# STAFF STUDIES

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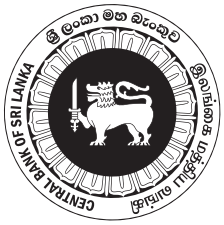


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# Symmetric or Asymmetric: How do Sri Lanka's Bilateral Trade Balances Respond to Real Exchange Rate Changes?

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***Abstract***

*This paper examines the impact of real exchange rate fluctuations on the trade balance between Sri Lanka and its major trading partners using the Non-linear Auto Regressive Distributed Lag model. Analysing data from the first quarter of 2007 to the fourth quarter of 2022, covering 10 trading partners, the study reveals varied reactions in the trade balance to real exchange rate depreciation versus appreciation, supporting an asymmetric effect. While some results align with conventional exchange rate theory, showing a positive long run effect of real depreciation, others indicate only a short run effect. The mixed empirical findings underscore the lack of uniformity in the relationship between real exchange rates and trade balances, which can be attributed to differences in the composition of traded goods. Given these asymmetries, it is evident that exchange rate policy alone has limited capacity to enhance the overall trade balance of the country. Therefore, adopting a comprehensive policy package to ensure Sri Lanka's global competitiveness is imperative to effectively address the multifaceted nature of trade dynamics.*

**Key Words**: *Real Exchange Rate, Bi-lateral Trade Balance, Non-Linear Model, Asymmetric Effects*

**JEL Classification***: C51; F31*

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## 1. Introduction

Exchange rate volatility presents a significant challenge to external trade, prompting policymakers, researchers, and stakeholders to scrutinise its correlation with external trade. Despite extensive theoretical and empirical research, findings remain inconclusive and ambiguous regarding the impact of currency depreciation on the trade balance. Nonetheless, certain studies utilising non-linear models have identified significant long term effects of depreciation on trade balance (Bahmani-Oskooee and Fariditavana 2015, Bahmani-Oskooee et al. 2016).

The link between exchange rate fluctuations and trade balance has important implications for a small open economy like Sri Lanka. There is a renewed interest in Sri Lanka to comprehend the effects of such changes on the trade balance due to the recent considerable depreciation of the Sri Lankan rupee against the US dollar. Therefore, the purpose of this study is to reevaluate the relationship between exchange rate volatility and trade balance in Sri Lanka.

Sri Lanka was on the fixed exchange rate regime at the time of gaining independence in 1948 and moved to the flexible exchange rate regime, passing several intermediate steps. Since the 1980s, Sri Lanka's external sector has been relaxed and hence this provided a valuable opportunity to examine the relationship between exchange rate fluctuations and external trade. Numerous studies that have looked into this matter, have produced ambiguous results (Vijayakumar 2014, Perera 2011, Alawattage 2009). One common feature of all these studies is that they assume a linear relationship among the variables.

Following research by Bahmani-Oskooee and Fariditavana (2015), this study attempts to apply a non-linear model to estimate the link between exchange rate fluctuation and the trade balance using quarterly data from 2007 to 2022[3] for Sri Lanka and its ten major trading partners. The main contribution of this paper to the existing literature is its attempt to use a non-linear model to examine the relationship between real exchange rate fluctuations and trade performances with the ten largest trading partners of Sri Lanka. Previous studies that have investigated the impact of the real exchange rate on Sri Lanka's trade balance assumed the link between the two is symmetric, which in this study we relaxed using a non-linear model. This enables us to ascertain whether the trade balance is affected by real exchange rate fluctuations in a symmetric or asymmetric manner. In addition, this study employs the bilateral trade balance and the exchange rate between Sri Lanka and its major ten trading partners to mitigate the aggregate bias and enhance the validity of the findings. The findings of the study corroborate the asymmetric effect by indicating that countries respond differently to real exchange rate depreciation than to real exchange rate appreciation.

The rest of the paper is structured as follows: a summary of the empirical research and theoretical background is provided in Section 2. The trade flows and exchange rate policy in Sri Lanka are described in Section 3. Section 4 presents the methodology and model specification. The empirical results and findings are discussed in Section 5, followed by a conclusion in Section 6.

[3] The Central Bank of Sri Lanka reclassified trade data in 2010 and retroactively adjusted figures from 2007; this is why the data from the first quarter of 2007 was chosen. Re-exports and re-imports from 2007 onward were not included in this upgrade.

## 2. Literature review

Many scholars focused their efforts on examining how exchange rate policies affect net exports and economic growth, particularly when exchange rates became extremely volatile with the adoption of the floating exchange rate regime. Theoretical aspects and the empirical regularity of the J-curve and the Marshall-Lerner condition are crucial concepts in these studies.

The Marshall-Lerner condition (after Alfred Marshall and Abba P. Lerner) is a criterion that determines whether a country's balance of trade will improve or worsen in response to a change in the exchange rate. It is based on the idea that a depreciation of the currency will lead to an improvement in the balance of trade if the sum of the price elasticities of demand for the country's exports and imports is greater than one. In other words, if the demand for a country's exports and imports is more sensitive to changes in price than the supply of these goods, the balance of trade will improve after the currency depreciates. The J-curve refers to the phenomenon in which a country's balance of trade initially worsens after it devalues its currency or otherwise reduces its trade barriers. This happens because the weaker exchange rate makes imports more expensive, while exports become cheaper and more competitive in the global market. As a result, demand for the country's exports may increase, leading to an improvement in the balance of trade over time. The improvement in the balance of trade is represented by the upward slope of a pattern that resembles the letter J, hence the J-Curve phenomenon. Accordingly, devaluation has two direct effects on trade balance i.e., the price effect and the volume effect. The price effect contributes to worsening the trade balance as exports become cheaper when measured in foreign currency, and imports become expensive when measured in the home currency. On the other hand, the volume effect contributes to improving the trade balance, as exports become cheaper, encouraging an increased volume of exports while imports become more expensive, thereby leading to a decreased volume of imports. The net effect depends upon whether the volume or price effect dominates. Further, in the medium to long run, when the country's exports are cheaper in foreign currency terms, foreign demand increases and local consumers also purchase less of the more expensive imports and try to substitute them with comparable local goods, resulting in an improvement in the trade balance.

The link between exchange rate fluctuations and trade performance has been investigated by many researchers using different econometric techniques and models in both multi-country panel regressions and individual-country studies. The empirical results of these studies are mixed. Several studies substantiate the significant relationship between exchange rate depreciation and the trade balance. Waliullah et. al (2010) examine the short and long run relationship between the trade balance, income, money supply, and real exchange rate in the case of Pakistan's economy using the bounds testing approach. Their results indicate that there is a stable long-run relationship between the trade balance and the considered variables. Similarly, Ncube and Ndou (2013) compare the effects of exchange rate appreciation on the trade balance of South Africa using recursive and sign-restriction vector autoregressive models. Their findings suggest that the trade-weighted exchange rate appreciation shocks worsen the trade balance as a percentage of GDP for longer periods than contractionary monetary policy shocks. The findings of Lal and Lowinger (2002) also confirm the proposition that a country's trade balance worsens immediately following currency depreciation but improves in the long run.

Furthermore, Stucka (2004) estimates the trade balance response to permanent domestic currency depreciation in Croatia for the period of 1994 Q1 - 2002 Q1, using three distinct econometric

techniques; the Autoregressive Distributed Lag (ARDL), the Bewley type ARDL approach, and the ARDL with instrumental variables approach. He concluded that an equilibrium trade balance is improved by 0.94 percent to 1.3 percent on average by a 1 percent permanent depreciation and J-curve evidence is also discovered. Nadenichek (2006) examines the dynamic response of the trade balance to changes in the real exchange rate between the USA and other G-7 countries, employing a partially identified structural vector error correction model. In five out of six country pairings, the results provide evidence in support of a J-curve pattern. Michael (2011) determines the impact of foreign exchange dynamism on Nigeria's export performance. Results from the chi-square analysis indicate that fluctuations in the Naira exchange rate affect non-oil exports. It suggests that to reduce the impact of the fluctuations on non-oil export, monetary authorities in Nigeria should stabilise the Naira exchange rate through monetary and fiscal policies. Truong and Vo (2023) investigate the asymmetric effects of the exchange rate on the trade balance of Vietnam for the period from January 2010 to June 2020 using the non-linear ARDL bound testing approach. The empirical findings confirm that the exchange rate has asymmetric effects on the trade balance in both the long run and short run. Tarawalie and Kpana (2022) investigate the effects of monetary policy and exchange rate fluctuations on the trade balance in Sierra Leone using the ARDL bound testing framework for 1980 - 2020. The long-run results reveal that money supply, real effective exchange rate (REER), and real GDP are the main factors influencing trade balance in Sierra Leone, and money supply and REER have negative effects on trade balance.

Chowdhury et al. (2014) examine the relationship between the exchange rate and trade balance in Bangladesh and find that the real exchange rate is an important variable to the trade balance, and devaluation will improve trade balance in the long run, which is consistent with Marshall-Lerner condition. Tiwari and Shahbaz (2011) examine the effect of India's exchange rate with the USA on the Indian trade balance, using the ARDL bound testing approach to cointegration and for dynamic analysis of Impulse Response Functions (IRFs) and Variance Decompositions (VDs). They conclude that the J-curve is validated in the case of India with the USA.

Arize et al. (2000) investigate the impact of real exchange rate volatility on the export flows of 13 less developed countries over the period of 1973 - 1996 using quarterly data and according to their results, there is a negative and statistically significant long-run relationship between export flows and exchange rate volatility in each of the 13 countries. Yuen-Ling et al. (2008) also find that there exists a long-run relationship between trade balance and exchange rate in the case of Malaysia.

Conversely, there exists another strand of literature that argues for the weak relationship between exchange rate fluctuations and trade balance. Using quarterly data for the period 1971 Q1 - 1994 Q4, Bahmani-Oskooee (2001) found weak statistical evidence between changes in exchange rate and the trade balance with respect to 11 Middle Eastern countries. Al-Shammari and Al-Salman (2010) investigate the impact of real exchange rate volatility on Kuwait's bilateral trade volume with its major trading partners, using an augmented gravity model including country specific fixed effects as well as time effects for the period of 1990 - 2005. According to their findings, there is a statistically significant influence of exchange rate variation for Kuwait's trade balance, nevertheless, the magnitude is small, with an upper limit of 2 percent. They conclude that the trade flows between Kuwait and its major trading partners are not so sensitive to variations in exchange rates.

Moreover, Ahmad and Yang (2004) do not find evidence to support the worsening of the trade balance in the short run as suggested by the J-curve concept. Similarly, a study on 5 countries in ASEAN and Japan by Liewa et al. (2003) for the period from 1986 to 1999 has shown that the trade balance in these countries is affected by real money rather than by the nominal exchange rate and conclude that previous studies had exaggerated the significance of exchange rate fluctuations in trade balances. Bhat and Bhat (2021) examine the asymmetric impact of exchange rate changes on the trade balance in India using the Non-linear Autoregressive Distributed Lag (NARDL) model for the period February 1996 - April 2017. The results indicate that in the short run, currency appreciation deteriorates the trade balance and currency depreciation improves it, and in the long run, a similar response is observed. The outcome of this result refutes the J-Curve phenomenon in the case of India.

Keho (2021) examines the asymmetric impact of real exchange rate on the trade balance in Cote d'Ivoire, employing the non-linear ARDL model over the years 1975 - 2017. The results show that trade balance responds asymmetrically to the REER changes in the long run, while the short run effect is symmetric. Furthermore, the estimations show that trade balance reacts more strongly to REER depreciations than to appreciations. Duasa (2007) examines the short run and long run relationships between trade balance, RER, income, and money supply in Malaysia. Using the ARDL co-integration approach, he finds a positive but statistically insignificant relationship between the trade balance and exchange rate. The money supply and domestic income have a strong negative and positive impact on the trade balance (consistent with the monetary approach and absorption approach, respectively). The results imply that the Marshall-Lerner condition does not hold up in the long run for Malaysia and that the country's trade balance should be examined from both an absorption and monetary perspective when formulating policies. Catalbas (2016) examines the relationship between nominal exchange rate and import and export in Turkey using the VAR model on three-month data. The results show that the exchange rate does not have a significant effect on the export, import and trade balance. He concludes that import restrictions would adversely affect exports.

A few studies have examined this issue in the context of Sri Lanka. Wignaraja (1998) examined the macroeconomic determinants of manufactured export performance of Sri Lanka using the Cointegration Test and the Error Correction Model (ECM). The study finds weak support for the hypothesis that export performance is expected to be positively affected by the REER. Moreover, Perera (2009) examines the impact of the real depreciation of the Sri Lankan Rupee on the trade balance in the short run and the long run employing bilateral trade data between Sri Lanka and its six major trading partners using the ARDL model. The results reveal that there is no evidence for the J-curve phenomenon in the trade balance between Sri Lanka and its trading partners, and there is no any specific pattern in response to the depreciation of the real exchange rate. Weliwita and Tsujii (2000) investigate how responsive is Sri Lanka's trade imbalance to devaluation using data from 1978 Q1 - 1997 Q4. The findings show that the trade imbalance kept going in the wrong direction despite continuous devaluation, indicating that the exchange rate policy was unable to create a favorable balance of trade position. Alawattage (2005) investigates how well the exchange rate policy of Sri Lanka contributes to its external competitiveness using quarterly data covering the period 1978 Q1 - 2000 Q4. The results indicate a muddled J-Curve phenomenon and show that the REER has no significant effect on improving the trade balance, especially in the near run. The cointegration tests indicate a long term relationship between trade balance and REER, but the impact on trade balance improvement over time is negligible.

