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Bangladesh's Trade Asymmetry: A Deeper Look at the J-Curve with the USA

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Abstract: This study explores the J-curve phenomenon in the context of Bangladesh's bilateral trade with the United States using a non-linear Autoregressive Distributed Lag (NARDL) approach. The J-curve effect describes a country's initial trade balance worsening following currency depreciation before improving in the long term. We use the NARDL model to examine short-term and long-term dynamics, taking into account the nonlinearities in trade responses using 29 years (1990-2019) trade data of Bangladesh. Given Bangladesh's significant trade relations with the United States and its reliance on textile and garment exports, understanding the impact of exchange rate fluctuations on the trade balance is critical. The results reveal significant insights into the complex relationship between exchange rates and trade balances. We find evidence suggesting asymmetric effects of currency depreciation on Bangladesh's trade balance with the USA. The analysis also points out that traditional linear models might not fully capture the dynamics of the J-curve phenomenon. Our findings suggest

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that currency depreciation in Bangladesh does not necessarily lead to an immediate improvement in the trade balance, challenging the traditional J-curve hypothesis. These findings have broader implications for policymakers in Bangladesh and other developing countries with similar economic structures and trade relationships. By applying a non-linear ARDL approach, this study provides valuable insights into the effects of exchange rate movements on trade dynamics, highlighting the need for more nuanced trade and economic policies to navigate the complex landscape of international trade.

Keywords: Asymmetric; J-curve; Exchange rate; Non-linear ARDL test; Trade Balance

JEL Code: F14; F31; F33; O53.

1. Introduction

Currency devaluation—by making exports cheaper and imports more expensive—can serve as a policy instrument for countries operating under fixed exchange rate regimes to improve their trade balance, provided that the Marshall–Lerner condition holds (Marshall-Lerner, 1956). However, empirical evidence suggests that the adjustment process may not be immediate. Magee (1973) demonstrated that currency devaluation can initially worsen a country's trade balance, with improvements emerging only in the long run. This dynamic adjustment pattern is widely known as the J-curve effect, which describes an initial deterioration followed by subsequent recovery.

Similarly, although currency depreciation is theoretically expected to enhance trade performance over time, it may produce a short-term decline in the trade balance (Zaman, 2024; Lubna & Saha, 2024). This short-run contraction—also referred to as the J-curve effect—was formally articulated by Magee (1973) and is primarily attributed to delays in trade adjustment due to pre-existing contracts. In the short run, the quantities of imports (despite becoming more expensive) and exports (despite becoming cheaper) remain relatively inelastic. Over time, as new contracts are negotiated under the depreciated exchange rate, export volumes increase and import volumes decline, ultimately leading to an improvement in the trade balance (Jabeen, 2025; Saha et al., 2022).

Despite the extensive body of literature examining the J-curve effect and the short-term trade deterioration following currency depreciation, empirical findings remain inconclusive. This lack of consensus can be attributed to several factors. First, studies differ in terms of sample periods, econometric techniques, and model specifications, limiting comparability. Second, many analyses rely on aggregate trade data, which may conceal country-specific trade dynamics. As noted by Bahmani-Oskooee and Brooks (1999), aggregate data can obscure situations where trade deteriorates with one partner while improving with another. Consequently, recent studies increasingly employ bilateral trade data to capture more nuanced and accurate trade adjustments.The J-curve effect (initial trade decline after weakening currency) has been studied extensively in many countries, using various data levels (overall trade,

trade with specific partners, and trade by industry). The results are mixed. For overall trade data, some early studies like Bahmani-Oskooee (1985) supported the J-curve, while others in Japan (like Bahmani-Oskooee & Goswami, 2003) did not. Similar mixed results were found for other developed economies like the US, Australia, and the UK.

Studies on developing countries also show no clear pattern. Some, like Wilson (2001) in Southeast Asia, found no J-curve, while Narayan (2006) in China saw a trade improvement without the J-curve dip. Onafowora (2003) in Southeast Asia found a long-term trade benefit from devaluation but with varying J-curve effects.

Research on specific trade partnerships also yields mixed results. Hacker and Hatemi-J (2004) found a J-curve in Eastern European countries trading with Germany, while Dash (2013) in India found it only with some partners. One reason for these mixed findings might be the limitations of traditional analysis methods. Recent studies use more advanced techniques that account for non-linearities in trade responses. These newer approaches, like the one by Bahmani-Oskooee and Fariditavana (2016), seem to find more evidence of the J-curve effect compared to older methods.

Bangladesh is a flourishing trade and investment target with a sustained approximate economic accrual of over the previous eleven years, around 7% (2008-2019). The International Monetary Fund (IMF) graded Bangladesh as the world's 44th-greatest economy in nominal GDP measures in 2017 and 32nd in terms of real GDP in its view of the global economy, 2018, in terms of purchasing power parity. In FY 2018–19, the nation's gross domestic output was $302.6 billion. Undergirding macroeconomic stability, South Asian economies are navigating a challenging period. While Pakistan's economic stability and strength have been steadily deteriorating from poor to worse, Sri Lanka's economy is already in danger of failing. India has experienced commendable growth in recent years but is also suffering from high unemployment and pressure from rising inflation (Saha, 2022). Bangladesh fared better economically than its counterparts in other South Asian countries (Alyi & Mudassar, 2025; Saha & Saha, 2023; Akter et al., 2024).

Recent data, however, demonstrate that the nation is not exempt from the typical economic issues that have troubled other emerging nations in the post-Covid era (Saha & Jeong, 2019; Alam et al., 2020). The nation has made every attempt to escape the chaos brought on by the Covid-19 outbreak. According to some estimates, the epidemic has caused up to 97 million individuals to fall below the threshold for extreme poverty (Dey & Saha, 2025). Not an exception is Bangladesh. According to statistics, in 2016, 21.6% of all people lived in poverty, which increased to nearly 42% in the years following the Covid scandal. Pulling those countless millions out of poverty would therefore be a complex undertaking for the nation, which is already struggling with rising inflation and fluctuating foreign exchange. Over the past two years, the production and distribution of products and services have been repeatedly disrupted (Saha, 2023; Shoron et al., 2025; Chakma et al., 2025). As a result, supply shortages have been noted in practically all economic sectors. The supply chain has once again been badly interrupted by the ongoing economic and political unrest on the global stage, particularly the drawn-out conflict between Russia and Ukraine. Likewise, the price of raw materials and the cost of industrial and critical consumer items have increased.

These indicate that the government of Bangladesh should look for measures to increase the inflow of dollars to refill the country's foreign exchange reserves. International trade theories contend that variations in the exchange ratio have a dominance on both imports and exports. Exports rise, and imports fall because of a home currency devaluation, improving the trade balance (Ganai & Khan, 2025; Akhi et al., 2024). While price adjustments have an immediate impact, earlier contracts or purchases remain unchanged after a devaluation, delaying the uplift in the trade balance. As a consequence, the value of export payments decreases while import payments increase. The "J-curve" impact is the temporary worsening of a country's balance of trade followed by a long-term uplift (Hasan et al., 2025; Sajad & Javed, 2020; Saha et al., 2026). The ML proviso and the J-curve yielding can be used to explore how the exchange rate impacts imports and exports. Trade theories claim that the export and import resiliencies determine whether devaluation has a positive impact. If the export and import elasticities exceed one, the balance of balance will increase after a devaluation of the currency.

Conversely, a currency devaluation may deteriorate the trade balance if the combined price elasticities of exports and imports are less than unity. If the sum of export and import elasticities equals unity, currency devaluation will have no effect on the trade balance (Ntsasa et al., 2025). Over the past few decades, extensive empirical and theoretical research has examined the relationship between exchange rates and the balance of trade. In this context, the present study investigates the relevance of both the J-curve phenomenon and the Marshall–Lerner condition for Bangladesh, with particular emphasis on its largest export destination, the United States.

Bangladesh's trade structure reflects strong regional and global linkages. Approximately 22% of total imports originate from China, followed by India (13%), Singapore (9.5%), and Hong Kong (5.6%). Owing to its strategic geographic location, Bangladesh serves as a transit route between India's interior and eastern regions. Although Bangladesh's tariff levels remain relatively high, the country has undertaken various trade-liberalization measures to reduce trade barriers, including the establishment of export processing zones, tariff incentives, duty drawback schemes to refund customs duties on raw materials, and high-level trade negotiations with prospective partner countries. As a least developed country (LDC), Bangladesh also benefits from preferential market access arrangements and relaxed export restrictions in the European Union. In terms of export destinations, the United States, Germany, and the United Kingdom account for approximately 20%, 15%, and 11% of Bangladesh's total exports, respectively.

Bangladesh has emerged as one of the fastest-growing economies in South Asia, supported by a strong manufacturing base and a rapidly expanding export sector (Saha, 2024). As a key participant in global textile and garment markets, the country's economic performance is closely tied to its international trade relationships. Among these, bilateral trade with the United States is particularly significant, as the USA remains one of Bangladesh's largest export markets (Laskar et al., 2025). Given this backdrop, a comprehensive understanding of the determinants of bilateral trade dynamics is essential for informed policymaking and strategic trade planning. The J-curve phenomenon is a concept within international trade that describes the pattern in which a country's trade balance initially worsens following a currency depreciation before eventually improving over time. This pattern is typically explained by the lag in adjustment to exchange rate changes. In the short term, exports may become more competitive, but contracts and supply chains require time to adapt, leading to an initial decline in the trade balance. Over the longer term, however, exports typically increase, and imports decrease, leading to an improvement in the trade balance. Understanding this dynamic is crucial for countries like Bangladesh, where exchange rate fluctuations can have significant impacts on trade.

