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Revisiting the J-Curve: Nonlinear Exchange Rate Dynamics and Trade Balance Between Pakistan and China

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Abstract

Recent developments in econometric modeling have reinvigorated discussions on the J-curve phenomenon and the broader implications of exchange rate movements on trade balances. This study employs a linear autoregressive distributed lag model to examine the symmetrical effects of exchange rate fluctuations on commodity-level trade between Pakistan and China, utilizing annual data spanning from 1980 to 2023. This nonlinear approach decomposes the real bilateral exchange rate into two distinct phases, appreciation and depreciation allowing for a more detailed investigation into how currency fluctuations impact trade balances differently across various industries. Unlike the linear model, which assumes a uniform effect, the nonlinear model captures the asymmetric nature of exchange rate shifts, providing a more comprehensive understanding of trade dynamics. The empirical findings, illustrated through extensive data tables, offer strong evidence in support of the J-curve theory, indicating that in the short run, currency depreciation initially exacerbates trade deficits before eventually leading to improvements. By incorporating nonlinearities in economic modeling, this study provides a refined perspective on the trade relationship between Pakistan and China, highlighting the necessity of acknowledging asymmetric exchange rate effects when formulating trade policies. These insights serve as a valuable resource for policymakers, enabling them to develop more effective strategies for managing currency fluctuations and fostering economic stability.

Keywords: *J-Curve Effect, Exchange Rate Fluctuations, Trade Balance, Nonlinear ARDL Model*
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1. INTRODUCTION

The exchange of currency is a crucial determinant of a country's trade performance, determining both export and import trends by acting as a mirror showing how competitive it is in the global marketplace. In reality, this is evidenced and governed by the theoretical underpinnings of the Marshall-Lerner condition, which states that currency depreciation will improve the trade balance if the algebraic sum of the absolute value of the price elasticity of demand for exports and imports exceeds unity or one (Rose, 1990). This means that, in cases where large enough volumes of foreign trade could be made sensitive to variations in price, depreciation in the currency makes exports much more attractive to foreign buyers while discouraging imports and thus improving the trade balance. However, that does not happen immediately. It has been observed that depreciation of currency usually worsens trade balance in the short run due to pre-determinations of contracts, time lags in production-related adjustments, and lags in response to new pricing behavior among consumers. Immediately, import costs start increasing on the domestic level, while export volumes stall because companies need time to increase production and establish links with new markets. In the long run, with increased production and export price reductions, foreign consumers consume more of domestic goods, which improves the trade balance gradually. This trend illustrates what Magee (1973) calls the J-curve effect, whereby, after the adverse initial effect on the trade balance, the trade balance gradually improves and finally turns positive as currency depreciation continues. The J-curve reflects the importance of recognizing time-dependent market responses while policy implications relating to exchange rate decisions are concerned. Future research should focus on untangling the

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interaction of external shocks, trade policies, and global economic conditions to affect the speed and extent of adjustment of the trade balance in response to exchange rate fluctuations.

Two definitions, the traditional and the alternative, are used by economists to characterize a J-curve phenomenon in international economics. According to the traditional definition, any depreciation of the value of a currency initially leads to poorer trade balances but improves over time. This implies that while undertaking empirical estimation, the exchange rate coefficients will be negative in the short run, then substantial and positive in time, exhibiting J-curve characteristics (Bahmani-Oskooee et al., 2019). The time lags could be attributed to contracts and price rigidities and to lags in trade adjustments. In the case of a depreciation of the domestic currency, the immediate increase in import prices would soon be followed by a similar increase in export prices since the level of export prices depends upon volume. In contrast, Rose and Yellen (1989) focused on defining the J-curve with long-run relationships instead of short-run dynamics. Specifically, the real exchange rate did negatively affect the trade balance in the short run due to short-run disruptions and surges in imports, but as trade adjustment takes place, the effect will turn to be positive and statistically significant from a longer-term coefficient perspective, which is precisely what the J-curve means. This means that depreciation worsens the trade balance at first when this trade balance improves net exports eventually, favoring that country with a steady depreciation.

Empirical research on the J-curve effect is generally divided into two methodological approaches: symmetric and asymmetric analyses. The symmetric approach operates under the assumption that exchange rate fluctuations impact the trade balance in a uniform manner, irrespective of whether the domestic currency appreciates or depreciates. In this framework, studies predominantly utilize linear econometric models to assess how trade balance adjustments respond to exchange rate movements. These models aim to determine whether currency depreciation initially leads to a deterioration in the trade balance, followed by a gradual improvement as market forces adjust.

The underlying premise of the symmetric approach is that the magnitude and direction of trade balance responses remain consistent across different exchange rate scenarios, meaning that appreciation and depreciation have equivalent but opposite effects on trade flows. By applying standard regression techniques, researchers in this category examine whether short-term trade imbalances eventually correct themselves as firms and consumers modify their behavior in response to altered price levels. However, the symmetric framework does not account for potential variations in the responsiveness of exports and imports to exchange rate changes, which has led to increasing interest in asymmetric analyses. Future research could explore how economic conditions, trade agreements, and global supply chain disruptions influence the validity of the symmetric assumption in J-curve studies. Conversely, the asymmetric approach challenges the assumption of uniform effects by recognizing that exchange rate movements may have different impacts depending on the direction and magnitude of the change. This line of research employs nonlinear models, such as threshold autoregressive or nonlinear autoregressive distributed lag models, to account for potential differences in how trade balance responds to exchange rate appreciation versus depreciation. These studies argue that firms, consumers, and policymakers may react differently to currency fluctuations depending on external economic conditions, market structure, and trade elasticity, leading to asymmetric trade balance adjustments. Numerous studies have been conducted over the past five decades to examine the relationship between exchange rates and trade balance in both developed and developing economies. Despite extensive research on the subject, empirical findings remain inconclusive, particularly concerning the influence of exchange rate fluctuations on trade balance dynamics in developing economies. While some studies provide empirical support for the J-curve hypothesis—demonstrating that currency depreciation initially worsens the trade balance before leading to improvements—others fail to identify a significant or consistent relationship between exchange rate variations and trade performance. The lack of consensus can be attributed to differences in economic structures, trade policies, exchange rate regimes, and external market conditions across nations. In some cases, weak industrial capacity, import dependency, and inflationary pressures offset the anticipated benefits of currency depreciation, preventing the expected trade balance recovery. Moreover, variations in methodological approaches, data periods, and model specifications further contribute to inconsistencies in empirical results. Some researchers argue that the effectiveness of exchange rate adjustments in improving trade performance depends on factors such as the price elasticity of demand for exports and imports, financial market development, and global demand fluctuations. Given these mixed findings, future research should explore country-specific factors that mediate exchange rate effects on trade balance, incorporating nonlinear models and structural break analyses to capture potential asymmetries in trade responses to currency movements. At the aggregate level, many studies adopting a symmetric assumption of exchange rate effects have found no substantial impact on trade balance in most countries. For instance, studies by Miles (1979), Himarios (1989), Rose and Yellen (1989), Bahmani-Oskooee and Alse (1994), Lal and Lowinger (2002), and Shahzad, Nafees, and Farid (2017) generally report insignificant or inconsistent effects of exchange rate movements on trade balance. This suggests that aggregate-level analyses may overlook critical country-specific or sectoral variations that influence trade dynamics. On the other hand, bilateral-level studies offer a different perspective.

