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Examining the J-curve and S-curve patterns in Pakistan's economic ties with the USA and China, the world's economic giants

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JEL: F1, F31

Abstract

Aim: Since the J- and S-curve concepts were first introduced, several researchers have tried to test their validity through empirical research. To offer recommendations for additional research, this study looked at the relevant literature.

Methodology: The idea of the S-curve is an extension of the J-curve, which shows how the trade balance improves over time despite initially being worse due to currency depreciation. According to the S-curve hypothesis, there is a positive cross-correlation between the current exchange rate and the future trade balance of a country, and a negative cross-correlation between the current exchange rate and the past trade balance. To understand the pattern of the relationships, the author considered time series data for fifteen 3-digit industries/commodities between Pakistan and its main trading partners – China and the USA – from 1980 to 2022.

Results: The results demonstrate that the minority of Pakistani industries, engaged in trade with the USA and China, supported J and S-curves behaviour.

Implications and recommendations: The study showed that improving the trade balance is not always possible with domestic currency devaluation.

Originality/Value: This study made an incremental contribution in that it critiqued a consumer price index (CPI) which has been used in literature on the aggregate level, and constructed commodity-based CPI for the analysis.

Keywords: the USA, S-curve, J-curve, China, currency depreciation, 3-digit industries, Pakistan

1. Introduction

Pakistan which has been experiencing a persistent trade deficit apart from 1951 and 1971, may choose to devalue or depreciate its currency. The country with a gross domestic product of less than $300 billion is experiencing a $43 billion trade deficit (Ministry of Finance, Government of Pakistan, 2020), although depreciation of own currency is a tool to influence the trade deficit. The trade balance deteriorates in the short term when the currency depreciates because of cheaper exports and more expensive imports (the price effect of depreciation). This is because export and import are inelastic in the short run, due to contracts signed between the countries, yet eventually exports and imports have elasticities that are greater than one when past contracts expire, as over time export and import volumes fluctuated in response to currency depreciation (see Bahmani-Oskooee 2015). As a result, exports increased and imports decreased, improving the trade balance over time. Decrease would function under the framework of flexible exchange rates and lead to an improvement in the trade balance in the future, whilst devaluation would result from this trade deficit when some lag adjustments are made. Unlike the hypothesis being tested, because of the simultaneous equation framework (see Blavasciunaite et al., 2020; Iqbal et al., 2024), using time series data covering the period 1980 to 2020, investigated the effects of exchange rate misalignment asymmetry on Bangladesh's economic growth. Exchange rate misalignment has a major effect on economic growth as the study results symmetrically demonstrated. However, the implementation of the nonlinear autoregressive distributed lag (NARDL) model provides significant evidence for asymmetric effects indicating that overvaluation impedes economic growth, while undervaluation promotes it. A market-based equilibrium exchange rate system should be put into place according to this analysis, which notifies decision-makers, regulators and market experts that sustained long-term economic growth is supported by the customised exchange rate policies.

For policymakers in both developed and developing countries, maintaining an effective exchange rate is a constant source of difficulty, i.e. to reduce the trade deficit. Pakistan, like many other countries, has frequently depreciated its currency (Aftab, & Khan, 2008). The economic literature essentially states that the depreciation of the domestic exchange rate is based on two approaches – the monetary approach and the absorption approach – both of which aim to improve the trade balance. The monetary approach contends that depreciation or devaluation lowers the real values of the cash balance and shifts the relative prices of tradable and non-tradable goods improving the trade balance (TB) (cf. Baharumshah, 2001). The absorption approach contends that depreciation or devaluation increases expenditure from imported to local goods, thereby improving the country's trade balance.

Three different methods were applied to investigate the relationship between trade balance and exchange rate, namely the J-curve approach, the S-curve function, and the Marshall-Lerner (ML) condition. The ML condition is an indirect way to assess how strongly devaluation enhances TB. It states that the real depreciation of the exchange rate will have a positive effect on trade flows if the total elasticity of the demand for imports and exports is greater than one. Most of the countries mentioned by Rose (1990), Bahmani-Oskooee and Niroomand (1998) etc., met the Marshal-Lerner requirement, nevertheless there have been instances where TB became worse, even though the ML condition was not met. Kousar et al. (2017) also tried to determine the presence of S-curve in case of some industries, including agriculture and manufacturing. The authors found that manufacturing industries do not follow the S-curve, unlike agriculture. The S-curve can also be referred to Meade (1988), Rose and Yellen (1989), and Bahmani (1985). Their research shifted attention to the short-run components that followed the post-depreciation time path of TB to the well-known J-curve given that the Marshall-Lerner condition is a long-term requireent, meaning that the short- and long-term elasticities of imports and exports differ. Contracts signed between the countries cause the export and import elasticities to be inelastic in the short run. As a result, when the currency depreciates, the trade balance deteriorates because imports become more expensive and exports less affordable (the price effect of depreciation). Eventually, export and import elasticities surpass unity (become elastic) when prior contracts expire, which may be due to overtime changes in import and export volumes being

a result of currency depreciation. Thus, exports increased and imports decreased, improving the trade balance with time (exports and imports quantities' adjustment).

It is not new to investigate how changes in exchange rates affect the trade balance. Studies have been conducted on the effects of appreciation and depreciation of exchange rates on the trade balance under the floating exchange rate regime. Prior to 1973, research showed a greater interest in examining the long-term effects of currency devaluation on trade balances. However, Magee (1973) noted that adjustment of export-import lags caused that the trade balance did not improve in the short run,, with delays in delivery recognition and production among others. In the short term, goods are transported at the previous exchange rates and prices, however TB starts to improve as soon as the contracts are fulfilled, and the new rates and prices take effect. This pattern of movement or behaviour was named the J-curve approach by Magee (1973), whilst Bahmani-Oskooee (1985) provided a method for testing the J-curve effect. Bahmani-Oskooee and Ratha (2004) have reviewed the existing literature. This concept was previously tested by Senhadji (1998) for developing economies. The literature on the S-curve effect is not as extensive as for the J-curve. According to the earlier publications, three different types of data were used in S-curve analysis: industry bilateral, and aggregate level data. Trade data at the aggregate level between a country and the rest of the world was used in the first set of studies.