This study investigates the existence of the J-curve phenomenon in Bangladesh's bilateral trade with the United States by employing a non-linear Autoregressive Distributed Lag (ARDL) framework. The ARDL methodology provides a flexible and robust approach to examining both cointegration and short-run and long-run dynamics without requiring all variables to be integrated of the same order. Its non-linear specification is particularly well suited to capturing asymmetric and complex adjustment processes that may not follow linear patterns. Through this approach, the study aims to identify the short-term and long-term effects of exchange rate movements on the bilateral trade balance between Bangladesh and the USA.

Several considerations underscore the relevance of this analysis. First, Bangladesh has experienced notable exchange rate volatility over time, raising important questions about its implications for trade performance. Second, the country's industrial structure—dominated by textiles and garments—is highly sensitive to external factors such as exchange rate movements, tariff structures, and trade policy changes (Poly et al., 2025). These sectors are central to Bangladesh's export earnings and constitute a substantial share of exports to the United States. Third, as economic interdependence between Bangladesh and the USA continues to deepen, a clearer understanding of the J-curve effect can provide valuable guidance for the formulation of future trade policies and bilateral agreements.

Beyond the Bangladesh–USA context, the findings of this study may also offer broader insights for other developing economies with comparable production structures and trade patterns. By examining the J-curve dynamics in a key bilateral trade relationship, this research contributes to a deeper understanding of international trade adjustment mechanisms and serves as a useful reference for policymakers seeking to strengthen trade performance while mitigating short-term adjustment costs.This study will assess the J-curve phenomenon in Bangladesh's bilateral trade with the USA using a non-linear ARDL approach, exploring how exchange rate fluctuations impact trade balances over time. The findings could offer meaningful guidance for policymakers, businesses, and other stakeholders involved in Bangladesh's trade and economic development.

This study aims to provide further evidence of recent developments in J-curve literature by applying both linear and nonlinear ARDL approaches to analyze the Bangladesh bilateral trade balance from 1990 to 2019. The Bangladesh economy has struggled with persistent trade deficits, especially since the 2001 financial crisis. During the last five decades, these deficits averaged about 5.89% of GDP, peaking at 12.69% of GDP in 1976 while the deficit reached at 8.02% in 2022 (World Bank, 2023) (as in Figure 1).

Bangladesh's trade deficits are largely financed by short-term capital inflows, which create significant external vulnerability, often leading to sharp exchange rate fluctuations, as seen in 1980, 2010, 2016, and 2021, or to financial crises, such as those in 1995 and 2008 (Figure 1). The impact of currency depreciation on the trade balance tends to be temporary, with early gains often reversing as the economy recovers.

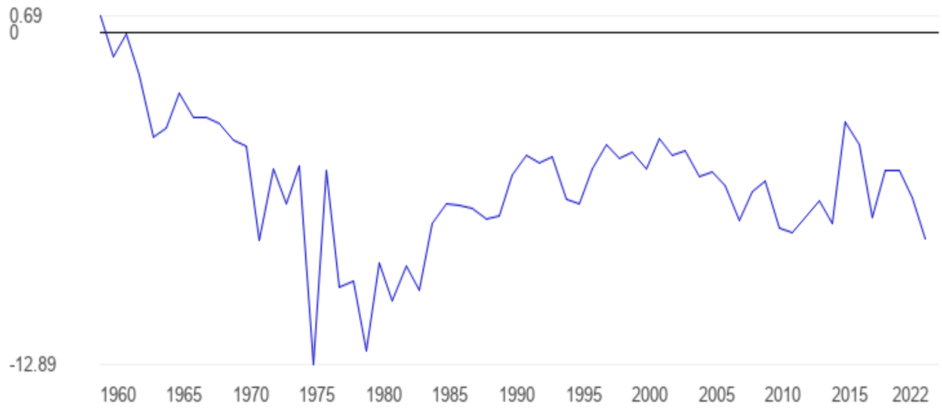

Figure 1. Trade balance of the last six decades (1960-2022)

Additionally, despite ongoing depreciation of the Bangladesh Taka (TK) since the second half of 2013, Bangladesh's trade deficits have remained high, averaging above 7% of GDP between 2013 and 2018. This makes Bangladesh an intriguing case study for J-curve analysis.

While previous research has investigated the connection between exchange rates and trade balances in Bangladesh, limitations exist. Many studies rely on broad, national-level data, leading to inconsistent findings. Additionally, research on Bangladesh's trade with individual countries is scarce.

The J-curve theory posits a two-stage adjustment of the trade balance following currency depreciation, characterized by an initial deterioration—where the trade deficit widens—followed by a long-run improvement that may result in a trade surplus. This phenomenon has been examined across various country contexts, with mixed empirical evidence, including some support for Bangladesh.

Nusair (2017) argues that the absence of consistent findings in earlier studies may stem from the restrictive assumption of linear relationships among variables. Addressing this limitation, subsequent studies have adopted more flexible modeling frameworks. For instance, Murshed et al. (2020) and Bahmani-Oskooee et al. (2018) incorporate non-linear dynamics into their analyses to better capture real-world adjustments. Murshed et al. (2020) provide evidence of a non-linear environmental Kuznets curve for Bangladesh, while Bahmani-Oskooee (2017) identifies short-run asymmetries in the J-curve effect across specific trading partners. Collectively, these studies underscore the importance of accounting for both non-linearity and asymmetry when evaluating the J-curve hypothesis.

Building on the methodological framework of Bahmani-Oskooee et al. (2018), the present study applies both linear and non-linear ARDL models. However, unlike earlier research that considered multiple trading partners, this analysis focuses exclusively on the United States—Bangladesh's most significant trading partner—accounting for approximately 14% of the country's total trade. Moreover, the study employs more recent quarterly data, allowing for an updated and more precise assessment of the J-curve effect.The findings from the non-linear ARDL model provide stronger support for the J-curve phenomenon compared to the linear model. This suggests that accounting for non-linearity reveals a clearer J-curve effect. In simpler terms, the impact of exchange rate fluctuations on Bangladesh's trade balance with the USA might not be symmetrical. Depreciation and appreciation might have different consequences.

Overall, this research contributes to a more comprehensive understanding of the J-curve phenomenon in the context of Bangladesh's trade with the USA. By focusing on a specific partner and employing a non-linear approach, the study sheds light on the potentially asymmetrical response of the trade balance to currency exchange fluctuations.

2. Literature Review

2.1. Theoretical Background

Elasticity Approach: This strategy bases fluctuations in the trade balance on the elasticity of import and export demand. Elasticity of demand is the number of wanted products and services respondent to price fluctuations (Howitt et al., 1980). Most debates on this elasticities approach to actual exchange rate fluctuations, in general, have focused on the volume and value of trade, which requires a perspective of the endue and assertion of imports and exports as well as the beginning volume of commerce. Consequently, to learn further about this strategy, we can compress it in the following picture:

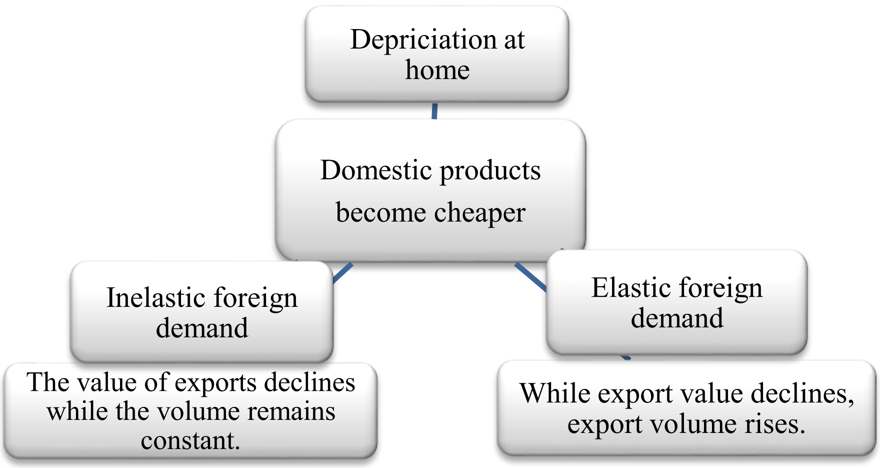

Figure 2. Elasticity Approach (foreign demand case)

Marshall-Lerner (M-L) condition is considered to expand the scope of the elasticities approach. According to Caves et al. (1996), exports will rise while imports fall when the M-L condition holds. This is because import and export supply curves are entirely elastic and import absolute value and export relative price ratios are more significant than unity.

So, to summarize, two are present fundamental presumptions of the M-L condition:

First, trade must be leveled to ensure that the ratio of the foreign currency worth of imports and exports is equal so as to the rate of exchange depreciated.

Second, prices must be set in the currencies of the sellers in order to guarantee unlimited supply elasticity. As a result, the accompanying figure provides a concise explanation of these assumptions.

A thorough body of literature has grown through time to explain the J-curve phenomena, which is the continuation of the ML condition and approach of elasticities. The J-curve phenomenon primarily refers to a country's balance of trade that initially deteriorates following weakening of its currency before improving to a higher level than where it started. Alternatively, the unfavorable impact of a depreciating currency on the balance of trade is meant by the j-curve phenomenon. This effect is shown in a country's balance of trade because of the expanded imports and more affordable exports than the weaker currency forces, which leads to a smaller initial trade surplus or deficit. However, since this afflicted nation's exports are now more competitively priced in terms of currency, local customers will choose to forgo the pricey imports in favor of more reasonably priced alternatives from their own country. As a result, the balance of trade steadily strengthens and rises to a greater level than before the exchange rate decline. By contrasting the long-run and short-run exchange rate coefficients doing with econometric analysis, the j-curve issue can be indirectly evaluated to determine whether the elasticity & M-L condition methodology works.