Considering their evaluation of aggregate data, Rose and Yellen (1989) disqualified that approach regarding the disconnection between exchange rates and trade balances, as it might cover the economy's indirect mechanisms. As for the U.S., the study would analyze this J-Curve hypothesis through the evaluation of trade balance variations as a result of domestic income fluctuations, foreign income changes, and real exchange rate movements. Strong empirical support for the J-Curve effect in the U.S. economy was based on aggregate data findings, but these same results were not apparent when using bilateral trade data. While the above outputs signal that exchange rate impacts are by no means

straightforward, the fact of the matter is that currency fluctuations and trade balance adjustments are influenced by a range of variables that include specific trade partners, particularities of the traded goods and services composition, and the nature of bilateral trading agreements (Ali, 2018; Ali, 2022; Hong & Zu, 2024). Furthermore, market structures, exchange rate pass-through effects, and different price elasticities of demand for exports and imports could lead to empirical results discrepancies. Since the phenomenon is complex, future works should engage disaggregated data with advanced econometric methods to obtain the duly nuanced effects of exchange rate fluctuations on trade performance across various economies and trade partnerships (Arshad & Mukhtar, 2019; Mordecai & Akinsola, 2021; Munir et al., 2024).

The interaction of exchange rate changes with the trade balance at the bilateral level has been assessed by different authors, finding that the effects differ from one trading partner to another and across different economic states. According to the findings of Wilson and Tat (2001), Arora et al. (2003), Bahmani-Oskooee and Wang (2006), Narayan (2006), and Bahmani-Oskooee, Economidou, and Goswami (2006), changes in exchange rates do not uniformly affect the trade balance; instead the extent of this impact is likely to depend upon export and import demand elasticity, market structure, and trade agreement. Further disaggregated analyses such as those undertaken by Ardalani and Bahmani-Oskooee (2007) remain cognizant of the importance of sectoral differences assessing the J-curve impact. Using monthly data, they studied the J-curve effect for 66 U.S. trading sectors. The results showed the presence of the J-curve in only six sectors, while 22 sectors showed a positive long-run association between real depreciation and trade balance. These findings indicate that the J-curve effect is not universally applicable across all industries but rather contingent on sector-specific factors, such as the responsiveness of supply chains, production capacities, and the level of global competition faced by domestic producers.

In Pakistan, the exchange rate has always been considered a crucial policy tool for increasing exports and decreasing imports. Given the country's continuous trade deficits, the question addressed by researchers is whether any movement in the exchange rate will have an effective influence upon the trade balance. Hameed and Kanwal (2009), Bahmani-Oskooee and Cheema (2009), Jalil et al. (2016), Rehman and Afzal (2003), Iqbal et al. (2015), Bahmani-Oskooee et al. (2017), Malik (2019), Arshad and Mukhtar (2019), Rakot (2019), and Audi (2024) studied the exchange rate versus trade balance relationship in Pakistan. The findings, however, remain inconclusive since a few of them claimed depreciation of the currency would improve the trade balance, whilst others reported minimal or no effect. The ambiguity in results may be due to several factors. The first is that the rate of exchange rate pass-through to domestic prices will determine how competitive the depreciation of the Pakistani exports will be. Namely, if the prices of imported goods are increased to a significant extent due to currency depreciation, this would result in an increase in production costs of export-oriented industries, thereby negating any potential benefit that this depreciation may have brought in. Secondly, the bulk of Pakistan's exports mainly comprise low-value-added goods such as textiles and agriculture, which may nullify the advantages of currency depreciation on these goods, as they are so highly competitive in the world markets. Thirdly, if exchange rate adjustments are to optimally boost the trade balance, they would need to be rendered effective through provision of clear export orientation policies, diversification of export products, and access to global marketing.

Moreover, the structural issues within Pakistan’s trade sector—such as supply-side constraints, reliance on imported raw materials, and inconsistent government policies—play a role in shaping the impact of exchange rate fluctuations. Some researchers argue that exchange rate policies alone may not be sufficient to address trade imbalances and that a combination of policy measures, including improved infrastructure, trade facilitation, and targeted export promotion strategies, is necessary to achieve sustained improvements in trade balance. While the exchange rate remains an essential factor in trade policy, empirical studies suggest that its impact on trade balance is not uniform. At both the bilateral and sectoral levels, the impact of exchange rate fluctuations on trade performance is shaped by several factors, including variations in demand elasticities, differences in trade structures, and broader macroeconomic conditions. In the context of Pakistan, the diverse empirical findings highlight the intricate nature of exchange rate dynamics, suggesting that currency depreciation or appreciation alone may not be sufficient to drive sustained improvements in trade balance. These complexities emphasize the necessity of a well-rounded trade policy that extends beyond mere exchange rate adjustments to enhance export competitiveness and foster long-term trade growth. Structural improvements in production efficiency, diversification of export markets, and the adoption of value-added industries are essential components of an effective trade strategy. Additionally, strengthening financial infrastructure, reducing trade barriers, and implementing regulatory reforms can further enhance Pakistan’s ability to compete in global markets. By employing disaggregated sector data and nonlinear econometric techniques, future studies would examine industry-specific responses to exchange rate movements based on a preliminary acceptance of the mixed findings of empirical studies. In this way, these studies would contribute to answering the emerging call in the literature on trade balance ever since it became clear that the exchange rate affects trade flows asymmetrically by reneging on the simplistic belief in the symmetrical responses of trade balances to changes in currency values. Most of the researchers have approached this with nonlinear models to allow differential reactions to currency changes, and some of the most recent developments in this direction include the studies initiated by Chinn and Frankel (1991), Lin and Fu (2015), Jibrilla Aliyu and Mohammed Tijjani (2015), Qayyum, Nazir, and Jawad (2016), Bahmani-Oskooee, Bose, and Zhang (2017), Bahmani-Oskooee and Fariditavana (2016), Soleymani, Chua, and Saboori (2011), Bahmani-Oskooee and Harvey (2017), Iqbal and Raza (2018), Nur and Kumar (2023), and Audi (2024). The consensus is compelling in favor of the

argument that nonlinear models yield stronger empirical evidence for the J-curve phenomenon in contrast to traditional linear models.

The main reason nonlinear models are preferred is that the effects of appreciation and depreciation of currencies on trade balance are not always symmetric because of various market distortions, price rigidities, and adjustment behavior in the structure of global trade. Thus, a depreciation of domestic currency instantly increases import prices and brings trade accounts to an initial deterioration before exports could adjust according to the new competitive pricing. However, when a currency appreciates, the expected negative effect on trade balance may not materialize as strongly because exporters often absorb some of the price increases to maintain market share, and importers may delay adjustments due to contractual obligations and established trade relationships (Mehdi, 2019; Feng & Tang, 2024).

Nonlinear econometric models, including threshold autoregressive (TAR) and nonlinear autoregressive distributed lag (NARDL) models, provide a more precise framework for analyzing asymmetric exchange rate effects on trade performance. These models differentiate between the impacts of currency appreciation and depreciation, allowing for a more nuanced understanding of exchange rate fluctuations. Unlike linear models, which assume uniform effects regardless of direction, nonlinear approaches account for potential asymmetries in how exchange rate movements influence trade balance adjustments. For instance, currency depreciation may have a more pronounced impact on export competitiveness compared to the adverse effects of appreciation on imports, particularly in economies with high import dependency. By incorporating threshold effects, TAR models identify critical levels at which exchange rate changes trigger significant trade responses, while NARDL models assess short- and long-term asymmetries in exchange rate transmission. The ability to capture these nonlinear relationships enhances the accuracy of empirical analyses, offering valuable insights for policymakers designing exchange rate strategies. Given the growing complexity of global trade dynamics, future research should further explore how structural economic factors, such as financial development and trade diversification, interact with nonlinear exchange rate adjustments to shape trade performance in both developing and advanced economies. The findings from these studies indicate that traditional linear models often fail to detect the J-curve because they assume a symmetric response, thereby overlooking the complexities involved in trade adjustments. By contrast, nonlinear models provide a more accurate representation of real-world trade behavior, demonstrating that depreciation-induced improvements in trade balance may take longer to manifest, while appreciation-induced deteriorations can be gradual or even muted. Additionally, these studies highlight that the asymmetric effects of exchange rate movements vary by country, industry, and trading partner, further reinforcing the need for country-specific policy considerations. For instance, economies with diversified export bases, strong domestic supply chains, and high elasticity of demand for exports are more likely to experience positive long-term effects from currency depreciation. Conversely, countries that rely heavily on imported inputs for production may not benefit as much from exchange rate adjustments due to increased costs associated with imported raw materials and intermediate goods.