Using the ARDL model, Abbbucker et al. (2021) investigate the relationship between the exchange rate and trade balance in Sri Lanka for the period of 1977 - 2019. The research findings suggest that the exchange rate has an adverse impact on the trade balance in the long run and conclude that the results are consistent with the J-Curve phenomenon and that the Marshall Lerner condition exists in Sri Lanka. Vijayakumar (2014) examines the effects of the exchange rate on the trade balance of Sri Lanka based on the two-country model involving trade between Sri Lanka and the USA. The results suggest that the REER has a significant positive influence on the trade balance both in the short run and the long run but there is no evidence for the J-curve effect. Chamindani (2017) investigates the determinants of manufacturing exports in Sri Lanka with specific emphasis on the impact of the REER for the period of 1970 - 2014 using ARDL model. The results suggest that REER is a key determinant of exports of Sri Lanka. Wimalasuriya (2007) examines exchange rate pass-through in Sri Lanka using monthly data from 2000:10 to 2005:12. The results of the VAR approach show that import prices react to changes in the exchange rate by a magnitude comparatively and considerably greater than that of export prices. This suggests that changes in the exchange rate have a major impact on the trade balance. Athukorala (2017) examines the determinants of exports in Sri Lanka using reduced form equation for the period 1970 - 2015. Results indicated that the RER is the most important determinant of export performance. Further, Rajakaruna (2017) investigates the factors that affect exchange rate fluctuations in Sri Lanka with monthly data for the period 2001 - 2010. The results of the Multiple Regression Model indicate that there is a negative relationship between exchange rate and terms of trade.

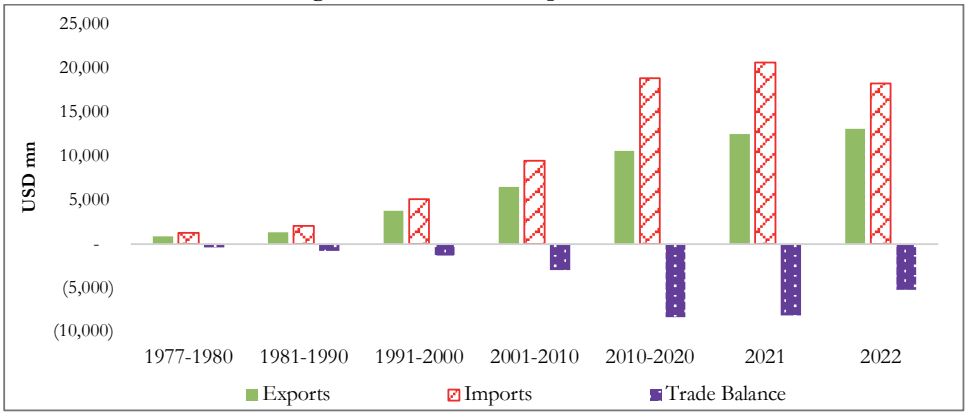
## 3. External trade performance and exchange rate policy in Sri Lanka

Sri Lanka liberalised its economy in 1977 well ahead of the rest of South Asian countries. Significant gains in international trade and trade openness were immediately realised as a result of the implementation of liberal economic policies, such as private sector-driven development, export-led growth, and encouragement of Foreign Direct Investment (FDI). Trade openness, which accounted to 36.4 percent in 1977 nearly doubled to 72.2 percent by 1979. Similarly, exports as a percentage of GDP, which was 18.7 percent in 1977 increased significantly to 29.2 percent by 1979 (Central Bank of Sri Lanka, 2017). Overall, manufactured export performance was positively related to an outward-oriented trade regime during the first two decades of post-liberalisation reforms (Wignaraja, 1998).

Further, with the trade liberalisation policies, a series of unilateral measures were implemented to simplify a country's tariff structure to a large extent. Export industries were supported with generous incentives made available in the form of tax concessions, duty-free imports of raw materials and investment goods, and institutional developments. With these developments, Sri Lanka's export composition was changed from primarily an agriculture-based export structure to a more value-added labour-intensive product structure. Although the composition of exports has changed, the export sector's low product diversification is still evident in the concentration of exports on two traditional products: garments and tea, which together account for more than half of the total export basket. In addition, even though industrial exports accounts for around 77 percent of total exports, high-tech exports are thought to make up less than 1 percent of total manufactured exports enabling competitors to imitate Sri Lankan export products easily (Central Bank of Sri Lanka, 2017). The export sector exhibits a lack of diversification in terms of markets as well. Europe and the USA continue to account for approximately two-thirds of total exports.

Although merchandise exports stagnated in past several years, they rebounded in 2017 and 2018. The main drivers of the growth in export earnings were the establishment of new trade relations, conducive external trade policies, strong institutional support, and the flexible exchange rate policy maintained by the Central Bank. Merchandise exports were severely impacted due to the containment measures taken during the Covid-19 pandemic in 2020, however, recovered faster than anticipated to pre-pandemic levels. Increasing trend in imports also reversed in 2020 due to the restrictions imposed on non-essential imports by the Government, low fuel prices in the international market, and a reduction in importation of intermediate goods with subdued economic activity in the country. However, once domestic activities resumed in 2021 and input demand soared, import expenditure increased significantly. The deficit in the trade account, which continuously recorded a deficit since 1978 with the introduction of open economic policy in the country narrowed by almost half to US dollars 5.2 billion in 2022 compared to US dollars 10.3 billion recorded in 2018 (CBSL, 2023).

**Figure 1: External sector performance**




Source: Central Bank of Sri Lanka

In terms of regional competitors, external trade of Sri Lanka has been lagging as compared to its regional counterparts during the period from 2000 to 2017 according to the Export Value Index of the World Bank. Sri Lanka has only increased its exports by 2.1 times, while Vietnam and India have increased by 14.8 times and 7.1 times, respectively (World Bank, 2019). Overall, the South Asian region is one of the least integrated regions in the world, accounting for less than 5 percent of intra-regional trade, although these countries have become increasingly trade-oriented in recent decades, with substantial potential for further trade gains, both intra-regionally and globally (Raihan, 2015). The region has lagged substantially behind the other regions across the globe, particularly Southeast Asia and East Asia.

The exchange rate policy in Sri Lanka has undergone several changes over the years in response to various economic and external factors. At the time of gaining independence from the British in 1948, Sri Lanka had a fixed exchange rate regime. The exchange rate was pegged to the Indian rupee, and currency was issued and managed by a Currency Board. The Currency Board was replaced by the Central Bank in 1950 aiming to stabilise the domestic and external values of the rupee and promoting economic growth. In 1951, Sri Lanka shifted to a managed float exchange rate system, where the Central Bank intervened in the foreign exchange market to stabilise the currency. By the mid-1960s, the country faced

a balance of payments crisis, driven by low export prices and a high volume of imports leading to force Sri Lanka to devalue the rupee in order to maintain export competitiveness. In 1968, a dual exchange rate system was introduced with one official rate applicable to essential imports and non-traditional exports, and another higher official rate applicable to all other exports and imports, aiming at export diversification and import compression. In 1977, as part of the liberalisation reforms package, the dual exchange rate system was eliminated and the new unified exchange rate was adjusted to reflect foreign exchange market condition. The rupee was initially allowed to float following the unification with limited intervention by the Central Bank. However, interventions soon intensified, particularly during the first half of 1980 and the float was abandoned in November 1982 (Jayasuriya, 2004). The Central Bank's role shifted to managing excessive volatility and intervening when necessary to maintain stability.

By the year 2000, Sri Lanka had experienced a significant decline in its official international reserves, as a result of the notable rise in expenditure on imports. The increased demand for foreign exchange placed tremendous pressure on the exchange rate. Within the managed floating exchange rate regime, this naturally resulted in increased pressure on international reserves. In order to defend the managed float, the Central Bank raised its policy interest rates to unprecedented levels, but this move ultimately proved to be costly and ineffective, which largely contributed to the only negative annual real GDP growth rate of the country's history. This prompted the Central Bank to revisit its exchange rate policy (Weerasinghe, 2017). In 2001, the Central Bank took a major step towards liberalising the foreign exchange market by allowing commercial banks to determine the exchange rate (independent float). With this move, the Central Bank stopped buying or selling foreign exchange at preannounced rates but reserved the right to intervene in the market to buy and sell foreign exchange at or near market prices, as and when it deemed necessary, depending on the movements of the exchange rate.

The Central Bank was compelled to stop intervening in the foreign exchange market to support the exchange rate in February 2012 due to an increasing current account deficit and a swift reduction in foreign exchange reserves. But starting in the fourth quarter of 2013, the Central Bank started to stabilise the currency rate again by using foreign exchange reserves accumulated from the issuance of sovereign bonds. Because of the continuous stability of the nominal exchange rate and domestic inflation that is higher than that of the trading partner countries, the real exchange rate appreciated by approximately 22 percent between 2005 and 2014 when compared to the previous five years, eroding the competitiveness of export-oriented and import-competing production in the economy. In early September 2015, the Central Bank allowed greater flexibility in the determination of the exchange rate. As a result, the currency depreciated by 6.5 per cent against the US dollar between the third quarter of 2015 and the second quarter of 2016, while real depreciation (as measured by the 24-currency real exchange rate index) accounted for 4.2 percent. The Central Bank was moving toward a flexible exchange rate regime in 2016 (ADB, 2017). The Central Bank intervened in the domestic foreign exchange market to avoid large volatility in the exchange rate.

In March 2022, the exchange rate was allowed to be determined by the market, leading to a significant depreciation. In this situation, to reduce the significant volatility driven by excessive speculations and its spillover effects on the economy, a variation band was introduced in May 2022, by announcing the band daily. Under this, a middle exchange rate was announced by the Central Bank based on the weighted average spot market exchange rate of the USD/LKR interbank transactions, with a variation margin on either side of the middle spot exchange rate. However, the Central Bank withdrew from announcing the

guideline band entirely in March 2023. The evolution of exchange rate policy in Sri Lanka reflects the country's efforts to balance economic stability, export competitiveness and inflation management in a changing global economic landscape.

## 4. Methodology and Model Specification

### 4.1 Estimated model

Assuming the domestic country to be Sri Lanka and the foreign country to be her trading partner j, following Bahmani-Oskooee and Fariditavana (2015), we adopt the following model in log-linear form as in Equation (1).

$$LnTB_{j,t} = \propto_0 + \propto_1 LnY_t^{SL} + \propto_2 LnY_{j,t} + \propto_3 LnREX_t + D1 + \varepsilon_t \quad (1)$$

Where TBj is a measure of trade balance defined as the ratio of Sri Lanka's imports from country *j* to its exports to country *j* [4]. $Y^{SL}$ is a measure of Sri Lanka's real income in index form, while $Y_{jt}$ represents the real income of trading partner j. $REX_j$ is the real bilateral exchange rate between Sri Lanka and its trading partner j.

However, since data consists of stationary and non-stationary series, equation 1 is then converted to the error correction version of the original model. The ECM not only addresses the non-stationarity issue but also estimates the long-run effect of exchange rate fluctuations on the trade balance.

$$\Delta LnTB_{j,t} = \beta_0 + \sum_{t=1}^{n1} \beta 1, i\, \Delta\, LnTB_{j,t-i} + \sum_{t=0}^{n2} \beta 2, i\, \Delta\, LnY_{t-i}^{SL} + \sum_{t=0}^{n3} \beta 3, i\, \Delta\, LnY_{j,t-i} + \sum_{t=0}^{n4} \beta 4, i\, \Delta\ \ LnREX_{t-1} + \gamma_0 LnTB_{j,t-1} + \gamma_1 LnY_{t-1}^{SL} + \gamma_2 LnY_{j,t-1} + \gamma_3\, LnREX_{t-1} + \mathrm{D}_1 + \epsilon_1 \quad (2)$$

With the aim of capturing the asymmetric effect of exchange rate changes on the trade balance, equation (2) is then modified as follows.

$$\Delta LnTB_{j,t} = \beta_0 + \sum_{t=1}^{n1} \beta 1, i\, \Delta\, LnTB_{j,t-i} + \sum_{t=0}^{n2} \beta 2, i\, \Delta\, LnY_{t-i}^{SL} + \sum_{t=0}^{n3} \beta 3, i\, \Delta\, LnY_{j,t-i} + \sum_{t=0}^{n4} \beta 4, i\, \Delta\ POS_{t-i} + \sum_{t=0}^{n5} \beta 5, i\, \Delta\, NEG_{t-i} + \gamma_0 LnTB_{j,t-1} + \gamma_1 LnY_{t-1}^{SL} + \gamma_2 LnY_{j,t-1} + \gamma_3\, POS_{t-1} + \gamma_4\, NEG_{t-1} + \mathrm{D}_1 + \epsilon_1 \quad (3)$$

[4] In the literature there are studies that define trade balance as a ratio of exports over imports (Brada et al., 1997 and Bahmani-Oskooee and Alse, 1994).

$POS_t$ represents exchange rate depreciations and $NEG_t$ represents exchange rate appreciations. As it has been mentioned in Shin et al. (2014), equation (3) is named as Non-linear Auto Regressive Model, which allows to capture the asymmetric effect of exchange rate fluctuations on the trade balance.