Similarly, Kayani et al. (2023) described the effects of increased exchange rate volatility on exports and imports vary among Pakistan, Malaysia, Japan, and Korea, looking at the effects of asymmetric exchange rates on trade flows in some Asian countries. The International Financial Statistics (IFS) database, kept up to date by the International Monetary Fund (IMF), was the source of the quarterly data for 1980 to 2018. For the estimation, the author used both non-linear and linear autoregressive distributed lag (ARDL) models. Whereas the linear models failed to show any discernible effects of exchange rate volatility on trade flows, the non-linear models produced more important results, and the conclusions imply that in the case of Pakistan both the linear and non-linear models showed that while lower volatility benefits both of them, higher exchange rate volatility had a negative impact on imports and exports. This suggests that maintaining exchange rate stability would be advantageous for trade with Pakistan, yet the linear model used for Malaysia did not demonstrate any long-term effects of exchange rate volatility on exports.

Since research on the S and J-curve effect is still in its early stages, any new findings are encouraging. Consequently, it was assumed that earlier research on Pakistan was limited because it examined the S- and J-curves in the context of Pakistan globally, and depended on trade data at aggregate level. To further the body of knowledge, this article reexamines the J- and S-curve in trilateral commodity trade involving China, Pakistan and the United States at disaggregate level for fifteen 3-digit industries. Note that the author considered a broad range of industries including both small and large manufacturing sectors; the same applies both to durable and non-durable commodities. Some industries were not included in the list because the necessary data were not available. The world's two largest economies, China and the USA, provided the focus and area of interest for this study. China is Pakistan's largest trading partner in terms of imports, while the USA is its largest trading partner regarding exports. Pakistan's economy depends heavily on imports from China, resulting in a $43 billion trade deficit between the two economies, therefore, when the government devalues the currency, this has a negative impact on the trade balance even though the USA receives most of Pakistan's exports. The economic theory that depreciation has a positive impact on the economic trade balance was tested in this study, hence the interest in the commodities trade of Pakistan with the USA and China, with some implications for other economies whose trade balance shows deficit. Thus the results demonstrated that depreciation does not have a positive effect on Pakistan's trade balance regarding its trade with China and the USA.

The rest of the paper is organized as follows: Section 2 presents the the literature review, Section 3 focuses on construction of variables, data source, and the method of generating the S-curve, whilst results and their interpretation are discussed in Section 4 and Section 5 contains the conclusion and recommendations.

2. Literature review

A number of studies have explored commodity trade using the J-curve and the S-curve. The J-curve concept was examined by Bahmani-Oskooee and Milixi (1992) for Korea, but they were unable to produce the J-curve behaviour, whilst Bahmani-Oskooee and Hosny (2012) researched the commodities trade between Egypt and the USA. The impact of exchange rates on trade flow was investigated using 59 industry-specific data sets; only 24 out of the 59 industries had an improvement in the trade balance according to the findings which demonstrated the pattern of the J-curve. In their evaluation of the J-curve effect in the US service trade, Bahmani-Oskooee and Xiu et al. (2022) revealed asymmetric J-curve behaviour in these sectors. Khan et al. (2020) examined the J-curve for China, and found evidence in favour of J-curve pattern in China's trade balance. The results showed that while China's trade balance was initially worse, over time its trade pattern improved, thus the J-curve theory was correct.

Ahmad et al. (2024) used disaggregated data to analyse the asymmetric S-curve between the trade balances of China and Pakistan at commodity level, and the results indicated that in 27 of the 32 industries examined, there was strong support for the asymmetric S-curve. The study demonstrated that depreciating one's own currency is not always a practical way to increase trade balance. Backus et al. (1994) presented this idea using a basic cross-correlation function to illustrate the relationship between trade balance and exchange rate. The S-curve was predicted to result from their theory that there may be a positive correlation between the current exchange rate and future trade balance values, and a negative correlation between the current exchange rate and those of the past.

Iqbal et al. (2023) investigated the S-curve for the Pakistan and China commodity trade levels, and found that the industries where the S-curve exists are in minority. Thus, currency depreciation is not favourable to increasing the Pakistan and China commodity trade level. Bahmani-Oskooee et al. (2008) suggested that the J-curve was an outdated notion, and the S-curve as a more recent concept represents the short-run relationship between the trade balance and terms of trade or the real exchange rate. According to the S-curve which was introduced in 1994, there is a positive correlation between the current exchange rate and the future value of the trade balance, but a negative cross-correlation exists between the past and present values of the trade balance. Among the relevant studies were: Senhadji (1998); Bahmani-Oskooee, Kutan and Ratha (2008) Backus et al. (1994) and Bahmani Gelen and Ratha (2008), yet their results were not important because of aggregation bias. The second group of researchers employed bilateral export-import data to remove this aggregation. As a result of aggregation bias, the results remain unimportant, hence the third group of studies used the commodity/industries data at disaggregation level to remove the aggregation bias associated with bilateral studies (cf. Bahmani-Oskooee, & Ratha, 2010; Bahmani-Oskooee, Xu 2014; Bahmani-Oskooee, & Zhang, 2013), whose conclusions are noteworthy. Moreover, Ahmad et al. (2023) investigated the asymmetric S-curve for the Pakistan and Japan commodity trade, and found that the evidence supported the asymmetric S-curve behaviour in their trade pattern. Kousar et al. (2017) discovered the S-curve pattern among minority of industries in Pakistan.