Recent empirical studies increasingly highlight that the impact of exchange rate fluctuations on trade balance is both nonlinear and asymmetric. Findings from nonlinear econometric models indicate that currency depreciation and appreciation influence trade balance adjustments differently, often exhibiting delayed or disproportionate effects. This reinforces the necessity of considering structural economic variations when designing exchange rate policies. Factors such as trade composition, financial development, and market competitiveness shape how exchange rate movements translate into trade performance. By utilizing nonlinear methodologies, researchers can better capture these complexities, offering a more refined perspective on trade dynamics. Unlike linear models, which assume uniform responses to currency fluctuations, nonlinear approaches reveal that depreciation may enhance export competitiveness more effectively than appreciation discourages imports. Additionally, exchange rate effects are often contingent on time lags, external shocks, and macroeconomic conditions, further complicating trade balance adjustments. Policymakers must therefore integrate a broader set of economic variables when assessing exchange rate strategies, ensuring that adjustments align with national economic objectives. Future research should explore sector-specific responses to exchange rate fluctuations, examining how industries with different elasticities of demand and supply react to asymmetric exchange rate movements, ultimately improving trade policy effectiveness. In almost all previous studies aggregation bias clouds the real effect of exchange rate variations on trade balance and could easily be attributed to the serious lack of significant effects. In order to add further credibility to their findings and resolve this issue, the present study disaggregates the exports and imports of Pakistan and China at the industry level. This lets more precision into measuring how changes in exchange rates affect the trade balance of certain industries which is more refined and accurate than an aggregate analysis.

Another key contribution of this study is its methodological shift from symmetric to asymmetric analysis. In a traditional sense, most of the studies have been framed around linear models to assess the symmetric impact of currency appreciation and depreciation on the trade balance. This assumption, however, does not give credence to the reality that it is different when the currency appreciates and depreciates because it influences trade in different ways. The present study adopts a nonlinear modeling strategy by rejecting the symmetry assumption i.e. that effects of appreciation and depreciation of the exchange rate are identical. In doing so, we consider the exchange rate along two axes: depreciation and appreciation. Because this marks a better differentiation between their trade balance effects, it paves the way toward a more precise analysis. It is well known that depreciations in currencies and appreciations of currencies vary greatly when adjusting for different reasons, including price adjustments, rigidities in trade contracts, and different elasticities of demand for imports and exports. In fact, it can at first make the trade balance worse, as imports become costlier before later improvements owing to a relatively competitive export condition. Conversely, currency

appreciation can reduce export competitiveness, but its impact on trade balance may be more gradual as businesses adjust prices and strategies to mitigate adverse effects.

The findings of Bussiere (2013), who contended that prices attached to imports and exports react to changes in exchange rates without symmetry, further strengthen rejection of the assumption of symmetry. In this respect, exporters and importers, respectively, change their pricing schemes depending on whether the domestic currency is appreciating or depreciating, as the example explains.: to keep market share, exporters may accommodate some of the impacts of currency appreciation, whereas, importers might fully pass on into consumers the cost of depreciation on the dollar. Such differences in price adjustment foretell nonlinear asymmetric responses. From this perspective, with an industry-level analysis and nonlinear modeling framework, this study attempts to better represent how exchange rates impact trade balances. Hence, while improving accuracy of results, this approach will also give insights to policymakers for better formulating exchange rate policies that reflect the more complicated and asymmetric nature of trade flows.

In the event that traded goods' prices respond asymmetrically to the exchange rate movement, one may naturally expect asymmetry in the behavior of trade balances due to their response to exchange rate fluctuations. Most studies until now have assumed symmetry in trade balance behavior, thus leading to inconclusive or partly conclusive findings. For instance, Aftab and Khan (2008) and Bahmani-Oskooee and Cheema (2009) considered the effects of the real exchange rate on Pakistan's trade balance under a symmetric framework. Their approach found depreciation of the currency to hurt Pakistan's trade balance but provided no clear evidence for the opposite effect of appreciation. The absence of the positive impact brings in some doubts about the possibility of asymmetric response of trade balance to exchange rate fluctuations. Thus, the current study intends to analyze the commodity-level trade between Pakistan and China in both linear and nonlinear setups with these concerns in mind. A nonlinear approach is particularly useful because it accounts for the possibility that depreciation and appreciation of the exchange rate do not have identical effects on trade balance. For example, currency depreciation may lead to an immediate rise in import costs while improvements in exports take time due to contract rigidities and supply-side constraints. On the other hand, appreciation may have a more gradual effect, as exporters adjust their pricing strategies to maintain competitiveness. These differences suggest that assuming symmetry in exchange rate effects may be an oversimplification that does not reflect the actual trade dynamics. Furthermore, previous studies that analyzed exchange rate effects at the aggregate trade balance level might have overlooked critical industry-specific variations. Aggregate analyses fail to capture how different industries respond to exchange rate movements, which can vary depending on factors such as price elasticity, production structure, and global competition. As a result, conclusions drawn from aggregate trade balance data may not fully represent the nuanced effects experienced by different sectors of the economy. Disaggregating trade balance data at the commodity level is, therefore, a crucial step in gaining a more accurate understanding of exchange rate effects. An industry-level analysis allows policymakers to determine the magnitude and direction of each sector's response to exchange rate fluctuations, providing more targeted insights for trade and exchange rate policy formulation. Policymakers can use this information to design industry-specific strategies, such as export incentives, tariff adjustments, or targeted exchange rate interventions, to mitigate adverse effects and enhance trade competitiveness. By addressing the limitations of past studies and employing a more granular approach, this study aims to provide a clearer picture of how exchange rate movements affect trade balance in Pakistan and China. The findings will contribute to a better understanding of asymmetric exchange rate effects and offer valuable insights for policymakers seeking to optimize trade policy in response to currency fluctuations.

This study enhances our understanding of how exchange rate fluctuations dynamically impact Pakistan’s trade balance at the industry level. By examining sector-specific trade responses, it provides a more nuanced perspective on the extent to which exchange rate changes influence exports and imports across different industries. Such insights are invaluable for policymakers in determining the appropriate magnitude and direction of exchange rate adjustments needed to regulate, forecast, and manage trade flows between Pakistan and China effectively. The findings of this study contribute to the ongoing discourse on whether the exchange rate serves as a reliable tool for improving trade balance. By distinguishing between industries that benefit from exchange rate depreciation and those that do not, this research enables policymakers to tailor exchange rate interventions to optimize trade outcomes. Moreover, it offers practical implications for the central bank in formulating exchange rate policies that support industrial competitiveness while mitigating potential adverse effects on import-dependent sectors. Additionally, this study serves as a reference for future research on trade balance dynamics in developing economies. It highlights the importance of adopting industry-specific approaches when analyzing exchange rate effects, encouraging further empirical investigations into how sectoral characteristics shape trade responsiveness to currency fluctuations. By addressing the limitations of aggregate-level analyses and incorporating asymmetric exchange rate effects, this research contributes to a more comprehensive understanding of the role of exchange rate policy in fostering sustainable trade and economic growth.

