing with exchange rates mainly focusing on economic aspects, in particular of developed countries. Wang et al. (2013) have analyzed the statistical properties of the exchange rate in China. The study reveals that the correlation coefficient of the foreign exchange market during the sample period is fat-tailed. Sivarajasingham and Thattil (2015) have investigated the statistical properties of the exchange rate in Sri Lanka. The study shows that the distribution of exchange rate was a non-linear asymmetric shape and non-stationary. Similarly, Sivarajasingham and Balamurali (2017) have tested the long memory for the USD/LKR exchange rate in Sri Lanka. The results provide strong evidence for long memory property in the daily exchange rate return.

However, very few studies have considered the statistical properties of exchange rate behavior in Sri Lanka. This study attempted to fill this gap. Further, statistical properties of exchange rate behavior during the pandemic period are not studied for Sri Lanka. This study focuses on the statistical properties of exchange rate behavior with more statistical precision with the comparison of two sample periods. The main objective of this study is to explore and explain the statistical properties of exchange rate behavior in Sri Lanka during COVID 19 period and pre COVID 19 period.

METHODOLOGY

The data include a set of daily nominal spot exchange rates of the US dollar against the Sri Lankan rupee. The sample covers the period from November 12, 2018, to June 30, 2021, which gives a total of 630 observations. The sample period was divided into two; Period I from November 12, 2018 - February 28, 2020 (PI) and period II from March 3, 2020 - June 30, 2021 (PII) to investigate and compare the statistical properties of the exchange rate behavior during the COVID – 19 (PII) period and pre COVID – 19 (PI) period. The data were collected from the Central Bank of Sri Lanka website.

ADF and PP unit root tests were conducted to test the stationarity property of the series. Numerical descriptive statistics and graphical techniques such as Line graphs, Histograms, Kernel density function, and Autocorrelation function are used to explore the properties of the exchange rate distribution. Further, the Autoregressive conditional heteroscedasticity (ARCH) model, generalized autoregressive conditional heteroscedasticity (GARCH) model are employed to study the volatility clustering of the exchange rate behavior in Sri Lanka.

FINDINGS

This study tries to identify the statistical properties of the exchange rate behavior during the sample period. The exchange rate series is presented in levels and logarithmic return for the two periods as ER1 and ER2 and RETURN 1 and RETURN 2 respectively. Figure 1 shows the movements of the LKR against the US dollar for the sample period, it clearly shows that the Sri Lankan exchange rate has an upward movement in both sample periods. The upward movement reflects the currency depreciation in both periods. Since March 2020, LKR is depreciating highly during the sample period. The low inflow of capital flow and the decrease in reserve, remittance, IMF grants, and the foreign loan may have caused the depreciation of the rupee.

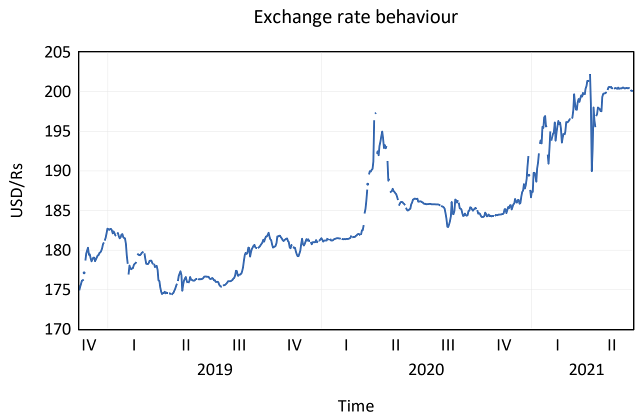


Figure 1: Exchange rate behavior in the level form during the sample period

Figure 2 shows the density distribution of the exchange rate in the level form. The Kernel estimates of the density distributions reveal that density distributions of the exchange rate in the level form are not normal. ER1 has a negatively skewed distribution and ER2 is positively skewed.