The dependent variable, trade balance (TB), is defined as the ratio of Sri Lanka's exports to country *j* over its imports from the same country, measured in US dollars in current terms. The reason for using the ratios in this study is that it can express the trade balance in the logarithm. Thus, the first differenced variables reflect the rate of change in each variable. Further, ratio measures remain unchanged whether the trade balance is expressed in real or nominal terms. $LNY^{SL}$ and $LNY_j$ represent the economic activity of Sri Lanka and its trading partners, respectively. The industrial production index of each country is used as the measure of economic activity except for Sri Lanka, USA, and China. For the latter three countries, Real GDP is converted into an index (2007 = 100). The bilateral real exchange rate (REX) is defined as NEX * Pi / $P_{SL}$, where $P_i$ is the Consumer Price Index (CPI) in the county *i*, $P_{SL}$ is the CPI in Sri Lanka and NEX is the bilateral nominal exchange rate (period average) defined as the number of Sri Lankan rupees (SLR) per unit of currency of country *i*. An increase in REX reflects the real depreciation of the SLR against the currency of country *i*. All variables in the models other than the dummy variable are used in natural logs.

It is observed that if $Y^{SL}$ raises imports, $\propto_1$ is expected to be negative. However, if the increase in $Y^{SL}$ is due to an increase in the production of import substitute goods, $\propto_1$ is expected to be positive. The estimated value of $\propto_2$ is anticipated to be positive due to the increase in foreign income and the demand for Sri Lanka's exports. However, if the increase in foreign income is due to an increase in the production of substitutes for Sri Lankan exports, exports of Sri Lanka will reduce, resulting $\propto_2$ being negative. If real depreciation, i.e., an increase in $REX_j$ is to increase exports and decrease imports, the estimate for $\propto_3$ should be positive. Finally, D1 is expected to have a negative relationship since the global financial crisis caused fewer exports.

Variables and their expected signs are presented in Table 1.

**Table 1: Descriptions of variables**

| Variable | Definition | Expected sign |
|---|---|---|
| $LNY^{SL}$ | Sri Lanka's economic activity is represented by real GDP which is converted into an index (2007 Q1 = 100) | +/- |
| $LNY_j$ | The economic activity of country j is represented either by the Industrial Production Index or an index derived from real GDP | +/- |
| LNREX | Bi-lateral real exchange | + |
| D1 | Dummy variable to capture the global financial crisis | - |

### 4.2 Data

This study covers 10 trading partner countries of Sri Lanka, which account for around 60 per cent of Sri Lanka's total trade during the period from 2007 Q1 to 2022 Q4.

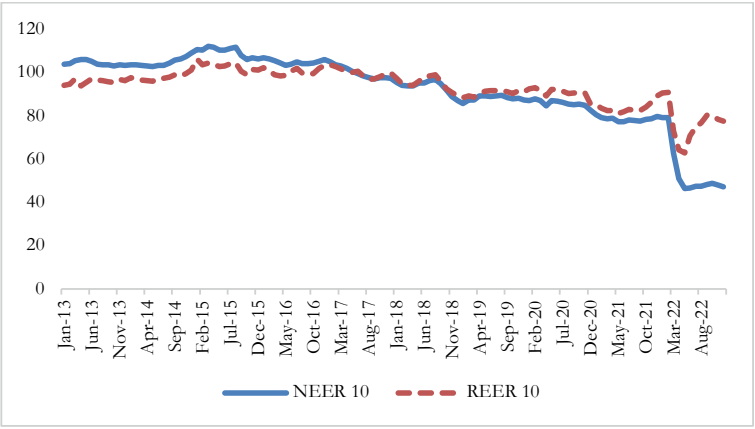
**Table 2: Sri Lanka's trade with major trading partners in 2022**

| Country | Value in USD million | | | Share (%) | | |
|---|---|---|---|---|---|---|
| | Exports | Imports | Total Trade | Exports | Imports | Total Trade |
| India | 860 | 4,738 | 5,598 | 6.6 | 25.9 | 17.8 |
| China | 255 | 3,285 | 3,540 | 1.9 | 18.0 | 11.3 |
| United States of America | 3,321 | 433 | 3,754 | 25.3 | 2.4 | 12.0 |
| United Kingdom | 963 | 243 | 1,206 | 7.3 | 1.3 | 3.8 |
| Germany | 742 | 286 | 1,028 | 5.7 | 1.6 | 3.3 |
| Malaysia | 66 | 969 | 1,035 | 0.5 | 5.3 | 3.3 |
| Singapore | 131 | 871 | 1,002 | 1.0 | 4.8 | 3.2 |
| Italy | 641 | 289 | 930 | 4.9 | 1.6 | 3.0 |
| Japan | 231 | 252 | 483 | 1.8 | 1.4 | 1.5 |
| Hong Kong | 168 | 247 | 415 | 1.3 | 1.3 | 1.3 |
| World | 13,106 | 18,291 | 31,397 | 100.0 | 100.0 | 100.0 |

Source: Central Bank of Sri Lanka

The data is obtained from IMF - International Financial Statistics, except data for Sri Lanka, which are obtained from the Annual Reports of the Central Bank.

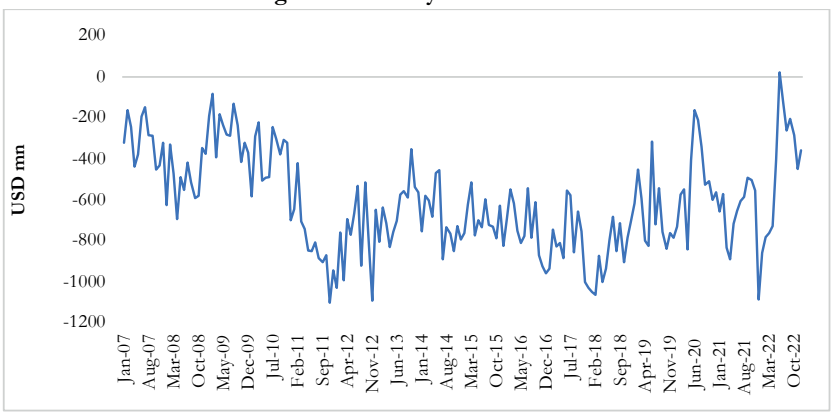
**Figure 2: Monthly exchange rates**




10-currency Nominal Effective Exchange Rate (NEER) and Real Effective Exchange Rate (REER) are depicted in Figure 2.

Both NEER and REER indices underwent substantial downward adjustment in early 2022, reflecting the nominal depreciation of the Sri Lanka rupee against the selected major currencies.

**Figure 3: Monthly trade balance**




As depicted in Figure 3, Sri Lanka's external trade balance continued to record a deficit, except June 2022.

## 5. Empirical results and findings

This study re-examines the link between real exchange rate fluctuations and the trade balance in the context of Sri Lanka. Both linear and non-linear models are estimated for 10 major trading partners of Sri Lanka. These 10 trading partners contribute to around 60 per cent of the total trade in Sri Lanka. This paper uses quarterly data spanning from 2007 to 2022 to estimate each model with each trading partner and the optimal model for each trading partner is selected based on the Schwartz selection criterion.

The ARDL setup is allowed to use variables of different orders of integration (less than I (2)). Therefore, to identify the order of integration of the variables, a group unit root test is performed for each country case, and results, which confirmed that none of the variables are of I (2), are given in Appendix table A.1.

Further, to test for the existence of a long-run relationship among the variables in concern, the bound test is used. The bound F test statistics for both models under each country case exceed the upper bound critical value (Appendix table A.2), confirming the existence of a cointegration relationship among the variables of interest.

The estimated results of the linear and non-linear models are given in Table 3 and Table 4, respectively. In order to increase the reliability of these results, standard diagnostic tests are carried out. The errors of the models are serially uncorrelated and normally distributed. The standard errors of all models are corrected for heteroscedasticity. The cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) suggest that the estimates of both models are stable.

**Table 3: Long run and short run estimation results of linear specification (ARDL)**

| | World | India | China | USA | Singapore | UK | Japan | Germany | Italy | Malaysia | Hong Kong |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long run estimations** | | | | | | | | | | | |
| Rex | 0.07 | 0.83 | -1.29 | -0.23 | -0.56 | 0.21 | 0.89 | 1.21** | 0.82 | -0.34 | -0.39 |
| | [1.02] | [1.47] | [-1.45] | [-0.23] | [-0.31] | [0.58] | [1.21] | [2.18] | [1.80] | [-0.27] | [-0.28] |
| $Y^d$ | -5.58*** | -6.08** | -9.21* | -7.45 | -10.13* | -0.25 | -18.35** | 0.36 | -0.28 | -4.56* | -18.55** |
| | [-4.72] | [-2.00] | [-1.92] | [-1.53] | [-1.69] | [-0.36] | [-2.45] | [0.45] | [-0.14] | [-1.69] | [-2.04] |
| $Y^i$ | -0.31*** | -0.1 | -4.21 | -3.30*** | 1.02 | -1.36*** | -7.62** | 1.93* | -1.39 | -3.23*** | 3.58** |
| | [2.93] | [-0.55] | [-1.49] | [-3.63] | [1.39] | [-2.77] | [1.21] | [1.85] | [-0.94] | [-3.37] | [3.01] |
| **Short run estimations** | | | | | | | | | | | |
| Coint_Eq | -0.59*** | -0.63*** | -0.86*** | -1.01*** | -0.73*** | -1.08*** | -0.56*** | -0.66*** | -0.39*** | -0.56*** | -0.70*** |
| | [6.56] | [-5.78] | [-7.38] | [-7.80] | [-6.50] | [-8.62] | [-5.83] | [-3.67] | [-4.00] | [-4.15] | [-4.01] |
| DTB(-1) | | | | | | | 0.24** | 0.13 | | -0.08 | -0.42** |
| | | | | | | | [2.06] | [0.76] | | [-0.57] | [-2.27] |
| DTB(-2) | | | | | | | 0.11 | 0.16 | | -0.21* | -0.01 |
| | | | | | | | [0.90] | [1.06] | | [-1.72] | [-0.05] |
| DTB(-3) | | | | | | | 0.44*** | -0.21 | | | 0.21 |
| | | | | | | | [3.34] | [-1.63] | | | [1.58] |
| DRex | -0.19 | | -0.25 | 1.99* | | -0.55 | | 0.41 | | | |
| | [-1.34] | | [-0.27] | [1.70] | | [-1.07] | | [0.92] | | | |
| DRex(-1) | | | 3.02*** | 1.74 | | 0.85 | | 0.43 | | | |
| | | | [3.19] | [1.41] | | [1.31] | | [0.83] | | | |
| DRex(-2) | | | | 1.2 | | -0.51 | | -1.49** | | | |
| | | | | [0.59] | | [-0.63] | | [-2.41] | | | |
| DRex(-3) | | | | 3.68* | | -1.92** | | | | | |
| | | | | [1.91] | | [-2.47] | | | | | |
| $DY^d$ | -1.59*** | -0.29 | -0.85 | -0.89 | -2.49** | | -3.28*** | | 0.56*** | | -0.11 |
| | [-5.49] | [-0.74] | [-1.13] | [-0.71] | [-2.39] | | [-3.48] | | [2.74] | | [-0.11] |
| $DY^d(-1)$ | 2.17*** | 3.03*** | 6.33*** | 2.15** | | | 1.18 | | | | 10.33*** |
| | [3.21] | [4.09] | [5.10] | [2.06] | | | [0.70] | | | | [3.96] |
| $DY^d(-2)$ | 0.83*** | 1.34*** | 2.36*** | | | | -0.88 | | | | 6.13*** |
| | [2.97] | [2.92] | [2.97] | | | | [-0.58] | | | | [2.90] |
| $DY^d(-3)$ | | | | | | | -1.66* | | | | 2.50** |
| | | | | | | | [-1.86] | | | | [2.16] |
| DYj | 2.17*** | | -1.06 | 4.02 | | 1.49* | 2.23 | | | -0.71 | -2.22 |
| | [3.21] | | [-0.73] | [1.26] | | [1.92] | [0.98] | | | [0.50] | [-0.85] |
| DYj(-1) | | | 3.12* | 12.09*** | | | | | | -2.92** | |
| | | | [1.89] | [3.62] | | | | | | [-2.03] | |
| DYj(-2) | | | 1.95 | | | | | | | -1.98 | |
| | | | [1.13] | | | | | | | [-1.42] | |
| DYj(-3) | | | 6.21*** | | | | | | | | |
| | | | [3.78] | | | | | | | | |

Note: ***, ** and * represent significance level of 1%, 5% and 10%, respectively.
Source: Author's estimation

Upon reviewing the findings of the linear ARDL model (Table 3), it becomes evident that there is no significant impact from fluctuations in the real exchange rate on Sri Lanka's trade balance, neither in the short run nor in the long run. When analysing bilateral exchange rates and trade balances, notable correlations emerge in the short term for Germany, China, the USA, and the UK. However, these associations tend to dissipate over time, except for Germany, where the effects remain in the long run.