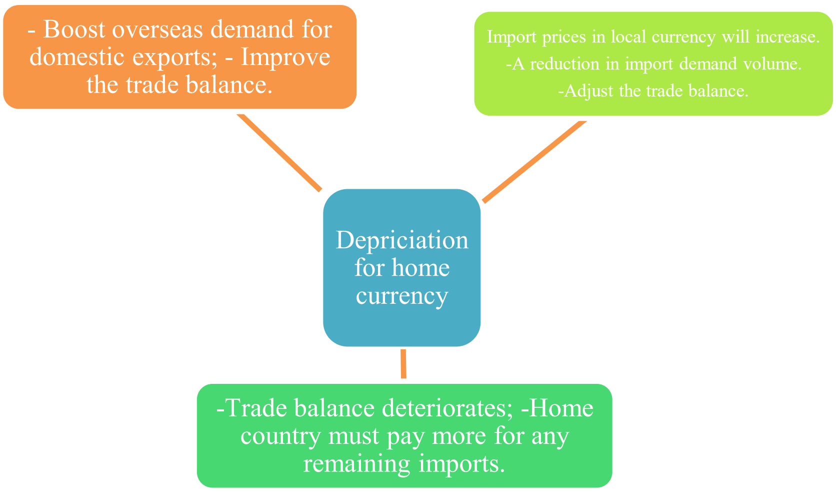

Figure 3. Marshall-Learner Condition

2.2. Empirical Literature Review

Researchers worldwide have been studying the effects of accurate, effective exchange rates on trade balances in developed and developing nations up to this point. The findings of these studies have been inconsistent overall and in both the short- and long-term, and most incorporate theories like the ML condition, the approach of elasticity, and the J-curve phenomenon (Zhu et al., 2025). Few academics discovered that a country's balance of trade would be impacted through its real effective exchange rate; others discovered that this impact is negligible, while others claimed that there is no connection between the two factors.

This is because a country's currency depreciation will only yield an upgrade in its balance of trade with rest of the Universe if the aggregate of its exports' and imports' price elasticities is higher than one (Saha, 2025). In contrast, if a country's total export revenue plummets as a consequence of inelastic demand for its exports and its total import costs increase due to additional products for its imports, this will exacerbate the trade deficit of the nation (Saha, 2023; Biswas et al., 2025). Devaluing the currency is, therefore, not necessarily the best course of action for a nation trying to close its trade imbalance. In honor of Russian economist Abba P. Lerner and British economist Alfred Marshall, the Marshall-Lerner condition was designed.

Recent empirical studies provide mixed but insightful evidence on the J-curve hypothesis and the role of exchange rate dynamics in shaping trade balances across countries. Using an ARDL–ECM framework with data extending to June 2024, Guo and Bouraoui (2025) examine the effects of Renminbi appreciation on China's textile trade in the context of the Marshall–Lerner condition and the J-curve effect. Their findings indicate that China's trade balance does not satisfy the Marshall–Lerner condition nor exhibit a J-curve response in the short run, although positive trade adjustments emerge in the long run.

In contrast, Alvi and Mudassar (2025) revisit the J-curve phenomenon in bilateral trade between Pakistan and China using a non-linear ARDL approach. Their results provide strong support for the J-curve hypothesis, revealing an initial deterioration in the trade balance followed by subsequent improvement. The study highlights the importance of accounting for asymmetric exchange rate effects when analyzing trade balance responses.

Similarly, Yılmaz (2024) applies both linear and non-linear ARDL models to investigate J-curve dynamics in Türkiye's bilateral trade with major partners. The evidence confirms the presence of J-curve effects for selected trading partners, such as Russia and the United Arab Emirates, underscoring the asymmetric influence of currency movements on bilateral trade balances.

Although not exclusively centered on the J-curve hypothesis, Sohrabji (2024) contributes to the literature by examining asymmetric exchange rate effects on

India's trade flows. The study demonstrates that exchange rate changes exert differential impacts on exports and imports in both the short run and the long run, reinforcing the relevance of non-linear trade adjustment mechanisms.

In an African context, Mbwambo and Mchukwa (2024) analyze the joint effects of exchange rate volatility and inflation on Tanzania's trade balance using the J-curve framework. Their findings provide empirical support for the existence of the J-curve effect, highlighting the role of macroeconomic instability in shaping trade balance dynamics.

Recent evidence from the BCIM-EC corridor (2024) employs non-linear ARDL models to examine asymmetric exchange rate effects on Bangladesh's bilateral trade with China, India, and Myanmar. The study confirms that exchange rate movements have significant asymmetric impacts on both export and import functions, offering important insights into broader J-curve dynamics in South Asian trade relationships.

Khatoon and Hasan (2017) examine trade balance–exchange rate relationship with satisfying J-curve effect and the Marshall–Lerner condition in the long run for Bangladesh in 2021. They do this technique on panel time series data and cross-section ally enhanced non-linear ARDL data. The outcome demonstrates aggregate bias and commonly associated effects on the Bangladeshi economy.

Muito et al. (2021) identified j-curve impacts in the seven biparous trading participants (symmetries exchange rate effects), and j-curve upshots are noticeable in the thirteen nations treating the stored mean group inwardly both linear and non-linear ARDL case (assuming asymmetries).

In order to evaluate the asymmetric J-curve actuality for every 58 industries that trade with the USA and Italy, Bahmani-Oskooee and Nouira (2021) used non-linear models. They discovered instance of the J-curve impact in 12 industries by estimating the linear and non-linear models.

Using the Nigerian trade time series data from 1960 to 2016, Nathaniel (2020) was impotant to assure the J-curve delusion using the NARDL limits attempt and the Bayer and Hanck (2013) test.

Recognizing that exchange rate appreciations and depreciations may exert both symmetric and asymmetric effects, Iqbal and Salahuddin (2020) examined the response of the trade balance to exchange rate movements using both linear and non-linear Autoregressive Distributed Lag (ARDL) models. Their empirical analysis focused on Pakistan's exchange rate–trade balance relationship at the bilateral level with its eight major trading partners to test the J-curve hypothesis. The results provide strong evidence that the non-linear ARDL framework outperforms the linear ARDL model in capturing exchange rate–trade balance dynamics.

Svrkaya and Ongan (2019) employed the Non-linear Autoregressive Distributed Lag (NARDL) cointegration approach to test the J-curve hypothesis within bilateral trade models between the United Kingdom and its 17 largest trading partners over the period 1981Q1–2015Q1. Their findings reveal no empirical support for the J-curve effect for any of the UK's major trading partners.

Chebbi and Olarreaga (2019) analyzed Tunisia's agricultural trade balance from 1965 to 2011 using a Vector Error Correction Model (VECM) alongside the Johansen–Juselius cointegration test. Contrary to much of the existing literature, their results indicate that currency depreciation had only a weak short-run effect and a negative long-run effect on the trade balance, largely attributable to the exchange rate policy reforms implemented during the 1980s.

Adnan et al. (2018) investigated the relationship between the real effective exchange rate (REER) and the trade balance in Malaysia using recent monthly time-series data and advanced econometric techniques, including ARDL and NARDL models. Their empirical results suggest that exchange rate movements significantly influence the trade balance and provide evidence of a temporary deterioration consistent with the J-curve phenomenon in Malaysia.

Iyke and Ho (2017) analyse how Ghana's balance of trade reacts to exchange rate shocks using the linear and non-linear ARDL confront to cointegration using quarterly data from 1986 to 2016. The study disproved the J-curve effect since it could not demonstrate the awaited short- and long-term relationships within the depreciation of the Ghanaian cedi and the nation's trade balance using the linear ARDL approach. However, when the non-linear ARDL estimation was applied, they verified the impression of the J-curve phenomena in Ghana.

Ivanovski and Nuhu (2017) use quarterly data from 1970 to 2016 to peruse the tests for the presence of the J-curve phenomena in Australia. The true effective exchange rate's implications on Australia's balance on trade over the short and long terms are investigated employing the ARDL cointegration and error correction approach. Baseline ARDL estimations do not clench the J-curve phenomena.

Bahmani-Oskooee et al. (2017) distinguish between both the short-term and retentive-term implications of real mutual changes on the rate of currency exchange on Korea's balance of trade and find that both the short-term and long-term yields of exchange rate variation impact the balance of trade.

In order to explore the asymmetric consequence of exchange rate fluidity on the trade balance, Bahmani-Oskooee and Fariditavana (2016) used the non-linear ARDL approach. They suggested that the connection may not be linear. The study shows that using an ARDL approach that is non-linear, data for the US and its six largest trading partners allowed them to find additional J-curve proof.

Using quarterly data from 1999 to 2012, Baba and Yazici (2016) additionally investigate the J-curve phenomena among Nigeria and 15 EU countries. According to the study, the ML proviso does not apply to Nigeria's balance on trade with the 15 EU nations and utilizing composite information for the same time frame for the 15 European states; it was also impossible to identify the J-curve phenomena.

The existing research on the J-curve phenomenon in Bangladesh's bilateral trade with the USA offers important insights, but several literature gaps persist. While the J-curve concept has been studied in various contexts, there's a lack of in-depth analysis focusing on Bangladesh's bilateral trade with the USA using non-linear ARDL methods. Most studies examine general trade patterns or use linear models, potentially overlooking complexities and nuances in non-linear relationships.

