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Abstract approved:

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Relationship between the exchange rate and the trade balance is a key component for a developing nation. Although, in theoretical sense, depreciation of currency would result in an improvement in the trade balance, sluggish response of trade flows to changes in currency has prompted researches to look in to the possible existence of a pattern. Studies conducted in this regard have predominantly tested for two such patterns i.e. the J-curve and the S-curve. J-curve theory postulates that depreciation would worsen the trade balance in the short-run before improving in the long-run. In contrast, S-curve theory postulates that in a general equilibrium model, there would be a positive correlation between the current exchange rate and future trade balance and a negative correlation between the current exchange rate and past trade balance. This study employs data from Sri Lankan bilateral and industry level trade in analyzing both curves. For the J-curve, the study employs the ARDL cointegration approach and error correction techniques. Cross-correlation functions are used to analyze the S-curve. Results demonstrate that for Sri Lanka, occurrence of the J-curve is not as strong as it would be compared to a developed nation mainly because (1) of data aggregation and (2) the possibility that Sri Lankan trade may not follow the assumptions made in deriving the J-curve. Underlying drivers as trade policies and supply demand shocks could be incorporated into the analysis of the J-curve for more comprehensive results. The study concludes that S-curve analysis should be considered preliminary and could be used as a precursor for further analyses.

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Exchange Rate Dynamics and the Trade Balance: The Case of Sri Lanka

by

Senal A. Weerasooriya

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Senal A. Weerasooriya, Author

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Exchange Rate Dynamics and the Trade Balance: The Case of Sri Lanka

1. Introduction

Researchers as well as policy makers have tried to understand the relationship between exchange rate and trade balance due to its integral role in a country's economy. The role of exchange rates becomes important especially in aligning a country's trade hence, macroeconomic goals. Policy makers see exchange rate as a powerful tool in making and aligning policy decisions to improve trade balance and hence the balance of payment. A country may seek to devaluate its currency under a fixed exchange rate or depreciate under a floating exchange rate system with the aim of improving the country's net exports via increasing competitiveness. The underlying theory the policy makers use is the well-known Marshall-Lerner (ML) condition brought forward by Alfred Marshall and Abba P. Lerner. The theory postulates that a country may improve its trade balance in the long-run via devaluation or depreciation if the sum of export and import demand elasticities is greater than unity i.e. one. Early studies made use of ML condition to estimate export and import price elasticities in an attempt to understand the effect of depreciation on trade balance. However, this approach was considered indirect and a long-run phenomenon. Although theory asserts favorable implications for trade balance after depreciation, results have been mixed for many countries. Further, in many cases, past data has shown a sluggish response in trade balance to exaggerated changes in exchange rate. This sparked new interests especially when the US trade balance deteriorated during 1971-73 despite devaluation of the dollar by 15% (Bahmani-Oskooee & Wang, 2008). Thus, the concept of J-curve was introduced by Magee (1973) which asserts that it is possible for devaluation or depreciation to worsen the trade balance in the short-run before improving in the long-run (Bahmani-Oskooee & Bolhasani, 2008). For an example, if the currency is devaluated or depreciated, the exports become cheaper and imports become expensive, resulting in exporting more and importing less i.e. volume effect. This would improve the trade balance. At the same time, devaluation or depreciation would increases the import unit value and thus worsens the trade balance. This is known as the price/value effect. It is assumed that the price effect dominates in the short-run whereas; the volume effect dominates in the long-run. Therefore, trade balances plotted against time would give rise to a J-curve. Hence, it became vital to understand the short-run impact in addition to the long-run. As a result, more recent studies have incorporated both short-run and long-run dynamics in assessing the validity of the J-curve hypothesis. This approach not only enables researches to infer the short-run and long-run effects, but also allows incorporation of other explanatory variables influencing trade balance. More details of these two types of studies could be found in Bahmani-Oskooee & Ratha (2004a).

Capitalizing on this concept Backus et al, (1994) introduced another approach to test for the short-run effects of exchange rate changes on trade balance. They showed that under certain conditions, the correlation between the current exchange rate and future trade balance could be positive and the correlation between the current exchange rate and past trade balance to be negative. They named this phenomenon the S-curve. While the J-curve relied on trade balance model and regression methods, S-curve made use of cross-correlation functions to analyze the impact of currency depreciation on trade balance (Bahmani-Oskooee & Hosny, 2012b).

What is the importance of such study for a country like Sri Lanka? Literature revealed that no studies have been done concerning J and S-curve analysis for Sri Lanka at bilateral and industry level trade. Thus, by conducting this study, a major contribution would be to aid policy makers anticipate changes in trade at several levels (i.e. bilaterally and at industry level) upon depreciation. Furthermore, this study enables the quantification of the relationship between currency and trade balance. In summary, the results indicated that the J-curve did not receive strong support for Sri Lanka. The study argued that the data used in the analysis may still suffer from aggregation bias. Further the assumptions made in the analysis may not be true for a developing nation characterized by Sri Lanka. Although, S-curve received support in some instances, the results should be treated as preliminary and should be used as a precursor for more comprehensive analyses. Reminder of the study is organized as follows. Section (2) describes the case of Sri Lanka followed by (3) the literature review and (4) the justification and the objective. Sections (5) and (6) present the econometric method used and the data used respectively. Section (7) presents the results followed by the conclusions in (8).

2. The Case of Sri Lanka

Since this study is concerning Sri Lanka, a brief overview of the Sri Lankan economy is in order. Upon the realization that centrally planned economies are much less efficient compared to market economies, Sri Lanka moved towards a free market approach starting from 1977. Since then, the country's trade deficit has increased significantly. From 53.1 million US Dollars in 1970, the trade deficit recorded a staggering 9,710 million US Dollars in 2011 (Central Bank of Sri Lank, 2011). Figure 01 depicts this rapid deterioration in the trade balance. As shown a rapid deterioration in the trade balance occurred after 1970's.

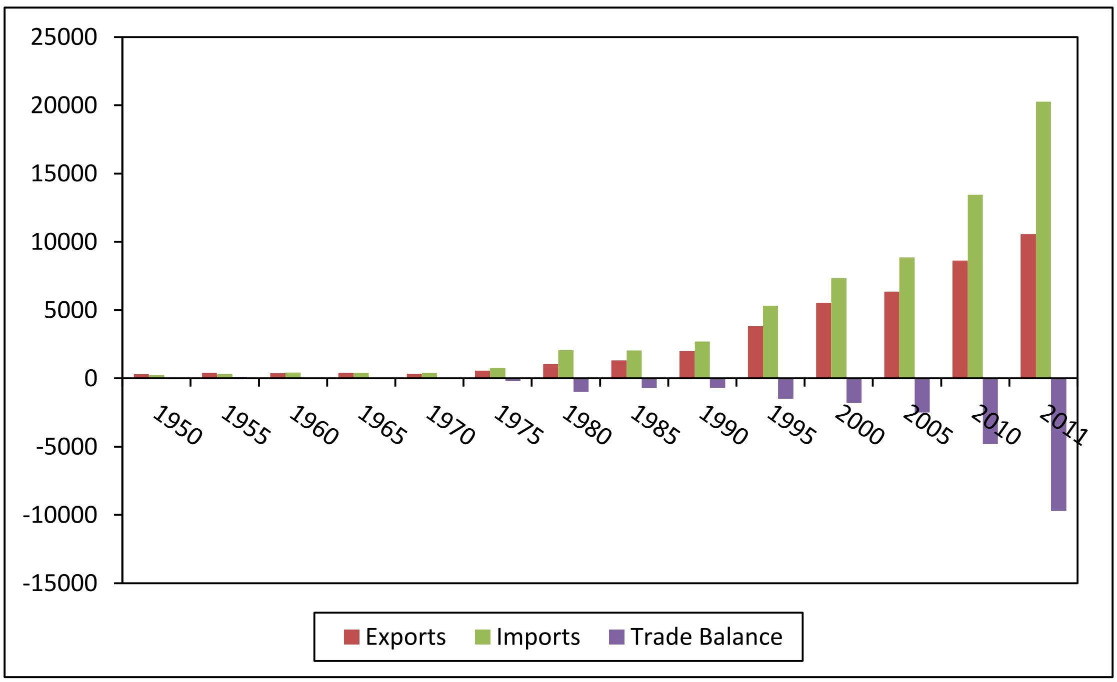

Figure 01: Changes in Export, Import and Trade Balance Values 1950 – 2011 (US$ million)
Source: Central Bank Annual Report 201

This decline in trade balance has been attributed to the increased imports in Sri Lanka. Especially, the import of intermediate goods such as petroleum and investment goods such as machinery and equipment has contributed significantly towards increasing the import bill. However, exports have been mainly limited to textiles and primary commodities such as tea. As a result, the export earnings have been relatively low due to the high competition in the world market.

Sri Lanka has undergone several exchange rate regimes. At the time of independence in 1948, Sri Lanka had a fixed exchange rate regime. However, by mid-1960 faced with a balance of payment crisis, the Central Bank adopted a dual exchange rate system to promote export diversification and import compression. Upon liberalizing its economy in 1977, Sri Lanka moved to a managed floating exchange rate system from a dual exchange rate system. Under the floating exchange rate system, Central Bank announced its buying and selling rates for the US Dollar for its transactions with commercial banks and commercial banks were to quote buying and selling rates for currencies within the specified margin for their transactions with customers. However in 2001, in order to provide commercial banks with more flexibility in quoting exchange rates, the independently floating exchange rate system was adopted allowing the commercial banks to determine the exchange rate. The Central Bank no longer bought or sold foreign exchange at preannounced rates, but monitored the movements of the exchange rate, reserving the right to intervene in the market, to buy and sell foreign exchange at or near market prices, as and when it is deemed necessary (Central Bank of Sri Lanka, 2006). The movement of the Nominal Exchange Rate (E) between Sri Lankan Rupee (SLR) and the US Dollar, Sterling Pound, Japanese Yen and Indian Rupee is shown in Figure 02. According to Figure 02, E for all 4 cases is having an increasing trend which suggested a devaluation or depreciation of SLR over the years.