3. Data and methodology

To prevent aggregation bias, the author also planned to investigate the S-curve presence in trade among China, Pakistan and the United States at commodity level using the same methodology as Bahmani-Oskooee and Ratha (2010), who examined the pattern of the S-curve for China. In terms of the J- and S-curve behaviour, this study differs greatly from the previous research which examined both patterns independently. However, the study also differs from others in that it examined the J and S-curve effects together. There is no research available that investigates the joint reinvestigation of the J- and S-curve shape.

The author identified fifteen 3-digit SITC industries involved in the trade and was able to locate time-series data for the period 1980–2022. The World Development Indicator (WDI) and the World Integrated Trade Solution (WITS) were the sources of all secondary data, and the study defined the variables from Pakistan's viewpoint as the reported country. Since the same method was also employed by Bahmani-Oskooee and Xu (2010, 2013, 2014), the trade balance was also a dependent variable in this study, defined as the difference between exports and imports and divided by the GDP of Pakistan $\frac{(X_i - M_i)}{\mathrm{GDP_{Pak}}}$. The gross domestic product of Pakistan is denoted by GDP_{pak} and the entire set of data was taken in nominal terms. X_i represents Pakistani exports of industry *i* to China, whilst M_i stands for Pakistani imports of the same industry from China. The US trade was also calculated using the same formula. The real exchange rate (RER) was indirectly defined in this study as $NER \cdot \frac{Commodity\ Prices_{PAK}}{Commodity\ Prices_{CHN}}$, where *NER* denotes the nominal exchange rate defined as the number of rupees penminbi using the bilateral CPI of that commodity. The same formula also was used for the United States for calculating the real exchange rate.

This study contributes to the existing research by showing that the S-curve is based on the cross-correlation function, and the existing literature also applied the cross-correlation method for testing the S-curve phenomena. The existing studies also used aggregate consumer price index (CPI), which is not an appropriate approach for constructing the real exchange rate because the aggregate CPI is a bundle of goods containing over four hundred commodities. However, the author also contributes to the existing studies by using the commodity-based CPI and the construction of real exchange rate, and then estimating the real exchange rate with the trade balance to test the S-curve patterns which is the extension of the J-curve; as a result, a rise in the nominal exchange rate on one side will translate to the other side and raise the real exchange rate, with the increase reflecting the appreciation or depreciation of the domestic currency (the rupee) in foreign (China's) currency (the renminbi) referred to as the foreign currency in this context, and Pakistani currency as the domestic one. Similarly, the real exchange rate calculation formula used for the USA was also $NER \cdot \frac{Commodity\ Prices_{PAK}}{Commodity\ Prices_{US}}$. Therefore, the increase reflects the foreign currency (US dollar) appreciation or depreciation of the domestic currency (rupee). Certain steps had to be followed befe estimating the S-curve. In the first step, the author had to de-trend the data through the Hodrick-Prescott (HP)[1] filter to remove the spurious outcome from the present data set, where the advantage of the Hodrick-Prescott filter is that it can extract the same trend for the set of variables. The next step was to estimate the cross-correlation which describes the relationship between current exchange rate and past (future) values of the trade balance are negative (positive). As the supposed real exchange rate depreciates, this will improve the balance of trade and then the cross-correlation coefficients must be positive. By studying the past literature, the cross-correlation function was defined through the following formula:

$$CORR = \frac{\sum(RER_t - \overline{RER})(TB_{t+k} - \overline{TB})}{\sqrt{\sum(RER_t - \overline{RER})^2 \sum(TB_{t+k} - \overline{TB})^2}}, \quad (1)$$

where the mean values of all data points for the real exchange rate and net exports are denoted by $\overline{RER}$ and $\overline{TB}$ respectively. To arrive at the S-curve, one first determined the cross-correlation between the real exchange rate *RER* and trade balance TB.sing these coefficients, it was possible to determine that the lead (future) values must be positive, and the lead (past) values must be negative.

Where $\overline{RER}$ and $\overline{TB}$ are the means of all observations over the study period, by allowing *k* to take negative values such as -5, -4, -3, -2, and -1, the author calculated the cross-correlation coefficients between the current exchange rate and the past values of trade balance. Moreover, by allowing *k* to

[1] Hodrick-Prescott (HP) filter is the data smoothing technique, applied to remove the short-term fluctuations in the data.

take positive values such as 1, 2, 3, 4, and 5, the same correlation was calculated between the current exchange rate and the future values of the trade balance. The shape of the S-curve can be obtained by plotting the constructed CORR coefficient of leads and lags. Since the S-curve is an extension of the J-curve, the study also emined the J-curve behaviour using this cross-correlation method as they can follow the S-curve's shape after the J-curve first appears.

Table 1. The historical values of the exchange rate (PKR to USD, 1999-2022)

Year	PKR to USD	Year	PKR to USD
1999	51.90	2011	88.6
2000	51.90	2012	96.5
2001	63.5	2013	107.2
2002	60.5	2014	103
2003	57.75	2015	105.20
2004	57.8	2016	104.6
2005	59.7	2017	110.01
2006	60.4	2018	139
2007	60.83	2019	163.75
2008	81.1	2020	168.88
2009	84.1	2021	179.16
2010	85.75	2022	239.9

Source: authors' own compilation.

Hence this paper employed the concepts of exchange rate and trade balance between Pakistan, the USA and China by exploring the relationship between the trade balance and the exchange rate (J-curve and S-curve). One should look at historical values of the exchange rate as well as at the size of Pakistan's trade balance in bilateral trade with the USA and China. Table 1 below contains the historical values of the exchange rate, i.e. PKR to USD from 1999 to 2022, while Figure 1 shows the historical values of the exchange rate, i.e. Chinese yuan CNY to PKR from 2009 to 2024.