2. LITERATURE REVIEW

This section presents a comprehensive analysis of the J-curve effect, synthesizing relevant empirical literature to assess the relationship between exchange rate fluctuations and trade balance adjustments. The review is structured into two main categories: symmetric and asymmetric studies. The first category includes research that utilizes aggregate, bilateral, and industry-specific data, with a particular focus on Pakistan's trade dynamics. The second section examines asymmetric studies that apply nonlinear econometric models to better understand exchange rate responses. At the conclusion of this review, a concise summary of key studies is provided for comparative insights.

Bahmani-Oskooee and Alse (1994) critically evaluate the contrasting findings of Himarios (1989) and Bahmani-Oskooee (1985), both of whom adopted different econometric methodologies—first difference stationary data and non-stationary data, respectively. They argue that results obtained from non-stationary data may suffer from bias and should be interpreted cautiously. Their empirical investigation reveals that currency devaluation leads to trade balance improvements in Turkey, Singapore, Ireland, Costa Rica, Brazil, and the Netherlands, while Ireland experiences a contrary effect, where devaluation negatively impacts its trade balance. These findings underscore the importance of accounting for country-specific economic structures and market conditions when evaluating the effectiveness of exchange rate adjustments in trade policy. Future research should explore the role of trade elasticity, financial market development, and external shocks in shaping the long-term trade balance response to currency fluctuations. When the Error Correction Model (ECM) is applied to Costa Rica, Singapore, Ireland, and Turkey, a J curve pattern emerges, characterized by an initial trade balance deterioration followed by subsequent improvements.

In stark contrast with earlier studies, Lal and Lowinger (2002) propose a nonparametric statistical methodology to investigate the J curve. Their analysis employs nonlinear criteria on trade balance behavior concerning exchange rate changes, cross-country GDP, and current account balances. The results provide scant evidence in support of the J-curve effect being operative, suggesting that exchange rate depreciation does not often engender trade balance improvement. Shahzad, Nafees, and Farid (2017) analyze the relation between currency depreciation and trade balance performance in South Asian economies by means of panel data unit root tests and the Pedroni Cointegration approach. Their empirical results indicate that there does not exist an influential long-run connection between exchange rate depreciation and trade balance adjustments in the region. This poses a serious challenge to conventional economic doctrines which predict a lagged improvement in trade balance following depreciation. Several factors could explain this disconnect, including structural rigidities, import dependency, and the low price elasticity of exports in South Asian economies. Additionally, external influences such as global trade conditions, inflationary pressures, and financial market inefficiencies may dampen the expected positive impact of depreciation. These findings highlight the need for a more comprehensive trade policy that goes beyond currency adjustments, incorporating export diversification, industrial development, and trade facilitation measures. Future research should further explore country-specific factors influencing exchange rate effectiveness in improving trade balances, particularly by integrating nonlinear modeling approaches to capture potential asymmetric effects. A groundbreaking study by Rose and Yellen (1989) critically evaluates the limitations of using aggregate data in J-curve analysis and reexamines the phenomenon within the framework of the U.S. economy. Their research incorporates essential macroeconomic indicators, including domestic income, foreign income, and the real exchange rate, to assess their impact on trade balance fluctuations. By integrating these variables, the study aims to provide a more comprehensive understanding of how exchange rate movements influence trade dynamics over time. Their findings highlight that relying solely on aggregate data may obscure important variations in trade responses, as different industries and bilateral trade relationships react differently to currency fluctuations. While their aggregate-level analysis offers support for the J-curve hypothesis, their bilateral trade examination presents mixed results, indicating that exchange rate effects are not uniform across trading partners. This suggests that the relationship between currency depreciation and trade balance adjustments is influenced by factors such as trade composition, price elasticities, and external economic conditions. Their study underscores the importance of disaggregated approaches in trade balance research, advocating for more refined econometric models that capture the complex interactions between exchange rates and trade flows. Future research should explore sectoral and country-specific responses to exchange rate changes to enhance the accuracy of trade policy recommendations. While the aggregate-level analysis confirms the presence of the J curve for the United States, the bilateral-level investigation does not provide similar evidence. Building upon these findings, Wilson and Tat (2001) examine trade relations between Malaysia, Korea, Singapore, Japan, and the United States. Using the Autoregressive Distributed Lag (ARDL) approach and the Instrumental Variable (IV) technique to mitigate simultaneity bias, they confirm the existence of the J curve for Korea. Similarly, Narayan (2006) employs the ARDL model to investigate trade balance co-integration between China and the United States. While the study finds that China's trade balance improves following currency depreciation, it does not identify a J curve pattern.

The authors Bahmani-Oskooee, Economidou, and Goswami (2006) study the trade relations of China with its 13 major trading partners for the purpose of adjudging the validity of the J-curve hypothesis. The result indicates that, if there is any J-curve effect, it is probably in trade with Hong Kong and United Kingdom; from the very nature of this relationship, the effect of exchange rate fluctuation on trade balance may vary considerably. The finding emphasizes the need for specific views in analyzing exchange rate effects on price elasticity and trade structure. Following that line of reasoning, Bahmani-Oskooee and Kovyryalova (2008) studying trade data from 177 industries, find that in roughly 60% of the industries, exchange rate fluctuation strongly affects trade balance in the short run; however, with respect to the industry classification of the J-curve aspect-the impact of exchange rate flow on trade-no clear conclusion can be drawn. These findings highlight the necessity of employing disaggregated analysis to capture the complexities of trade balance adjustments.

Similarly, Bahmani-Oskooee and Mitra (2008) investigate trade between India and the United States across 38 industries, further reinforcing the notion that exchange rate effects on trade balance vary depending on industry characteristics, production structures, and global supply chain integration. Future research should explore how trade agreements, technological advancements, and market competition influence the responsiveness of different industries to currency fluctuations. Their results indicate that real depreciation leads to a J curve effect in three industries under

the traditional definition and in eight industries under a revised definition of the J curve. These findings reinforce the idea that different industries respond to currency fluctuations in varied ways, necessitating a disaggregated approach to J curve analysis. Soleymani, Chua, and Saboori (2011) further explore the J curve effect in Malaysia's trade balance with Japan, using the ARDL and ECM models for 67 industries. Their empirical results show that depreciation affects trade balance asymmetrically, with the J curve effect being evident in only 22 sectors. The study also finds that Korean exports and imports exhibit greater short-run responsiveness to exchange rate movements than Japanese exports and imports, but this relationship weakens over the long run. These studies indicate that the presence of the J curve effect is highly dependent on methodological approaches, time horizons, and levels of disaggregation. While some research confirms the J curve at an aggregate level, industry-level studies highlight significant variations in how different sectors respond to currency fluctuations. Additionally, nonlinear models have been increasingly adopted to better capture asymmetric exchange rate effects, providing a more refined understanding of trade balance dynamics.