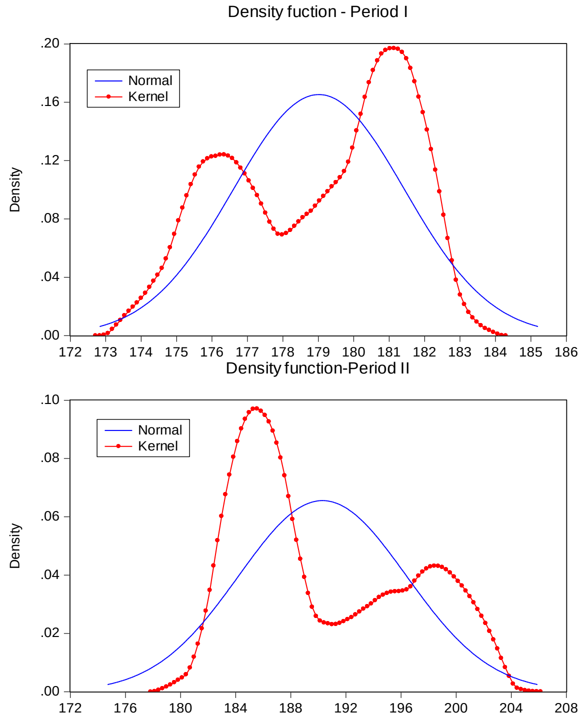


Figure – 2 Density functions of exchange rates, ER1 and ER2

According to Figure 3 and Figure 4, ER has behaved differently during the COVID – 19 period and pre COVID – 19 period. Means, standard deviations, skewness and kurtosis differ between these two periods. The mean of the distribution is higher in Period II than Period I. The histogram and the JB statistics also indicate that both periods have non-normal distributions. The standard deviation of the exchange rate is larger in period II compared to Period I. This indicates that the variability of the exchange rate is higher in period II (SD=6.09) than in period I (SD=2.41). Kurtosis of the distribution is also higher in Period II than Period I.

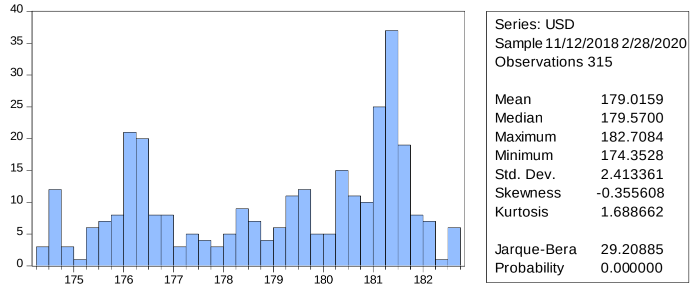


Figure - 3 Summary statistics of exchange rate distributions during the sample period I

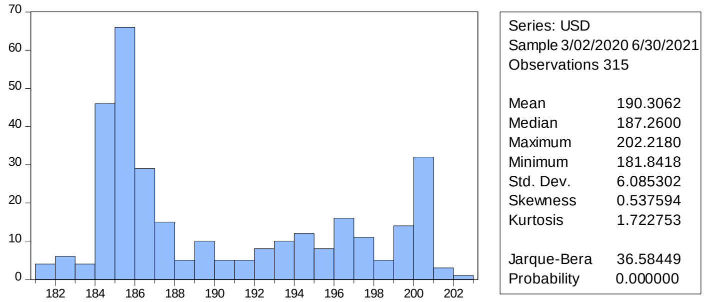


Figure - 4 Summary statistics of exchange rate distributions during the sample period II

The exchange rate returns behavior during the sample periods are given below in Figure 5. The returns behavior is explained using descriptive statistics in Figure 6 and Figure 7.