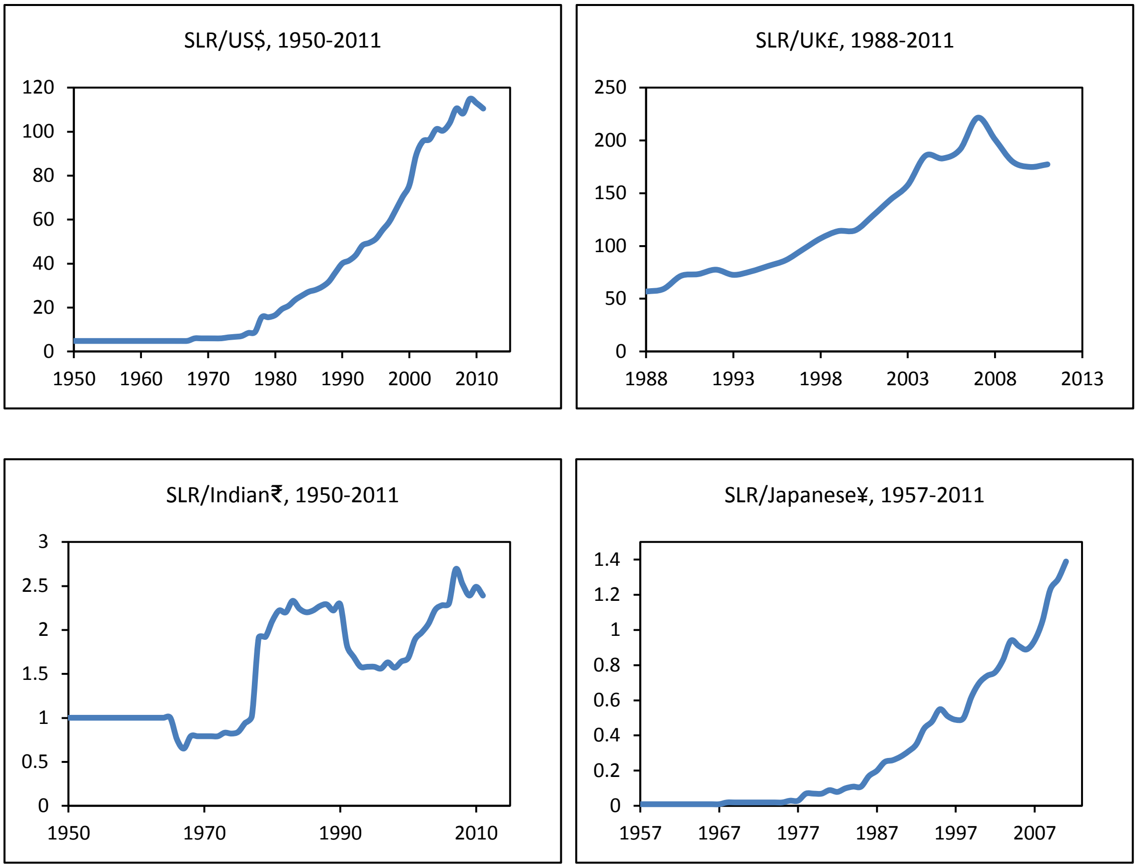

Figure 02: Changes in the Nominal Exchange Rate for 4 Trading Partners
Source: Central Bank of Sri Lanka

3. Literature Review

Under literature review, we attempt to identify how the J and S-curves are formed, followed by how analytical methods evolved in estimating both curves, past studies exploring the existence of both curves in different contexts and existing studies for Sri Lanka.

3.1. The J-Curve

3.1.1. Theoretical Framework

In this section, an attempt was made to provide a brief theoretical basis for the J-curve. Theories dealing with the relationship between currency and trade balance fall into three categories: elasticity approach, absorption approach and monetary approach. Elasticity approach makes use of demand and supply elasticities of exports and imports. The absorption approach suggests that any improvement in trade balance requires an increase in domestic income over total domestic expenditure. The monetary approach asserts that the trade balance is essentially a monetary phenomenon. Here the money and assets markets determine the trade balance (more precisely the current account) via changes in supply and demand of the stock of money (Baek et al., 2009). This study employed the elasticity approach used by Magee (1973) in explaining the J-curve phenomenon. The trade balance is defined as the difference between a country's export and import value. This can be expressed as given in equation *(1)*

$$TB = \overline{P_X}X - E\overline{P_X^*}M \tag{1}$$

where TB is the trade balance in domestic currency, $\overline{P_X}$ $(\overline{P_X^*})$ is the domestic (foreign) export price in domestic (foreign) currency, X is the supply of domestic exports, M is the demand for domestic imports and E is the Nominal Exchange Rate[1]. Equation *(1)* can be re-written to reflect the Real Trade Balance (RTB)

$$RTB = \frac{\overline{P_X}X - E\overline{P_X^*}M}{P} = P_X X - RER \cdot P_X^* M \tag{2}$$

where $P(P^*)$ is the domestic (foreign) country's price level, $P_X(P_X^*)$ is domestic (foreign) country's relative price of exports[2] and RER is the Real Exchange Rate defined as $RER = (P^* \cdot E)/P$. In order to investigate the impacts of RER changes on RTB, equation *(2)* should be differentiated with respect to RER and then written using elasticity form. This yields the form of the generalized Bickerdike-Robinson-Metzler condition shown in *(3)*

$$\frac{dRTB}{dRER} = P_X X \left[\frac{(1+\epsilon_S)\epsilon_D^*}{\epsilon_D^* + \epsilon_S}\right] - RER \cdot P_X^* M \left[\frac{(1-\epsilon_D)\epsilon_S^*}{\epsilon_S^* + \epsilon_D}\right] \tag{3}$$

where $\epsilon_D(\epsilon_D^*)$ is the absolute price elasticity of demand for domestic (foreign) country and $\epsilon_S(\epsilon_S^*)$ is the absolute price elasticity of supply for domestic (foreign) country. If the RTB is zero ($RTB = 0$) at initial equilibrium and both supply elasticities are infinite ($\epsilon_S \to \infty$ and $\epsilon_S^* \to \infty$), equation *(3)* will reduce to ML condition (i.e. real depreciation improves real trade balance when $\epsilon_D + \epsilon_D^* > 1$).

J-curve theory postulates that a short-run adjustment of trade balance afterwards depreciation can be divided into three parts; currency contract period, the pass-through period and the quantity adjustment period (Magee 1973). Currency contract period is a brief period soon after the depreciation in which the contracts negotiated before the change fall due. For an example, if a case existed where export contracts are dominated in domestic currency and imports are contracted in foreign currency, depreciation will

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[1]Here E or the Nominal Exchange Rate is defined as the number of units of domestic currency per unit of foreign currency

[2]$P_X = \overline{P_X}/P$ and $P_X^* = \overline{P_X^*}/P^*$

worsen the trade balance before any price volume adjustment. In the pass-through period, prices could change although quantities of exports and imports remain the same. This is same as the value (price) effect described before. The trade balance may deteriorate or improve based on the scale of demand and supply elasticities of exports and imports specified in *(3)*. For an example, assume a situation where both domestic and foreign demands for imports are inelastic in the short-run. When currency is depreciated, the import price measured in domestic currency will increase although the demand is still the same. This will result in an increase in the value of imports in terms of domestic currency. However, the export price in foreign currency decreases by the same proportion of the exchange rate variation and the export price in domestic currency remain unchanged. As a result, no change occurs in the export value. Coupling both export and import values, deterioration in trade balance would take place. In the quantity-adjustment period, the quantities start to adjust in response to the price changes. In this period, both export and import elasticities increase. This is the volume effect explained earlier. Under this setup, as long as the ML condition is satisfied, the trade balance is deemed to improve.

3.1.2. Evolution of Past Studies

Studies that have looked at J-curve hypothesis by relating trade balance to exchange rates fall into three main categories. The first category employs aggregate trade data. The aggregated approach considered trade balance of a country with respect to the rest of the world using effective exchange rates (trade weighted exchange rates), domestic GDP and trade weighted foreign GDP as explanatory variables (Bahmani-Oskooee et al., 2006). The list studies includes but is not limited to Felmingham & Divisekera (1986), Felmingham (1988), Rosenweig & Koch (1988), Himarios (1989), Bahmani-Oskooee & Alse (1994), Demirden & Pastine (1995) and Brada et al., (1997). However, the validity of these studies was questioned by Rose & Yellen (1989) who criticized that such studies suffered from aggregation bias. Further, use of some non-stationary variables was problematic with standard OLS procedures. To overcome this limitation of aggregation bias, the second category emerged which used disaggregate data. The researchers mainly incorporated bilateral trade data, GDP and exchange rates into the analysis. Such data was first used by Rose & Yellen (1989) to study the J-curve for the US vis-à-vis her six trading partners. They used the Engle & Granger (1987) cointegration methodology and did not find any evidence of the J-curve. However, Marwah & Klein (1996) and Bahmani-Oskooee & Brooks (1999) used a different speciation for trade balance which did not have a unit measurement problem in their analysis[3]. Both these studies employed the Autoregressive Distributed Lag model (ARDL) in the cointegration analysis. Following Bahmani-Oskooee & Brooks (1999), many studies have used the ARDL model in estimating the short-run and long-run dynamics of currency devaluation on trade balance. However, it was argued that the use of bilateral trade data would not remove the problem of aggregation bias entirely. Thus, the third category emerged analyzing the J-curve effect using disaggregated industry level trade data between two countries.

3.1.3. J-Curve in Different Contexts

In many studies which researched the J-curve phenomenon, the results are mixed. Certain studies have found no evidence for J-curve phenomenon. Some have found that the trade balance is improved in the long-run but not in the short-run. Another set of studies have found that, in the long-run, the trade balance could be improving with one trading partner and at the same time deteriorating with another. This section provides an insight into several key studies done in this regard.

Many studies have tested the J-curve for the United States (US). Bahmani-Oskooee & Brooks (1999) analyzed the J-curve phenomenon for bilateral trade between the US vis-à-vis six of her trading partners. They found no specific short-run pattern supporting the J-

[3]Rose & Yellen (1989) specified trade balance as the difference between exports and import values. However, Marwah & Klein (1996) and Bahmani-Oskooee & Brooks (1999) specified trade balance as the ratio between export and import values.

curve. However, they found that the long-run results supported economic theory i.e. real depreciation of the US dollar has a favorable long-run effect on the US trade between six of her trading partners. Bahmani-Oskooee & Ratha (2004b) extended this study to 18 trade partners and still were unable to discover any J-curve pattern. In the long-run, they find real depreciation of the dollar has favorable effects on the US trade balance in most cases. Other studies include Rose & Yellen (1989) for the US vis-à-vis her six trading partners, Marwah & Klein (1996) in their analysis of the US vis-à-vis Canada, Bahmani-Oskooee & Wang (2007) for the US vis-à-vis Australia and Baek et al., (2009) for the US agricultural sector. Apart from the US, many studies have used other developed nations in analyzing the J-curve. Bahmani-Oskooee et al., (2006) used bilateral trade data of the United Kingdom (UK) and her 20 major trading partners to test for the J-curve. They employed the ARDL model and used data from 1973Q1 to 2001Q3. In most instances, they found no evidence for J-curve in the short-run. However, in the long-run, they found only 5 cases where the exchange rate had a significant impact on trade balance. Bahmani-Oskooee & Ratha (2007c) used the ARDL model to analyze the J-curve between Sweden and her 17 major trading partners. Empirical results revealed that depreciation of the Swedish Krona has short-run effects on trade balance in 14 cases. They found support for the J-curve in 5 cases i.e. between Sweden and Austria, Denmark, Italy, Netherlands and the UK. However, in most cases they found that the short-run effects do not last into the long-run. Bahmani-Oskooee et al., (2005) analyzed the J-curve for Australia and her 23 major trading partners. They found that the results from the bound testing approach for cointegration and error-correction modeling does not provide much support for the J-curve phenomenon. Bahmani-Oskooee & Goswami (2003) tested for the J-curve for Japan and her major trading partners. They used bilateral trade data and employed a cointegration analysis to find J-curve phenomenon for trade between Japan and Germany and Italy. Further, they found evidence of favorable long-run effects of exchange rate devaluation on trade balance in the cases of Japan versus Canada, the UK and the US.