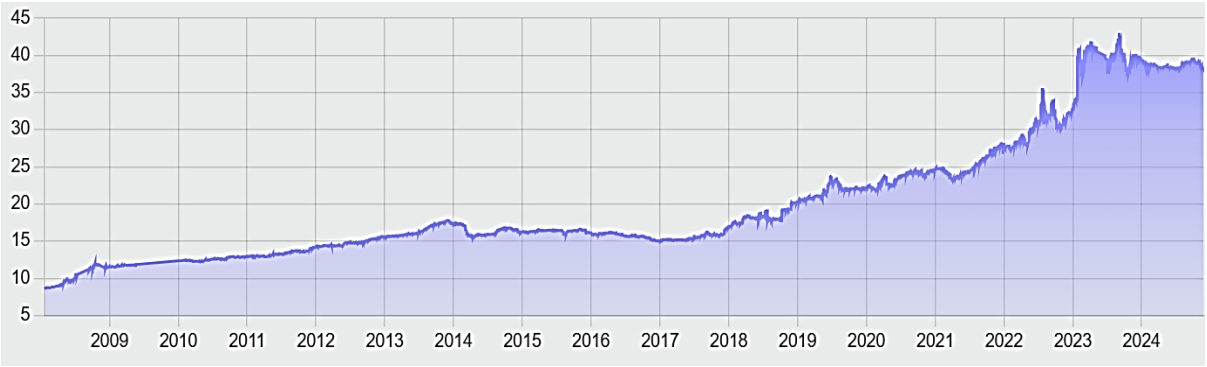


Fig. 1. The historical values of the exchange rate (CNY to PKR, 2009-2024)

Source: data taken from World Bank Source.

Additionally, it was also important to show the historical trade balance between Pakistan, the USA and China. Figure 2 shows the trade flows between Pakistan and the USA, while Figure C shows the same for Pakistan and China.

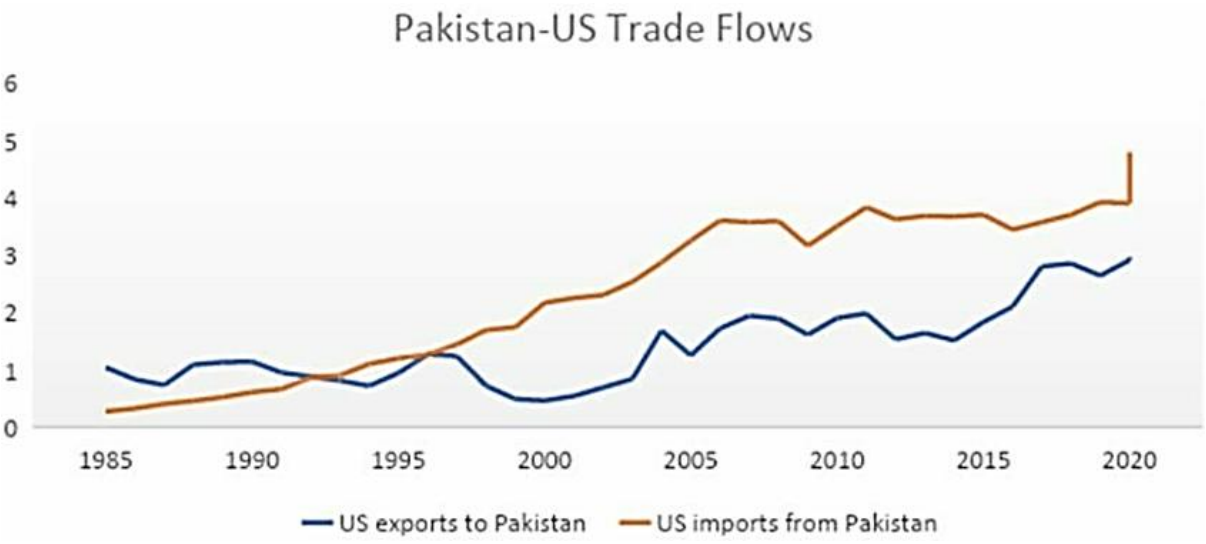


Fig. 2. Pakistan-USA trade flows

Source:WITS website.

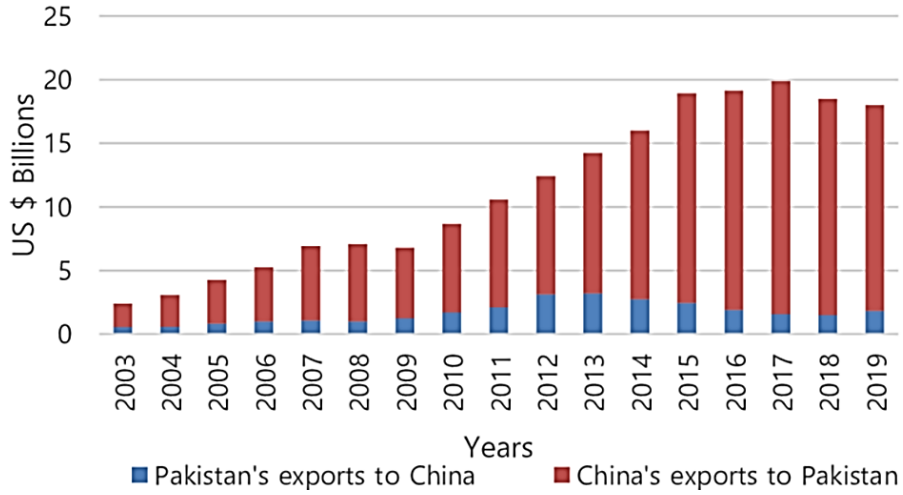


Fig. 3. Pakistan-China trade flows

Source: WITS website.