**Table 4: Long run and short run estimation results of the non-linear specification (NARDL)**

| | World | India | China | USA | Singapore | UK | Japan | Germany | Italy | Malaysia | Hong Kong |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long run estimations** | | | | | | | | | | | |
| Rex_P | 0.04 | 1.85*** | -1.30 | 1.87 | -5.82 | -0.24 | 0.32 | 2.26*** | 0.64 | -0.97 | -0.40 |
| | [0.32] | [3.02] | [-1.30] | [0.93] | [-1.17] | [-0.33] | [0.43] | [4.78] | [1.04] | [-0.61] | [-0.28] |
| Rex_N | 0.18** | 0.35 | -1.33 | 2.55 | -0.13 | -0.19 | 1.03 | 1.23*** | 0.71 | 0.03 | 0.23 |
| | [2.29] | [0.55] | [-0.89] | [1.17] | [-0.04] | [-0.39] | [1.48] | [3.93] | [1.04] | [0.02] | [0.13] |
| $Y^d$ | -5.49*** | 0.76 | 0.53 | -7.3 | -21.8 | 0.89 | -25.43*** | 1.73* | 2.24*** | -4.98* | -22.31** |
| | [4.31] | [-1.05] | [0.94] | [-1.19] | [-1.66] | [1.09] | [-3.40] | [1.90] | [2.86] | [-1.70] | [-2.22] |
| $Y^f$ | 0.02 | -1.10* | -6.38* | -4.19 | 7.05 | -1.06 | -4.11 | -1.65 | -1.67* | -1.65 | 4.18** |
| | [0.07] | [-1.99] | [-1.80] | [-1.19] | [1.36] | [-1.08] | [-1.30] | [-1.51] | [-1.73] | [-0.74] | [2.16] |
| **Short run estimations** | | | | | | | | | | | |
| Coint_Eq | -0.62*** | -0.62*** | -0.88*** | -0.87*** | -0.53*** | -1.14*** | -0.57*** | -1.08*** | -0.60*** | -0.54*** | -0.71*** |
| | [-6.79] | [-6.74] | [-7.08] | [-5.52] | [-4.69] | [-6.04] | [-6.29] | [-6.32] | [-6.85] | [-4.27] | [-4.16] |
| DRex_P | -0.08 | | 2.57* | 4.00** | -4.36 | 1.13 | | 2.76*** | 1.72** | | |
| | [-0.29] | | [1.90] | [2.46] | [-1.68] | [1.08] | | [3.74] | [2.65] | | |
| DRex_P(-1) | -0.1 | | | 1.05 | -5.31 | -0.34 | | -2.10** | 0.75 | | |
| | [-0.59] | | | [0.52] | [-1.05] | [-0.31] | | [-2.37] | [1.18] | | |
| DRex_P(-2) | -0.21 | | | -2.95 | 8.60* | 3.17*** | | -0.8 | 1.51** | | |
| | [-0.70] | | | [-1.51] | [1.74] | [3.06] | | [-1.01] | [2.24] | | |
| DRex_P(-3) | -0.03 | | | -5.36* | | -0.29 | | -2.55** | | | |
| | [-0.17] | | | [-1.88] | | [-0.20] | | [-2.22] | | | |
| DRex_N | -0.08 | | -5.62*** | 1.85 | 7.95 | -1.75* | | -1.59** | -1.10** | | |
| | [-0.25] | | [-3.37] | [0.54] | [1.67] | [-1.84] | | [-2.38] | [-2.04] | | |
| DRex_N(-1) | -0.21 | | | -3.14 | 10.88* | 1.19 | | 0.67 | -0.26 | | |
| | [-1.16] | | | [-0.84] | [1.99] | [1.26] | | [0.89] | [-0.44] | | |
| DRex_N(-2) | 1.09*** | | | 11.91*** | -12.51** | -1.92 | | -1.90** | -1.20*** | | |
| | [3.45] | | | [2.76] | [-2.25] | [-1.50] | | [-2.12] | [-2.88] | | |
| DRex_N(-3) | -0.68*** | | | 8.68** | | -2.64** | | 1.01 | | | |
| | [3.54] | | | [2.24] | | [-2.24] | | [-1.08] | | | |
| $DY^d$ | -1.48*** | 0.29 | 0.35 | 0.92 | -4.36 | | -4.03*** | | | | -0.4 |
| | [-5.23] | [0.85] | [0.41] | [0.70] | [-1.68] | | [-4.22] | | | | [-0.38] |
| $DY^d$(-1) | 2.31*** | 2.50*** | 0.44 | 3.92*** | | | 3.56* | | | | 12.00*** |
| | [4.42] | [4.17] | [0.36] | [3.01] | | | [1.94] | | | | [4.16] |
| $DY^d$(-2) | 0.85*** | 1.27*** | -1.7 | | | | 0.20 | | | | 6.76*** |
| | [3.12] | [3.00] | [-1.41] | | | | [0.14] | | | | [3.03] |
| $DY^d$(-3) | | | -1.43* | | | | -1.34 | | | | 2.63** |
| | | | [-1.78] | | | | [-1.58] | | | | [2.25] |
| DYj | 2.43*** | | -0.48 | 1.68 | | 0.95 | 4.05* | -0.49 | | -0.13 | -1.66 |
| | [3.91] | | [-0.31] | [0.53] | | [1.23] | [1.86] | [-0.48] | | [-.09] | [-0.64] |
| DYj(-1) | | | 4.33** | 11.70*** | | | | 3.51*** | | -3.26** | |
| | | | [2.51] | [3.34] | | | | [2.99] | | [-2.30] | |
| DYj(-2) | | | 2.20 | 7.87* | | | | 1.64 | | -2.17 | |
| | | | [1.32] | [1.99] | | | | [1.54] | | [-1.58] | |
| DYj(-3) | | | 6.44*** | | | | | 2.93*** | | | |
| | | | [3.90] | | | | | [2.73] | | | |
| DTB(-1) | -0.16 | | | -0.36*** | -0.24** | 0.20 | 0.25** | 0.26* | | -0.10 | -0.41** |
| | [-1.63] | | | [-2.82] | [2.10] | [1.09] | [2.20] | [1.85] | | [-0.68] | [-2.29] |
| DTB(-2) | | | | -0.22** | | -0.01 | 0.17 | 0.40*** | | -0.22* | -0.01 |
| | | | | [-2.09] | | [-0.05] | [1.46] | [3.30] | | [-1.90] | [-0.06] |
| DTB(-3) | | | | | | 0.26** | 0.46*** | | | | 0.19 |
| | | | | | | [2.19] | [3.69] | | | | [1.50] |

Note: ***, ** and * represent significance level of 1%, 5% and 10%, respectively.
Source: Author's estimation

The analysis of the non-linear models demonstrates a clear asymmetry in the impact of real exchange rate fluctuations on the trade balance. While there is no significant evidence supporting the hypothesis that real exchange rate depreciation enhances the overall trade balance, it is evident that real exchange rate appreciation positively affects the trade balance both in the short run and in the long run. This

underscores Sri Lanka's heavy reliance on imported intermediate goods and raw materials for production and exports. Consequently, while real depreciation may enhance the competitiveness of domestic producers, this advantage could be offset by rising import prices. On the other hand, when the exchange rate appreciates, it can lower the prices of imported raw materials and intermediate goods, which might help improve the trade balance to some extent. These findings are further examined by analysing bilateral real exchange rates and trade balances of the ten selected countries. The non-linear specifications of these countries highlight the asymmetric effects of exchange rate changes on bilateral trade balances with Sri Lanka. In most cases, changes in bilateral real exchange rates significantly influence respective trade balances in the short term, except for Germany and India. Specifically, significant coefficients for either real exchange rate depreciation (POS) or appreciation (NEG) are observed in the short term for Germany, the USA, China, Singapore, the UK, and Italy. This impact persists in the long run only in the case of Germany. Meanwhile, for India, a significant relationship between exchange rate movements and the trade balance is only found in the long run. Nevertheless, three out of ten trading partners, i.e., Japan, Malaysia, and Hong Kong, yield no significant evidence to support the hypothesis explaining the link between exchange rate changes and the trade balance under either linear or non-linear models. Therefore, the remainder of the analysis mainly focuses on the seven trading partners of Sri Lanka that exhibit some form of relationship between real exchange rate changes and the trade balance in either the linear or non-linear models.

India stands as a prominent trading partner for Sri Lanka, contributing to 17 percent of total trade. According to linear model estimates, the bilateral real exchange rate exhibits no significant short run or long run effects on the trade balance. However, non-linear specifications indicate that the depreciation of the real exchange rate notably boosts the India-Sri Lanka trade balance in the long run. Conversely, real appreciation shows no significant impact, indicating an asymmetric effect of bilateral real exchange rate fluctuations on the trade balance between India and Sri Lanka.

China ranks as Sri Lanka's second largest trading partner. However, neither the linear nor the non-linear specifications support the existence of a link between the exchange rate and the trade balance in the long run. Nevertheless, both models indicate a significant impact of the real exchange rate on the bilateral trade balance in the short run. Further, evidence from the NARDL suggests that real exchange rate depreciation has a notably positive effect on the China-Sri Lanka trade balance, while real exchange rate appreciation exerts a significantly negative and comparatively larger impact on the bilateral trade balance in the short run.

Although long run estimates indicate no significant impact of the bilateral real exchange rate on the trade balance between the USA and Sri Lanka, short run specifications reveal that real exchange rate depreciation significantly influences the trade balance. Specifically, in the short run, real exchange rate depreciation bolsters the trade balance, while real appreciation weakens it. Even though the impact of depreciation is slightly larger than that of real exchange rate appreciation, the symmetry test failed to confirm the asymmetric impact of changes in the bilateral real exchange rate on the Sri Lanka trade balance.

The bilateral real exchange rate also affects the Singapore-Sri Lanka trade balance in the short run, as indicated by the results of the non-linear specification. However, contrary to previous findings, it is observed that real exchange rate appreciation significantly boosts the trade balance, while real exchange

rate depreciation has a notable negative impact. This distinction may be attributed to the inelastic nature of imports to Sri Lanka from Singapore. Approximately 60 percent of imports from Singapore consist of petroleum products, which remain insensitive to price changes under any circumstance. Consequently, currency depreciation could worsen the Singapore-Sri Lanka trade balance, whereas currency appreciation would enhance it.

Germany, Sri Lanka's fourth largest export destination, stands out as the sole country demonstrating a significant relationship between the bilateral exchange rate and the trade balance, evident in both short run and long run scenarios, and under both linear and non-linear specifications. Consequently, fluctuations in the bilateral real exchange rate positively impact on the trade balance, with currency depreciation exerting a larger influence than appreciation. This observed asymmetry may be attributed to the nature of the traded goods between the two countries.

The findings also indicate a significant relationship between the real exchange rate and the UK-Sri Lanka trade balance in the short run, as evidenced by the non-linear specification. According to the analysis, real exchange rate appreciation would unfavorably affect the UK-Sri Lanka trade balance in the short run, while real exchange rate depreciation would yield a positive impact. Furthermore, the results unveil the presence of asymmetric effects stemming from real exchange rate fluctuations on bilateral trade balances between Italy and Sri Lanka.

These models also uncover additional significant features. It is evident that the impact of Sri Lankan income on the trade balance is negative, as anticipated. However, when examining each bilateral trade balance, negative relationships are observed in the models pertaining to Japan, Malaysia, and Hong Kong, while contrasting results are noted in the case of Italy. The relationship between trading partners' income and the trade balance presents mixed outcomes. Specifically, the models concerning India, China, and Italy reveal significant negative relationships between each country's income and the respective trade balances, whereas for Italy, the link between trading partners' income and the trade balance is found to be positive.

## 6. Conclusion

The link between exchange rate fluctuations and the trade balance carries significant implications for an economy, particularly for small open economies like Sri Lanka. Despite numerous studies in the literature investigating this issue, findings have often been ambiguous. Against this backdrop, this paper aims to provide new insights into the relationship between exchange rate fluctuations and the trade balance, employing a non-linear modeling technique. This approach enables the identification of any asymmetry between the effects of currency depreciation and appreciation on the trade balance.

To investigate the impact of real exchange rate fluctuations on the trade balance in Sri Lanka and its ten major trading partners, this paper employs both linear and non-linear models using quarterly data spanning from 2007 to 2022. The findings lend support to the hypothesis favoring non-linear models over linear ones for a deeper understanding of the link between exchange rate fluctuations and the trade balance. The results reveal a long run enhancement of Sri Lanka's trade balance following real exchange rate depreciation in the cases of Germany and India. In the short run, a significant improvement (or deterioration) of the bilateral trade balance is observed following real exchange rate depreciation (or appreciation) in the cases of the USA, UK, China, Germany, and Italy. Additionally,

the results confirm the presence of asymmetry between the effects of currency appreciation and depreciation on the trade balance. However, the three trading partners do not provide evidence to support the hypothesis explaining the significant link between currency fluctuations and the trade balance under either linear or non-linear specifications.

In sum, the impact of currency fluctuation on trade balance, in the context of Sri Lanka, is more prevalent in this study than has been found in previous studies which used linear specifications. Results relating to some countries provide support for the conventional wisdom of exchange rate theory, implying that the long run effect of a real depreciation has been positive in the long run. Further, it is found that countries have different reactions to real exchange rate depreciation as compared to real exchange rate appreciation supporting the asymmetric effect.

Nevertheless, the mixed empirical results suggest that there exists no single pattern of real exchange rate-trade balance relationship between countries mainly due to the structure of the goods that are traded between countries. In line with these results, it is evident that the exchange rate policy alone has limited capacity to enhance the overall trade balance. Therefore, adopting a comprehensive policy package aimed at ensuring Sri Lanka's global competitiveness is imperative to address the multifaceted nature of trade dynamics. Such a policy package should include measures to diversify export products, improve trade infrastructure, strengthen trade relationships, enhance productivity, and foster innovation. Additionally, it should implement supportive macroeconomic policies to create a stable economic environment conducive to sustainable trade growth.

In this study, our analysis is confined to Sri Lanka's top ten trading partners in its external trade. While these partners represent a significant share of the country's international trade, they may not fully capture the complexity of global trade dynamics. This limitation could potentially overlook crucial indirect effects or dependencies on other countries or regions. To address this, future research could expand the scope by including a broader range of trading partners for a more comprehensive analysis.

Moreover, it is important to acknowledge that different industries may react differently to exchange rate fluctuations. While detailed product-level data could offer valuable insights, obtaining and processing such data presents resource-intensive challenges. Besides, this study focuses on a limited set of variables, namely real GDP and bilateral real exchange rate, without taking into account of other potentially influential factors such as political stability or non-tariff barriers. Additionally, changes in monetary and fiscal policies throughout the study period may have influenced the trade balance independently of exchange rate fluctuations. Future studies could address this by considering a wider array of factors and their impacts on trade dynamics.