Few authors have tried to analyze the J-curve in a developing or industrializing country context. Bahmani-Oskooee & Kantipong (2001) tested the J-curve for Thailand and its major trading partners using bilateral trade data. Their cointegration analysis yielded evidence of the J-curve for the US and Japan. Arora et al., (2003) using bilateral trade data for India, employed the ARDL model and found that India's trade balance improved in the long-run with Australia, Germany, Italy and Japan. However, they found no evidence of a J-curve. Bahmani-Oskooee & Harvey (2009) investigated the short-run as well as the long-run effects of bilateral exchange rate on the bilateral trade balance between Indonesia and each of her 13 trading partners. They found evidence for the J-curve effect in 5 cases. Bahmani-Oskooee & Cheema (2009) did a similar study for Pakistan and her major trading partners and the results did not support for the existence of a J-curve. They found only half of the cases where real bilateral exchange rate impacted trade balance. Wilson (2001) employed the partial reduced form model of Rose and Yellen (1989) to analyze the J-curve for bilateral trade in merchandise goods between Singapore, Korea, and Malaysia and the US and Japan on a quarterly basis. Author found no evidence for the J-curve in the case of Singapore and Malaysia. For Korea, however, the data were found to be consistent with some J-curve effects with respect to both Japan and the US. A study done by Sim & Chang (2007) for Korea showed that there is weak evidence for the J-curve in Korea's bilateral trade with the UK, Germany and China. However, in contrast they found that the depreciation leads to an initial improvement in Korean trade balance with many partners.

3.1.4. Studies with further Disaggregation of Trade Data

In order to minimize the problem of aggregation bias, more recent studies have used industry level trade data in analyzing the J-curve phenomenon. This has enabled researchers to uncover significant results that are obscured at a higher level of aggregation (Bahmani-Oskooee & Hegerty, 2010). J-curve hypothesis has found strong support at industry level trade data as oppose to aggregated and bilateral trade data. Bahmani-Oskooee & Kovyryalova (2008) analyzed the J-curve using disaggregate trade data at industry level between the US and the UK. They found 107 cases out of 177 industries where trade balance responded to a real depreciation in the British Sterling Pound in the short-run. They further identified 66 industries in which the short-run effects lasts into long-run supporting a J-curve. Bahmani-Oskooee & Bolhasani (2008) used disaggregated trade data by commodity between Canada and the US over a period of 1962-2004 to test for the J-curve. They used the bound testing approach to cointegration and error correction modeling to show that depreciation of the Canadian dollar has short-run effects on trade balance in two-thirds of the industries. However, they found only 50% of the cases translated the short-run effects into favorable long-run effects. Bahmani-Oskooee & Wang (2007) tested the J-curve for trade between the US and Australia at industry level. They used similar data and cointegration techniques to determine the impact of currency devaluation on trade balance. They found 64 out of 108 industries where short-run effects were present. Positive and long-run effects were only present in 35 industries supporting the J-curve. Looking at studies done between developed and developing nations, Bahmani-Oskooee & Wang (2008) used similar type of data and methods for the US and China across 88 industries. They found support for the J-curve in 22 industries. 34 industries reacted favorably to the real depreciation of the US dollar most of which, from the durable commodity groups. Bahmani-Oskooee & Hegerty (2011) extended the same method and data types to NAFTA and tried to look at trade between the US and Mexico. They found that depreciation of the Mexican Peso had a positive long-run impact on 24 and a negative long-run impact in 19 Mexican industries from a total of 102. However, they found only 7 cases where the J-curve hypothesis was supported. Bahmani-Oskooee & Hosny (2012b) used disaggregated trade data across commodities and cointegration analysis for the case of Egypt and the European Union. They tested for the J-curve across 59 industries between 1994Q1 and 2007Q4. Their findings showed evidence for the J-curve in 24 industries.

Apart from these, there have been studies done validating the J-curve phenomenon on different sectors at both aggregated and disaggregated level. These include Bahmani-Oskooee & Ardalani (2006) for the US industry data, Yousefi & Wirjanto (2003) for oil exporting countries, Huchet-Boudron & Korinek (2011) for selected OECD countries across agricultural and manufacturing sector, Wijeweera & Dollery (2012) for goods and service sectors in Australian trade and Baek et al., (2009) for the US agricultural trade.

3.2. The S-Curve

3.2.1. S-Curve Defined

With the interest sparked in finding short run and long run dynamics on trade balance with the movement of exchange rates, many studies emerged with different techniques. Backus et al., (1994) introduced an alternative method to regression analysis to quantify the relationship between trade balance and the terms of trade via cross-correlation functions. If these two variables were defined in a way that a positive relationship implied favorable effects of depreciation on trade balance, they postulated that in a two-country dynamic general equilibrium model, both trade balance and terms of trade are endogenous and there would be a positive correlation between the current terms of trade and future values of trade balance whereas; a negative correlation between the current terms of trade and past values of trade balance[4]. They considered two countries that produced imperfectly substituting good using capital and labor, which were subjected to persistent shocks. Authors argued the importance of such shocks in describing the S-curve pattern. For an example, a favorable productivity shock increases the output, consumption and investment while deteriorating the terms of trade. With persistent shocks, the increase in the consumption and investment could typically exceed the increase in output. This would result in a trade deficit during raising output. Over time, the boom in consumption and investment fades and the trade deficit turns into a surplus. This dynamic response led to a countercyclical movement in trade balance and an

[4]Terms of trade is defined as the price of imports relative to price of exports. Since data on import and export prices were not present, this study used bilateral real exchange rate (RER) as a proxy for terms of trade following S-curve literature.

asymmetric cross-correlation function between terms of trade and trade balance. Backus et al., (1994) termed this asymmetric relationship as an S-curve.

3.2.2. Evolution of Past Studies

Similar to the J-curve, S-curve analysis via cross-correlation functions has been applied in three categories namely; aggregated data, bilateral data and industry level data (Bahmani-Oskooee & Hegerty 2010). The first group of studies analyzed the trade balance between one country and rest of the world. Backus et al., (1994) initially analyzed the S-curve for 11 OECD countries and found significant support in many cases. Other studies includes but is not limited to Senhadji (1998), Parikh & Shibatha (2004), Bahmani-Oskooee et al., (2008a) and Bahmani-Oskooee et al., (2008b). The second group of studies employed bilateral trade data to test the S-curve citing the possibility of aggregation bias. The third group of studies employed disaggregated industry level trade data between two countries. Rationale for the use of industry level data was to overcome the aggregation bias in bilateral trade data.

3.2.3. S-Curve in Different Contexts

Backus et al., (1994) initially introduced and tested the S-curve for a set of OECD countries i.e. developed countries. Following them, many studies have tried to analyze the existence of an S-curve in a developed country setting. Bahmani-Oskooee & Ratha (2007b) used bilateral trade data to analyze the S-curve phenomenon between US and its 24 major trading partners. They found support for the S-curve in many cases. Bahmani-Oskooee & Ratha (2007a) used the same method to analyze the S-curve for Japan vis-à-vis 12 trading partners using quarterly data from 1980 to 2005. They too found strong support for S-curve in many cases. Other studies included Bahmani-Oskooee & Ratha (2008) for US-UK commodity trade, Bahmani-Oskooee & Ratha (2009) for US-Canada commodity trade, Bahmani-Oskooee & Ratha (2010) for US and China commodity trade and Bahmani-Oskooee & Ratha (2011) for US-Australia commodity trade.

Another set of studies have tried to evaluate the S-curve for developing countries. Most prominent study was done by Senhadji (1998). The author used data from 30 Low Developing Countries (LDC's) from 1960 to 1993 and was able to replicate the S-curve for a large set of LDC's. Author concluded that the S-curve can be reproduced by a small open economy model which captures some important features of LDC's. Following Backus et al., (1994), author established that the S-curve is robust to the variations in the model i.e. external shocks. Parikh & Shibatha (2004) provided evidence in support of the S-curve in 59 developing countries using aggregated data. Bahmani-Oskooee et al., (2008a) analyzed the S-curve phenomenon in 20 African nations and concluded that 8 countries support S-curve. Bahmani-Oskooee & Hosny (2012a) studied the S-curve phenomenon between Egypt and her two largest trade partners i.e. US and European Union (EU) at industry level. They found evidence for S-curve in 20 industries out of 95 most of which were small industries.

3.3. Existing Studies for Sri Lanka

Only limited number of studies has been done evaluating the impact of exchange rate changes on trade balance for Sri Lanka. Wijesinghe (1988) analyzed the impact of exchange rate on the trade balance in Sri Lanka. The study aimed at constructing an effective exchange rate index using the simulated trade balance effects of the exchange rate changes as weights. The study used a multilateral trade model to analyze the effects of both nominal and real exchange rate changes during 1971 to 1985 on Sri Lankan trade balance. According to the simulation results, author found nominal exchange rate devaluation has induced improvements in Sri Lankan trade balance for most years. However, the trade balance effect of real exchange rate changes was not so impressive owing to the high rates of inflation. De Silva & Zhu (2004) studied the effect of SLR devaluation on the trade balance and GDP using vector autoregressive and error correction models. They showed that currency depreciation has contractionary impact on output although it improved the trade balance. Alawattage (2005) examined the effectiveness of exchange rate policy using a conventional two country trade model for the period of 1978Q1 to 2000Q4. Results suggested real effective exchange rate did not have significant impact on improving trade particularly in the short-run implying a weak J-curve. Although the cointegration analysis revealed long-run relationship between exchange rate and trade balance, the findings were found to be very marginal. Arize et al., (2000) investigated the impact of real exchange rate volatility on the export flows of 13 less developed countries which included Sri Lanka. They estimated cointegrating relations via Johansen's multivariate procedures and short-run dynamics via error correction techniques. The major results showed that increased exchange rate volatility exerted a significant negative effect on export demand in both short and long-run for all 13 countries. Perera (2009) in a more recent study tested for the J-curve for Sri Lankan bilateral trade for its major trading partners using an ARDL model. Results revealed no support for the J-curve and also no specific pattern in response to depreciation of real exchange rate.

Literature review revealed no studies investigating the J-curve phenomenon at industry level for Sri Lanka. Further, no studies were found investigating the S-curve phenomenon at bilateral and industry level for Sri Lanka.

4. Research Justification and Objectives

4.1. Research Justification

Literature review reveals that there is limited number of studies done regarding the effect of exchange rate depreciation on Sri Lankan trade balance. Such analysis is quite important especially for Sri Lanka where the trade dependency has historically been very high[5]. Further, history has shown that Sri Lanka has used exchange rates as means of improving its balance of payment. Given the context, it is just to evaluate the relationship between RER and the trade balance. Studies investigating this relationship have predominantly investigated 2 patterns i.e. J and S-curves. Both curves have been tested for developing small open economies which fits the description of Sri Lanka. Limited number of studies analyzing both curves[6] for Sri Lanka provides justifiable grounds to study how trade balance behaves upon depreciation. Most studies have employed bilateral and industry level trade data to overcome the issue of aggregation bias. Analyzing the relationship between RER and trade balance for Sri Lanka at both bilateral and industrial level would not only enable policy makers to look into the impact at bilateral level but; study the impact at industry level to help align future policies concerning exchange rates accordingly.

4.2. Objectives

The objective was to identify if J and S-curve patterns existed in Sri Lankan trade at both bilateral and industry level trade. Analyzing the J-curve is conducted in two stages. First this study analyzed the J-curve phenomenon using bilateral trade data for Sri Lanka and four of her trading partners; India, United Kingdom, Japan and the United States. Secondly the J-curve phenomenon was analyzed at industry level using trade between Sri

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[5] 52.1% in 2011 (Central Bank of Sri Lanka 2011)

[6] 2 studies for the J-curve and no studies for the S-curve

Lanka and India. India being Sri Lanka's closest neighbor, influences Sri Lankan trade at many levels. Both countries have given much emphasis on trade between them and as a result in 1999 a free trade agreement was signed which became operational in 2000.

Similarly, S-curve analysis was conducted in two stages. First, using bilateral trade data for Sri Lanka and 14 of her trade partners; India, United States, United Kingdom, Japan, Singapore, European Union, Switzerland, Sweden, Australia, Canada, Norway, Hong Kong, Denmark and New Zealand[7] and secondly, using industry level trade between Sri Lanka and India.