Bahmani-Oskooee and Harvey (2017) treat the trade balance of Malaysia with its trading partners, given the earlier literature that suggested an asymmetry in the effect of changes in exchange rate and trade balance. They used a nonlinear Autoregressive Distributed Lag (ARDL) model to carry out short- and long-run assessments of the impacts of appreciation and depreciation of the currencies. Adjustment asymmetry in the sense of short and long covers the findings, and asymmetries of concurring impacts seem to hold true for Malaysia's bilateral trade with some Asian countries. The study further showed that the conventional explanation of the J curve that entails short-run deterioration and long-run improvement changes quite drastically since it proposes that the consequences of exchange rate adjustment may not be symmetric through time after the adoption of the ECM and Cointegration techniques. The standard ARDL approach, as developed by Pesaran, Shin, and Smith (2001), assumes a linear relationship between economic variables. Bahmani-Oskooee and Fariditavana (2016) critically re-evaluate the traditional assumption of a uniform J-curve effect in their study of bilateral trade between the United States and its key trading partners. Their research challenges the prevailing notion that exchange rate depreciation consistently improves trade balance over time. By employing nonlinear econometric techniques, they investigate whether trade balance adjustments respond symmetrically to exchange rate fluctuations. Their findings suggest that currency depreciation does not necessarily lead to trade improvements across all trading partners, reinforcing the argument that the J-curve effect is not universally applicable. Instead, their results highlight the presence of asymmetric responses, where some trading relationships exhibit stronger reactions to depreciation than appreciation, while others show little or no significant impact. These variations emphasize the role of country-specific economic structures, trade policies, and market dynamics in determining the extent to which exchange rate fluctuations influence trade performance. Their study underscores the importance of adopting nonlinear modeling approaches to better understand trade balance dynamics. Future research should further explore how trade agreements, sectoral dependencies, and financial market conditions shape the responsiveness of trade balance adjustments to currency movements in diverse economic contexts. Their research assumed that the exchange rate-trade balance relationship follows a nonlinear pattern. The results provided stronger evidence in support of the J curve under the nonlinear framework than in traditional linear models, reinforcing the argument that symmetric models may not fully capture the complexities of trade balance dynamics.

An extensive review of the literature on the J-curve effect indicates that existing studies can be categorized into two major groups: symmetric and asymmetric analyses. Symmetric studies predominantly rely on aggregate trade data, bilateral trade flows, and, in some cases, industry- or commodity-specific data to examine how exchange rate fluctuations influence trade balance adjustments. So far the heap of literature on the subject has generated very inconsistent findings, without a single definite pattern emerging in differing national and inter-national contexts. After depreciation of currency, some studies do show the trade balance begins to initially retract, only to then show improvement(the theory being dependent on). However, quite a few others are unable to find a clear-cut positive or negative relation between exchange rate changes and trade performance, hinting that perhaps certain other factors, for example, market structures, production capacities, and external economic conditions, are important determinants behind the trade balance outcome. Such divergent outcomes have pointed to the weakening of symmetric models that treat all responses to exchange rate changes as being determined by a common mechanism, regardless of whether the currency in question appreciates or depreciates. In such a backdrop, the interest in asymmetric models—allowing for different effects of exchange rate fluctuations on trade balance—is increasing. Future research should consider further investigating sector-specific trade relations using nonlinear econometrics in order to improve predictions of the trade balance and analyze any relevant policies accordingly. As such, the above-mentioned discrepancies arise because, by most symmetric models, the positive or negative effect of exchange rate depreciation and appreciation is assumed to be evenly distributed, while empirical evidence suggests otherwise. Meanwhile the asymmetric studies assert that the relationship between exchange rates and trade balance is nonlinear by its very nature. The studies evaluate trade balance adjustment as being dependent on whether the currency is depreciating or appreciating, external characteristics relevant for the economy in question, and the economy of its respective partners. The nonlinear empirical results show that, depending on industry, time horizon, and trade relationship, the exchange rate effects do exhibit high levels of variation, deepening our understanding of trade balance dynamics.

In the case of Pakistan, previous research has largely focused on aggregate trade flows or bilateral trade relationships while maintaining the assumption of a symmetric exchange rate-trade balance relationship. However, no prior study has systematically investigated whether this relationship exhibits nonlinear characteristics at the commodity or industry

level. Recognizing the limitations of existing research, this study aims to disaggregate Pakistan's trade data at the commodity level and rigorously examine the J-curve effect in both linear and nonlinear frameworks, specifically in the trade relationship between Pakistan and China. By incorporating a nonlinear approach, this research seeks to capture potential asymmetries in how exchange rate fluctuations influence trade balance adjustments, acknowledging that depreciation and appreciation may have differing impacts across industries. This methodological shift enables a more detailed understanding of sector-specific trade responses to currency movements, offering valuable insights for policymakers and trade analysts. The findings of this study are expected to contribute to more effective trade policy formulation by identifying industries that are more sensitive to exchange rate fluctuations, thereby allowing for targeted interventions that enhance export competitiveness. Future research should expand on this approach by examining additional trading partners and incorporating structural factors such as trade agreements and global supply chain dynamics.

3. METHODOLOGY

In studying asymmetric Cointegration and the J-curve effect in the trade balance models between Pakistan and China, this thesis reviewed various sources of data such as WDI and WITS, among others, in order to take a holistic approach to the macroeconomic and trade variables involved in robust empirical analysis. Due to the restrictions imposed by data unavailability, this study runs from 1980 to 2023, furnishing long-run perspectives on the dynamics of trade balance between the two countries; WDI provided data on both nominal exchange rate and real gross domestic product for Pakistan and its major trading partner China. These variables are essential in capturing macroeconomic influences on trade balance fluctuations. Meanwhile, commodity trade flow data, which form the core of this study's analysis, were extracted from the WITS database. By using disaggregated trade flow data at the commodity level, the study overcomes aggregation bias, which is a common limitation in prior research that relied on country-level trade balance estimates. By focusing on commodity-specific trade balances, this study provides a more granular perspective on how exchange rate fluctuations affect different industries differently. The dataset enables a sectoral decomposition of trade flows, which allows for the identification of industries that are more responsive to exchange rate movements. This approach facilitates an examination of whether certain commodities exhibit a clearer J-curve effect, where trade balance initially deteriorates following a currency depreciation before improving over time.

Furthermore, the study employs advanced econometric techniques, including asymmetric Cointegration methods, to test whether the effects of exchange rate appreciation and depreciation differ across industries. The methodology acknowledges that exchange rate movements do not always affect trade balance symmetrically; thus, separating the effects of appreciation and depreciation provides a more accurate representation of trade dynamics between Pakistan and China. This research not only improves empirical understanding of the J-curve phenomenon and its asymmetric effects in the case of Pakistan-China trade, but also makes it broad by integrating reliable global databases, extending the timelines of the studies, and applying a disaggregated approach. For imparting its empirical analysis, this study first employs unit root testing. The test was applied to the augmented Dickey and Fuller (ADF) unit root test, which was developed by Dickey and Fuller (1979). Moving forward as unit root analysis, both linear and nonlinear econometric approaches are then used to test the relationship between exchange rate and trade balance. For the linear model, it is based on the framework set by Rose and Yellen (1989) which assumes that impact of the exchange rate fluctuation for trade balance is symmetric. On the other hand, the nonlinear model is on the basis of the approach developed by Bahmani-Oskooee and Fariditavana (2016) whereby asymmetric effects are accounted through differentiating depreciation from appreciation in the exchange rate. Because of the two methodologies introduced, a comprehensive coverage in assessing trade balance adjustment relates to currency movement short- and long-run effects. Thus, a linear model tests whether the trade balance has shown some J-curve effects first by deterioration and then by recovery. The analysis is done by the nonlinear model in which changes in exchange rate are regarded positive and negative variations, enabling a much more detailed understanding of how the trade balance reacts to appreciation and depreciation. This dual approach enhances the robustness of the findings, offering deeper insights into Pakistan's trade dynamics with China. Future research should explore the role of external macroeconomic factors, trade agreements, and sectoral dependencies in shaping these exchange rate-trade balance interactions. The long-run specification of the model is given below:

$$LnTB_{i,t} = a + bLnY_{PAK,t} + cLnY_{Chn,t} + dLnREX_{i,t} + \in_{t,t} \qquad (1)$$

The above equation is modified according to the Error correction framework for the short-run effects.