Furthermore, this analysis does not differentiate between various exchange rate regimes in Sri Lanka, which could affect trade dynamics differently. Exploring these differences could provide deeper insights into the relationship between exchange rate fluctuations and trade balances.

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## Appendices

**Table A.1: Time series properties of the data**

| Trade Partner | ADFH0 : Xt ~ I(1) H0 : Xt ~I(0) With trend | | | | ADFH0 : Xt ~ I(1) H0 : Xt ~I(0) First difference | | | |
|---|---|---|---|---|---|---|---|---|
| | TB | Rex | $Y^d$ | $Y^i$ | TB | Rex | $Y^d$ | $Y^i$ |
| World | -4.12*** | -2.48 | -14.91*** | 0.94 | -7.15*** | -5.87*** | -10.88*** | -4.83*** |
| India | -4.91*** | -3.02 | -14.91*** | -2.81 | -7.13*** | -6.31*** | -10.88*** | -13.30*** |
| China | -7.31*** | -4.22*** | -14.91*** | -4.58*** | -9.28*** | -9.68*** | -10.88*** | -10.98*** |
| USA | -3.30* | -2.38 | -14.91*** | -3.75** | -8.81*** | -6.52*** | -10.88*** | -19.73*** |
| Singapore | -6.48*** | -2.99 | -14.91*** | -3.25* | -12.68*** | -9.01*** | -10.87*** | -9.27*** |
| UK | -6.19*** | -2.84 | -14.91*** | -4.26*** | -6.80*** | -6.42*** | -10.88*** | -9.22*** |
| Japan | -1.67 | -2.07 | -14.91*** | -3.14 | -7.74*** | -6.25*** | -10.88*** | -4.51*** |
| Germany | -3.68** | -2.25 | -14.91*** | -2.79 | -8.20*** | -7.99*** | -10.87*** | -7.55*** |
| Italy | -2.64 | -2.32 | -14.91*** | -3.37* | -14.39*** | -7.76*** | -10.87*** | -3.67** |
| Malaysia | -1.94 | -2.67 | -14.91*** | -2.70 | -8.22*** | -8.67*** | -10.87*** | -8.38*** |
| Hong Kong | -6.26*** | -3.58** | -14.91*** | -0.15 | -7.21*** | -9.34*** | -10.87*** | -3.37* |

Note: ***, **, and * represent significant level of 1%, 5% and 10%, respectively.

Source: Author's estimation

**Table A.2: Results of the bounds tests for cointegration**

| Trade Partner | F-Statistic |
|---|---|
| World | 8.31*** |
| India | 7.86*** |
| China | 9.19*** |
| USA | 12.986*** |
| Singapore | 4.02*** |
| UK | 6.59*** |
| Japan | 7.22*** |
| Germany | 7.17*** |
| Italy | 8.60*** |
| Malaysia | 4.54*** |
| Hong Kong | 3.03*** |

Notes: ***, **, * indicates significance at 1%, 5%, and 10%, respectively.
Critical values for 60 observations at 1%, 5%, and 10% significance levels are 5.676, 4.314 1, and 3.712, respectively.

# Predicting Exchange Rate Changes in Sri Lanka Using the LSTM-based Deep Neural Network Model

R H Nayomi Geethanjali Ranamuka [1]

**Abstract**

The exchange rate is a significant macroeconomic variable reflecting a country's economic position and directly impacts the economic condition through its fluctuations. Therefore, improved prediction of exchange rates would be immensely valuable for key economic stakeholders to make the right decisions on economic activities. Therefore, accurate exchange rate prediction is crucial for policymakers, especially for decision making based on economic forecasts.

Various macroeconomic and global market factors contribute to fluctuations in the exchange rate, while political, economic, and social sentiments can also influence its movements. Therefore, accurate prediction of exchange rates is widely acknowledged as a challenging task. This study identifies the most appropriate macroeconomic variables and global market factors for exchange rate prediction in Sri Lanka, including oil price, Dow Jones Industrial Average (DJIA) stock market index, interest rates, and secondary market treasury bill rates. In addition, this study considers public sentiment through news headlines to understand the impact of socioeconomic and political factors on exchange rate fluctuations. Input sequences for the deep learning model were generated from text features extracted from Tweets related to the foreign exchange market and the most appropriate macroeconomic and global market factors for exchange rate prediction in Sri Lanka.

This paper suggests a Long Short Term Memory (LSTM)-based Deep Neutral Network (DNN) model to predict the exchange rate, incorporating macroeconomic and global market factors with financial sentiments. The Mean Absolute Percentage Error (MAPE) value achieved for the model is 0.6693%.

**Key Words:** *Exchange rates, LSTM, Keras, Deep Learning, Machine learning, Text Analytics*

[1] The views presented in this paper are those of the author and do not necessarily indicate the views of the Central Bank of Sri Lanka

## 1. Introduction

The exchange rate is a crucial indicator in open economies that reflects the country's economic condition. It represents the price of one currency in relation to another currency. Due to economic globalisation, the foreign exchange market has expanded significantly. Further, exchange rate fluctuations directly affect the decisions of policymakers, entrepreneurs, and investors. Due to the exchange rate's high volatility, policymakers must predict the exchange rate accurately to make the necessary decisions to enhance the country's economic condition.

The complicated and volatile nature of the foreign exchange market makes exchange rate prediction difficult. According to Yasir et al. (2019), macroeconomic and volatile global market variables affect exchange rate fluctuations. In addition, Xing et al. (2021) confirm the predictive power of high-frequency news sentiment for exchange rate prediction. Meanwhile, machine learning and deep learning techniques have been successful in the field of finance. Thus, various researchers have used them to predict the exchange rate.

Moreover, since numeric factors with public sentiment collectively affect exchange rate fluctuation, it is necessary to incorporate machine learning techniques to predict the exchange rate more accurately with numeric and text features. This study proposes a novel hybrid model to predict the exchange rate in Sri Lanka. It incorporates macroeconomic and global market factors such as crude oil and gold prices and political sentiment derived from public opinion data. This study examines text analytics and deep learning techniques to improve the accuracy of exchange rate predictions.

## 2. Literature Review

### 2.1 Introduction

The exchange rate is one of the most important economic variables that reflects the economy in the long run, especially for export-oriented countries (Chang & Chien, 2017). Exchange rate prediction is significant for decision making parties such as policymakers, bankers, and investors (Henríquez & Kristjanpoller, 2019). It is a very complicated and challenging task since the foreign exchange market is a multivariable non-linear system (Shen et al., 2015). Yasir et al. (2019) claim that the exchange rate is affected by several factors, including socioeconomic and political factors. In addition, they emphasise the importance of an accurate exchange rate prediction mechanism. Therefore, as claimed in the above cited literature, forecasting exchange rates is a challenging task that should be performed accurately to make right decisions.

### 2.2 Exchange rate forecasting in Sri Lanka

The managed float exchange rate regime was introduced in Sri Lanka in November 1977 (Weerasinghe, 2018). Several studies have been conducted to identify the behaviour of exchange rates in Sri Lanka. Jayasuriya and Perera (2016) have identified that the net foreign assets, trade balance, and workers' remittance can be used to predict the exchange rate successfully. The exchange rate has a relationship between inflation, interest rate, remittances, terms of trade, and foreign purchases (Rajakaruna, 2017). Nanayakkara et al. (2014) claimed that Artificial Neural Network has performed better than the GARCH model for forecasting the exchange rate with higher accuracy. Nanthakumaran and Tilakaratne (2018) have introduced a hybrid model using empirical mode decomposition (EMD) and feedforward

neural networks (FNN). According to the above-cited literature, the exchange rate in Sri Lanka can be predicted by macroeconomic variables such as inflation, interest rate remittances, etc.

### 2.3 Use of macroeconomic variables and global market factors to predict the exchange rate in other countries

Numerous studies have examined the factors influencing exchange rate movements in various countries. A study about Pakistan identified current balance, inflation, and Foreign Direct Investment as negatively correlated with the exchange rate, while GDP is positively correlated (Mohsin et al., 2018). Further, Malaysian research shows that commodity prices affect exchange rates. Meanwhile, prices of crude oil, palm oil, rubber, and gold have been found to influence fluctuations in exchange rates (Ramakrishnan et al., 2017; Mensah et al., 2017). In addition, Yasir et al. (2019) emphasise the use of oil and gold prices for exchange rate prediction.

### 2.4 Use of text analytics to predict exchange rate

As suggested by Khadjeh Nassirtoussi et al. (2015), Jin et al. (2013), Chen et al. (2019), and Yono et al. (2019), unstructured textual information in the news, forums, social media, and tweets have been used to determine economic sentiment index for several economic research areas including sentiment analysis for exchange rate prediction and stock market prediction. Accordingly, it is evident that public opinions that derive from unstructured textual information can influence the direction of the foreign exchange market based on the public's financial activities.

Natural language processing, text analysis, and computational linguistic techniques are used to conduct the sentiment analysis using unstructured textual information (Komariah et al., 2016). Mainly, two primary methods exist for conducting sentiment analysis based on supervised and unsupervised algorithms.

*A lexicon-based approach* is an unsupervised approach that uses positive and negative opinion words such as "good", "amazing", "worse", and "lose", which express the polarity of the sentiment for deriving the sentiment score for a sentence or phrase. There are three main lexicon based approaches: manual, dictionary based, and corpus based. The manual approach is known as a very time-consuming method (Shuhidan et al., 2018). There are some drawbacks associated with the lexicon based approach. The effectiveness of the lexicon based approach highly depends on the lexical resource. In addition, a huge disadvantage is the inability to determine the sentiment value of a word when it has several meanings based on its use and context. Seifollahi and Shajari (2018) have obtained 91.67% accuracy in predicting price movements in the FOREX market using an improved Word Sense Disambiguation (WSD) method.

The supervised learning approach uses a training dataset and its corresponding output values to predict the sentiment polarity. The algorithm has enhanced predictive accuracy for specific domains regarding unknown data. According to Kirchner (2019), the supervised learning approach has outperformed the lexicon based method. Naive Bayes Classification, Support Vector Machines (SVM), and Maximum Entropy (ME) are widely used supervised learning algorithms.

Yasar and Kilimci (2020) developed a powerful method to predict the US Dollar/Turkish Lira exchange rate by combining financial sentiment and time series analyses. They used separate models for analysing

financial sentiment and time series, and then combined them for prediction. Word embeddings (including Word2Vec, GloVe, and fastText) and deep learning models (CNN, RNN, and LSTM) were used for sentiment analysis. The combination of LSTM and GloVe word embeddings achieved the highest performance in the study

### 2.5 Exchange rate forecasting using machine learning and deep learning techniques

Numerous studies have explored using machine learning and deep learning techniques to predict exchange rates. Dautel et al. (2020) have found that LSTM and GRU algorithms offer the best predictions for exchange rates compared to other deep learning models tested in their study. It emphasises the potential of LSTM for accurate exchange rate forecasting. Meanwhile, Samarawickrama and Fernando (2019) found that Multivariate Regression, SRNN, and LSTM have outperformed the other GRU and CNN models in multi-step exchange rate prediction. They have shown the potential of applying deep learning techniques for accurate exchange rate forecasting. Moreover, Ranjith et al. (2018) have identified the LSTM as the most effective model compared to SRNN and GRU models.

## 3. Methodology

Table 1 presents input data identified by a combined analysis of literature and industry expert interviews. The data set for this study was gathered from 01 January 2014 to 15 December 2020.

**Table 1: Details of input data for the study**

| Data | | Description |
|---|---|---|
| **Numeric Data** | | |
| Indicative US Dollar SPOT Exchange rate | | The weighted average rate of USD/LKR SPOT transactions conducted in the previous business day |
| **Global market factors** | Oil price | Global production of crude oil data |
| | Gold price | Daily gold price |
| | Dow Jones Industrial Average (DJIA) Index | DJIA is a stock market index that representing the performance of companies registered under the stock exchange in the United States. |
| | USA Treasury Bill Rates | Following USA treasury bill rates were considered for the study.<br>▪ USA Treasury Bill Rate BD 4 weeks<br>▪ USA Treasury Bill Rate CE 4 weeks<br>▪ USA Treasury Bill Rate BD13 weeks<br>▪ USA Treasury Bill Rate CE 13 weeks<br>▪ USA Treasury Bill Rate BD26 weeks<br>▪ USA Treasury Bill Rate CE 26 weeks<br>▪ USA Treasury Bill Rate BD52 weeks |
| **Macro-economic factors** | Interest rates | The following interest rates in Sri Lanka, which directly involve the Sri Lankan monetary policy, were considered for the study.<br>▪ Average Weighted Call Money Rate<br>▪ Inter-Bank Call Weighted Average Rate<br>▪ Market Repo Weighted Average Rate |
| | Sri Lanka Secondary Market Treasury Bill Rate | Following Sri Lankan, secondary market treasury bill rates were considered for the study.<br>▪ Secondary Market Yield Rate – 091 days<br>▪ Secondary Market Yield Rate – 182 days<br>▪ Secondary Market Yield Rate – 364days |
| **Text Data** | | |
| **News headlines** | | Tweets of Bloomberg tweet account |

### 3.1 Pre-processing tweet data set

Several key steps are associated with the tweet-text preprocessing task such as removing empty values, HTML tags, URLs, user mentions, and special characters, lowercasing all text, and expanding contractions. These preprocessing steps are essential for preparing the data for further analysis and natural language processing tasks. In addition, empty and duplicate tweets were removed to ensure data quality. The most relevant tweets for the financial domain were identified using a pre-trained language model called FinBert (Araci, 2019). Each tweet was classified as positive, negative, or neutral. Then, each day's positive and negative tweets were concatenated to acquire the most relevant financial text. In addition, lemmatization and stop word-removing processes were employed to concatenated text of tweets before getting text features. Further, if the previous business day were a holiday, then the text features of the holiday were also concatenated with the text features of the considering day.