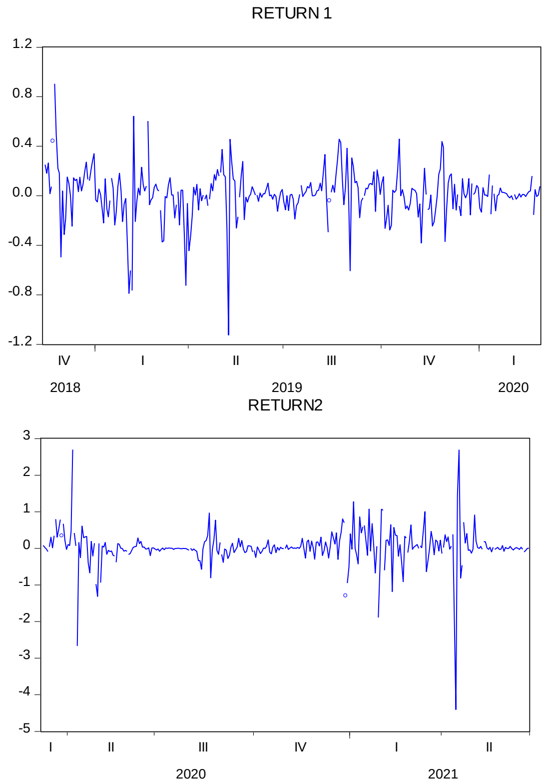


Figure 5: Exchange rate behavior in return

Figure 6 and Figure 7 show the basic descriptive statistics of the Sri Lankan rupee exchange rates against USD in the logarithmic return form for Period I and Period II. Summary statistics show that the kurtosis of both distributions is much larger than the normal value. The kurtosis of the exchange rate return is high in period II than Period I. Means, standard deviations, skewness and kurtosis differ between these two periods. Sivarajasingham and Thattil (2015) found that mean, skewness and variance of the distribution vary over time. The return series become much more volatile in Period II than in Period I.

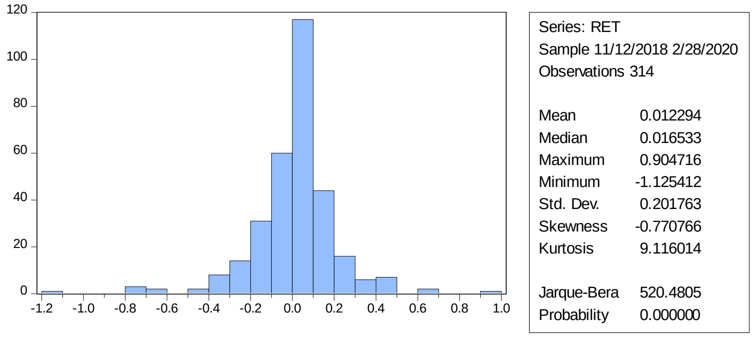


Figure 6: Descriptive Statistics of Return Distribution for period I

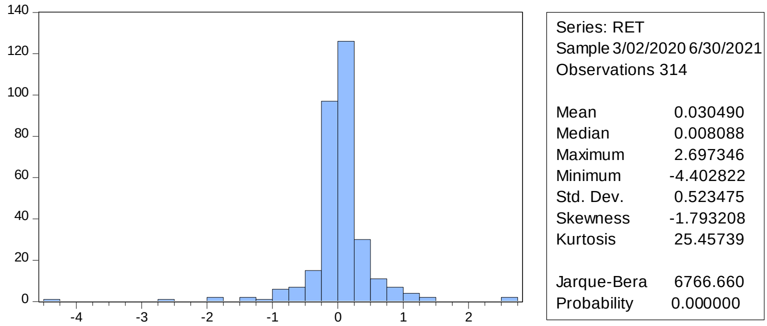


Figure 7: Descriptive Statistics of Return Distribution for period II

Figure 8 shows that empirical density functions of the return series have longer and fatter tails than the corresponding normal distribution, excess peakedness at the mean. The distributions are approximately symmetric and leptokurtic (heavy-tailed). The primary differences between these densities are in their means, variances, skewness and kurtosis. The density function of Period II has a fatter tail and more peaks than Period I.