$$\Delta \mathrm{LnTB}_{\mathrm{i,t}} = \alpha + \sum_{\mathrm{j=1}}^{\mathrm{n}} \beta_{\mathrm{j}} \Delta \mathrm{LnTB}_{\mathrm{i,t-j}} + \sum_{\mathrm{j=0}}^{\mathrm{n}} \delta_{\mathrm{j}} \Delta \mathrm{LnY}_{\mathrm{PAK,t-j}} + \sum_{\mathrm{j=0}}^{\mathrm{n}} \gamma_{\mathrm{j}} \Delta \mathrm{LnY}_{\mathrm{Chn,t-j}} + \sum_{\mathrm{j=0}}^{\mathrm{n}} \pi_{\mathrm{j}} \Delta \mathrm{LnREX}_{\mathrm{i,t-j}} + \lambda_1 \mathrm{LnTB}_{\mathrm{i,t-1}} + \lambda_2 \mathrm{LnY}_{\mathrm{PAK,t-1}} + \lambda_3 \mathrm{LnY}_{\mathrm{Chn,t-1}} + \lambda_4 \mathrm{LnREX}_{\mathrm{i,t-1}} + \mu_{\mathrm{t,t}} \qquad (2)$$

4. RESULTS AND DISCUSSIONS

Table 1 shows the results of the Augmented Dickey-Fuller (ADF) test at industry-level trade variables between Pakistan and China, which were tested for stationarity properties at both levels and first differences. The test is carried out with two specifications: intercept-only and trend-intercept models. Stationarity is a fundamental requirement to meet in a time series analysis since failure to account for unit roots may lead to misleading or spurious regression results. The ADF test determines if any given series is non-stationary, with the presence of a unit root being the null hypothesis

(Dickey & Fuller, 1979). The rejection of the null hypothesis indicates that the time series is stationary, pertaining to time-invariant statistical properties. The results of this test then define the appropriate econometric approach for the subsequent analysis, assuring sound inference in either a linear or nonlinear modeling framework. If the variables exhibit stationarity at levels, standard regression techniques can be applied, whereas first-differencing or advanced cointegration methods are necessary for non-stationary series. Understanding the stationarity characteristics of industry trade variables enhances the robustness of exchange rate-trade balance relationship assessments. Future research could incorporate structural break tests to account for potential policy shifts or economic shocks affecting trade patterns. Variables that are stationary at level are integrated of order zero, I(0), while those requiring first differencing are integrated of order one, I(1). The results show that most variables, including lnREX, NEG, lnY_PAK, lnAVOF, lnBT, lnCHM, lnCT, lnCMIEF, LnFLA, LnMTE, and lnMMI, are stationary at level (I(0)). This implies that these variables do not require differencing for further analysis, suggesting that their means and variances remain constant over time. The stationarity of exchange rates (lnREX) and output variables (lnY_PAK) at level is consistent with previous literature, which finds that nominal variables in developing economies often stabilize in the long run (Harris, 1992). On the other hand, variables like POS, lnY_CHN, LnMGC, and LnMFL are non-stationary at level but become stationary after first differencing (I(1)), indicating that these series follow a random walk process and require differencing to achieve stationarity. The non-stationarity of China's output (lnY_CHN) aligns with findings suggesting that rapidly growing economies often exhibit persistent shocks in output (Phillips & Perron, 1988).

The positive and negative shocks (POS and NEG) display mixed results. POS is I(1), suggesting that positive shocks in the exchange rate require differencing to become stationary, while NEG is I(0), indicating that negative shocks have a more immediate stationary effect. This asymmetry could be explained by the differing market responses to appreciation versus depreciation in currency, consistent with previous studies on exchange rate pass-through effects (Bahmani-Oskooee & Kutan, 2009). The lag order selection, determined using criteria like the Akaike Information Criterion (AIC), ensures that the tests account for serial correlation. Most variables have lag orders of zero or one, which is appropriate for avoiding overfitting while capturing short-term dynamics. Overall, the results confirm that a mix of I(0) and I(1) variables warrants the use of autoregressive distributed lag (ARDL) models or bounds testing approaches for co-integration analysis, as they accommodate different integration orders without requiring I(2) variables (Pesaran et al., 2001). This finding is particularly relevant when analyzing trade relationships between Pakistan and China, as the variables' integration properties suggest long-run equilibrium relationships alongside short-term fluctuations.

Table 1: ADF test results of Pakistan and China industry trade

Variables	Intercept	Trend & Intercept	I(1) Intercept	I(1)(Trend & Intercept	Lag Order
lnREX_(i,t)	-0.6058	0.0389			I(0)
POS	0.1347	1.6382	-0.7819	-0.1084	I(1)
NEG	0.8042	0.7443			I(0)
lnY_PAK	-0.4635	0.8232			I(0)
lnY_CHN	1.0868	1.7881	-0.6561	0	I(1)
lnAVOF	0.3947	0.2699			I(0)
lnBT	0.6761	-0.8502			I(0)
lnCHM	-0.8077	0.1732			I(0)
lnCT	-0.3293	0.0119			I(0)
lnCMIEF	-0.802	-0.0239			I(0)
LnFLA	0.1971	-0.6828			I(0)
LnMTE	0.5189	-0.6087			I(0)
LnMGC	0.6146	0.7518	-0.7697	0.0876	I(1)
LnMFL	1.0068	-0.1899	-0.7828	-0.1674	I(1)
lnMMI	0.0301	-0.0685			I(0)

Table 2 presents the findings from both the linear autoregressive distributed lag (L-ARDL) and nonlinear autoregressive distributed lag (NL-ARDL) models, which are utilized to examine industry-level trade between Pakistan and China. The ARDL methodology is particularly suitable for this analysis due to the presence of a mix of stationary [I(0)] and non-stationary [I(1)] variables, allowing for an in-depth exploration of both short-run and long-run relationships among key economic factors (Pesaran et al., 2001). By applying the L-ARDL model, the study assesses whether economic output, exchange rate movements, and asymmetric shocks influence bilateral trade dynamics. The results indicate that Pakistan's economic output (lnYPAK\ln Y_{PAK}lnYPAK, coefficient = -0.47528) exhibits a negative association with industry trade, implying that higher domestic production reduces reliance on industry trade, likely due to an increase in domestic consumption or import substitution effects. This finding suggests that as Pakistan's industrial sector grows, firms may shift toward meeting local demand rather than

engaging in external trade. Meanwhile, the NL-ARDL model provides further insights into how exchange rate fluctuations asymmetrically affect trade balance adjustments, capturing the differential impacts of currency appreciation and depreciation. These results highlight the complexity of trade dynamics and emphasize the importance of considering both symmetric and asymmetric effects in trade policy formulation. Future research should incorporate external macroeconomic variables, such as inflation and global commodity prices, to further refine the understanding of industry trade responses to exchange rate fluctuations.. The lagged values of Pakistan's output (lnY_PAK,t-1 to lnY_PAK,t-3) exhibit varying signs, reflecting fluctuations in trade responses over time. This dynamic effect is consistent with literature on output-trade relationships in developing economies, where growth phases influence trade patterns (Bahmani-Oskooee & Kantipong, 2001). China's output (lnY_i, coefficient = 0.280429) positively affects industry trade, indicating that Chinese economic growth boosts bilateral trade with Pakistan. The lagged terms (lnY_i,t-1 to lnY_i,t-3) show alternating signs, highlighting short-term volatility but an overall positive long-term association. This supports findings that trade with China significantly influences partner economies due to China's export-driven growth strategy (Yu et al., 2010).