4. Results and discussion

The results for fifteen 3-digit industries showed trade commodities on a trilateral basis, where the J- and S-curves patterns can be seen. The study used time series data spanning from 1980 to 2022. In order to understand the J-curve's presence or absence at disaggregate level in the industries that trade with China, the USA and Pakistan, the author first concentrated on explaining the S-curve. The name and average trade share of each industry for the most recent year of 2022 are shown in Figure 4 which summarises the findings for all the industries in order to save space in the publication.

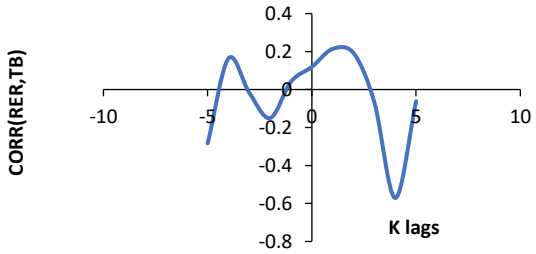
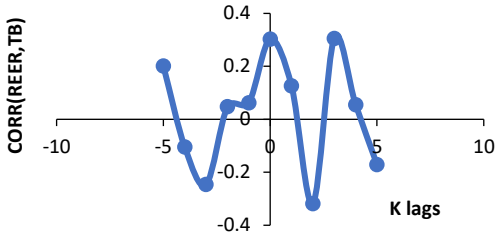
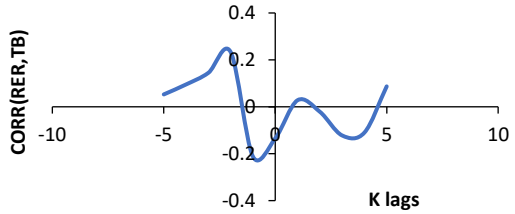
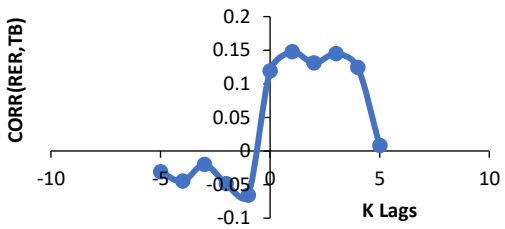
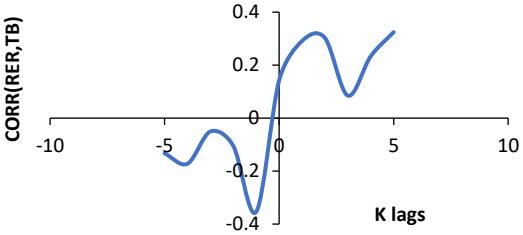
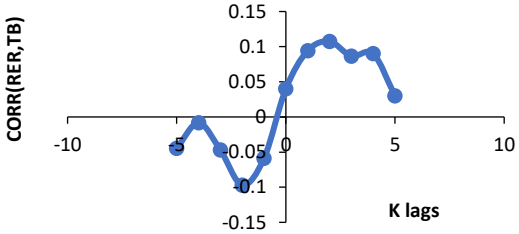
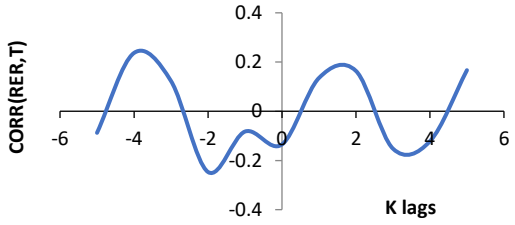
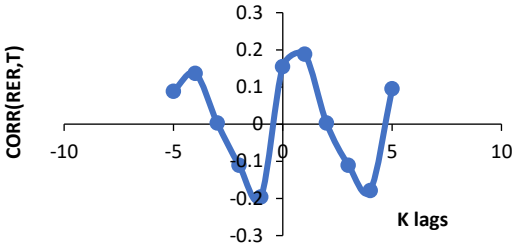
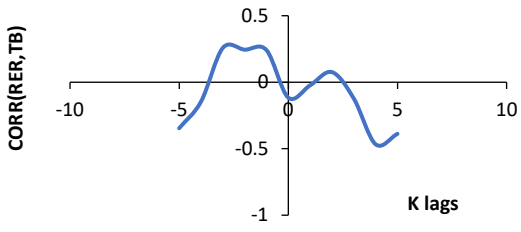
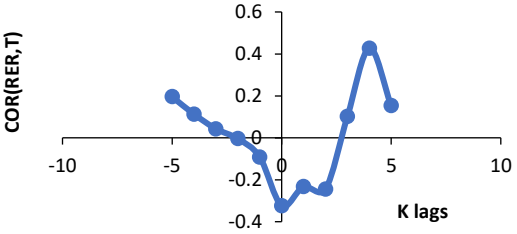
The S-curve patterns in these sectors of the economy align with accepted economic theories, most notably the product life-cycle theory. The quick rise of the pharmaceutical industry is proof that industries go through stages of introduction, growth, maturity and decline. Technological developments which are essential for sectors such as pharmaceuticals that rely heavily on innovation, help these industries grow slowly at first before quickly expanding. S-curves are also determined by market saturation or maturity as observed in the wool market. Through trade regulations and