[7] See Appendix A for bilateral trade statistics.

5. Econometric Model and Methodology

5.1. The J-Curve

5.1.1. Unit Root Testing

A time series data set is needed to be tested for stationarity before data analysis. For a stationary data set, the probability distribution is stable over time i.e. if a collection of random variables is taken in a sequence and then shift that sequence ahead h time periods, the joint probability distribution must remain unchanged (Wooldridge, 2009). If the data set is non-stationary, misleading conclusion could be made via spurious regression. Therefore, this study examined the stationarity of all the log variables used in the model. The test used was the Augmented Dickey Fuller (ADF) test. If the individual variable is y_t the ADF test is based on the following regression

$$y_t = \alpha + \rho y_{t-1} + \mu_t; \quad -1 < \rho < 1 \tag{4}$$

where, μ_t is the error term with zero mean and constant variance. If $\rho = 1$ there would be a unit root and therefore, the variable would be non-stationary. The above equation *(4)* is often expressed in a much more convenient way as given below in *(5)*. This is derived by subtracting y_{t-1} from both sides of equation *(4)* and defining $\theta = \rho - 1$;

$$\Delta y_t = \alpha + \theta y_{t-1} + \mu_t \tag{5}$$

Testing is done for $H_0: \theta = 0$ against $H_A: \theta = 1$. If the null hypothesis is accepted the implication is that the variable is non-stationary. Thus, the first difference of the variables is tested for unit roots[8].

[8] In most cases if the level variable is non-stationary, the first difference of that variable becomes stationary (Wooldridge, 2009)

5.1.2. Trade Balance Model

Trade balance model was derived based on the two country imperfect substitute model, assuming that neither imports nor exports are perfect substitutes for domestic goods (Rose & Yellen, 1989). As the first step, import demand and export supply equations were defined for a two country setting. Following two equations represent the import demand of home and foreign country

$$M = M(Y, P_M) \tag{6}$$
$$M^* = M^*(Y^*, P_M^*) \tag{7}$$

where $M(M^*)$ is the demand of home (foreign) imports and $P_M(P_M^*)$ is home (foreign) country's relative price of imports[9]. Relative price of home imports P_M could be written as in equation *(8)*. This is substituted back to *(6)* and the equation is re-written as in *(9)*.

$$P_M = \frac{\overline{P_M}}{P} = \frac{\overline{P_M}/\overline{P_X^*}}{P/\overline{P_X^*}} = \frac{E}{P/\overline{P_X^*}} = \frac{E \cdot \overline{P_X^*}}{P} = \frac{E \cdot P^* \cdot \overline{P_X^*}}{P \cdot P^*} = RER \cdot P_X^* \tag{8}$$
$$M = M(Y, RER \cdot P_X^*) \tag{9}$$

Similarly for P_M^*, equation *(10)* was derived and was substituted back to *(7)* which yielded *(11)*.

$$P_M^* = \frac{\overline{P_M^*}}{P^*} = \frac{\overline{P_M^*}/\overline{P_X}}{P^*/\overline{P_X}} = \frac{\overline{P_X}}{E \cdot P^*} = \frac{P \cdot \overline{P_X}}{E \cdot P^* \cdot P} = P_X/RER \tag{10}$$
$$M^* = M^*(Y^*, P_X/RER) \tag{11}$$

[9]More precisely P_M is defined as $\overline{P_M}/P$ where $\overline{P_M}$ is the home country's import price in its own currency while P is the domestic price level. Similarly P_M^* is defined as $\overline{P_M^*}/P^*$ where $\overline{P_M^*}$ is the foreign country's import price in its own currency while P^* is her domestic price level. Similarly P_X is defined as $\overline{P_X}/P$ where $\overline{P_X}$ is the home country's export price in its own currency and P_X^* is defined as $\overline{P_X^*}/P^*$ where $\overline{P_X^*}$ is the foreign country's export price in its own currency.

Export supply at home and in the foreign country was assumed to be a function of their relative prices as depicted in equations *(12)* and *(13)*.

$$X = X(P_X) \tag{12}$$

$$X^* = X^*(P_X^*) \tag{13}$$

where $X(X^*)$ is the supply of home (foreign) exports, and $P_X(P_X^*)$ is home (foreign) country's relative price of exports. Quantities traded between two countries would be determined by the below given equilibrium conditions.

$$X = M^* \tag{14}$$

$$M = X^* \tag{15}$$

Given that $P_M = RER \cdot P_X^*$ and $P_M^* = P_X/RER$, the equilibrium quantities traded and relative prices should be a function of RER and Y. If trade balance (TB) was defined as the ratio between exports and imports, following equation *(16)* can be written.

$$TB = \frac{X}{M} = \frac{M^*}{M} = \frac{M^*(Y^*, P_X/RER)}{M(Y, RER \cdot P_X^*)} \tag{16}$$

Equations *(6)* to *(11)* are structural equations which could be solved using *(14)* and *(15)*. Assuming constant relative prices P_X and P_X^*, Rose & Yellen, (1989) showed that the partially reduced form could be written as a function of RER, Y^* and Y which yields the standard trade balance model.

$$TB = TB(Y, Y^*, RER) \tag{17}$$

5.1.3. Bilateral Trade

Trade balance model asserts that the trade balance is a function of three explanatory variables. Assuming that the domestic country is Sri Lanka and the foreign country is her trade partner, a log-linear model was defined following Bahmani-Oskooee & Brooks (1999).

$$ln\left(\frac{X_i}{M_i}\right)_t = a + blnY_t^i + clnY_t^{Sl} + dln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_t + \varepsilon_t \quad (18)$$

where X_i is the value of exports from Sri Lanka to country i, M_i is the value of imports to Sri Lanka from country i, Y^i is the real income of country i, Y^{Sl} is the real income of Sri Lanka, P_i is the price level of country i, P_{Sl} is the price level of Sri Lanka and E is the Nominal Exchange Rate (SLR's per unit of country *i's* currency). The trade balance has been defined as a ratio as it overcomes the unit measurement problem. Further, it enables expressing trade balance in logarithm and therefore the first differenced variable becomes the rate of change for each variable (Bahmani-Oskooee & Kantipong, 2001) and this would narrow the range of variables to make it less susceptible to outliers (Wooldridge, 2009). If the foreign country's income Y^i increases, it is reasonable to assume that the trade balance would improve since it would increase exports. Therefore, the expected sign for b would be positive. On the other hand, if the increase in foreign income is due to an increase in the production of Sri Lankan made good, then one might get a negative coefficient. If Sri Lankan income Y^{Sl} increases, it would decrease the trade balance via increase in imports thus; the expected sign for c would be negative. However, Bahmani-Oskooee & Kantipong (2001) argued, that c could be positive if Y^{Sl} increase is due to an increase in import substitute goods. They argued that this is plausible given that economic growth causes export growth. Increase in the RER implied a real depreciation of the SLR hence; it would improve the trade balance via increase of exports. As a result, the expected sign for d would be positive. The above equation *(18)* deals with current levels of variables thus depict a long-run relationship among these variables. Since the J-curve is a short-run phenomenon, short-run dynamics should be incorporated in to model *(18)* via an error correction format. Engle-Granger (1987) specification was followed which is given below in *(19)*

$$\Delta ln\left(\frac{X_i}{M_i}\right)_t = \alpha + \sum_{k=1}^{n} \beta_{t-k} \Delta ln\left(\frac{X_i}{M_i}\right)_{t-k} + \sum_{k=0}^{n} \delta_{t-k} \Delta lnY_{t-k}^{i} + \sum_{k=0}^{n} \gamma_{t-k} \Delta lnY_{t-k}^{Sl} + \sum_{k=0}^{n} \pi_{t-k} \Delta ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-k} + \varphi\varepsilon_{t-1} + \mu_t \quad (19)$$

where Δ specifies a first differenced variable and, ε_{t-1} is the lagged stationary residual of equation *(18)*. The short-run dynamics are captured by the size and significance of π. If π takes negative signs for low values of k and positive signs for higher values, the J-curve is affirmed. The long-run relationship among the variables in equation *(18)* is confirmed if there is cointegration[10] established i.e. that all the variables in equation *(18)* are non-stationary but their residuals are stationary. Alternatively, this is also affirmed by the sign of φ which is for the lagged error correction term ε_{t-1}. If φ is negative and significant, then cointegration among variables is confirmed and OLS estimates for equation *(18)* will yield the long-run impact of all explanatory variables on the trade balance.

Pesaran et al., (2001) in a pioneering study have modified this equation *(19)* by solving for ε_{t-1}. This involved taking the lags of all variables in equation *(18)* and solving for ε_{t-1}. This is given in equation *(20)*.

$$\varepsilon_{t-1} = ln\left(\frac{X_i}{M_i}\right)_{t-1} - a - blnY_{t-1}^{i} - clnY_{t-1}^{Sl} - dln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-1} \quad (20)$$

Substituting *(20)* into *(19)* yields Pesaran et al., (2001) speciation shown in equation *(21)*.

[10]A formal definition for cointegration: x_t and y_t are said to be cointegrated if there exists a parameter ϕ such that $u_t = y_t - \phi x_t$ is a stationary process.

$$\Delta ln\left(\frac{X_i}{M_i}\right)_t = \alpha + \sum_{k=1}^{n} \beta_{t-k} \Delta ln\left(\frac{X_i}{M_i}\right)_{t-k} + \sum_{k=0}^{n} \delta_{t-k} \Delta lnY_{t-k}^{i} + \sum_{k=0}^{n} \gamma_{t-k} \Delta lnY_{t-k}^{Sl} + \sum_{k=0}^{n} \pi_{t-k} \Delta ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-k} + \varphi_1 ln\left(\frac{X_i}{M_i}\right)_{t-1} + \varphi_2 lnY_{t-1}^{i} + \varphi_3 lnY_{t-1}^{Sl} + \varphi_4 ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-1} + \mu_t \qquad (21)$$

One major advantage of using equation *(21)* is that it avoided classification of the variables into $I(1)$ or $I(0)$ and unlike standard cointegration tests, there is no need to test for unit roots. Further, this enables short-run and long-run impacts to be estimated simultaneously. This is known as the ARDL model. This model has been predominantly subjected to testing the J-curve phenomenon via inferring to the impact of currency depreciation on trade balance. The list of studies includes but is not limited to Bahmani-Oskooee & Brooks (1999), Bahmani-Oskooee & Kantipong (2001), Arora et al., (2003), Bahmani-Oskooee et al., (2006), Sim & Chang (2007), Bahmani-Oskooee & Wang (2007), Halicioglu (2007), Bahmani-Oskooee & Ratha (2007c), Bahmani-Oskooee & Wang (2008), Bahmani-Oskooee & Bolhasani (2008), Bahmani-Oskooee & Cheema (2009), Bahmani-Oskooee & Harvey (2009), Baek et al., (2009), Perera (2009), Petrović & Gligorić (2010) and Bahmani-Oskooee & Hosny (2012b). First, it is important to identify if the inclusion of the lagged-level variables in model *(21)* is valid i.e. whether these variables have long-run relationships. *F* test is used to check the validity where the joint significance of the lagged level variables is tested[11]. This is done by standard *F* values but now with new critical values defined by Pesaran et al., (2001). These critical values have been tabulated based on whether the variables are $I(0)$ i.e. lower bound or $I(1)$ i.e. upper bound or even fractionally integrated. If the calculated *F* statistic is above the upper bound the null is rejected implying cointegration. If the *F* statistic falls below

[11]The null hypothesis of $H_0: \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = 0$ (no cointegration) is tested against the alternative hypothesis $H_A: \varphi_1 \neq 0,\ \varphi_2 \neq 0,\ \varphi_3 \neq 0,\ \varphi_4 \neq 0$ (cointegration).

the lower bound, null is not rejected implying no cointegration. If however, it falls within the band, the result is inconclusive. Once cointegration is confirmed, the model specified in equation *(21)* can be estimated. However, if cointegration is not confirmed, a simple distributed lag model without the lagged level variables is used. If the variables are cointegrated, the short-run effects are given by the values and signs of π's. The J-curve is affirmed if the first few π's i.e. at small values of k have significant and negative coefficients followed by significant and positive values for larger k. The long-run effect of the currency depreciation is given by the estimate φ_4 normalized on φ_1[12].