The real exchange rate (lnREX_i, coefficient = 0.149196) in the L-ARDL model positively impacts trade, implying that currency depreciation improves export competitiveness. However, the significant positive effect of lagged exchange rates (lnREX_i,t-1, coefficient = 3.630043) suggests that exchange rate adjustments take time to fully affect trade flows, in line with the J-curve hypothesis (Bahmani-Oskooee, 1991). The NL-ARDL model captures asymmetries in exchange rate movements through positive (POS) and negative (NEG) shocks. The negative coefficient for POS (-0.05745) indicates that currency appreciation reduces industry trade, while the positive lagged effect (POS_t-1, coefficient = 14.03485) suggests delayed adjustments in trade volumes following appreciation. Conversely, the NEG shock (NEG_t, coefficient = 0.039195) indicates that currency depreciation initially promotes trade, but the negative long-run coefficient (-3.66289) reveals diminishing effects over time, highlighting asymmetric exchange rate pass-through effects (Shin et al., 2014). The constants in both models are positive, with a higher value in the NL-ARDL model (3.141106) than in the L-ARDL (0.569706), suggesting that unobserved factors may have a stronger influence when accounting for nonlinearities. Overall, the NL-ARDL model captures the complexities of asymmetric adjustments in exchange rates and trade flows more effectively than the linear model. The results support policy recommendations emphasizing stable exchange rates and diversified export strategies to mitigate the adverse effects of currency volatility on trade. Additionally, the findings suggest that both Pakistan's and China's economic activities significantly influence bilateral trade, albeit with differing short- and long-term impacts.

Table 2: Linear ARDL (L-ARDL) and Nonlinear ARDL (NL-ARDL) Models for Pakistan and China

Variable	LARDL	NLARDL
lnY_(PAK,t)	-0.47528	-0.12933
lnY_(PAK,t-1)		7.784844
lnY_(PAK,t-2)		-7.41765
lnY_(PAK,t-3)		6.591946
lnY_(i,t)	0.280429	0.249466
lnY_(i,t-1)		-1.9026
lnY_(i,t-2)		-2.77091
lnY_(i,t-3)		
lnREX_(i,t)	0.149196	
lnREX_(i,t-1)		3.630043
lnREX_(i,t-2)		
lnREX_(i,t-3)		
POS_t		-0.05745
POS_(t-1)		14.03485
POS_(t-2)		-2.80083
POS_(t-3)		-4.42526
NEG_t	0.039195	-3.66289
NEG_(t-1)		
NEG_(t-2)		
NEG_(t-3)		
lnY_PAK	-0.23639	-0.3863
lnY_i	-0.1964	-0.08471
lnREX_i	-0.25515	
POS		-0.03018
NEG		-0.04636
Constant	0.569706	3.141106

Table 3 presents the estimation results from the Linear ARDL (L-ARDL) and Nonlinear ARDL (NL-ARDL) models, which examine the trade relationship between Pakistan and China across various model specifications (CM & ID, FD & LA, MC & TE, MG). These models are designed to analyze both short-run trade dynamics and long-run equilibrium relationships while capturing the asymmetric effects of economic output, exchange rate fluctuations, and external shocks on industry-level trade (Pesaran et al., 2001; Shin et al., 2014). The L-ARDL model evaluates whether economic variables exert symmetric effects on trade flows, while the NL-ARDL model allows for a more nuanced understanding of how exchange rate appreciation and depreciation impact trade differently. By incorporating multiple specifications, the analysis provides a comprehensive assessment of sector-specific trade responses to macroeconomic changes. The results highlight significant variations in trade adjustments based on industry characteristics and the direction of exchange rate shifts. Capturing these asymmetries is crucial for formulating trade policies that enhance export competitiveness and mitigate adverse effects of currency volatility. Future research should consider integrating additional macroeconomic indicators, such as inflation, foreign direct investment, and global supply chain disruptions, to further refine the understanding of trade balance adjustments in response to exchange rate fluctuations. In the CM & ID model, Pakistan's output (lnY_PAK, coefficient = -0.59583) exhibits a negative relationship with industry trade, implying that higher domestic production in Pakistan may reduce reliance on imports through import substitution. Conversely, China's output (lnY_i, coefficient = 2.317589) shows a positive and significant effect, suggesting that Chinese economic growth stimulates bilateral trade with Pakistan. This pattern aligns with research indicating that partner country economic expansions boost export opportunities (Yu et al., 2010). The FD & LA model reveals an opposite relationship for Pakistan's output (lnY_PAK, coefficient = 1.075838) compared to the CM & ID model, suggesting that under different specifications, domestic growth in Pakistan can encourage imports of intermediate goods necessary for industrial production. However, lagged output variables (lnY_PAK,t-1 to lnY_PAK,t-3) show fluctuating signs, reflecting complex short-term trade adjustments. The negative coefficient for China's lagged output (lnY_i, coefficient = -7.79414) suggests that rapid Chinese growth may increase domestic production, reducing reliance on imports from Pakistan.

Table 3: Linear ARDL (L-ARDL) and Nonlinear ARDL (NL-ARDL) Models for Pakistan and China industry

	CM & ID	FD & LA	MC & TE	MG
lnY_(PAK,t)	-0.59583	1.075838	0.440926	-6.4281
lnY_(PAK,t-1)	0.971286	-4.0816	-6.91668	
lnY_(PAK,t-2)		-0.67779	31.31941	31.81678
lnY_(PAK,t-3)		-2.80272	-23.4144	-21.2542
lnY_(i,t)	2.317589	1.320128		0.17254
lnY_(i,t-1)		-2.00236		
lnY_(i,t-2)		-1.19544	-14.6637	-7.65892
lnY_(i,t-3)		3.847501	2.673611	-14.9139
lnREX_(i,t)	0.007585		2.303581	3.094079
lnREX_(i,t-1)	-0.62317		-10.1331	-9.09726
lnREX_(i,t-2)	0.07079		0.437093	
POS_t		-1.06579		2.665252
POS_(t-1)			3.807994	
NEG_t		1.721335	-3.43186	
NEG_(t-1)	-1.40545		-0.45488	
lnY_PAK		17.20109	-2.4017	-2.97476
lnY_i	8.069117	-7.79414	0.45581	2.521098
lnREX_i	-3.49799		0.051619	
POS	0.624531	0.739451	-0.49773	
NEG			-1.36033	
Constant	3.107052		19.85132	39.67069

In the MC & TE model, the exchange rate (lnREX_i, coefficient = 2.303581) positively affects trade, indicating that depreciation of the Chinese yuan or Pakistani rupee improves export competitiveness. The strong negative lagged effect (lnREX_i,t-1 = -10.1331) highlights delayed trade volume contractions following currency appreciations, consistent with the J-curve effect (Bahmani-Oskooee & Kantipong, 2001). The MG model indicates that Pakistan's economic growth has a substantial negative long-term effect (lnY_PAK = -6.4281) on industry trade, supporting the notion that

increased self-sufficiency reduces dependence on imports. In contrast, China's economic activity (lnY_i, coefficient = 2.521098) positively impacts trade, consistent with China's role as a major trading partner in Asia (Yu et al., 2010). The exchange rate effect (lnREX_i, coefficient = 3.094079) remains positive, reinforcing the idea that currency depreciations benefit trade. The nonlinear aspects (POS and NEG shocks) capture asymmetric exchange rate effects. Positive shocks (POS) display varying signs across models, with the MG model showing a significant positive effect (2.665252), indicating that currency appreciation in China leads to increased imports from Pakistan. Conversely, negative shocks (NEG) show negative coefficients (e.g., -3.43186 in MC & TE), suggesting that currency depreciations initially boost exports but have diminishing returns over time (Shin et al., 2014).

The constants in all models are positive, with the highest value in the MG model (39.67069), indicating stronger baseline trade levels when accounting for both linear and nonlinear factors. Overall, the results indicate that China's economic growth consistently stimulates bilateral trade, while Pakistan's output has mixed effects depending on the model specification. Exchange rate fluctuations have significant asymmetric impacts, underscoring the importance of stable currency policies for trade enhancement. The NL-ARDL model captures complex dynamics better than the L-ARDL, emphasizing the necessity of accounting for asymmetries in trade analysis.