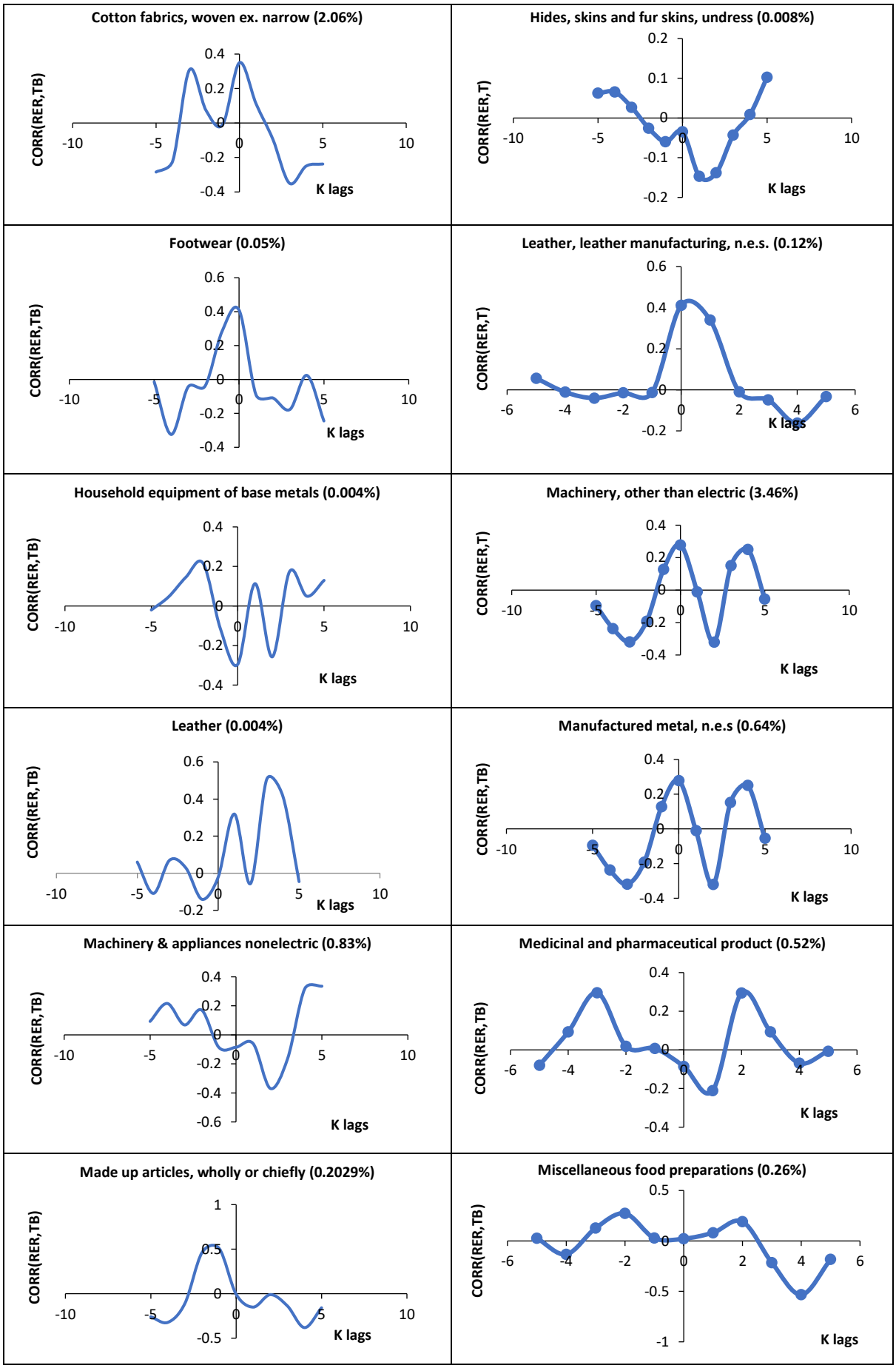
consumer preferences, global economic trends such as those affecting cotton production, have an impact on demand. The dried fruit industry is growing because of changes in consumer preferences and processing methods. Trade dynamics represented in trade shares, influence industries such as pharmaceuticals through international partnerships and legislative modifications. A thorough understanding of each industry's distinct trajectory was possible by noting that the observed S-curve patterns were the consequence of a confluence of factors which include product life-cycle dynamics, technological advancements, market maturity, global economic trends, innovation and trade dynamics. In brief, the author estimated the correlation between each commodity trade balance and the real exchange rate shown in Table 1, and plotted the results to observe how the J- and S-curve effects behaved. The study employed a single methodology to examine both the S- and J-curves, in contrast to previous research that investigated them independently. This is the first study that examined the J- and S-curve behaviour graphically in a single industry figure. Out of the fifteen industries involved in the commodity trade between Pakistan and China, Figure 4 clearly shows that only three of them had the S-curve validated. This conclusion is based on the plot of the cross-correlation coefficients for each of the five lag and lead values. drawn. The lack of an S-curve in Figure 4 was undoubtedly the result of aggregation bias. Since China is the world's largest economy and Pakistan's top import partner, the S-curve is not present in most industries. China is Pakistan's main source of imports, yet the country receives relatively little of Pakistani exports. Due to currency depreciation, Pakistan recorded a $43 billion trade deficit with China, which does not improve the trade balance as depreciation increases import bills for Pakistani importers, thus making the trade balance worse. According to this analysis, commodity attributes do not appear to be very important, whilst Pakistani rupee's depreciation would benefit the trade balance of these three industries (cotton, medicinal and pharmaceutical products, and mineral manufacture) in the future, and thus the correlation between the current exchange rate and the future trade balances is positive. The potential low demand elasticities for the remaining twenty-one industries could explain their apparent lack of benefits from the rupee's depreciation. One could now explain the J-curves behaviour in the commodities trade between China and Pakistan. The J-curve and S-curve coexist in the industries where the S-curve is found, as the S-curve is an extension of the J-curve, therefore drawing the conclusion that J-curves are present in these three industries.