Many studies on the J-curve in Bangladesh use older data sets, possibly missing recent trends or changes in trade policies that could affect the J-curve behavior. An updated analysis could provide a more accurate representation of the current trade dynamics.

There is often a lack of consideration for external variables like global economic trends, political shifts, or trade agreements that might influence the J-curve effect. Understanding these external influences could give a clearer picture of the underlying factors impacting bilateral trade.

Research tends to focus on Bangladesh in isolation, with little comparison to similar countries in terms of economy and trade with the USA. A broader comparative approach could reveal unique patterns or commonalities, enhancing the understanding of the J-curve phenomenon in different contexts. Studies often do not adequately discuss the policy implications of their findings. Exploring how the J-curve effect might inform trade policy, economic strategy, or bilateral agreements could offer practical value to policymakers.

Addressing these gaps can lead to a more comprehensive understanding of the J-curve phenomenon in Bangladesh's bilateral trade with the USA and provide a foundation for further research and policy development.

3. Data and Research Methodology

3.1. Data Description

In this empirical study, we look into the existence of the j-curve impact on the balance of trade of Bangladesh with the US in the short and long run. The association between Bangladesh's Trade Balance and some of the factors is used to support this theory. Here we use the exchange rate in taka, GNID, GNIF & RMT in USD, and inflation rate in percentage as control parameters. To simplify our analysis, we should take the variables' log values. The time - series data used in this perusal go from 1990 to 2019.

Trade Balance (TB): Trade balance is the distinction among a country's imports and exports for a appointed period. The balance of trade makes up most of a nation's balance of payments (BOP). It is the aggregate of exports and imports of accessories and services surveyed as a share of the gross domestic product. This is measured on the US dollar.

Exchange Rate (ER): Official exchange rate mentions to the exchange rate destined by state officials, or the rate ascertained in the lawfully commissioned exchange market. They count it as a yearly average emerged on per month averages (topical currency units allied to the U.S. dollar).

Gross National Income (GNID): The Gross National Income (GNI, formerly GNP) is the total of all value added by local manufacturers, any product taxes (minus subsidies) that are not taken into account in valuing output, and net receipts of basic income (employee remuneration and property income from abroad). Data are presented in current US dollars.

Gross Foreign Income (GNIF): Net primary income contains the SNA's components for net labour income, net property income, and net entrepreneurial income. Compensation for employees paid to non-resident employees is covered by labour income. Usury income from the ownership of exotic financial claims (interest, dividends, rent, etc.) and non-financial property income are both included in property and entrepreneurial income (patents, copyrights, etc.). Data are presented in current US dollars.

Inflation Rate (IR): The perennial percentage change in the moat consumer's cost of earning a basket of goods and services, which may be set or modified at predetermined interims, such as annually, is reflected in inflation as dimensioned by the consumer price index. Most often, the Laspeyres formula is treated.

Remittance (RMT): Cash receipts encompass personal payments and employee compensation. Recent transfers of money or goods made by residing households to or from residing households are all considered personal exchanges. Any recent business dealings with residents and non-residents are therefore regarded as personal contributions. Compensation of employees refers to the income earned by seasonal, temporary, and other non-seasonal employees working in an economy where they do not dwell as well as by residents working for non-resident companies. Data are presented in current US dollars.

Data of TB, ER, GNID, GNIF and RMT are in current U.S. dollars. Data for IR is measured on the percentage of consumer prices. The World Development Indicator (WDI) (2021) of the World Bank is the additional variable data root, and all data are gathered from the World Bank. We use the naturalistic logarithm for each variable in exploratory analysis.

3.2. Model Specification

In establishing the balance of trade between two nations, we follow Rose and Yellen (1989), considering the economic activity levels in both nations to account for their needs of one and the actual bidirectional exchange rate to take into account relative pricing. But in order to describe the balance of trade in logarithmic form and make the balance of trade unit understandable, we adhere to the literature—more specifically, Bahmani-Oskooee and Fariditavana (2016)—and take the following specification:

$$ln(TB_t) = \alpha_0 + \beta_1 lnER_t + \beta_2 lnGNID_t + \beta_3 lnGNIF_t + \beta_4 lnIR + \beta_5 lnRMT_t + e_t \quad \ldots\ldots\ldots\ldots\ldots(1)$$

Where TB_t stands for Bangladesh's trade balance with trading partner USA and is defined as the difference between Bangladesh's imports from its partner and exports to partner. We define the bilateral trade balance in such a way that an increase in the bidirectional balance of trade accompanied by a decline in the exchange rate is indicated by an optimistic estimate of the coefficient linked to the rate of exchange. ER_t refers to the exchange rate, measured by the Bangladesh currency rate against the USD. $GNID_t$ & $GNIF_t$, respectively, shows the gross national income of Bangladesh and the gross foreign income of Bangladesh; both are measured in US dollars. IR is the annual 1 % change in Bangladesh's consumer price index for a basket of goods and services. Finally, the RMT_t is the remittance for Bangladesh measured in US dollar.

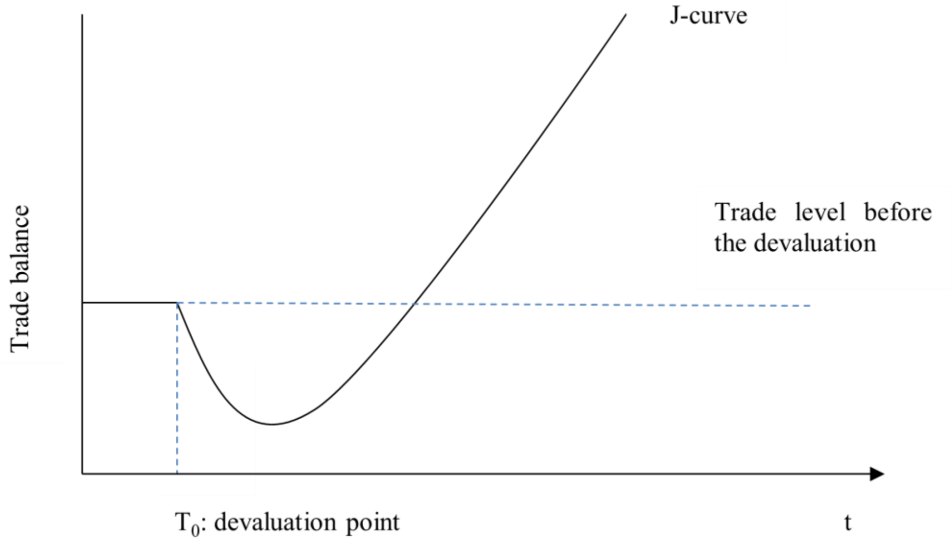

Figure 4. J-curve phenomenon

3.2.1. Autoregressive Distributive Lag Model (ARDL)

If the throw-back model in a regression analysis of time series data comprises both the present and lagged values of the explanatory variables, it is referred to as a distributed-lag model. An autoregressive model is one that encircles one or more lagged values of the regressand variable with its explanatory variables. So, these two concepts are combined into one in the autoregressive distributed lag model (ARDL). An OLS-based model for non-stationary time series and time series with mixed order of integration is called an autoregressive distributed lag (ARDL) model. A typical ARDL model looks like this:

$$\triangle ln(TB)_t = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} \triangle ln(TB)_{t-i} + \sum_{i=0}^{m} \alpha_{2i} \triangle lnER_{t-i} + \sum_{i=0}^{m} \alpha_{3i} \triangle lnGNID_{t-i} + \sum_{i=0}^{m} \alpha_{4i} \triangle lnGNIF_{t-i} + \sum_{i=0}^{m} \alpha_{5i} \triangle lnIR_{t-i} + \sum_{i=0}^{m} \alpha_{6i} \triangle lnRMT_{t-i} + \beta_1 ln(TB)_{t-1} + \beta_2 lnER_{t-1} + \beta_3 lnGNID_{t-1} + +\beta_4 lnGNIF_{t-1} + \beta_5 lnIR_{t-1} + \beta_6 RMT_{t-1} + \varepsilon_t \quad (2)$$

Where Δ express the operator of first difference, t is time; α_0 indicates an intercept term, α_{1i} to α_{4i} be the short-run coefficients, and β_1 to β_4 be the long-run parameters of the model. The null hypothesis in the equation is that $\beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$, which means the non-subsistence of a long-run relationship. In this case, the long-run relationship's persistence was investigated using an ARDL bound test. Bounds tests were first started in the unconstrained model, or more specifically, an ARDL (p,p,p,p) model, by Pesaran et al. in 2001. They give the co-integration test two crucial values. All variables are assumed to be I(0) in the lower critical bound and I in the higher critical bound (1). The decision criterion states that the null inference of no co-integration cannot be abandoned if the estimated F-statistics fall below the lower bound critical values. But let's say the calculated F-statistics are higher than the critical upper bound values. In that situation, the null hypothesis that there is no co-integration is rejected, implying that there is co-integration among the model's variables. Be aware that if the estimated F-statistics fall inside the lower and upper boundaries, the conclusion would be inconclusive. The ARDL long-run model can be estimated as follows if there was any co-integration among the variables.