### 3.2 Preprocessing numeric data set

This study aims to forecast the exchange rate in Sri Lanka for only Sri Lankan business days. The Last Observation Carried Forward (LOCF) method was employed to address the missing values of global market factors. Data normalisation was implemented to standardise the range because of the variations in scales of numerical variables. The Minmax scaler method converted each variable into a standardized range between 0 and 1. The formula of the Minmax scaler is as follows:

$$MinMaxScaler(x_i) = \frac{x_i - \min(x)}{\max(x) - \min(x)} \quad (1)$$

### 3.3 Identify the most effective factors for exchange rate prediction

The Granger causality test, a statistical method for analysing the potential causal relationships between financial time series, was employed in this study. The purpose of applying this test is to identify the financial series that can effectively contribute to predicting the exchange rate. Due to the non-stationary nature of the time series variables, logarithmic transformations were employed prior to applying the Granger causality test. It was conducted for fifteen lags, and lag three produced the best results.

The null hypothesis was rejected for probabilities below the significance level of 0.05. The macroeconomic and global financial variables in Table 2 cause exchange rate values for lag 3. Therefore, these variables and the previous day's exchange rate offer potential for predicting future exchange rates.

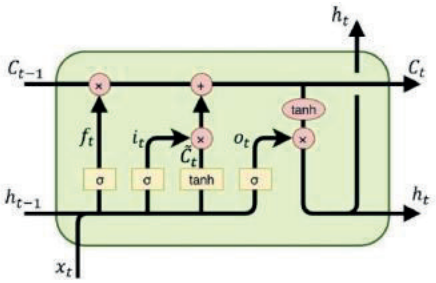
**Table 2: Most suitable variables to predict the exchange rate**

| **Macroeconomic and global factors** | |
|---|---|
| Oil price | |
| DJIA stock market index | |
| Interest rates | Average weighted call money rate |
| | Inter-Bank Call Weighted Average Rate |
| | Market Repo Weighted Average Rate |
| Secondary market Treasury Bill rates | Secondary Market Yield Rate – 182 days |
| | Secondary Market Yield Rate – 364 days |

### 3.4 Long Short Term Memory (LSTM) architecture

LSTM was created as a solution to the vanishing gradient problem that exists with the RNN (Hochreiter & Schmidhuber, 1997). It can capture the long term dependencies in long sequences without suffering optimisation. It is mostly used for the sequential data domains. As per Fischer and Krauss's (2018) study, LSTM has outperformed statistical models.

**Figure 1: LSTM cell**




The LSTM cell is composed of three main gates such as input gate($i_t$), output gate ($o_t$), and forget gate($f_t$). These three gates connect to the cell state $C_t$ as depicted in Figure 1. Cell state is updated by the input gate using the current input value. Subsequently, the concatenated value of the input and the output of the hidden state is processed by the tanh activation function.

Further, the sigmoid function is applied to the input. Pointwise multiplication is applied for the output values of tanh and sigmoid functions (Hassanien et al., 2018). Forget gate determines the information which should be eliminated. The hidden state for the next input is determined by the output gate. The equations related to the LSTM cell are as follows:

$$i_t = \sigma(W_i .[h_{t-1}, x_t] + b_i) \quad (2)$$

$$f_t = \sigma(W_f .[h_{t-1}, x_t] + b_f) \quad (3)$$

$$o_t = \sigma(W o .[h_{t-1}, x_t] + b_o) \quad (4)$$

$$\tilde{C}_t = tanh(W_c .[h_{t-1}, x_t] + b_c) \quad (5)$$

$$C_t = f_t * C_{t-1} + i_t * \tilde{C}_t \quad (6)$$

$$h_t = o_t * \tanh(C_t) \quad (7)$$

where $i_t$ represents input gates, $f_t$ represents forget gate, $o_t$ represents output gates, $C_t$ represents cell state at time step t, $\tilde{C}_t$ represents a candidate for cell state at time step t and $h_t$ represents hidden state vector.

### 3.5 Create Deep Neural Network (DNN) model using Keras

Keras is a deep learning API that runs on top of the TensorFlow machine learning platform. It provides an interface for addressing research issues effectively. Keras consists of two main model creation methods: the sequential API and the functional API. Functional API facilitates the creation of complex models with multiple inputs and outputs or shared layers without having a sequential layering scheme.

The inputs for the deep learning model in this study consist of text and numeric values. Keras Functional API is well suited for handling multiple inputs in the deep learning model to accommodate these distinct input categories. Therefore, Keras Functional API was used in this research to develop the deep learning model.

### 3.6 Implementation of the LSTM-based Deep Neural Network (DNN) model

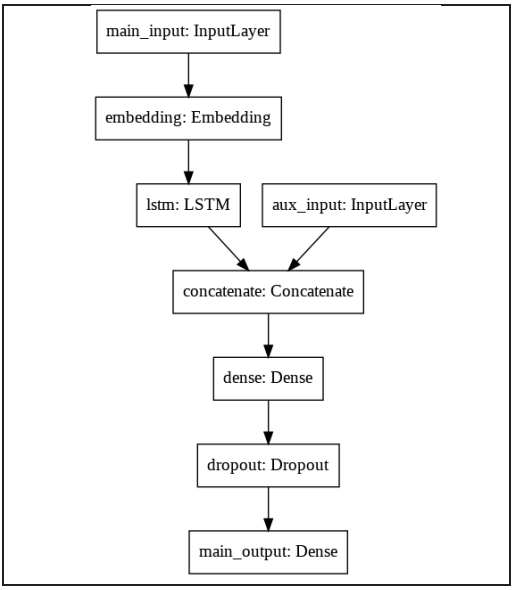
This study employed the GloVe model, a standard pre-trained word embedding model, and 100-dimensional word embedding of tweets were used. The dataset was divided into training/validation (80%) and testing (20%) sets. The training/validation set was further divided into 80% for training and 20% for validation. Keras Functional API was employed to construct an LSTM-based deep neural network model. Hyperparameter optimisation was conducted to identify the best parameters for the model. Table 3 includes the best parameters for the model.

**Table 3: Best parameters identified through the hyper-parameter training process**

| Parameter Name | LSTM based DNN Model |
|---|---|
| lstm/gru | 150 |
| first_activation | Linear |
| main_activation | Linear |
| first_neuron | 150 |
| drop_out | 0.01 |
| batch_size | 32 |

The main input of the model was an input sequence derived from tweet text features. The LSTM- based deep neural network will process it through the created embedding layer. In addition, numerical variables were provided as the auxiliary input for the model, as depicted in Figure 2. Afterward, the output of the LSTM deep neural network was combined with the auxiliary input, and a deep, densely connected network was stacked onto the top of the created layers. The exchange rate for the next three days was the main output of the model.

**Figure 2: LSTM based model architecture**




## 4. Evaluation measures

**Mean Squared Error (MSE)**

MSE is used to measure the average squared difference between predicted values and observed values. MSE is measured by

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(x_i - \hat{x}_i)^2 \tag{8}$$

where $x_i$ are the observations, $\hat{x}_i$ are predicted values and n is the number of observations.

**Root Mean Square Error (RMSE)**

RMSE is used to measure the difference between predicted values and observed values. The standard deviation of the residuals is represented by RMSE. RMSE is measured by

$$RMSE = \sqrt{\frac{\sum_{i-1}^{N}(x_i - \hat{x}_i)^2}{N}} \tag{9}$$

where $x_i$ are the observations, $\hat{x}_i$ are predicted values and N is the number of observations.

**Mean Absolute Error (MAE)**

MAE represents the average value of all absolute errors. MAE is measured by

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|x_i - \hat{x}_i| \tag{10}$$

where $x_i$ are the observations, $\hat{x}_i$ are predicted values and N is the number of observations. It indicates the error that we can expect from the prediction process.

**R-Squared**

It represents the proportion of the variance in the dependent variable. Moreover, it measures the strength of the dependent variable and the model using 0 to 1 scale. R-squared is measured by

$$R^2 = 1 - \frac{RSS}{TSS} \tag{11}$$

where RSS is the sum of squares of residuals and TSS is the total sum of squares. The closer to 1 indicates that the dependent variable is predicted accurately.

**Mean Absolute Percentage Error (MAPE)**

It is used as a loss function for regression problems specially in machine learning. MAPE is measured by

$$M = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{x_i - \hat{x}_i}{x_i}\right| \tag{12}$$

where $x_i$ are the observations, $\hat{x}_i$ are predicted values and n is the number of observations.

## 5. Results

**Table 4: Model accuracy**

| Measurement | LSTM based DNN |
|---|---|
| Root Mean Squared Error (RMSE) | 1.8002 |
| Mean Squared Error (MSE) | 3.2406 |
| Mean Absolute Error (MAE) | 1.2405 |
| Mean Absolute Percentage Error (MAPE) | 0.6693% |
| R-squared Value (r_score) | 0.74047 |

Table 4 provides the testing accuracy received for the LSTM-based DNN model. The LSTM-based DNN model was implemented as per the parameters obtained from the grid search function, which was conducted for the hyperparameter optimization process. As per the results shown in Table 4, r_squared value is 74.047%. Therefore, it ensures that the model correctly fits the data to predict the exchange rate. As per the values of RMSE, MSE, MAE, MAPE, and r_score, the LSTM-based DNN model has achieved an acceptable level of accuracy in predicting the exchange rate.

**Figure 3: Training/Validation loss curves for LSTM based DNN model**

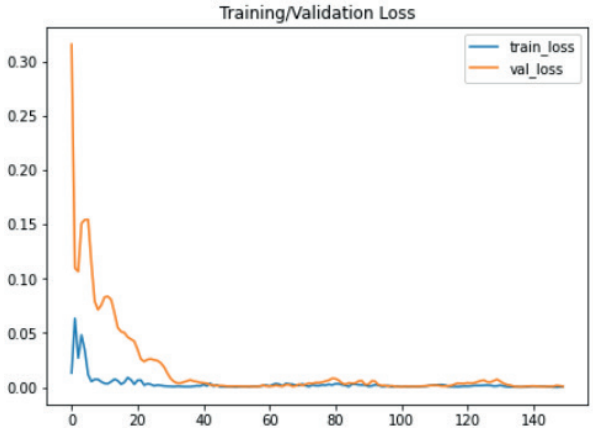



Figure 3 shows the training validation loss curves for the LSTM-based DNN model which ensures the right fitting of the model.

## 6. Conclusion

Due to the high volatility nature of exchange rate movements, it is a very challenging task to predict exchange rates accurately. Several studies have been conducted to predict the exchange rate in Sri Lanka using macroeconomic variables. However, according to existing literature, financial sentiment factors have not been considered for the exchange rate prediction in Sri Lanka. Therefore, this study proposes a novel hybrid model by integrating highly influential macroeconomic and volatile factors with financial sentiments to predict the exchange rate more accurately. Thus, it is a significant contribution to the field of financial economics. Furthermore, the proposed hybrid model incorporates the most appropriate factors for exchange rate forecasting in Sri Lanka. Another specialty associated with this study is extracting the most relevant news headlines for the financial domain to obtain the text features for the DNN model. To gain a deeper understanding of financial sentiment's impact on exchange rates, this study has incorporated text features in addition to numerical sentiment factors.

Furthermore, expanding the research to consider other exchange rates in addition to the USD/LKR rate will be more beneficial. This study has used a single source for news headlines, and it would be more helpful to consider the multiple data sources related to the foreign exchange market. In addition to the current LSTM-based DNN model, exploring alternative architectures, such as GRU, CNN, TCN, and Bidirectional LSTM, would be advantageous to obtain more accurate results.

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# Does Anti-Money Laundering and Countering the Financing of Terrorism Drive the Economic Growth of Emerging Economies?

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**Abstract**

This paper examines the impact of the Anti-Money Laundering and Countering the Financing of Terrorism (AML/CFT) regime on the economic performance of emerging economies. This study uses a panel dataset of 44 emerging economies and constitutes of four economic variables, namely, the GDP growth rate, Basel AML Index, annual growth rate of exports of goods and services, and annual growth rate of gross capital formation, for the 10-year period from 2012 to 2021. The Panel Dynamic Ordinary Least Squares technique is used to estimate the impact of selected economic variables on the economic performance of emerging economies. The findings reveal that the Basel AML Index has a negative yet insignificant relationship with the GDP growth, whereas the annual growth rates of exports of goods and services and gross capital formation have a positive and significant association with the GDP growth rate of emerging economies. The lack of indicators to measure and reflect the status of AML/CFT regimes of countries, and the limited sample, as the BASEL AML Index being relatively new, are the major limitations faced during the study. In the meantime, money laundering and terrorist financing may take a relatively long time to create real repercussions in the economy. Therefore, a sample with a longer timeframe, and additional variables can be considered in future studies about this area.

**Key Words***: Money laundering, terrorist financing, panel data, economic performance, emerging economies*

**JEL Classification**: *C2, C10, C43, C81, C82, C83, D12, E31, R21, R30, R31*

[1] The views presented in this paper are those of the author and do not necessarily indicate the views of the Central Bank of Sri Lanka

## 1. Introduction

Drivers of growth have attracted much research interest but with less attention to money laundering and terrorist financing, which is widely regarded as a stumbling block to growth prospects. While economies have been striving to upgrade to robust financial systems, money laundering and terrorist financing have increasingly become a significant risk due to greater economic openness to international capital markets and resultant loss of integrity and soundness of these financial systems. Evidence suggests that money laundering and terrorist financing give rise to severe consequences to countries both in the short run and long run by way of a tarnished reputation, increased corruption, deteriorated economic performance, loss of government revenue, undermined legitimate economic activities, depleted integrity of financial markets, unbearable income inequality, and economic instability (McDowell & Novis, 2001).