The second step discusses the S- and J-curves' behaviour in relation to the commodities trade between Pakistan and the USA. According to this study, only three industries supported the S-curve shape in the fifteen industries involved in the US-Pakistan trade. It clarified that only three of the fifteen industries would see an improvement in their trade balance because of currency depreciation, namely those belonging to the export-import industry: cotton, raw plant and animal materials, and naturally occurring textile fibres. These three figures showed that the J-curve is also present. In industries where the S-curve is present, J-curves first appear and then adopt the S-curves behaviour, therefore drawing the conclusion that the J- and S-curves are present in minority of industries because of low demand elasticities during Pakistan's involvement in trading with China and the USA. Pakistan's exports to China consist primarily in cotton textiles, minerals, leather goods, agricultural products and sports goods. Pakistan imports footwear, machinery, electronics, textiles, clothing, consumer goods and chemical products from China in exchange. Pakistan is the sixth-largest rice exporter in the world, and a significant supplier of rice and cotton products to China,yet a grave problem is that Pakistan exports these products mostly unprocessed and uncompliant with international standards, and lower export revenues are the result of the quality gap. China contributes to Pakistan's trade deficit with China by improving the quality of the imported goods and then re-exporting them to Pakistan at higher prices. The formulation of a strategic planning policy and informed decision-making in Pakistan's dynamic industrial landscape are all based on this nuanced understanding.

Moreover, the percentages in the below figures (in brackets) represent the share or contribution of the specific product category to overall trade or trade balance between Pakistan and China, and Pakistan and the USA. More precisely, in total trade between Pakistan and China, the share of clothing except fur clothing was 0.06%. Similarly, for the same countries, the share of crude animal materials

was 0.64%, cotton industry 1.18%, etc. The highest share in total trade between Pakistan and China was of textile yarn and thread at 11.18%. On the other side, in total trade between Pakistan and the USA, Cereals and cereal preparations had a share of 1.18%, furniture 0.79%, crude animal and vegetable material 0.085%, etc. The highest share in total trade between Pakistan and the USA was clothing with 38.30%.

Pakistan-China	Pakistan-the USA
Clothing except fur clothing (0.06%) 	Cereals and cereal preparations (1.18%) 
Raw animal materials (0.64%) 	Clothing (38.30%) 
Cotton industry (1.18%) 	Raw animal and vegetable materials (0.08%) 
Crude vegetable materials (0.022%) 	Electrical machinery, apparatus (1.32%) 
Floor coverings, tapestries, etc. (0.067%) 	Furniture (0.79%) 


Cotton fabrics, woven ex. narrow (2.06%)
CORR(RER,TB)
K lags
Hides, skins and fur skins, undress (0.008%)
CORR(RER,T)
K lags
Footwear (0.05%)
CORR(RER,TB)
K lags
Leather, leather manufacturing, n.e.s. (0.12%)
CORR(RER,T)
K lags
Household equipment of base metals (0.004%)
CORR(RER,TB)
K lags
Machinery, other than electric (3.46%)
CORR(RER,T)
K lags
Leather (0.004%)
CORR(RER,TB)
K lags
Manufactured metal, n.e.s (0.64%)
CORR(RER,TB)
K lags
Machinery & appliances nonelectric (0.83%)
CORR(RER,TB)
K lags
Medicinal and pharmaceutical product (0.52%)
CORR(RER,TB)
K lags
Made up articles, wholly or chiefly (0.2029%)
CORR(RER,TB)
K lags
Miscellaneous food preparations (0.26%)
CORR(RER,TB)
K lags