$$ln(TB)_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i}\, ln(TB)_{t-i} + \sum_{i=0}^{m} \beta_{2i} lnER_{t-i} + \sum_{i=0}^{m} \beta_{3i} lnGNID_{t-i} + \sum_{i=0}^{m} \beta_{4i} lnGNIF_{t-i} + \sum_{i=0}^{m} \beta_{5i} lnIR_{t-i} + \sum_{i=0}^{m} \beta_{6i} RMT_{t-i} + \varepsilon_t \quad (3)$$

Accordingly, the servitor error correction model for the above equation is decided as follows:

$$\triangle\, ln(TB)_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} \triangle\, ln(TB)_{t-i} + \sum_{i=0}^{m} \beta_{2i} \triangle\, lnER_{t-i} + \sum_{i=0}^{m} \beta_{3i} \triangle\, lnGNID_{t-i} + \sum_{i=0}^{m} \beta_{4i} \triangle\, lnGNIF_{t-i} + \sum_{i=0}^{m} \beta_{5i} \triangle\, lnIR_{t-i} + \sum_{i=0}^{m} \beta_{6i} \triangle\, InRMT_{t-i} + \varphi_1 ect_{t-1} + \varepsilon_t \quad (4)$$

$$\triangle\, ln(ER)_t = \delta_0 + \sum_{i=0}^{m} \delta_{1i} \triangle\, ln(TB)_{t-i} + \sum_{i=1}^{m} \delta_{2i} \triangle\, lnER_{t-i} + \sum_{i=0}^{m} \delta_{3i} \triangle\, lnGNID_{t-i} + \sum_{i=0}^{m} \delta_{4i} \triangle\, lnGNIF_{t-i} + \sum_{i=0}^{m} \delta_{5i} \triangle\, lnIR_{t-i} + \sum_{i=0}^{m} \delta_{6i} \triangle\, lnRMT_{t-i} + \varphi_2 ect_{t-1} + \varepsilon_t \quad (5)$$

$$\triangle\, ln(GNID)_t = \lambda_0 + \sum_{i=0}^{m} \lambda_{1i} \triangle\, ln(TB)_{t-i} + \sum_{i=0}^{m} \lambda_{2i} \triangle\, lnER_{t-i} + \sum_{i=0}^{m} \lambda_{3i} \triangle\, lnGNID_{t-i} + \sum_{i=1}^{m} \lambda_{4i} \triangle\, lnGNIF_{t-i} + \sum_{i=1}^{m} \lambda_{5i} \triangle\, lnIR_{t-i} + \sum_{i=1}^{m} \lambda_{6i} \triangle\, lnRMT_{t-i} + \varphi_4 ect_{t-1} + \varepsilon_t \quad (6)$$

$$\triangle\, ln(GNIF)_t = \sigma_0 + \sum_{i=0}^{m} \sigma_{1i} \triangle\, ln(TB)_{t-i} + \sum_{i=0}^{m} \sigma_{2i} \triangle\, lnER_{t-i} + \sum_{i=0}^{m} \sigma_{3i} \triangle\, lnGNID_{t-i} + \sum_{i=1}^{m} \sigma_{4i} \triangle\, lnGNIF_{t-i} + \sum_{i=1}^{m} \sigma_{5i} \triangle\, lnIR_{t-i} + \sum_{i=1}^{m} \sigma_{6i} \triangle\, lnRMT_{t-i} + \varphi_5 ect_{t-1} + \varepsilon_t \quad (7)$$

$$\triangle\, ln(IR)_t = \sigma_0 + \sum_{i=0}^{m} \sigma_{1i} \triangle\, ln(TB)_{t-i} + \sum_{i=0}^{m} \sigma_{2i} \triangle\, lnER_{t-i} + \sum_{i=0}^{m} \sigma_{3i} \triangle\, lnGNID_{t-i} + \sum_{i=1}^{m} \sigma_{4i} \triangle\, lnGNIF_{t-i} + \sum_{i=1}^{m} \sigma_{5i} \triangle\, lnIR_{t-i} + \sum_{i=1}^{m} \sigma_{6i} \triangle\, lnRMT_{t-i} + \varphi_5 ect_{t-1} + \varepsilon_t \quad (8)$$

$$\triangle\, ln(RMT)_t = \sigma_0 + \sum_{i=0}^{m} \sigma_{1i} \triangle\, ln(TB)_{t-i} + \sum_{i=0}^{m} \sigma_{2i} \triangle\, lnER_{t-i} + \sum_{i=0}^{m} \sigma_{3i} \triangle\, lnGNID_{t-i} + \sum_{i=1}^{m} \sigma_{4i} \triangle\, lnGNIF_{t-i} + \sum_{i=1}^{m} \sigma_{5i} \triangle\, lnIR_{t-i} + \sum_{i=1}^{m} \sigma_{6i} \triangle\, lnRMT_{t-i} + \varphi_5 ect_{t-1} + \varepsilon_t \quad (9)$$

The term "error-correction" refers to the fact that the last period's detachment from a long-run equilibrium, the error, dominates its short-run dynamics, where φ is the swiftness of adjustment parameter or error correction term. In this way, after a change in other variables, ECMs quickly account for agility as a dependent variable returns to equilibrium. Merely until we discover that all the parameters are co-integrated in the ARDL bound test direction does this error correction term exist; otherwise, they only have a short-term link.

3.2.2. Non-Linear Autoregressive Distributive Lag Model (NARDL)

The nonlinear ARDL (Autoregressive Distributed Lag) technique adds a nonlinear component to error-correction and cointegration analysis, allowing for a more complex adjustment process. This approach provides a way to assess if the effects of currency depreciation on the trade balance vary in the short term versus the long term, and whether these effects are balanced or unbalanced. In other words, it helps to reveal whether changes in the trade balance respond differently to currency depreciation, depending on whether these impacts are immediate or spread over time, and whether they follow a similar pattern in both scenarios.

Equation (4) assumes that so as to a devaluation ennobles the balance of trade, an appreciation must worsen it by the identical amount as Bahmani-Oskooee and Fariditavana (2016). Nothing has to be this way. They follow Shin et al. (2014) and sequence of currency fluctuations into two lines, one representing just appreciation and one representing only depreciation, to establish and evaluate the likelihood of asymmetric impacts. This is accomplished by creating lnER, which includes excellent or negative changes and indicates appreciation (depreciation). The two new times series variables are then created using the partial sum approach as follows:

$$POS_t = \sum \Delta lnER_j^+ = \sum_{i=1}^{t} MAX(\Delta lnER_i, 0),$$
$$NEG_t = \sum \Delta lnER_j^- = \sum_{i=1}^{t} MIN(\Delta lnER_i, 0),$$

In (12), the POS represents the partial sum of positive changes that only represents currency evaluation, while the NEG represents the partial sum of negative changes that reflect only currency depreciation. The following step is to return to Error-Correction Model (2) and substitute the two new partial sum variables for LnER to get at:

$$\triangle ln(TB)_t = \alpha'_0 + \sum_{i=1}^{m} \alpha'_{1i} \triangle ln(TB)_{t-i} + \sum_{i=0}^{m} \alpha'_{2i} \triangle POS_{t-i} + \sum_{i=0}^{m} \alpha'_{3i} \triangle NEG_{t-i} + \sum_{i=0}^{m} \alpha'_{4i} \triangle lnGNID_{t-i} + \sum_{i=0}^{m} \alpha'_{5i} \triangle lnGNIF_{t-i} + \sum_{i=0}^{m} \alpha'_{6i} \triangle lnIR_{t-i} + \sum_{i=0}^{m} \alpha'_{7i} \triangle lnRMT_{t-i} + \beta'_1 ln(TB)_{t-1} + \beta'_2 POS_{t-i} + \beta'_3 NEG_{t-i} + \beta'_4 lnGNID_{t-1} + +\beta'_5 lnGNIF_{t-1} + \beta'_6 lnIR_{t-1} + \beta'_7 RMT_{t-1} + \varepsilon_t \quad (10)$$

The non-linear ARDL specification (13) model is also an error-correction model. Building the two partial sum variables results in the introduction of nonlinearity. Specification (4), in contrast, is referred to as the linear ARDL model. Typically, OLS is used to estimate both models. Because the two partial sum variables depend on one another, Shin (2014) advises considering them as a single variable and applying the same F test critical values in both linear and non-linear models.

A couple of asymmetrical assumptions could be tested after (13) is approximated. First, if the estimate of α'_2 at each lag i differs from the estimate of α'_3, there may be short-run asymmetries in the impact of exchange rate fluctuations on the trade balance.

The second sign of short-run cumulative or impact asymmetry will be $\sum\widehat{\alpha'_2} = \sum\widehat{\alpha'_3}$.This inequality will be examined using the Wald test. Third, there will be a short-run "reconcilement imbalance" if the number of lags the DPOS variable takes differs from the number of lags the DNEG variable takes. Lastly, if the normalized estimate for the POS variable differs sufficiently from the average estimate for the NEG variable, that will signify long-term asymmetries. In part, after this, we estimate both models.

4. Empirical Results

4.1. Unit Root Test

When we conduct an autoregressive distributed lag model, a variable is not required to obtain stationary at the level. This model can make utilize both stationary and non-stationary variables. It is applicable to time series with mixed integration orders and non-stationary time series. Then, we want to make sure that all variables are stationary. To achieve this, we employ the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) stationary tests, two well-known statistical techniques.