Table 4 presents the estimation results from both the Linear ARDL (L-ARDL) and Nonlinear ARDL (NL-ARDL) models, along with their extended versions (Misc LARDL and Misc NLARDL), to analyze bilateral industry trade between Pakistan and China. These models assess both short-term fluctuations and long-run equilibrium relationships, providing insights into how trade responds to macroeconomic changes over different time horizons. The nonlinear models are particularly valuable as they capture the asymmetric effects of exchange rate movements and economic output fluctuations, differentiating between the impact of positive and negative shocks (Pesaran et al., 2001; Shin et al., 2014). By incorporating these asymmetries, the analysis highlights whether currency depreciation and appreciation have disproportionate effects on trade balance adjustments, allowing for a more comprehensive understanding of trade dynamics.

Table 4: Linear ARDL (L-ARDL) and Nonlinear ARDL (NL-ARDL) Models for Pakistan and China industry

Variable	LARDL	NLARDL	Misc LARDL	Misc NLARDL
lnY_(PAK,t)	4.6	-4.04	0.46	0.28
lnY_(PAK,t-1)		6.67		0.35
lnY_(PAK,t-2)		7.6		0.31
lnY_(PAK,t-3)		-18.11		-0.48
lnY_(i,t)	-2.28	8.57	-0.71	-0.59
lnY_(i,t-1)		-6.91	0.44	0.55
lnY_(i,t-2)		2.47	-0.31	-0.46
lnY_(i,t-3)		-9.15		
lnREX_(i,t)	1.98		0.06	
lnREX_(i,t-1)	-2.65		-0.002	
lnREX_(i,t-2)	2.4		0.03	
lnREX_(i,t-3)		-0.05		
POS_t		5.01		-0.04
POS_(t-1)		-8.94		0.15
POS_(t-2)		7.28		
POS_(t-3)		4.21		
NEG_t	-2.21		0.1	
NEG_(t-1)			-0.12	
NEG_(t-2)			0.11	
NEG_(t-3)				
lnY_PAK	6.7	3.88	0.07	0.05
lnY_i	-3.31	-0.79	-0.02	0.04
lnREX_i	0.36		0.06	
POS		-3.79		-0.15
NEG		-1.43		0.006
Constant	-74.88	-73.37	-1.2	-2.38

The inclusion of miscellaneous versions further refines the results, offering alternative specifications to assess the robustness of findings. These insights contribute to the formulation of more effective trade and exchange rate policies, particularly in addressing industry-specific trade imbalances. Future research should explore how additional external factors, such as global commodity price volatility, financial market conditions, and trade policy changes, influence the exchange rate-trade balance relationship in emerging economies. In the L-ARDL model, Pakistan's current output (lnY_PAK, coefficient = 4.6) positively affects industry trade, indicating that economic growth in Pakistan encourages import demand for industrial inputs. However, lagged values show fluctuating effects, with lnY_PAK,t-3 having a significant negative effect (-18.11), suggesting delayed adjustments or reversal in trade patterns. Such patterns are consistent with the trade-growth literature that emphasizes the varying lagged impacts of domestic output on trade (Bahmani-Oskooee & Kantipong, 2001). In the NL-ARDL model, Pakistan's output (lnY_PAK, coefficient = -4.04) negatively affects trade, highlighting that accounting for asymmetries changes the relationship. This indicates that certain economic expansions might reduce trade reliance, possibly due to import substitution policies. Lagged terms are not included in this version, focusing on immediate effects. The miscellaneous models further illustrate weaker but positive effects of Pakistan's output, showing the sensitivity of estimates to model specifications.

China's output (lnY_i) exhibits contrasting signs between models. In the L-ARDL, the current effect is negative (-2.28), implying that higher Chinese production may reduce imports from Pakistan. Conversely, the NL-ARDL model shows a positive coefficient (8.57), indicating that nonlinearities reveal a trade-promoting effect of Chinese economic growth. These findings align with studies suggesting that trade impacts can differ based on demand shifts and production cycles in major trading partners (Yu et al., 2010). The exchange rate variable (lnREX_i) in the L-ARDL model shows a positive current effect (1.98), consistent with the idea that currency depreciation improves export competitiveness. Lagged effects, however, are mixed, with lnREX_i,t-1 negatively affecting trade (-2.65), indicating short-term volatility typical of exchange rate movements (Bahmani-Oskooee, 1991). The miscellaneous models report smaller exchange rate impacts, reflecting model-specific sensitivities. The NL-ARDL model captures asymmetries through positive (POS) and negative (NEG) shocks. Positive shocks (POS_t) have a significant positive immediate effect (5.01), suggesting that currency appreciations increase trade volumes, possibly through cheaper imports. Lagged POS values show varying impacts, with POS_(t-1) being negative (-8.94) and POS_(t-2) positive (7.28), highlighting adjustment delays. Conversely, negative shocks (NEG_t) are mostly negative across models, indicating that depreciations may reduce trade in the long run, despite potential short-term boosts (Shin et al., 2014). The constant terms are significantly negative in both primary models (-74.88 in L-ARDL and -73.37 in NL-ARDL), indicating the influence of unobserved factors reducing baseline trade levels. The miscellaneous models have smaller negative constants, reflecting less pronounced baseline adjustments. Overall, the NL-ARDL model better captures the complexities of bilateral trade by incorporating asymmetries, while the L-ARDL model provides useful baseline estimates. Positive economic growth in Pakistan generally promotes trade, while China's impact is more nuanced, depending on model specifications. Exchange rate effects are significant but vary over time and across models, underscoring the importance of considering both immediate and lagged dynamics in trade policy analysis.

5. CONCLUSIONS

We conclude that the balance of payments adjustment approach focusing on elasticity cannot work well independently. Therefore, it should be complemented with income and monetary approaches for a more robust economic scheme. The falling of the nominal exchange rate does not necessarily imply that there will be a parallel falling of the real exchange rate, meaning that a nominal depreciation policy will only work if it translates into real depreciation. The applicability of this point rests on one condition: the stability of domestic prices with their foreign counterparts. Once domestic prices experience a high level of increase, the benefits from exchange rate adjustments will not likely materialize, hence limiting the real impact on trade balance improvement. Furthermore, rather than depending primarily on external policies that stimulate trade balance adjustments, the government should concentrate on improving the domestic supply side. Creating an enabling environment for the production of competing goods and services towards both export and import substitution will be a more sustainable solution. The findings of this study stress that an exclusive reliance on external policy measures for improving the balance of trade, such as currency devaluation or depreciation, has not yielded the expected results. This is primarily because many developing nations, including Pakistan, function as price takers in the global market and lack the ability to influence international demand for exports through price adjustments alone. However, despite these limitations, currency devaluations remain a crucial policy tool for improving trade balance in several industries engaged in trade between Pakistan and China. Another key policy implication is that the government should adopt strategies aimed at enhancing the real gross domestic product of Pakistan to improve trade balance outcomes. To achieve this, policymakers should implement policies that promote productivity and expansion in key sectors such as agriculture and manufacturing, ensuring that these industries can meet both foreign and domestic demand for goods and services. Encouraging investment, particularly from foreign investors, in the manufacturing and agricultural sectors could serve as a catalyst for economic growth, increasing industrial output and improving Pakistan's trade balance. By fostering a business-friendly environment, enhancing infrastructure, and providing targeted incentives for industrial growth, the government can improve economic competitiveness and support long-term trade balance stability. Ultimately, this study underscores the importance of a balanced approach that integrates exchange rate policies with structural economic reforms. A combination of targeted monetary, fiscal, and trade policies—rather than an

overreliance on nominal exchange rate adjustments—would provide a more effective and sustainable path toward improving trade balance and overall economic stability.

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