5.1.4. Trade Data at Industry Level

Based on the trade balance model, equations *(18)* to *(21)* were used for this analysis of trade at industry level between Sri Lanka and India. Equation similar to *(21)* was subjected to econometric analysis[13].

5.2. The S-Curve

Following past studies, cross-correlation functions were used in this section to study the S-curve dynamics. The trade balance (TB) is defined as $TB = ((X_i - M_i)/GDP_{Sl})$ where X_i is the value of export from Sri Lanka to country i, M_i is the value of imports to Sri Lanka from country i and GDP_{Sl} is the real GDP of Sri Lanka. All terms are in Sri Lankan Rupees. RER is defined as $RER = ((P_i \cdot E)/P_{Sl})$ where P_i is the price level of country i, P_{Sl} is the price level of Sri Lanka and E is the Nominal Exchange rate. Based on this specification of RER, an increase would imply a real depreciation of the Sri Lankan Rupee. The correlation between TB and RER is expected to be positive.

[12]Normalization is carried out by dividing the estimate φ_4 by $-\varphi_1$. The same logic applies for other long-run estimates. Formal Derivation is given in Appendix B.
[13]These models are derived same as equations *(18)* to *(21)*. However, the notations are now different. The derivation is given in Appendix C.

However, if this correlation is negative, Harbeger-Larsen-Metzler (HLM)[14] effect is said to be present. Letting ρ_k denote the cross-correlation between RER and TB_{t+k}, following literature, the equation given in *(22)* is used for the analysis of the S-curve for bilateral trade[15].

$$\rho_k = \frac{\sum(RER_t - \overline{RER})(TB_{t+k} - \overline{TB})}{\sqrt{\sum(RER_t - \overline{RER})^2(TB_{t+k} - \overline{TB})^2}} \qquad (22)$$

k can be either lag or lead and was allowed to take values from -6 to 6. When k is negative the correlation is between past values of the TB and the current RER. However, when k becomes positive the correlation is now between future values of the TB and the current RER. Plotting ρ_k against k would give rise to the S-curve. In order to remove spurious results, all variables were de-trended using the Hodrich-Prescott (HP) filter. According to Ravn and Uhlig (2002), HP filter has become a standard method for removing trend movements in the business cycle literature. The HP filter removes a smooth trend τ_t from a time series X_t by solving the minimization problem specified in *(23)* with respect to τ_t.

$$min \sum_{t=1}^{T} [(X_t - \tau_t)^2 + \lambda\,((\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1}))^2] \qquad (23)$$

Here, λ is known as the smoothing parameter. Common wisdom has been to use $\lambda = 1600$ when applying the HP filter to quarterly economic data. Ravn and Uhlig (2002) further showed that different values should be used for λ when the data is annual or monthly (6.25 for annual data, and 129,600 for monthly data).

[14]Result that a terms of trade deterioration will cause a decrease in savings due to the decrease in real income, and therefore that a real depreciation will cause an increase in real expenditure.
[15]Same equation with different notations was used for commodity level trade. This is given in Appendix D.

6. Data

6.1. The J-Curve

6.1.1. Bilateral Trade

Quarterly bilateral time series trade data was collected from 1996Q1 to 2011Q4 for Sri Lanka versus its trade partners (India, United States, United Kingdom and Japan). Export and import data (X_i and M_i) came from the International Monitory Fund (IMF) Direction of Trade statistics database. The real income of trading partner (Y^i), price levels (P_i and P_{Sl}) came from the IMF International Financial Statistics database. It should be noted that the Consumer Price Index (CPI) (2005=100) of each country was used as a proxy for price levels. Real income of Sri Lanka (Y^{Sl}) and the Nominal Exchange Rates were obtained from the Central Bank of Sri Lanka. Quarterly GDP (2005=100) was used as real income for both Sri Lanka and the trading partner.

6.1.2. Trade Data at Industry Level

Annual time series trade data was collected from 1979 to 2011 for Sri Lanka versus India at industry level. Commodities were classified based on the SITC revision 1 (Standard International Trade Classification)[16] and the data came from the UNComtrade database. Annual income and price data came from the IMF International Financial Statistics database and the Nominal Exchange Rates (SLR per unit Indian Rupee) came from the Central Bank of Sri Lanka.

[16] Trade data was collected for 10 sectors. The details are given in Appendix E.

6.2. The S-Curve

Quarterly bilateral time series trade data was collected from 1996Q1 to 2011Q4 for Sri Lanka versus 14 of her trade partners. The same data sources specified in section 6.1.1 were used. For the industry level trade analysis, annual time series trade data was collected from 1979 to 2011 for Sri Lanka versus India at industry level. The same data sources specified in 6.1.2 were used for this analysis.

7. Empirical Results

7.1. The J-Curve

ADF test was carried for unit roots although it was not necessary with the use of the ARDL model specified by Pesaran et al., (2001). The test was carried out for each variable at the level and at their first difference[17]. From the results it could be seen that the first differenced variables have become stationary although most of the level variables are non-stationary.

7.1.1. Bilateral Trade

Equation *(21)* was subjected to empirical analysis and the results are given in this section. First task was to confirm if the lagged level variables in equation *(21)* should be retained in the model i.e. if they are cointegrated. For this purpose *F* statistic was employed to look at the joint significance of these variables. Bahmani-Oskooee & Brooks (1999) found that the *F* test was sensitive to the number of lags imposed on the first differenced variables (*k* value). Hence, the *F* test was carried out for equation *(21)* where lags 1 from 8 were imposed on all first differenced variables. The results are shown in Table 01.

[17]Results are given in Appendix F.

Table 01: *F* Statistics for Cointegration for Bilateral Trade

Trading Partner	F Statistic at Different Number of Lags									
	1	2	3	4	5	6	7	8	F Statistic at Optimal lags	Optimal lag order via AIC*
India	1.55	0.88	0.63	1.00	1.03	1.02	0.71	1.64	1.48	(1,8,0,8)
United Kingdom	5.48	3.74	4.94	3.66	1.05	1.04	1.59	1.26	6.86	(1,1,4,1)
Japan	1.91	2.12	2.48	3.95	6.78	5.26	1.98	3.63	4.05	(6,1,6,5)
United States	4.7	4.92	5.09	5.58	2.22	3.86	4.98	4.06	4.24	(8,2,8,1)

**Example (1,8,0,8) means that AIC selected one lag for the trade balance, 8 lags for India's income, zero lags for Sri Lanka's income and 8 lags for the real exchange rate in equation (21)*
Note: The upper bound critical value for the F test for cointegration with four variables is 3.52 at the 10% significance and 4.01 at 5% significance level. The lower bound critical values are 2.45 at 10% and 2.86 at 5% respectively. These values are taken from Pesaran et al., (2001 Table CI (iii), page 300)

It is evident from Table 01 that the *F* statistic is sensitive to the order of the lag. It appears that there is strong evidence for cointegration in the UK, Japan and the US. This validates the inclusion of lagged level variables in equation *(21)*. Only for India no evidence was found implying cointegration. However, Bahmani-Oskooee & Brooks (1999) and Bahmani-Oskooee & Kantipong (2001) have argued that the results obtained here should be viewed as preliminary. For an example at 1 lag two countries, at 4 lags three countries and at 7 lags none of the countries were found to be supporting cointegration. Therefore, following Bahmani-Oskooee & Kantipong (2001), the lagged level variables were retained in the model for India. Bahmani-Oskooee & Kantipong (2001) reported two benefits of retaining them in the model. First, even if variables are not cointegrated, a significant error correction model term is a useful way of establishing cointegration. Second, lack of cointegration in the *F* test could be attributed to the arbitrary choice of lag lengths.

The second task was to identify the optimal lag length. Information criterion was employed to select the optimal lag length in equation *(21)*. Following literature Akaike's Information Criterion (AIC) was used in determining the optimum lag length[18]. Using

[18]In addition to AIC, the Schwarz's Bayesian information criterion (SBIC) and the Hannan and Quinn information criterion (HQIC) were calculated. The results are given in Appendix G.

these optimal lags, equation *(21)* was subjected to empirical estimation. The F statistics and the optimal lag structure are given in Table 01. Since the interest was in the effect of SLR depreciation on trade balance and for brevity, only the short-run estimates relating to RER were reported in Table 02[19].

Table 02: Short-Run Coefficient Estimates for RER and Error Correction Term for Bilateral Trade

	Trading Partner			
	India	United Kingdom	Japan	United States
$\Delta ln(RER)_t$	1.5220 (0.94)	-1.1490 (1.41)	-0.7880 (0.93)	-0.5445 (1.18)
$\Delta ln(RER)_{t-1}$	-4.0486** (2.14)	-1.3527* (1.83)	0.9273 (1.08)	-3.7727 (1.31)
$\Delta ln(RER)_{t-2}$	-3.1210* (1.72)	-	-0.8802 (0.96)	-
$\Delta ln(RER)_{t-3}$	2.8979 (1.51)	-	0.6102 (0.60)	-
$\Delta ln(RER)_{t-4}$	-1.6874 (0.88)	-	0.2156 (0.25)	-
$\Delta ln(RER)_{t-5}$	-2.7642* (1.77)	-	1.5200* (1.75)	-
$\Delta ln(RER)_{t-6}$	-2.0106 (1.33)	-	-	-
$\Delta ln(RER)_{t-7}$	-0.9799 (0.61)	-	-	-
$\Delta ln(RER)_{t-8}$	-1.4599 (0.91)	-	-	-
ε_{t-1}	-0.3402** (2.57)	-0.8649*** (5.41)	-0.7867*** (4.21)	-1.7809*** (4.33)

**Significant at 10%*
***Significant at 5%*
****Significant at 1%*
Note: Numbers inside the parenthesis are absolute values of t ratios

According to the results in Table 02, India, United Kingdom and Japan depicted short-run effects. In the case of India and United Kingdom, short term depreciation of the SLR worsened the trade balance. However, for Japan, we see that there is a positive improvement in the trade balance. In order to investigate how the short-run effects are

[19]The short run estimates relating to other first differenced variables are given in Appendix H

transformed into long-run effects, estimates φ_2 - φ_4 were normalized on φ_1 and were presented in Table 03.