Table 1. Unit root test

Variables	**Augmented Dickey-Fuller (ADF) H_0: Variable has a unit root**				**Phillips-Perron (PP)**			
	Intercept &Trend		**Intercept**		**Intercept &Trend**		**Intercept**	
	Level	1st difference	Level	1st difference	Level	1st difference	Level	1st difference
$lnTB_t$	-4.796***	-10.37***	-2.58*	-10.43***	-4.832***	-12.3***	-2.28	-12.46***
$lnER_t$	-3.025	-5.12***	-3.98***	-4.64***	-3.08	-5.07**	-4.26**	-4.2***
$lnGNID_t$	-0.265	-7.3***	-1.81	-7.57**	-3.293*	-8.10***	0.013	-7.76***
$lnGNIF_t$	-2.319	-4.86***	-7.34***	-3.49**	-2.29	-4.73***	-7.6***	-2.88**
$lnIR_t$	-5.98***	-10.7***	-5.73***	-10.72***	-6.24***	-13.65***	-6.6***	-13.10***
$lnRMT_t$	-7.628***	-8.72***	-4.20***	-8.61***	-6.20***	-8.211***	-3.40**	-8.64***

Table 1 represents the estimated result for ADF and Phillips-Perron (PP) test statistics and associated critical values for different acceptable levels. If the associated test statistics are more significant than the accepted level of critical value (typically 5%), then we can reject the null hypothesis that the variable has a unit root. When we reject this unit root null hypothesis, we can say the variable is stationary. Considering this criterion, we regard in the above scheme that the variable Trade balance ($lnTB_t$), Inflation rate ($lnIR_t$), & Remittance ($lnRMT_t$) is stationary at the level from both of the process using, but the exchange rate ($lnER_t$), gross domestic income ($lnGNID_t$), & gross foreign income ($lnGNIF_t$) are not stationary at the level because their associated test statistics are not more significant than 5%. However, they all become stationary as we adjust the variable as a whole at the first difference since their related test statistics are more important than the 5% critical value or even the 1% value. So, in conclusion, we can say that all the variables become stationary at the first difference level although all of them were not stationary at level form.

4.2. ARDL Bound Test

We employ the ARDL bound test approach, first established by British-Iranian economist M. H. Pesaran, to examine the long-term relationships among the variables in our study Pesaran and co. (2001) conduct the bounds tests in the unrestricted model or name, an ARDL (p,p,p,p,p) model and secondly adopt the ARDL (p,q,r,s,v) approach to the estimation of the level relations. In their approach, they assume the critical values for the bounds test are I(0) or I(1). Here I(0) is the lower bound critical value, and I(1) is the upper bound critical value. The lower bound critical values are calculated assuming all the variables included in the ARDL model are integrated of order zero.

In contrast, the upper bound is calculated, assuming the variables are integrated into order 1. The results of the ARDL bounds test for both models are presented in Table 2. Furthermore, we test the following hypothesis from equation 4:

$$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$$

$$H_1: \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$$

Based on the abovementioned hypothesis, if calculated F-statistics is greater than the upper bound I(1) critical value for a reasonable significance level, we cannot take out the null hypothesis that the variables don't have long-run relationship. Furthermore, if this is lesser than the lower bound I(0) critical value, we cannot reject the null hypothesis. Note that if the considered F- statistics lies between the lower and upper bounds, the result would be inconclusive.

For the optimal lag chosen for ARDL bound test, we use the VARSOC statistics in Stata; this helps us by AIC criteria to choose the maximum satisfactory lag for the variables; the results are shown in the following table 2. The varsoc shows the optimal lags for ARDL bound test is 4 by AIC criteria.

Table 2. VARSOC for Variables

lag	LL	LR	dF	P	AIC
0	-118.158		36	0.000	6.3671
1	149.461	535.24	36	0.000	-5.5108
2	213.652	128.38	36	0.000	-6.9565
3	251.652	76.001	36	0.000	-7.0591
4	327.067	150.83*	36	0.000	-9.0803*

Endogenous: var14 lnTB lnER lnGNID lnGNIF lnIR lnRMT

Exogenous: _cons

Nevertheless, for the ARDL bound test with a satisfactory result, we use ARDL maximum lag criteria by AIC for the variables and get a long-run and short-run relationship model among them. The F-statistics are shown in the following table:

Table 3. ARDL bound test

F-test	**Bound critical values (Unrestricted intercept and no trend)**	
Significance Levels	**Lower bound I(0)**	**Upper bound I(1)**
10% critical value	2.26	3.35
5% critical value	2.62	3.79
2.5% critical value	2.96	4.18
1% critical value	3.41	4.68
F-statistics	8.4447	
K	5	

k: # of non-deterministic regressors in the long-run relationship

Using the aforementioned theory as a guide, we can observe that the estimated F-statistics reported in table 3 surpass the upper bound critical value at a 5% significance level, demonstrating that we do not accept the null hypothesis that the variable has no long-term association. As a result, we may state that there is a strong long-term link between the variables since we can reject the null hypothesis. A long-run relationship means that the models have some fixed mean value, but in the short run, the variable would fluctuate among this, but its inherent tendency to converge to its long-run fixed value.

4.3. ARDL Long-run Model and Short-run Model

The ARDL-estimated long-run equilibrium connection between the variables (1, 3, 3, 3, 3) is given in the table below:

Table 4. Estimated ARDL long-run model

Dependent variable $lnTB_t$					
Variables	**Coefficients**	**Standard error**	**t-Statistics**	**Probability**	**[95% Conf. Interval]**
$lnER_t$	-11.97566***	3.537534	-3.39	0.028	-21.79743 -2.15389
$lnGNID_t$	2.910978***	.714419	-4.07	0.015	-4.894523 -.927433
$lnGNIF_t$	-9.373302***	2.341827	4.00	0.016	2.871347 15.87526
$lnIR_t$	.03371	.022554	1.49	0.209	-.0289099 .0963299
$lnRMT_t$	-2.278093***	.5047599	4.51	0.011	.8766546 3.679531

** Significance at 10 percent level, ** Significance at 5 percent level, *** Significance at 1 percent level*

The above long-run results show that the coefficients are significant for the variables $lnER_t$, $lnGNID_t$, $lnGNIF_t$, $lnRMT_t$ as their associated p-value is less than the required level 5% level except for IR_t. We are using the dependent variable trade balance, and most of the variables are showing significant results. The result shows that in the long run, Bangladesh's ER, $GNIF$ & RMT have negative, whereas $GNID$ & IR have positive impact Bangladesh's trade balance.

Table 5. Estimated ARDL short-run model

The dependent Variable is ΔTB				
Variable		**Coefficient**	**Standard Errors**	**P-values**
ECT_{t-1}		-264.6001 ***	54.98493	0.009
TB_t	$\triangle lnTB_{t-1}$	-1.305749***	.3612202	0.022
	$\triangle lnER_t$	-7.45814***	2.351645	0.034
ER_t	$\triangle lnER_{t-1}$	6.857421***	1.9013	0.023
	$\triangle lnER_{t-2}$	1.783501	1.610144	0.330
	$\triangle lnGNID_t$	7.400189***	2.381294	0.036
$GNID_t$	$\triangle lnGNID_{t-1}$	.24748	2.225982	0.917
	$\triangle lnGNID_{t-2}$	4.967626***	1.676455	0.041
	$\triangle lnGNIF_t$	3.652705*	1.982752	0.139
$GNIF_t$	$\triangle lnGNIF_{t-1}$	-3.161425*	1.62442	0.023
	$\triangle lnGNIF_{t-2}$	-1.345087	1.526645	0.428
	$\triangle lnIR_t$	.0206267	.0173952	0.301
IR_t	$\triangle lnIR_{t-1}$	.0227676*	.0135375	0.168
	$\triangle lnIR_{t-2}$	.0274598***	.0090348	0.038
RMT_t	$\triangle lnRMT_t$	.0949287	.4076957	0.827

$\triangle lnRMT_{t-1}$	-1.813582	.7121215	0.064
$\triangle lnRMT_{t-2}$	-1.332079*	.7111679	0.134
Constant	-264.6001***	54.98493	0.009

** Significance at 10 per cent level, ** significance at 5 per cent level, *** significance at 1 per cent level*

To confirm the J-curve hypothesis in Bangladesh, the sign of the coefficient on independent variable ER should be negative in the short run and positive in the long term. Empirical results from the short-run ARDL model, as presented in table 5, show that the IR & $GNID$ coefficient is positive in the short run. However, they are not significant at 5% level, but the coefficient of another lag of IR & $GNID$ are statistically significant. Table 5 also shows the other short-run coefficient value at different lag periods. From that, we see that all the lag of gross foreign income ($GNIF$) and remittance (RMT) variables have negative and statistically significant as their associated p-value is relatively low which is relevant to our prior assumption. Another variable, ER, has an expected negative sign & this are statistically significant. The needed error correction term, ECT, is likewise shown in Table 4. It has a negative sign and is highly significant even at a 5% level. This shows that the dependent variable and the independent variable have long-term importance. In addition, the value of the ECT coefficient is -264.60, which signifies that it takes a considerable time for reconciliation to equilibrium. Thus, many years are required for the disequilibrium to backward to the long-term equilibrium within the period. So, from this finding we have seen that, there is no existence of j-curve phenomena in both short & long run TB in Bangladesh.