Several global institutions have attempted to quantify the amount of money laundered in the world economy to assess its gravity and the extent of its negativity on the performance of economies. The United Nations Office on Drugs and Crime (2011) estimates the amount of money laundered globally in a year to be circa 2 per cent to 5 per cent of global GDP which is equivalent to around US dollars 800 billion to US dollars 2 trillion. The Committee of Experts on the Evaluation of Anti-Money Laundering Measures and the Financing of Terrorism (2020) also estimates that the money laundered worldwide annually ranges between US dollars 500 billion to US dollars one trillion, on average. Further, statistics of the amount of money laundered globally varies among different sources as well (Raol, 2022). An overview of the global context shows surprising statistics, such as around 90 per cent of the money laundering activities are undetected per year, 48 per cent of banks use outdated technology that prevent meeting of AML/CFT compliance, fiat currency instead of cryptocurrencies are used 400 times more in money laundering and only 0.1 per cent of the total laundered money is recovered by AML investigations (Marley, 2023). The year 2019 marked several milestones in AML/CFT areas where around 60.5 percent of fines imposed on banks, which amounted to around US dollars 10 billion, were due to non-compliance with anti-money laundering laws. Conviction statistics showed that 91.1 percent of those accused of money laundering were subject to imprisonment. Further, evidence for 2021 indicates that the number of institutions fined has increased while the fined amounts have relatively reduced when compared to 2020 (AML Fines 2021).

Adaptation of the latest technology and streamlined knowledge about AML/CFT laws have been identified as vital for banks to mitigate the exposure to risks of money laundering and terrorist financing schemes and to avoid the resulting penalties and fines (AML Fines 2021). Scrutiny of statistics and extensive studies about money laundering and terrorist financing have revealed several trends where the use of cryptocurrencies such as bitcoins and the application of identity theft in these schemes are presently on the rise (Cipher Trace , 2018).

There is no consensus on a positive or negative association between money laundering, terrorist financing, and economic growth. The adverse effects of money laundering and terrorist financing as a global risk seem to be higher in emerging economies over developed economies due to the fragility of financial systems, bureaucracy, relatively low resilience, and vulnerabilities towards market shocks (Effects of Money Laundering on Development, 2022). The absence of proper AML/CFT regimes will force emerging economies to sacrifice rapid economic growth trajectories and licit investment opportunities. Yet, money laundering and terrorist financing induce people towards easy money-making and lucrative profits (Lilley, 2000). Surprisingly, money laundering may yield favourable results in economic activities especially in the short run (Stancu and Rece, 2009),

in the event the laundered money is invested in consumption and investment of countries. Nevertheless, the repercussions at each stage of money laundering and terrorist financing may lead to economic and social setbacks demanding a dire need for strict AML/CFT rules and regulations in place.

Against this backdrop, this research observes how AML/CFT regimes have contributed to the growth trajectories of emerging economies using a panel data analysis. This research appears to be the first attempt to study the impact of strengthening the AML/CFT regime on economic performance of emerging economies[2]. The structure of the paper consists of five sections, including Section 1, the introduction. Section 2 reviews the literature on money laundering, terrorist financing, and its impact on economies. Section 3 outlines the theoretical framework for conducting the research, and Section 4 presents the empirical findings. Finally, Section 5 concludes the study with a policy decision, a few limitations, and suggestions for further research.

## 2. Literature Review

### 2.1 Money laundering and terrorist financing in the modern world

Numerous global institutions interpret money laundering and terrorist financing in diverse ways. The Financial Action Task Force (2022) defines money laundering as the conversion of criminal proceeds to conceal the illegal origin which could occur in any part of the world, mainly in countries with weak AML regimes. The European Commission (2022) identifies money laundering as a complex process designed to cleanse unlawful activities undertaken to generate funds from illegal sources. At the same time, Interpol (2022) defines money laundering as disguising the origins of illegally earned proceeds to make them appear to have originated from legitimate sources. Regarding terrorist financing, the United Nations Office on Drugs and Crime (2022) identifies terrorist financing as any act encompassing various ways and means of securing funds for terrorist activities. Simultaneously, the glossary given by the Financial Action Task Force (2022) explains terrorist financing as the funding of terrorists, their acts, and organisations. Additionally, the International Monetary Fund (2000) identifies terrorist financing as requesting, assembling, or supplying funds to assist terrorist acts or entities.

Money laundering is a process with three stages, namely, placement, layering, and integration. During placement, funds that are generated by exploiting illegal means, such as drug trafficking, arms trafficking, human smuggling, corruption, and bribery, are placed in the financial system. Throughout the placement stage, money launderers deceive authorities to bypass the controls placed in the financial system in different ways such as depositing numerous small value deposits and funds below the mandatory reporting thresholds to inject illicit funds into the financial system. Such deceptions could result in manipulations of formal banking channels and pave the way for other illegal activities (King, 2018). During the layering stage, money launderers reroute the illegally generated funds injected into the financial system at the placement stage by adding multiple layers between the source of funds and the funds themselves placed in the financial system by moving it among numerous companies, countries, banks, and bank accounts employing a complex series of transactions. Manipulating the banking sector to divert funds and conceal their illegal origin implies that the country's financial system is weak and easily facilitates money laundering, which will lead to impeding investor confidence and

[2] To the best of the author's knowledge

deteriorating economic performance (Dow Jones, 2022). Finally, during the integration stage, the illicit funds injected (placement) and moved around (layering) are absorbed into the financial system. Absorption of funds happens through investment (purchase of assets such as real estate, securities, jewellery, gem, automobiles, and incorporating ventures), savings (opening fixed deposits, bills, and bonds), and expenditure (purchase of consumables, travels, and tours). This is the stage where illicit funds blend with the legal tender which makes it onerous to distinguish between the legal or illegal status of the sources of funds (St Paul's Chambers, 2021).

In the same vein, the process of terrorist financing has three steps, namely collection, transfer, and utilisation of funds. At the *collection* stage, where terrorist financiers gather funds from both legal and illegal sources to finance terrorism, adverse effects are created on the economy in two main ways. On one hand, the exploitation of legal sources of funds, such as profits from businesses and charitable organisations and personal donations, will diminish the faith of people in licit economic activities; on the other hand, funds collected through illegal sources will encourage many illicit acts, money laundering, and informal money/value transfer systems, such as Hawala/Undiyal (Bailiwick of Guernsey, 2022). The *transfer* stage of terrorist financing is about ensuring the undetected allocation of the funds gathered at the collection stage. Freeman and Ruehsen (2013) identify different techniques such as informal money/value transfer systems, banking channels, value cards, false trade invoicing, and cash couriers to transfer funds to terrorism. Finally, at the u*tilisation* stage, the funds collected (collection) and transferred (transfer) will be used in planning terrorist activities, procuring raw materials and expertise, producing weapons and equipment, training people into terrorists, and sustaining all activities that support terrorism (King, 2018).

### 2.2 Contemporary studies on whether money laundering and terrorist financing drive the growth of economies

A growing body of literature emerges with mixed evidence to exhibit the nexus of money laundering/ terrorist financing and economic performance. Several research studies support the norm that there is a negative relationship between money laundering and economic growth. Sota and Kolaneci (2013) posit that a negative correlation exists between the growth rate and money laundering in Albania based on a study covering five years, from 2007 to 2011. Apart from the growth rate, this study focuses on other economic variables, such as government expenditure, imports, exports, net exports, and foreign direct investments. The negative correlation is explained by the fact that anti-money laundering policies discourage criminal activities. The findings of this study are in line with the inverse relationship between money laundering and economic growth accepted worldwide. However, this study uses the number of cases of money laundering instead of monetary values due to the absence of the exact amount of money laundering in the public domain moderating the money laundering variable. Ndubuisi et al. (2016) observe that the impact of money laundering on the economy of Nigeria is negative. In the aforementioned study, the money laundering proxy is fraud, and its impact on three economic variables of the Nigerian economy is investigated. The money laundering variable is constrained in this study since only fraud is used as the proxy of money laundering, whereas several predicate offences lead to money laundering. A negative and significant correlation exists between fraud and the three economic variables, gross domestic product, federal government revenue, and gross fixed capital formation. The study highlights that the review of anti-money laundering laws, reassessment of statutory functions of institutions overseeing economic crimes, and collaboration with foreign nations to build up the country's international reserves would pave the way for further improvement in the AML/CFT regime of the country.

Nevertheless, a few research studies show results that contrast with the norm. Instead, they depict a positive relationship between money laundering and economic growth. Stancu and Rece (2009) observe a positive correlation between growth and money laundering in the USA, Russia, Romania, and eleven other European countries. The study applies a linear regression model and ascertains that increased volumes of laundered money lend funds for investment and consumption, boosting economic growth in the short run. In this exercise, the laundered money, one of the key explanatory variables, has been estimated by considering eleven most profitable money laundering predicate offences and multiplying the average profit of each offence with the number of crimes recorded for each country and subsequently adjusted based on GDP per capita. However, the quality of the study can be extended by incorporating more predicate offences to derive the laundered money. The estimated outcome of the significant positive correlation in the study is deemed surprising given many other well-known factors influencing economic growth. Researchers state that money laundering indirectly benefits the economy in the short run if the launderers invest the laundered funds in productive activities that could lead to betterment of the country.

Jayasekara (2020) studies the impact of global AML/CFT standards on combating money laundering/ terrorist financing by developing an AML/CFT Effectiveness Index. Jayasekara (2020) observes that both the presence and execution of a sound AML/CFT regime are essential to combating money laundering/ terrorist financing. The AML/CFT Effectiveness Index is limited to few proxies such as corruption, bribes, and crimes where more money laundering predicate offences can be accommodated for comprehensive results. Issah et al. (2022) conducted a panel study across 51 African countries from 2012 to 2019 to assess the impact of anti-money laundering regulations on the banking sector stability in Africa. This study uses the z-score, a measure of the solvency risk of banks, which compares capitalisation and returns with risk from the volatility of returns, as the banking sector stability proxy. The Basel AML index has been used as the anti-money laundering regulations proxy. At a 5 per cent significance level, anti-money laundering regulations show the existence of a significant positive relationship with banking sector stability irrespective of the degree of effectiveness of anti-money laundering regulations. The results of this study illustrate the importance of maintaining a fair degree of anti-money laundering regulations for a stable banking sector. The study could be further expanded to assess the relationship between AML/CFT and the economic sector.

At the same time, there are research studies with mixed relationships depending on time frames and variables used. Saddiq and Abu Bakar (2019) investigate the impact of economic and financial crimes on the economies of emerging and developing countries by following a combination of systematic review and meta-analysis. This study uses three eligibility criteria based on the focus of the research in selecting studies, namely, the impact of economic and financial crimes in emerging and developing countries, non-violent economic and financial crimes such as corruption and money laundering, and policy measures that should be put in place in developing and emerging countries aimed at tackling such issues. The population of this study comprises 103 studies across the years 2007 to 2017 and after filtering it pursuant to the predetermined eligibility criteria, six studies were selected as the final input of the analysis. All six studies show that economic and financial crimes impose negative effects on emerging and developing economies. But the results of the meta-analysis of the sample depict a moderately positive impact of economic and financial crimes in emerging and developing economies. This could be due to the sudden boost such crimes could bring into the economy in terms of short-

term investments, surges in consumption, and peaks in savings. However, the researchers emphasise the need to cooperate with all stakeholders to minimise economic and financial crimes and conduct more studies to assess the negative impact between economic and financial crimes and the economies of emerging and developing countries.

Moses and Henry (2020) assess the short run and long run relationship between money laundering and economic growth in Trinidad and Tobago for the period from 1990 to 2017. This study uses fraud and narcotics offences as money laundering proxies and a cointegration analysis and error correction model as the research methodology. The estimations yield contrasting results among the money laundering proxies and the time frames. In the short run, at a 5 per cent significance level, fraud offences show a significant, negative relationship with economic growth, whereas narcotics offences do not depict any relationship. The resulting inverse association between the money laundering proxy and economic growth stems from the nurturing of crime and corruption in economies leading to inefficiencies and hindered growth. In the long run, fraud offences show a significant, positive relationship with economic growth, and narcotics offences show a significant, negative relationship with economic growth. The study highlights that irrespective of these findings, it is crucial to take necessary steps to minimise the repercussions of money laundering.

Although the literature on money laundering and economic growth provides ambiguous results, these findings appear to be country specific or methodology specific.

### 2.3 Basel AML Index

The key variable used in this study is the Basel AML Index to reflect the level of AML/CFT efforts of economies. It is a global index issued by the Basel Institute on Governance in Switzerland since 2012 ranking money laundering and terrorist financing risks of countries. It is not a quantitative measure of the level of money laundering and terrorist financing. Instead, it ranks countries based on their vulnerability and ability to combat such risks. The Basel AML Index is based on five aspects of countries, namely, the quality of the AML/CFT framework, bribery and corruption, financial transparency and standards, public transparency and accountability, and legal and political risk. The Basel AML Index value ranges from 0 to 10, where 0 indicates the lowest risk level, and 10 indicates the highest risk level

## 3. Theoretical framework and data

Theories suggest money laundering and terrorist financing broadly affect both economic and financial aspects of a country. AML/CFT and macroeconomic policy objectives go hand in hand without conflicts, and when combined, lead to favourable effects on the economy (Quirk, 1996). Research studies use the Basel AML Index as an autonomous measure of the AML/CFT regime of a country. Accordingly, Islam et al. (2017) uses the Basel AML Index to measure the anti-money laundering practices among South-Asian countries, Naheem (2020) uses the Basel AML Index as an independent indicator of a country's AML/CFT infrastructure, and Issah et al. (2022) uses the Basel AML index as the anti-money laundering regulations proxy.