Table 03: Long-Run Coefficient Estimates for Bilateral Trade

Trading Partner	Constant	lnY_i	lnY_{Sl}	RER
India	0.3180 (0.08)	12.3589* (1.72)	-5.0172 (1.60)	10.7789* (1.98)
United Kingdom	6.3452*** (2.82)	-1.5187 (0.82)	0.7794** (2.08)	1.0408 (1.47)
Japan	-4.1199 (0.53)	1.2066 (0.49)	-0.0892 (0.55)	0.1637* (1.82)
United States	8.6370 (1.32)	-1.0082 (0.39)	0.0177 (0.04)	0.2931 (0.37)

**Significant at 10%*
***Significant at 5%*
****Significant at 1%*
Note: Numbers inside the parenthesis are absolute values of t ratios

According to Table 03, excluding the UK and the US, there is a positive and significant impact of SLR depreciation on trade balance in the long-run[20]. A one percent depreciation of the SLR against the Japanese Yen has increased Sri Lanka's exports relative to imports to Japan by 0.16 percent. A one percent depreciation of the SLR against the Indian Rupee has increased Sri Lanka's exports relative to imports to India by 10.77 percent. Incorporating both short-run and long-run dynamics, it was clear that the J-curve existed only in the case of India. None of the other countries show a J-curve pattern thus no evidence was found to support any pattern in bilateral trade for Sri Lanka[21]. Further, the long-run positive effects for India and Japan imply a failure of Purchasing Power Parity Theory (PPP). If PPP holds in the long-run, RER would be constant and will have no impact on the trade balance. Even a depreciation shock will have no effect once the prices and exchange rate adjust and reach the PPP level. As a result, the insignificant long-run results for the remaining countries indicate that the PPP holds in these cases.

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[20]Estimated coefficients for the UK and the US are positive although not significant.
[21]Similar observations were made by Perera (2009).

The third task was to verify the inclusion of the lag level variables in equation *(21).* The estimates $\varphi_1 - \varphi_4$ were used to calculate the lagged linear combination included in equation *(21)* over time i.e. ε_{t-1}[22]. Next the linear combinations of lagged level variables were replaced by ε_{t-1} and equation *(21)* was re-estimated imposing the optimal lags. This is another way of establishing cointegration according to Pesaran et al., (2001) where cointegration is affirmed if ε_{t-1} receives a negative and significant coefficient. These results are included in Table 02. According to the results, for all countries, the coefficient for ε_{t-1} is negative and significant. This affirmed that there is cointegration present in the variables used in the model.

7.1.2. Trade Data at Industry Level

An equation similar to *(21)* was used in the analysis. First the *F* statistics were calculated in order to determine joint significance of the lag level variables i.e. the inclusion of the lag level variables in equation *(21)*. Due to the limitation in observations, the number of lags was limited to three[23]. Therefore, using 1 to 3 lags for all first differenced variables in the model *F* statistic was calculated. The results are given in Table 04.

[22]See Appendix I for the formal derivation
[23]In some cases two or one lag was imposed due to limited data observations

Table 04: *F* Statistics for Cointegration for Industry Level Trade

SITC Code	Industry	F Statistic at Different Number of Lags: 1	2	3	F Statistic at Optimal lags	Optimal lag order via AIC
0	Food and live animals	3.12	2.71	2.85	6.76	(3,1,3,1)
1	Beverages and tobacco*	0.48	-	-	0.48	(1,1,1,1)
2	Crude materials, inedible, except fuels	5.91	10.89	0.9	10.48	(2,1,2,1)
3	Mineral fuels, lubricants and related materials**	3.12	2.06	-	2.83	(0,2,2,0)
4	Animal and vegetable oils and fats	0.61	1.22	6.49	1.47	(2,1,1,1)
5	Chemicals	2.57	1.86	3.39	2.89	(2,1,2,0)
6	Manufacture goods classified chiefly by material	2.82	3.65	6.64	5.76	(0,2,2,1)
7	Machinery and transport equipment	2.28	0.34	2.63	2.55	(3,1,2,1)
8	Miscellaneous manufactured articles**	1.07	1.74	-	2.51	(0,1,2,0)
9	Commodities & transactions not classified according to kind**	0.64	1.32	-	2.45	(2,2,1,1)

**Maximum of one lag imposed*
***Maximum of 2 lags imposed*

Based on critical values provided by Pesaran et al., (2001), there was cointegration present only in three cases (SITC codes 0, 2 and 6) at optimal lags. However, as earlier, these results were considered preliminary and the lag level variables in the model were retained for the cases which did not report significant *F* statistics. In the second step, the model was estimated using the optimal lag lengths as specified by AIC. The short-run estimates for RER in ten sectors are given below in Table 05.

Table 05: Short-Run Coefficient Estimates for RER and Error Correction Term for Industry Level Trade

SITC Code	Industry	$\Delta ln(RER)_t$	$\Delta ln(RER)_{t-1}$	$\Delta ln(RER)_{t-2}$	$\Delta ln(RER)_{t-3}$	ε_{t-1}
0	Food and live animals	5.607 (1.53)	-5.185* (2.12)	-	-	-2.032*** (5.77)
1	Beverages and tobacco	-3.957 (0.5)	5.009 (0.61)	-	-	-0.855* (2.20)
2	Crude materials, inedible, except fuels	-1.433 (1.09)	-0.769 (0.61)	-	-	-2.256*** (7.06)
3	Mineral fuels, lubricants and related materials	-4.995 (0.51)	-	-	-	-0.917*** (3.84)
4	Animal and vegetable oils and fats	9.043* (1.80)	5.309 (0.75)	-	-	-0.564** (2.71)
5	Chemicals	1.912 (0.79)	-	-	-	-0.426*** (3.25)
6	Manufacture goods classified chiefly by material	-1.177** (2.48)	1.954 (0.75)	-	-	-0.637*** (3.17)
7	Machinery and transport equipment	-1.134* (1.84)	0.030 (0.02)	-	-	-1.039*** (3.52)
8	Miscellaneous manufactured articles	3.427 (1.25)	-	-	-	-0.692*** (3.41)
9	Commodities & transactions not classified according to kind	2.555 (0.27)	-11.458 (0.98)	-	-	-1.341*** (3.96)

**Significant at 10%*
***Significant at 5%*
****Significant at 1%*
Note: Numbers inside the parenthesis are absolute values of t ratios

From Table 05, it was evident that there are 4 industries with short-run impacts. More precisely, a short term depreciation of the SLR with respect to India improved trade balance in food and live animals (SITC code 1) and Animal and vegetable oils and fats (SITC code 4) whereas; the trade balance has worsen in Manufactured goods (SITC code 6) and Machinery and transport equipment (SITC 7).

Table 06: Long-Run Coefficient Estimates for Industry Level Trade

SITC Code	Industry	Constant	lnY_{Ind}	lnY_{Sl}	RER
0	Food and live animals	39.8013** (2.23)	-2.0177 (0.51)	5.0801 (0.91)	4.5780*** (3.58)
1	Beverages and tobacco	65.4803 (0.62)	53.7357 (0.83)	-69.4429 (0.78)	-7.0731 (0.40)
2	Crude materials, inedible, except fuels	9.1248* (1.86)	3.4949** (2.59)	-4.046** (2.32)	-1.7411*** (3.96)
3	Mineral fuels, lubricants and related materials	67.6159 (0.68)	59.4821 (0.90)	-77.3140 (0.87)	0.4458 (0.05)
4	Animal and vegetable oils and fats	8.0486 (0.20)	15.7376 (0.36)	19.2311 (0.34)	2.2665 (0.28)
5	Chemicals	9.7891 (0.90)	6.4856 (0.77)	-10.0315 (0.89)	-0.9590 (0.50)
6	Manufacture goods classified chiefly by material	-20.2997 (1.72)	-7.3512 (0.73)	13.3628 (1.02)	-3.5795* (2.13)
7	Machinery and transport equipment	-25.6750 (1.37)	-8.3665 (1.06)	12.5606 (1.11)	-3.8419** (2.59)
8	Miscellaneous manufactured articles	-23.416** (2.09)	-7.1578 (0.83)	13.3923 (1.17)	3.6513 (1.50)
9	Commodities & transactions not classified according to kind	279.667* (2.16)	-139.004* (2.29)	182.977* (2.27)	7.8066 (1.07)

**Significant at 10%*
***Significant at 5%*
****Significant at 1%*
Note: Numbers inside the parenthesis are absolute values of t ratios

Long-run estimates are reported in Table 06. Out of 10 industries, only 4 had long-run impacts of SLR depreciation. In the long-run, trade balance improved for food and live animals sector (SITC code 0). However, the trade balance worsened for crude materials, inedibles except fuels (SITC code 2), manufacturing goods classified chiefly by materials (SITC code 6) and machinery and transport equipment (SITC code 7). Considering both short-run and long-run dynamics, only three industries had the short-run impacts last into long-run impacts. However, J-curve existed only for Food and live animals. Trade balance continued to deteriorate from short-run to long-run in the case of manufacturing goods classified chiefly by materials and machinery and transport equipment giving no support for a J-curve.