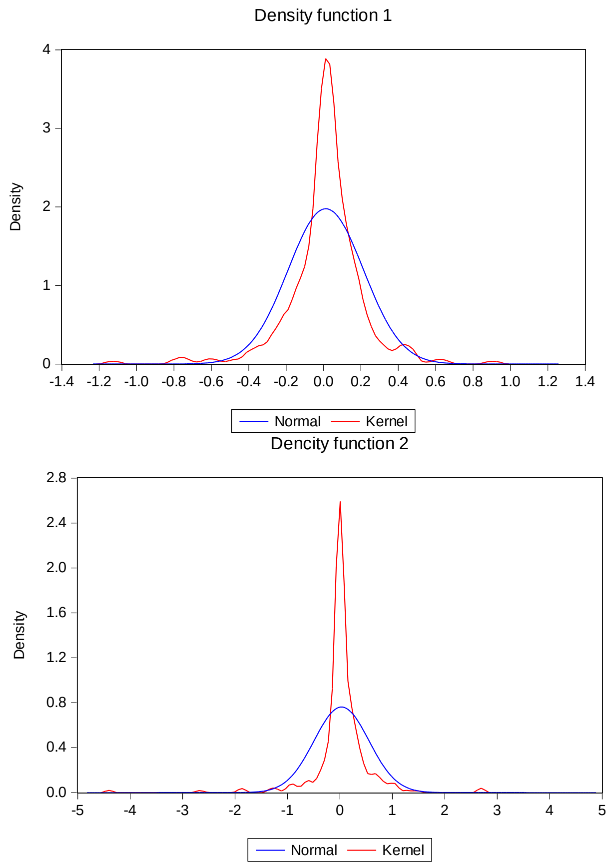


Figure 8: Comparison of Empirical Return (kernel) Density Functions.

Table 1: Unit Root Tests Results

Pre COVID 19 period	ADF test statistics	PP test
Level ($\boldsymbol{er_t}$)	-1.925358 (0.3204)	-1.99649 (0.2884)
First difference ($\boldsymbol{r_t}$)	-12.85052 (0.0000)	-12.8469 (0.0000)
COVID 19 period		
Level ($\boldsymbol{er_t}$)	-1.15533 (0.6943)	-1.22014 (0.6666)
First difference ($\boldsymbol{r_t}$)	-15.10652 (0.0000)	-15.7537 (0.0000)

Note: Probability values are given in the parenthesis

Table 1 reports the unit root test results for the exchange rate (er_t) and its first difference (r_t). The results indicate that the unit root hypothesis cannot be rejected in both periods for the (er_t) and rejected for the first difference (r_t). It indicates that er_t followed random walks and integrated in order (1) during both sample periods.

The empirical autocorrelation function (ACF) of the exchange rate series helps to identify the dependency nature of the stochastic process. Autocorrelation values of exchange rate series vary between ER1 and ER2. ACF decays faster in the pre-COVID -19 period than during the COVID -19 period. This finding is similar to the finding of Sivarajasingham and Thattil (2015).

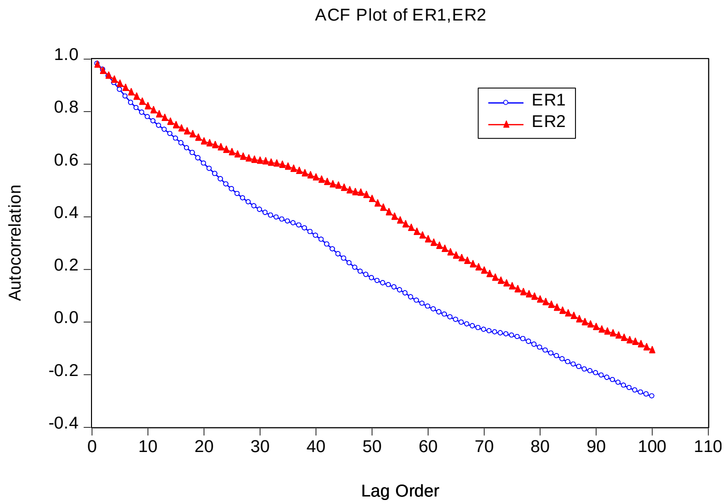
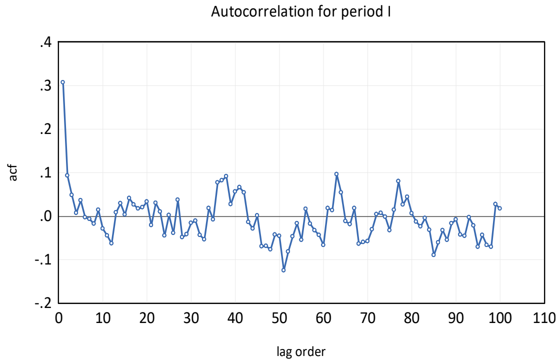