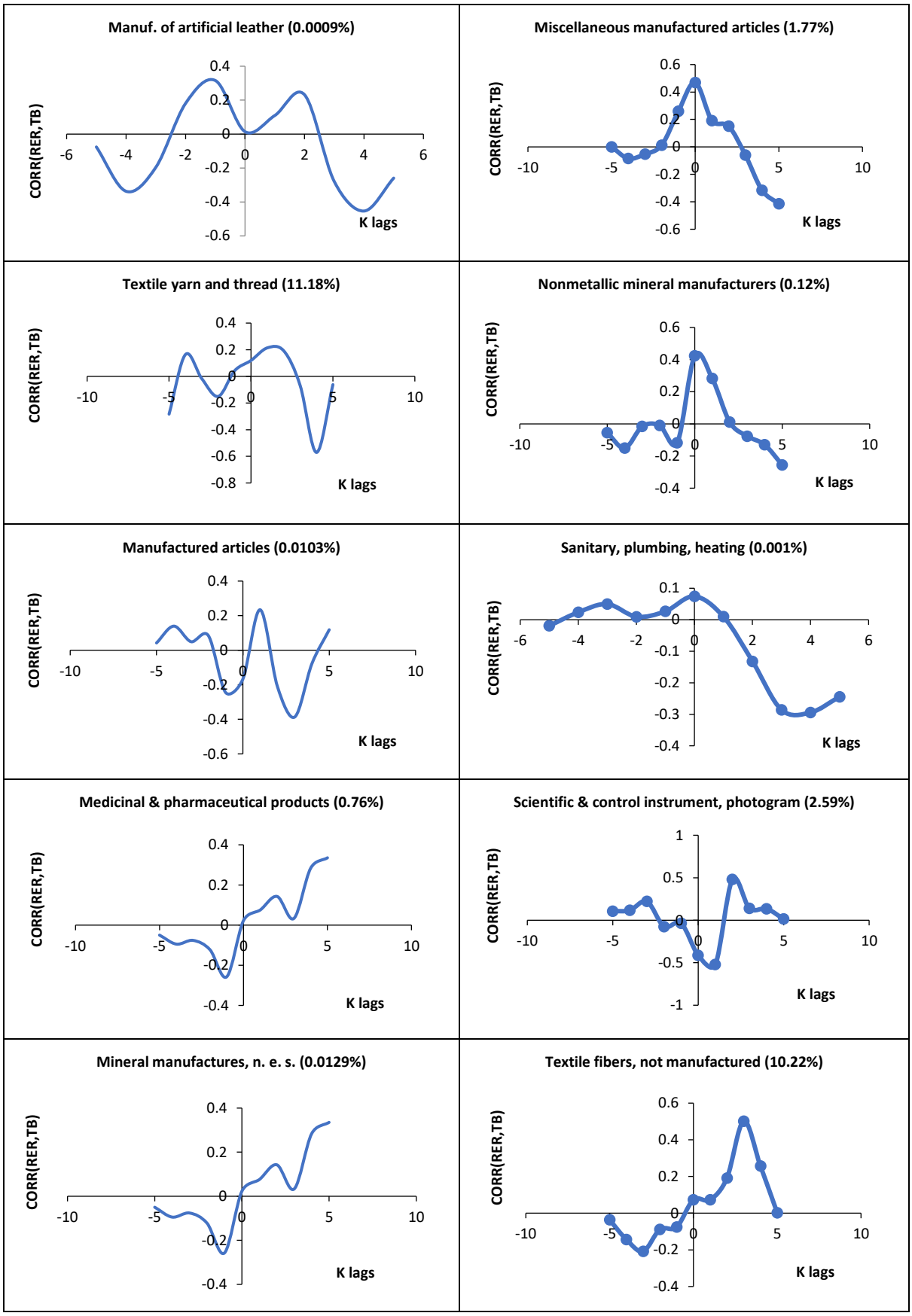


Fig. 4. The J- and S-curves in Pakistan commodity trade with the USA and China

Source: authors' own construction through Excel.

5. Conclusion and policy suggestions

Due to the ongoing trade imbalance crippling Pakistan's economy, policy exporters occasionally turn to devaluation or depreciation as a solution to the trade deficit. Therefore, it was highly beneficial to investigate how each industry reacted to changes in the exchange rate. The primary goal of this study was to reexamine the J- and S-curves to show that positive correlations exist between the current exchange rate and future trade balance if a country's trade balance improves with currency depreciation. The goal was trilateral, i.e. commodity trade at the 3-digest industry level broken down by Pakistan, China and the United States. Since both are Pakistan's top trading partners in terms of volume of trade, these two sizable economies were chosen. In terms of imports, China is Pakistan's top trading partner while the United States is its top trading partner regarding exports.

The results indicated that of the fifteen industries involved in the commodity trade between China and Pakistan, only three have had the S-curve validated. The conclusion was based on the plot of the cross-correlation coefficients for each of the five lag and lead values. The lack of the S-curve in Figure 4 was undoubtedly the result of aggregation bias since Pakistan's trade deficit with China the S-curve is absent from most industries. Pakistan imports most goods from China, hence currency depreciation is unfavourable for trade with that country. The current exchange rate and future trade balances were positively correlated, suggesting that the depreciation of the Pakistani rupee would help the trade balance of these three industries in the future, namely cotton, pharmaceutical and medicinal products, and mineral manufactures. There could be low demand elasticities for the 21 remaining industries which do not appear to benefit from the rupee's depreciation. The J-curve behaviour in the commodities trade between China and Pakistan could be explained next, as the S-curve is an extension of the J-curve if one looks at the industries where the S-curve is found, one would see first the J-curve and then S-curve. Therefore, the conclusion can be drawn that J-curves are present in these three industries. The depreciation of the Pakistani rupee is expected to enhance the trade balance of three industries in the future: cotton, pharmaceuticals and medicinal products, and mineral manufacture. This is supported by the positive correlation between the current exchange rate and future trade balances. Since the remaining 21 industries do not seem to benefit from the depreciation of the rupee, there may be low demand elasticities for them, which would explain the J-curve behaviour in the China-Pakistan commodities trade. Since the S-curve is a continuation of the J-curve, it will appear first in industries where the S-curve is found, followed by the S-curve. As a result, one can conclude that these three industries have J-curves. Due to Pakistan's significant trade deficit with China and the United States, many industries do not support the J- and S-curves. The trade deficit is predicted to rise if the value of the Pakistani rupee declines, therefore Pakistan cannot benefit from depreciation to improve the trade balance. According to the empirical findings, devaluation helps just a small number of industries at the expense of most of them.

5.1. Limitations of the study

Potential aggregation bias in industry analysis – especially in Figure 4– was a significant research limitation. The S-curve phenomenon cannot be fully understood if industries are not broadly categorised, which could obscure industry-specific differences. This restriction results from Pakistan's substantial trade deficit with China and the fact that different industries are affected differently by currency depreciation. The aggregation of data in the study made it impossible to fully capture the effects on the other 21 industries in the analysis, even though it offered insights into industries such as cotton, pharmaceuticals and mineral manufacture. The scope of generalisability was further limited by the focus on trade between the United States, China and Pakistan because the trade dynamics with other countries were not considered.

5.2. Future research perspectives

These findings could be applied outside of Pakistan, China and the USA by conducting future studies to examine the S-curve behaviour in other economies or areas to see if any comparable patterns emerge. To lessen aggregation bias and better capture the effects of currency depreciation on trade balances, future research could also use disaggregated data at a more detailed level of industry or product categories. Additionally, as observed in the majority of industries, examining the demand elasticities of various industries may offer a deeper understanding of why some industries do not profit from depreciation. More sophisticated approaches including structural econometric models or simulation techniques could be used in future studies to evaluate the long-term effects of currency depreciation on trade balances in a variety of industries. The knowledge of how the trade balance reacts to fluctuations in exchange rates could be greatly enhanced by these future directions, which could also help with developing more sensible policy recommendations.

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Availability of data and materials: *The data sets used during the current study are available from the corresponding author on reasonable request.*