7.2. The S-Curve

7.2.1. Bilateral Trade

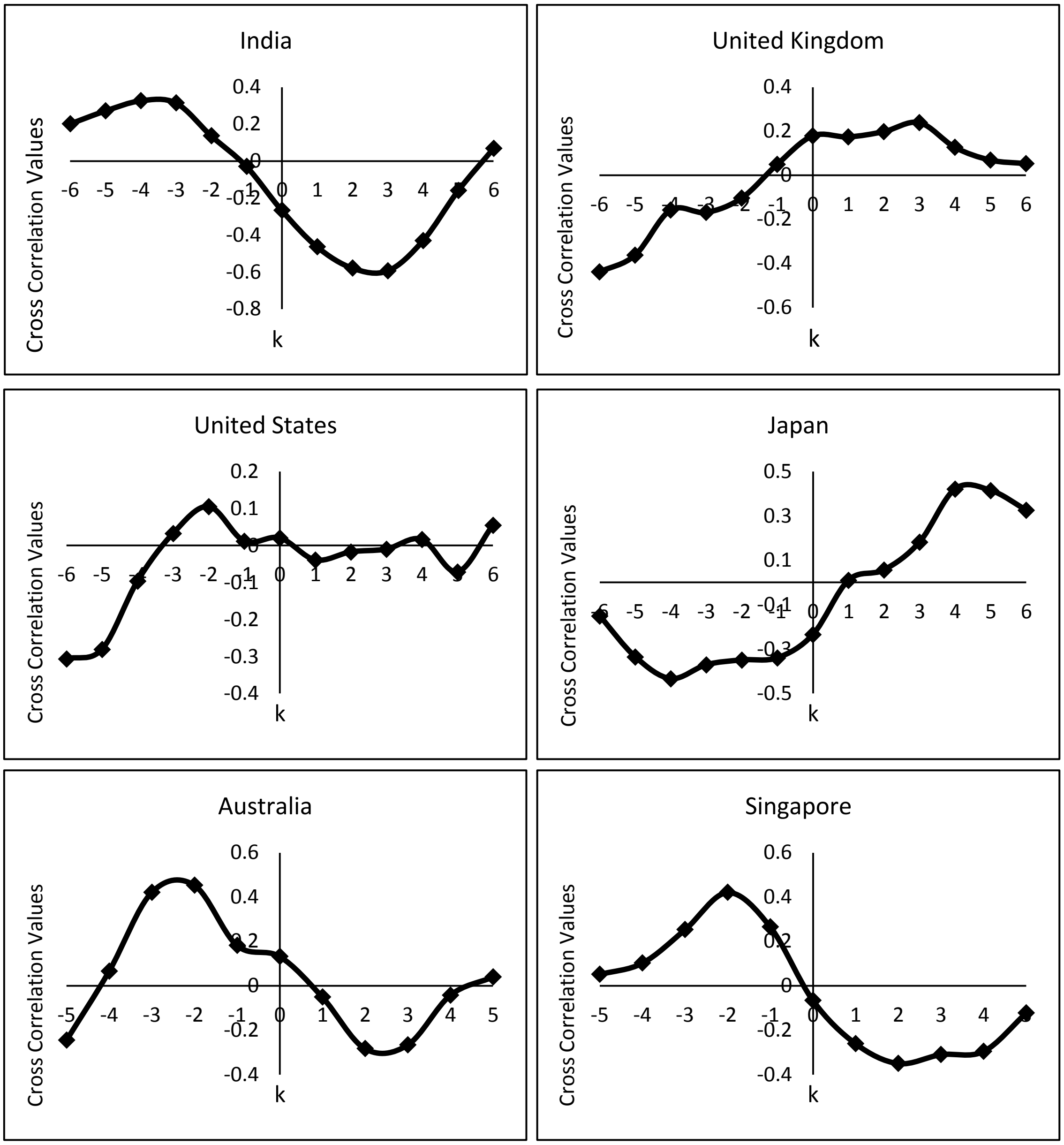


Figure 03: Relationship between ρ_k and k for Sri Lanka and 14 Trading Partners

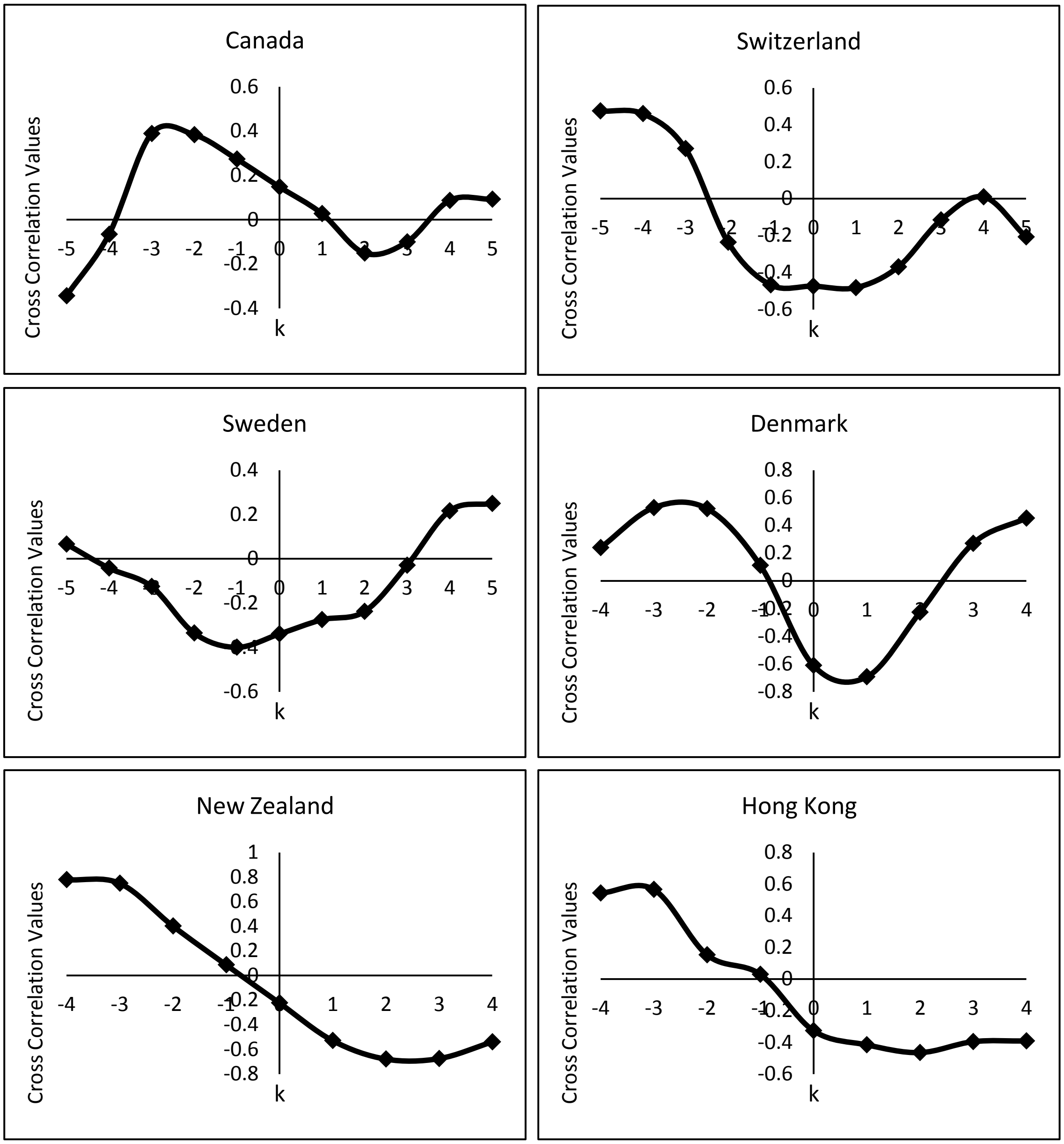
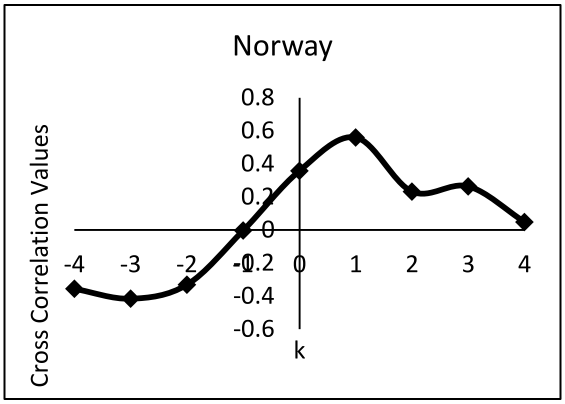


Figure 03: Relationship between ρ_k and k for Sri Lanka and 14 Trading Partners (Continued)



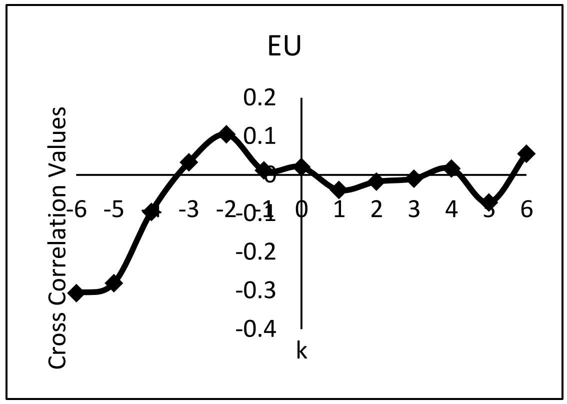


Figure 03: Relationship between ρ_k and k for Sri Lanka and 14 Trading Partners (Continued)

Figure 03 depicts the graphs showing the relationship between ρ_k and k for Sri Lanka and 14 trading partners. Out of 14 cases, S-curve pattern existed only for trade between Sri Lanka and the UK, Japan and Norway. Rather weak support for an S-curve was found for the trade between Sri Lanka and the US and the EU. There were cases of S shaped curves although they did not conform to the theory (i.e. negative correlation for lags and positive correlation for leads).

7.2.2. Trade Data at Industry Level

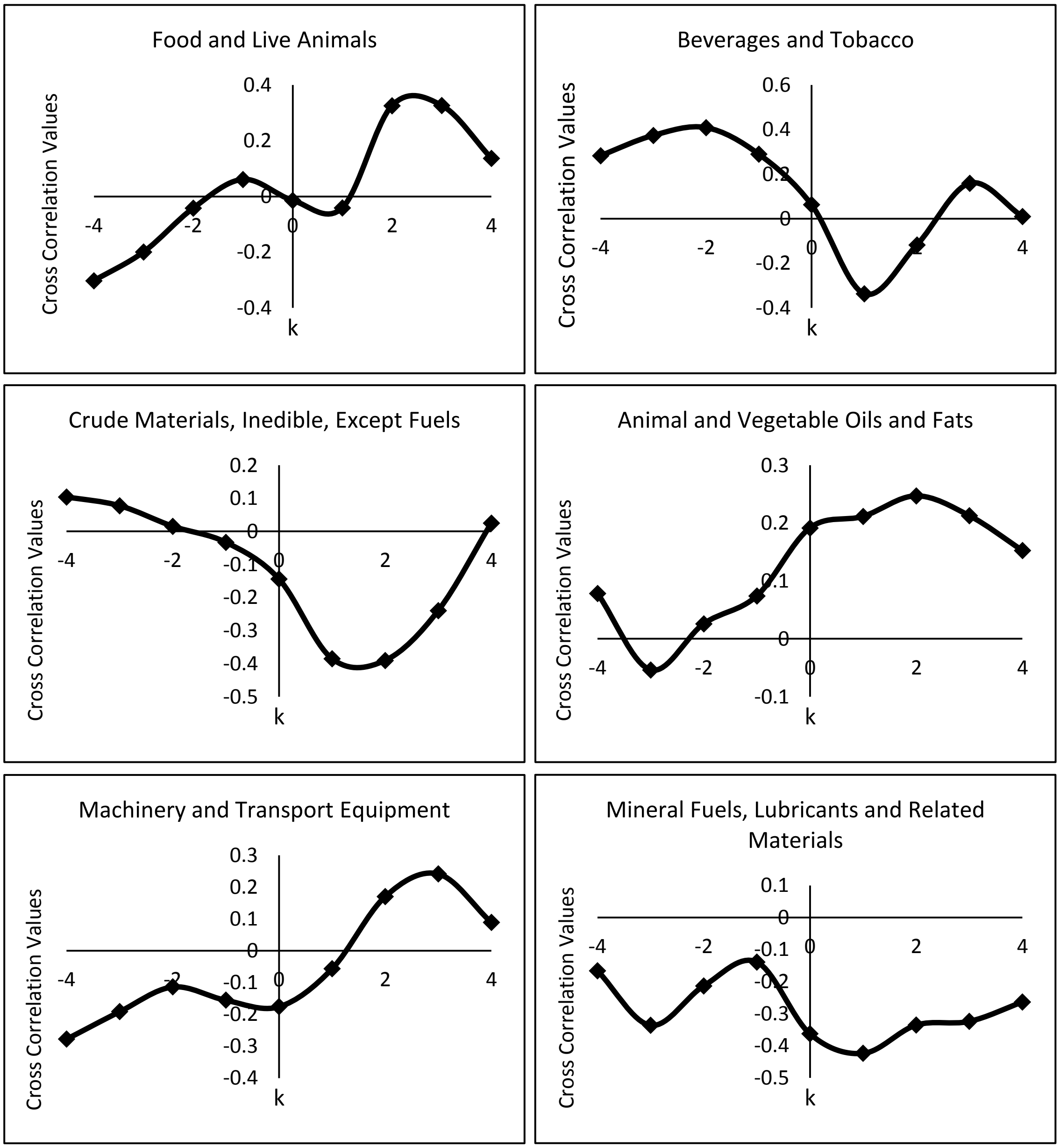


Figure 04: Relationship between ρ_k and k for 10 Industries between Sri Lanka and India