In addition to AML/CFT, other economic variables such as exports also drive the growth of emerging economies (Pekarcikova et al., 2022) where a rise in exports stimulates an increase in aggregate economic

growth (Emery, 1967). Further, Carrington and Edwards (1979) identify capital formation as an assistant to economic development, and Solow (1962) claims that a high rate of capital formation is required if the growth of output is to accelerate. Accordingly, the following basic empirical panel growth model will be used for this study including four economic variables affecting economic growth as given in Table A1 in Appendices:

$$y_t = X_t'\beta + D_{1t}'\gamma_1 + \sum_{j=q}^{s} \Delta X_{t+j}'\delta + v_{1t}$$

where $y_t$ is the dependent variable, $X_t$ is a vector of stochastic regressors, $D_{1t}$ is a vector of deterministic regressors, $\beta, \gamma_1$ and $\delta$ are vectors of coefficients and $v_{1t}$ is the error term. The dependent variable of this study is the real GDP growth rate, a widely used measure of the economic performance of countries. The independent/stochastic variables of this study include the Basel AML Index, annual growth rate of exports of goods and services, and the annual growth rate of gross capital formation, as explained in Table A1 in Appendices. Apart from the Basel AML Index, all independent variables are commonly known to be direct growth drivers. The Basel AML Index, the key interest variable of this study, represents the strength of the AML/CFT regimes of emerging economies. Further, a deterministic regressor is used to identify the impact the COVID-19 pandemic exerted on the economic performance of emerging economies in 2021.

Panel Dynamic Ordinary Least Squares is used to estimate the coefficients of a cointegrating relationship, and it is considered an improved version of the Pooled Ordinary Least Squares estimation due to several reasons. The Panel Dynamic Ordinary Least Squares method allows the use of variables with different unit root properties and is ideal for small sample sizes (Mahraddika, 2020). Further, it considers any dynamic nature of the selected study by accounting for the leads and lags of the presumed relationship irrespective of the presence or absence of cointegration between the explanatory variables and the error term. The Panel Dynamic Ordinary Least Squares also involve a relatively simple computation, reduced bias, and greater precision.

As per the Fiscal Monitor (2023), emerging economies are defined as any country other than countries classified as advanced economies or low income developing countries. Emerging economies generally inherit few features of developed economies and are in the process of becoming developed. As given in Table A2 in Appendices, the 44 emerging economies in this study are derived based on the Fiscal Monitor (2023) and the availability of data on the selected drivers of economic growth in the World Bank's (WDI) database.

This panel study spans ten years from 2012 to 2021 since the key interest variable, the Basel AML Index, is available from 2012 onwards. Further, this empirical study uses the EViews software to statistically assess the relationship between the selected independent and dependent variables. Accordingly, while the null hypothesis ($H_0$) claims that there is no relationship between respective population parameters, the alternative hypothesis ($H_1$) claims that there is a relationship between respective population parameters. As such, the following hypotheses are developed to provide a clear account of the main research problem of this study:

$H_0$ – The AML/CFT regime has no relationship with economic growth.
$H_1$ – The AML/CFT regime has a relationship with economic growth.

The number of lags and leads in the Panel Dynamic Ordinary Least Square model was selected based on the Akaike Information Criteria. Given the limited time covered in the sample, only a few explanatory variables could be used in the model

## 4. Empirical results

### 4.1 Data validation

Several tests were carried out to identify the properties of the selected variables. Table A3 in Appendices includes the unit root test results on stationarity of the variables. Different tests provide ambiguous results on the stationarity property of the variables, when only individual intercept, both individual intercept and trend, and without individual intercept or trend are considered. Therefore, all variables could be either I (0) or I (1) variables. However, variables with different unit root properties can be used in the Panel Dynamic Ordinary Least Squares method (Mahraddika, 2020).

Table A4 shows the descriptive statistics of the four variables used in this study. As per the correlation matrix given in Table A6, there is no correlation coefficient exceeding 0.8 showing no signs of multicollinearity. This study uses the Kao Residual Cointegration Test to assess the long term relationship among the variables (cointegration). The null hypothesis of this test is that there is no cointegration. As per the probability values given in Table A7 in the Appendices, the null hypothesis can be rejected indicating that there is a long run association among the variables.

### 4.2 Results of the Panel Dynamic Ordinary Least Squares Method

As per the results given in Table 1, the Basel AML Index has a negative effect on the GDP growth rate where a one-point increase in the Basel AML Index will increase the GDP growth rate by 0.4873 percentage points. However, the relationship is not significant reflecting the minor role of AML/CFT as an economic growth driver in the long run in emerging economies during the sample period. The insignificant impact of AML/CFT on economic growth could also be due to a possible non-linear relationship between the two variables or due to the short time span covered in the sample. Since the Basel AML index is only available for a ten-year period, the sample used for this study has been limited, preventing further exploration of the non-linear relationship between the Basel AML index and economic growth. A non-linear relationship is particularly possible, since the improvements in the AML/CFT regime could positively contribute to economic growth only up to a threshold level, and any further strengthening of AML/CFT efforts may not have any impact or may even have a negative effect on growth as excessive controls could be more costly, thereby repressing economic activities.

However, both annual growth rates of exports of goods and services and gross capital formation have a positive long run relationship with the GDP growth rate at a 1 per cent significance level. A percentage point increase growth in exports of goods and services and growth in gross capital formation will increase the GDP growth rate by 0.0992 and 0.1154 percentage points, respectively. These results agree with past literature where exports (Loungani et al., 2017) and capital investments (Appiah et al., 2019) act as determining factors of economic growth by favourably affecting the performance of economies.

The R-squared of the Panel Dynamic Ordinary Least Squares model stands at 91.37 per cent indicating that a significant extent of the variation in the GDP growth rate can be explained by the independent variables. Correlogram of residuals show that there is no autocorrelation up to four lags.

**Table 1: Panel Dynamic Ordinary Least Squares Method**

| | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| **Basel AML Index** | -0.487301 | 0.363024 | -1.342338 | 0.1812 |
| **Exports of goods and services** | 0.099220 | 0.022270 | 4.455257 | 0.0000*** |
| **Gross capital formation** | 0.115353 | 0.019309 | 5.974047 | 0.0000*** |

Note: *** represent the level of significance at 1 per cent.
Source: Author's calculations using EViews

## 5. Conclusion

The main purpose of this research is to assess the impact of strengthening the AML/CFT regime on the economic performance of emerging economies which appears to be the first empirical study concerning emerging economies. The Basel AML Index is used as the indicator of the risks related to money laundering and terrorism financing activities. In addition to the above, this research also focuses on the impact generated by several other economic variables, namely, the annual growth rate of exports of goods and services and annual growth rate of gross capital formation on the economic performance of emerging economies. Findings of this study show that the AML/CFT regime has insignificant impact on real GDP growth of emerging economies within the sample period, whereas export growth and gross capital formation growth have a notable positive impact on economic growth.

Indicators to measure and reflect the degree of money laundering and terrorist financing risks and the status of AML/CFT regimes of countries are scarce and the Basel AML Index is a relatively new indicator. Such scarcity of indicators is a major limitation faced in this research since the impact of strengthening the AML/CFT regime on the economic performance of emerging economies could be studied only for a ten-year period. At the same time, the limited sample hindered the use of additional explanatory variables and further analysis on non-linear relationships between AML/CFT regime and economic growth. Further, money laundering and terrorist financing are criminal processes that penetrate different layers of the society in the local as well as international contexts. The flow of funds to different parts of the world, involvement of multiple parties and transfer mechanisms, diverse investments, and penetration of different classes of society including both white collars and blue collars in money laundering and terrorist financing, may take a relatively long time to create real repercussions. These characteristics of money laundering and terrorist financing require investigations about it to dig deep to the roots (INTERPOL, 2022) and identify the predicate offence generating the proceeds, and follow the money to break networks (Basel Institute on Governance, 2022). Therefore, a longer timeframe can be considered in future studies about this area to assess whether money laundering and terrorist financing lead to a negative/positive impact on the economic performance of emerging economies with concrete evidence.

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## Appendices

**Table A1: Function variables**

| No. | Variable | Description | Source |
|---|---|---|---|
| 1 | GDP growth rate | Annual percentage growth rate of GDP at market prices based on constant local currency | WDI (World Bank) |
| 2 | Basel AML Index | An independent annual ranking that assesses the risk of money laundering /terrorist financing risk around the world | Basel AML Index published by the Basel Institute on Governance |
| 3 | Exports of goods and services | Annual percentage growth rate of exports of goods and services | WDI (World Bank) |
| 4 | Gross capital formation | Annual percentage growth rate of gross capital formation | |

**Table A2: List of emerging economies**

| No. | Country | No. | Country |
|---|---|---|---|
| 1 | Albania | 23 | Kazakhstan |
| 2 | Algeria | 24 | Lebanon |
| 3 | Angola | 25 | Malaysia |
| 4 | Armenia | 26 | Mauritius |
| 5 | Bolivia | 27 | Mexico |
| 6 | Bosnia and Herzegovina | 28 | Mongolia |
| 7 | Botswana | 29 | Montenegro |
| 8 | Brazil | 30 | Morocco |
| 9 | Bulgaria | 31 | Pakistan |
| 10 | Chile | 32 | Paraguay |
| 11 | Colombia | 33 | Peru |
| 12 | Costa Rica | 34 | Philippines |
| 13 | Dominican Republic | 35 | Poland |
| 14 | Ecuador | 36 | Romania |
| 15 | Egypt | 37 | Russia |
| 16 | El Salvador | 38 | Saudi Arabia |
| 17 | Georgia | 39 | Serbia |
| 18 | Guatemala | 40 | South Africa |
| 19 | Hungary | 41 | Sri Lanka |
| 20 | India | 42 | Tunisia |
| 21 | Indonesia | 43 | Ukraine |
| 22 | Jamaica | 44 | Vietnam |

Source: Fiscal Monitor

**Table A3: Unit root test results**

| Variables at level | Levin, Lin & Chu t | | | Im. Pesaran And Shin-W-stat | | ADF – Fisher Chi-square | | | PP – Fisher Chi-square | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Individual intercept | Individual intercept and trend | None | Individual intercept | Individual intercept and trend | Individual intercept | Individual intercept and trend | None | Individual intercept | Individual intercept and trend | None |
| **GDP growth rate** | 0.3738 | 0.5344 | 0.0000*** | 0.4487 | 0.7861 | 0.3944 | 0.6816 | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |
| **Basel AML Index** | 0.0143 | 0.0000*** | 0.0002*** | 0.5078 | 0.5881 | 0.1439 | 0.4505 | 0.5558 | 0.0006*** | 0.0068 | 0.0534 |
| **Exports of goods and services** | 0.3793 | 0.5007 | 0.0000*** | 0.0613 | 0.5920 | 0.0602 | 0.4133 | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |
| **Gross capital formation** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0481 | 0.0000*** | 0.0003*** | 0.0000*** | 0.0000*** | 0.0000*** | 0.0000*** |

Note: ***, **, and * represent the level of significance of 1%, 5%, and 10% respectively. Null hypothesis is that the panel data set contains unit roots (non-stationary).
Source: Author's calculations using EViews

**Table A4: Descriptive statistics**

| | GDP growth rate | Basel AML Index | Exports of goods and services | Gross capital formation |
|---|---|---|---|---|
| **Mean** | 2.568055 | 5.564003 | 3.045249 | 2.477297 |
| **Median** | 3.202125 | 5.540000 | 3.387565 | 2.905988 |
| **Maximum** | 19.04728 | 8.600000 | 86.04330 | 81.30731 |
| **Minimum** | -21.39990 | 3.120000 | -53.74363 | -56.08066 |
| **Std. Dev.** | 4.329713 | 0.906460 | 12.05113 | 12.94399 |
| **Skewness** | -1.168915 | 0.092665 | 1.001440 | 0.559703 |
| **Kurtosis** | 6.913187 | 2.658934 | 14.86138 | 10.68978 |
| **Jarque-Bera** | 380.9388 | 2.762340 | 2652.902 | 1107.073 |
| **Probability** | 0.000000 | 0.251284 | 0.000000 | 0.000000 |
| **Sum** | 1129.944 | 2448.161 | 1339.910 | 1090.011 |
| **Sum Sq. Dev.** | 8229.676 | 360.7132 | 63755.89 | 73553.13 |
| **Observations** | 440 | 440 | 440 | 440 |

Source: Author's calculations using EViews

**Table A6: Correlation**

| | GDP growth rate | Basel AML Index | Exports of goods and services | Gross capital formation |
|---|---|---|---|---|
| **GDP growth rate** | 1 | | | |
| **Basel AML Index** | 0.092384 | 1 | | |
| **Exports of goods and services** | 0.607096 | -0.008036 | 1 | |
| **Gross capital formation** | 0.517220 | 0.018406 | 0.223336 | 1 |

Source: Author's calculations using EViews

**Table A7: Panel Cointegration Model**
***Kao Residual Cointegration Test***

| | t-Statistic | Prob. |
|---|---|---|
| **ADF** | -2.623672 | 0.0043*** |

Note: *** represents the level of significance of 1%
Source: Author's calculations using EViews

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