4.4. Non-Linear ARDL Model

This section explores the long-term and short-term relationships between two key macroeconomic variables in Bangladesh using a nonlinear ARDL model. The results, presented in Table 4, were obtained through econometric software Eviews. It's important to note that since the variables are measured as rates (e.g., growth rate), the estimated coefficients in the table should be interpreted as percentage point changes (Hasan, 2017). The estimated result of the Non-linear Auto Regressive Distributive lag (NARDL) model using appropriate lags is showing below:

Table 6. Estimated Short run NARDL model

Variables	Coefficient	Standard Error	P-value
$\boldsymbol{lnTB_t}$	.6343604	-2.381534	0.018
$\boldsymbol{lnTB_{t-1}}$	.2135851	.3167314	0.000
(POS$_t$) $\boldsymbol{lnER_t^+}$	-13.83866	7.2366	0.092
(NEG$_t$) $\boldsymbol{lnER_t^-}$	39.15325	35.63294	0.004

(POS_{t-1}) $\boldsymbol{lnER_{t-1}^{+}}$	-10.26975	14.73193	0.105
(NEG_{t-1}) $\boldsymbol{lnER_{t-1}^{-}}$	96.62141	35.00899	0.025
(POS_t) $\boldsymbol{lnGNID_{t}^{+}}$	4.23607	9.329293	0.062
(NEG_t) $\boldsymbol{lnGNID_{t}^{-}}$	-18.02124	13.72002	0.125
(POS_{t-1}) $\boldsymbol{lnGNID_{t-1}^{+}}$	19.32772	7.742428	0.037
(NEG_{t-1}) $\boldsymbol{lnGNID_{t-1}^{-}}$	-71.75782	36.11084	0.082
(POS_t) $\boldsymbol{lnGNIF_{t}^{+}}$	11.47379	9.696736	0.271
(NEG_t) $\boldsymbol{lnGNIF_{t}^{-}}$	20.02965	65.26621	0.767
(POS_{t-1}) $\boldsymbol{lnGNIF_{t-1}^{+}}$	19.32772	7.742428	0.037
(NEG_{t-1}) $\boldsymbol{lnGNIF_{t-1}^{-}}$	-71.75782	36.11084	0.082
Variables	**Coefficient**	**Standard Error**	**P-value**
(POS_t) $\boldsymbol{lnIR_{t}^{+}}$	-.0368713	.1203536	0.067
(NEG_t) $\boldsymbol{lnIR_{t}^{-}}$	-.1120163	.2111573	0.610
(POS_{t-1}) $\boldsymbol{lnIR_{t-1}^{+}}$	.0081671	.0875546	0.928
(NEG_{t-1}) $\boldsymbol{lnIR_{t-1}^{-}}$	-.0247825	.0546768	0.662
(POS_t) $\boldsymbol{lnRMT_{t}^{+}}$	-3.280995	2.810095	0.277
(NEG_t) $\boldsymbol{lnRMT_{t}^{-}}$	30.73835	9.381208	0.011
(POS_{t-1}) $\boldsymbol{lnRMT_{t-1}^{+}}$	-3.164708	4.657036	0.516
(NEG_{t-1}) $\boldsymbol{lnRMT_{t-1}^{-}}$	-18.56616	4.740999	0.004
Cons.	-26.30858	23.99703	0.305

The non-linear ARDL model represents that the coefficient of the variable (POS_t) $\boldsymbol{lnER_{t}^{+}}$ has demonstrated the expected sign (in both level and lag), that it increases or depreciates, the trade balance will worsen in the short run which is significant in the short run at 1% level. The findings also indicate the asymmetric results of (POS_t) $\boldsymbol{lnER_{t}^{+}}$ & (NEG_t) $\boldsymbol{lnER_{t}^{-}}$

Table 7. Estimated Long run NARDL model

	Long-run effect [+] |			**Long-run effect [-]**		
Exog. var.	coef.	F-stat	P>F	coef.	F-stat	P>F
$\boldsymbol{lnER_t}$	-4.312	.4972	0.501	-40.571	8.56	0.019
$\boldsymbol{lnGNID_t}$	8.116	6.422	0.035	30.131	3.423	0.001
$\boldsymbol{lnGNID_t}$	6.111	.8542	0.382	-97.144	2.905	0.127
$\boldsymbol{lnIR_t}$	-0.108	1.699	0.229	-0.021	.03238	0.162
$\boldsymbol{lnRMT_t}$	-2.354	4.557	0.065	-27.852	22.85	0.001

According to empirical findings, the variables in the non-linear ARDL long-run model had similar and dissimilar signs to those in the linear model. However, some of them were statistically insignificant. The coefficient on the exchange rate ($\boldsymbol{lnIR_t}$)

should have a negative sign over the short term to support the J-curve proviso in Bangladesh by the study period. In the long run non-linear model, we can look on that the increase in the exchange rate has also a negative coefficient sign; that means an increase in the exchange rate will reduce balance of trade, and the decrease in the rate of exchange also shows a negative sign; that is a decrease in exchange rate will enhance balance of trade in Bangladesh during the study period. The non-linear ARDL model indicates that both appreciation and depreciation of the exchange rate remain negative coefficient sign. This therewithal amplifies the asymmetric influence of the exchange rate on Bangladesh's balance of trade by the study period. These results show that the J-curve theory is invalid throughout the research period as we do not get the accurate symmetric results of exchange rate on the balance of trade of Bangladesh.

4.5. Asymmetric Cointegration Test

The authors examine if variables move together in the long run using an asymmetric cointegration technique. This method is important because standard models might miss this relationship. The analysis relies on an F-statistic - a high value indicates cointegration, a low value means no cointegration, and values in between are inconclusive. Table 5 presents the test results.

Table 8. Wald test findings of asymmetric Cointegration for long-run

Wald test			
Asymmetric Non linear ARDL			
Test Statistic	Value of the statistic	Degrees of freedom	Probability
F	9.23433	(2.8)	0.0001
Chi- Square	21.3213	4	0.0002
Bound test level of significance	I(0)	I(1)	
1 percent	6.68	7.52	K=3
5 percent	4.94	4.94	
10 percent	4.04	4.04	
Null Hypothesis: C (2) = C (3) = C (4) = 0			

Note: k represents the number of long run regressors. And bound test critical values for unrestricted and no trend.

Based on Table 8, the results strongly suggest asymmetric cointegration between the two variables at a 1% significance level. This means the null hypothesis, which assumed no asymmetric cointegration, is rejected. The calculated F-statistic (9.23433) exceeds the upper bound critical value (7.52), indicating a long-term relationship with unequal adjustments. The next section will likely explore the asymmetry between positive and negative changes in inflation.

4.6. Testing the Presence of Asymmetry

This section investigates if the positive and negative changes in inflation have statistically different effects on economic growth in Bangladesh, even though the NARDL model suggested a positive long-run impact from both. In other words, the question is whether the model exhibits asymmetry. An asymmetry test is employed to see if the coefficients for positive and negative inflation changes are equal. If they are not equal, there's evidence of asymmetry. To test this for long-run effects, the Wald test is conducted. The null hypothesis (H_0) states that the coefficients are equal (symmetry), while the alternative hypothesis (H_1) suggests they are different (asymmetry). A p-value below 5% on the Wald test would lead to rejecting the null hypothesis, indicating asymmetry. Table 6 shows the results of the Wald test for this analysis.

Table 9. Wald test results for asymmetry test

Wald test			
Asymmetric non linear ARDL			
Test Statistic	Value of the statistic	Degrees of freedom	Probability
t	7.5632	11	0.0030
F	62.23345	(2, 11)	0.0001
Chi- Square	55.4513	4	0.0002
Bound test level of significance	I(0)	I(1)	
1 percent	6.68	7.52	K=3
5 percent	4.94	4.94	
10 percent	4.04	4.04	
Null Hypothesis: C (2) = C (3) = C (4) = 0			

The Wald test results in Table-6 indicate that the null hypothesis of symmetry is rejected (p-value < 5%). This implies an asymmetry in the long-run impact of inflation on economic growth in Bangladesh. Positive changes in inflation appear to have a stronger influence on growth compared to negative changes. This suggests that inflation-controlling policies by the Bangladesh bank might not be beneficial. The next section will examine the robustness of the results using diagnostic tests.

4.7. Diagnostic Tests

4.7.1. Stationary Test for Residuals of NARDL Model

This section dives into whether the results from the NARDL model are reliable. A unit root test for the model's residuals is conducted to check for spurious regression. Spurious regression occurs when the model outputs nonsensical results due to non-stationary residuals (errors). In simpler terms, the test determines if the errors in the model have a constant trend (non-stationary) or not (stationary).

Here, the null hypothesis (H_0) assumes the residuals have a unit root (non-stationary), while the alternative hypothesis (H_1) suggests they are stationary. A p-value below 5% on the unit root test (ADF test) leads to rejecting the null hypothesis, indicating stationary residuals and a valid regression model. Conversely, failing to reject the null hypothesis suggests non-stationary residuals and potentially unreliable model results.

The key takeaway is that if the residuals, obtained by regressing the model on potentially non-stationary data, are themselves stationary, then the regression results are likely not spurious and hold some meaning.

Table 7. Stationary test for residuals

ADF test statistic		t statistic	Probability
		-3.5341	0.0001
Critical value	1% level	-5.6598	

4.8. Heteroscedasticity Test

In statistics, heteroscedasticity takes place when a projected variable's standard deviations, monitored over different values of a regressor or as related to prior periods, are non-constant. The Breusch-Pagan test, created in 1979 by Trevor Breusch and Adrian Pagan, is used in statistics to determine if a linear regression model exhibits heteroskedasticity. It is a chi-squared test; the test statistic is distributed $n\chi2$ with k degrees of freedom. If the test statistic has a p-value below an appropriate threshold (e.g. $p < 0.05$), then the null hypothesis of homoskedasticity is rejected, and heteroskedasticity is assumed. So, we test the following hypothesis:

H_0: variables are heteroscedastic

$H_{1:}$ variables are homoscedastic

If the possible value of Chi-square statistics is less than 0.05, we can reject the null hypothesis at 5% significance. However, if it is not, we cannot reject the null hypothesis that variables have heteroscedasticity.