Figure 9: Autocorrelation function of exchange rate

The sample ACFs of ER1 and ER2 have a very large value of first-order autocorrelation, then started to decline slowly. The autocorrelation coefficient starts at a very high value (0.982) close to 1 and declines very slowly toward zero with lag values. ACF provides strong evidence of the presence of the serial correlation in both sample periods. Results indicate that exchange rare series has a very long memory or long-term dependence. According to Figure 10, the autocorrelation of the return, the series has a lack of dependence in both periods.



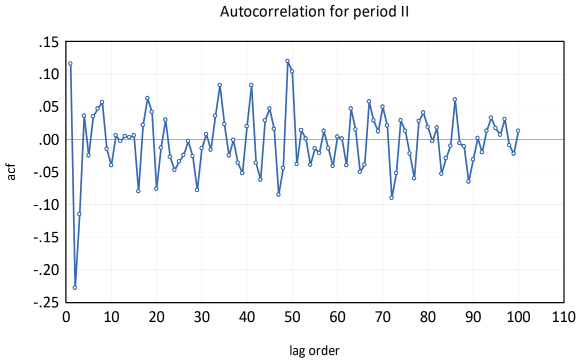


Figure 10: Autocorrelation function of Return Series

Table 2: ARCH and GARCH effects for the two periods

	Period I	**Period II**
ARCH effect ($\boldsymbol{\alpha}$)	0.335451	0.348900
GARCH effect ($\boldsymbol{\beta}$)	0.625868	0.646477
Volatility persistent ($\boldsymbol{\alpha}+\boldsymbol{\beta}$)	0.961319	0.995377

GARCH (1, 1) model is used to identify the ARCH and GARCH effect in the exchange rate returns. GARCH (1, 1) refers to the presence of a first-order GARCH term and a first-order ARCH term. ARCH effect and GARCH effects are statistically significant at the 5 percent significance level. The sum of the ARCH and GARCH coefficients ($\alpha+\beta$) is very close to one in both periods indicating that shocks to the conditional variance are highly persistent in both periods.

CONCLUSIONS

The main objective of this study is to explore and explain the statistical properties of exchange rate behavior in Sri Lanka during COVID 19 period and pre COVID 19 period using daily exchange rate data. As per the findings of this study, the Sri Lankan exchange rate series was a nonlinear, asymmetric shape, and non-stationary series with the stochastic trend I(1). The logarithmic return of the daily exchange rate series has fatter tails, serial dependence, volatility clustering, and ARCH effects in both sample periods. Moreover, the results confirm that the exchange rate is more volatile during COVID - 19 period than pre COVID - 19 period. Investors and policymakers can make effective decisions about the exchange rate by considering these findings in the future. Further, these findings will be helpful to make important suggestions regarding the balance of payments, risk modeling and management, forecasting, market efficiency and statistical inference in empirical work.

REFERENCES

Sivarajasingham, S. & Balamurali, N. (2017). Testing for long memory in the LKR/USD exchange rate: Evidence from Sri Lanka. *Journal of Business Studies*, *4*(1), 79 - 90.

Sivarajasingham, S. & Thattil, R. O. (2015). An empirical analysis of stochastic behavior of Sri Lankan exchange rate changes. *Journal of Management*, *2*(12), 62 - 82.

Rimarčík, M. (2006). Statistical properties of exchange rates. *Biatec*, *14*(3), 6 – 8.

Wang, G. J., Xie, C., Chen, Y. J., & Chen, S. (2013). Statistical properties of the foreign exchange network at different time scales: evidence from detrended cross-correlation coefficient and minimum spanning tree. *Entropy*, *15*(5), 1643-1662.