Table 8. Breusch-Godfrey test for Heteroscedasticity

Chi-square
6.756
(0.0455)

* **Significance at 5 percent level.*

Probability in the parenthesis.

Based on the above hypothesis, we see in table 4.8 that in the Breusch-Godfrey test, the Chi-square value is not significant at a 5% significant level, which sign that we cannot reject the null hypothesis that there has heteroscedasticity, but this is not true if the acceptance significance level is about 10%.

4.9. Autocorrelation Test

Autocorrelation is a lagged version of itself over sequential frequency ranges and a mathematical representation of harmony within a time series. If residuals from one time period are connected to residuals from another, then there is autocorrelation. This study uses the Durbin-Watson d test to investigate residual autocorrelation. In the Durbin-Watson d-statistic, we test the following hypothesis:

H_0: Positive autocorrelation does not exist (residuals are not correlated)

H_1: Positive autocorrelation is present (residuals are correlated)

The possible value of d-statistics calculated from this test is between 0 and 4. However, only when d-statistics is close to 2, then we accept the null hypothesis that the residuals are not correlated, and if it is less than two may sign positive autocorrelation and more significant than two may sign negative correlation.

Table 9. LM test for autocorrelation

LM test
Durbin-Watson d-statistic
d-statistics
1.977

Based on the above hypothesis, we see in table 4.9 that On the Durbin-Watson d-statistic is less than two, as shown in table 4.9, indicating positive autocorrelation in the residual.

4.10. Ramsey RESET

The Ramsey Regression Equation Specification Error Test (RESET) test is a common specification test for the linear regression model. It investigates whether the fitted values can be used in non-linear ways to further explain the response variable.

H_0: The model specification is not incorrect

H_1: The model specification is incorrect

Table 10. Ramsey RESET Test

Ramsay RESET Test
Prob. Value
0.8902

4.10.1. Constancy of the Model

According to Pesaran and Pesaran, we utilize the cumulative sum (CUSUM) of recursive residuals and the cumulative sum of square (CUSUMSQ) tests to check for stability in the aforementioned model (1997). Figures 5 and 6 below provide a graphical representation of CUSUM and CUSUMSQ statistics.

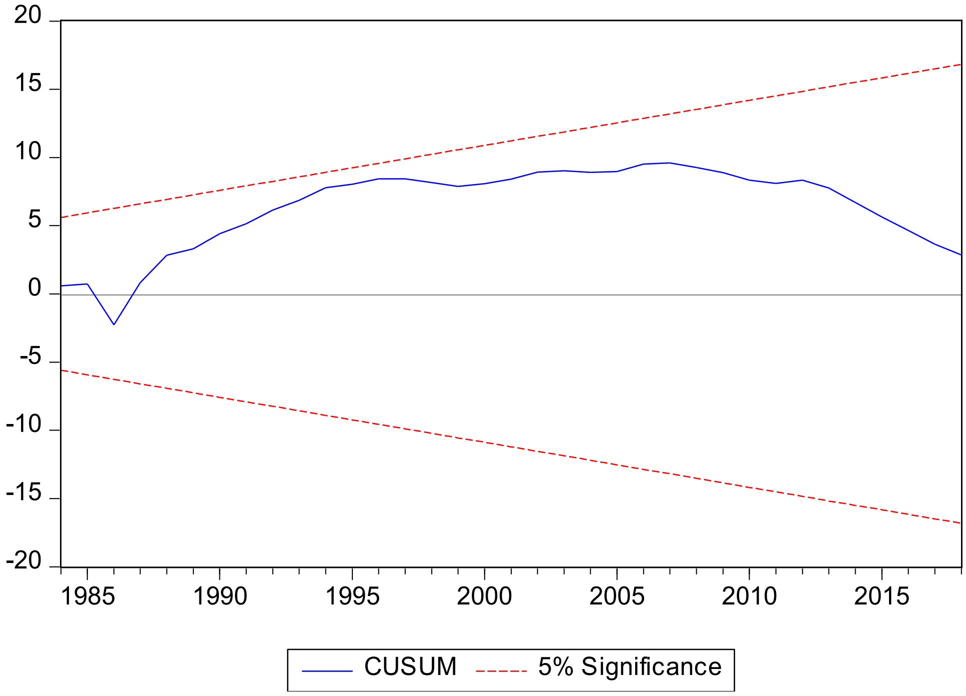

Figure 5. Plot of CUSUM tests

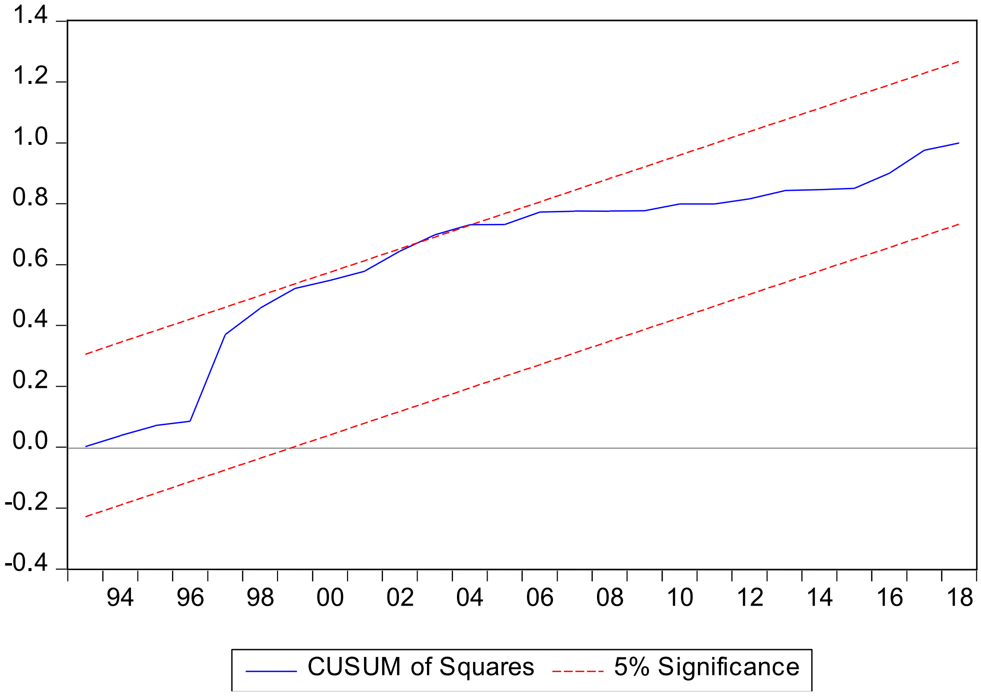

Figure 6. Plot of CUSUM of squares tests

A consistent change in the regression coefficients can be found using the cumulative sum test. Figures 5 and 6 show the results of the CUSUM and CUSUMSQ tests, respectively, and show how the cumulative sum of squares test distinguishes rapid changes from the consistency of the regression coefficients. The plots of the CUSUM and CUSUMSQ statistics lie inside the crucial bands of the 5 percent confidence intervals of parameter stability, indicating that there is no instability of the coefficients. Therefore, these statistics support the model's stability and show that, at a 5% level of significance, no systematic change in the coefficients was found during the study period.

5. Conclusion and Policy Recommendations

One of the most critical unanswered problems in international macroeconomics is the role of the currency rate as a tool for policymakers to modify external equilibrium or the trade deficit. The J-curve effect and short-run adjustment lags were cited as the fundamental causes of the trade balance's short-term decline but the potential for long-term improvement.

Previous studies conducted aggregate trade streams of one country and the rest of the globe to assess the J-curve effect and supposition that the impacts of exchange rate fluctuations were symmetric. The J-curve effect did not receive significant support from the estimation of linear models. Asymmetry analysis and non-linear exchange rate adjustment are two recent developments that have opened up new research opportunities and provided substantial evidence supporting the J-curve effect.

By examining the trade balances between Bangladesh and its leading trading partner, the United States, we add to this new body of knowledge using data from the period 1973 to 2019. We estimate non-linear bilateral trade balance models based on Shin's (2014) non-linear ARDL technique and asymmetric co-integration and linear bilateral trade balance models based on Pesaran et al. (2001),'s linear ARDL approach to error-correction modelling and co-integration. The easiest way to sum up the findings is to say that the J-curve phenomena in the bilateral trade balance models of Bangladesh and the US were supported by linear models while not by non-linear models. Estimates of the non-linear models did, however, produce extra data that had policy conjugations for decision-makers. We investigate the effect of exchange rate on the balance of trade of Bangladesh by both linear and non-linear model. Furthermore, we test the order of integration by ADF & PP test of the recommended variables. We discovered that all models exhibit unequal short-run effects of exchange rate fluctuations. In our non-linear analysis we have seen that the regressor exchange rate does not have symmetric effect on trade balance of Bangladesh. Moreover, the impact of rate of exchange also indicates that the hypothesis for j-curve does not holds for Bangladesh during the time span. After examining the tests, we check some diagnostic checking like, Heteroscedasticity test, autocorrelation test & Ramsey Reset test for the estimated models. Our findings have some repercussions for Bangladesh's trade and exchange rate policies, as weakening the Taka will increase trade with Bangladesh. We were undoubtedly manipulating the exchange rate-only available policy to address the trade balance. Bangladesh has to change its trade policies to increase the variety of its trading partners to reduce this trade deficit.

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