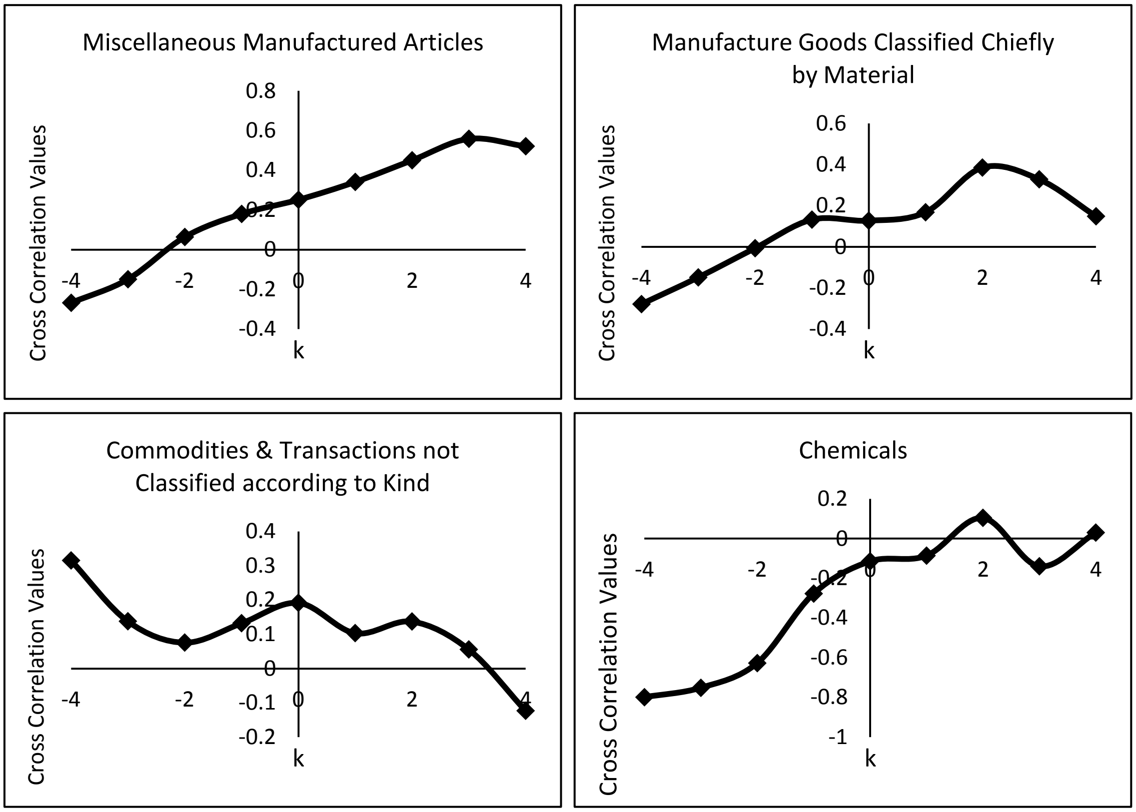


Figure 04: Relationship between ρ_k and k for 10 Industries between Sri Lanka and India (Continued)

Figure 04 depicts graphs showing the relationship between ρ_k and k for 10 industries between Sri Lanka and India. From 10 cases only 4 cases were found to be supporting the S-curve namely; Food and live animals, manufacture goods classified chiefly by material, machinery and equipment and miscellaneous manufactured articles. There was rather weak support for the S-curve in 2 industries namely; Animal and vegetable oils and fats and chemicals.

8. Discussion and Conclusion

8.1. The J-Curve

Through the analysis of the J-curve at both bilateral and industry level, it was apparent that the pattern did not exist in most cases for Sri Lanka. Literature review revealed two main reasons for lack of evidence for J-curve hypothesis. First is the level of aggregation. J-curve received strong support when it was analyzed at disaggregated industry level trade data between two countries. Although this study employed disaggregated trade data for 10 industries, it could be argued that the issue of aggregation may have still existed due to the limited number of industries. Most of the studies done in this regard, have analyzed the J-curve for trade between developed countries across large number of industries (more than 50). However, for the case of Sri Lankan trade, only SITC revision 1 with 10 industries was available for a continuous time scale adequate to run a regression analysis. Secondly, there can be an issue with the assumptions made in analyzing the J-curve. Most reasonable justification for this outcome would be that Sri Lankan trade may not meet the necessary conditions for the pass-through effect i.e. Sri Lankan and foreign price elasticities of demand are inelastic. In the short-run, it is reasonable to assume that Sri Lankan exports are inelastic, while demand is relatively elastic due to the availability of other major export substitutes. Under these circumstances, a depreciation of the SLR would increase the SLR price of Sri Lankan exports but the SLR price of imports will not change. As a result, Sri Lankan trade may not show an initial deterioration of trade balance[24]. However, Sim & Chang (2007) argues that one may observe the J-curve if the following conditions are satisfied i.e. (a) an initial trade deficit (or surplus) and (b) sufficiently low domestic demand and supply elasticities in the long-run. This maybe the reason a J-curve was present in some cases. Although the J-curve phenomenon may not be as strong as in the case of a developing country, the effect is at least theoretically plausible.

[24]Similar arguments were made by Sim & Chang (2007) and Baek et al., (2006)

Although there was little evidence for a J-curve for Sri Lankan trade at bilateral and industry level, there was evidence of a relationship between RER and Trade balance. In bilateral trade, short-run impacts were found in all countries excluding the US (India, Japan and the UK). This impact lasted into the long-run for two countries (India and Japan). At industry level, short-run impacts were evident in 4 cases and for long-run impacts again 4 cases were evident. However, only 3 cases were found where both short-run and long-run impacts were significant. Below Table 07 summarizes the results obtained.

Table 07: Summary of the Results for J-Curve

Country/Industry	Short run Impact	Long run Impact	J-Curve
India	Yes (negative)	Yes (positive)	Yes
Japan	Yes (positive)	Yes (positive)	No
United Kingdom	Yes (negative)	No	No
United States	No	No	No
Food and live animals	Yes (negative)	Yes (positive)	Yes
Beverages and tobacco	No	No	No
Crude materials, inedible, except fuels	No	Yes (negative)	No
Mineral fuels, lubricants and related materials	No	No	No
Animal and vegetable oils and fats	Yes (positive)	No	No
Chemicals	No	No	No
Manufacture goods classified chiefly by material	Yes (negative)	Yes (negative)	No
Machinery and transport equipment	Yes (negative)	Yes (negative)	No
Miscellaneous manufactured articles	No	No	No
Commodities & transactions not classified according to kind	No	No	No

This implied that although there is no J-curve, the impact of RER on trade balance is evident for most cases. Such analysis is vital as it would help policy makers to identify how trade balance would change at bilateral and industry level. This would enable them to anticipate future movements in the trade balance across countries that trade with Sri Lanka as well as across various industries.

It should be noted that there were few shortcoming of this analysis. One major problem was the availability of data. Due to lack quality time series data, this study had to be limited to trade between Sri Lanka and four trading partners at bilateral level and for only 10 industries for trade between Sri Lanka and India. Better trade data availability especially for large number of industries for Sri Lanka and her major trading partners would enable future research to find stronger support for a particular pattern. This becomes critical for a developing country like Sri Lanka where data management is not given much emphasis. Hence, responsible authorities should give attention in maintaining and updating databases which would aid research and development. Another major shortcoming was the assumption that trade balance is determined only through Y, Y^* and RER. However, one can expect other variables to influence trade balance. Literature specifies the importance of trade policies and supply demand shocks in determining trade balance. For a country like Sri Lanka, there would be a possibility that these variables maybe the underlying cause for the changes in trade balance. Therefore, this analysis could be enriched by relaxing several assumptions made in the trade balance model and incorporating other variable/shocks (Baek et al., 2006)

8.2. The S-Curve

S-curve was evident for 5 instances in bilateral trade and 6 instances for industry level trade. Analysis of S-curves relied upon cross-correlation functions and hence should be treated preliminary. While the J-curve employs regression analysis, the S-curve relies upon cross-correlation functions. Therefore, the S-curve can only show the pattern and the direction in which trade balance moves and cannot be used to infer, for example, the impact of 1% depreciation on trade balance (Bahmani-Oskooee & Hegerty, 2010). Hence, it would be unwise to make policy decisions based on S-curve analysis but it can be used to understand the movement of these variables and then use as a precursor for more comprehensive methods to identity the relationship between exchange rates and trade balance.

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APPENDICES

Appendix A: Sri Lanka's Trade with 14 Trading Partners from 2008-2011 (US$ Thousands)

Trading Partner	2008		2009		2010		2011	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
World	8176817	13629063	7121491	9431851	8304052	12353708	10011282	19696480
India	417947	2836231	325022	1694021	467182	2549435	521264	4349226
	(5.11%)	(20.81%)	(4.56%)	(17.96%)	(5.63%)	(20.64%)	(5.21%)	(22.08%)
United Kingdom	1090109	243056	1024061	217565	1021905	265819	1110297	314338
	(13.33%)	(1.78%)	(14.38%)	(2.31%)	(12.31%)	(2.15%)	(11.09%)	(1.60%)
Japan	162150	424334	140639	221788	169301	584841	223492	1025097
	(1.98%)	(3.11%)	(1.97%)	(2.35%)	(2.04%)	(4.73%)	(2.23%)	(5.20%)
United States	1886241	297450	1589753	264585	1767685	168382	2143901	287989
	(23.07%)	(2.18%)	(22.32%)	(2.81%)	(21.29%)	(1.36%)	(21.41%)	(1.46%)
European Union	3019378	1739439	2736443	1241346	2907142	1532332	3558960	1933574
	(36.93%)	(12.76%)	(38.43%)	(13.16%)	(35.01%)	(12.40%)	(35.55%)	(9.82%)
Switzerland	72927	190038	52300	119383	67471	153473	87895	679086
	(0.89%)	(1.39%)	(0.73%)	(1.27%)	(0.81%)	(1.24%)	(0.88%)	(3.45%)
Denmark	30447	32910	17286	20499	24271	27161	26714	32157
	(0.37%)	(0.24%)	(0.24%)	(0.22%)	(0.29%)	(0.22%)	(0.27%)	(0.16%)
Sweden	60335	105818	38991	33026	58402	49633	78626	58801
	(0.74%)	(0.78%)	(0.55%)	(0.35%)	(0.70%)	(0.40%)	(0.79%)	(0.30%)
Hong Kong	143595	694227	96812	515919	116872	580390	108884	717158
	(1.76%)	(5.09%)	(1.36%)	(5.47%)	(1.41%)	(4.70%)	(1.09%)	(3.64%)
Singapore	76919	1599310	87636	1104987	186345	1615423	406427	1538834
	(0.94%)	(11.73%)	(1.23%)	(11.72%)	(2.24%)	(13.08%)	(4.06%)	(7.81%)
Norway	18836	6337	13291	5941	15938	5210	21458	9770
	(0.23%)	(0.05%)	(0.19%)	(0.06%)	(0.19%)	(0.04%)	(0.21%)	(0.05%)
Australia	93691	195272	81946	132790	102520	185234	126586	273486
	(1.15%)	(1.43%)	(1.15%)	(1.41%)	(1.23%)	(1.50%)	(1.26%)	(1.39%)
Canada	89572	346315	74176	272142	94584	253231	126164	330205
	(1.10%)	(2.54%)	(1.04%)	(2.89%)	(1.14%)	(2.05%)	(1.26%)	(1.68%)

Source: UNComtrade Database
Values in Parenthesis includes the percentages from world export import values

Appendix B: Formal Derivation for the Normalization of Long-run Estimates

Lag level variables in equation *(18)* was set to equal zero as in equation *(B1)*

$$\varphi_1 ln\left(\frac{X_i}{M_i}\right)_{t-1} + \varphi_2 lnY^i_{t-1} + \varphi_3 lnY^{Sl}_{t-1} + \varphi_4 ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-1} = 0 \qquad (B1)$$

Next it was solved for $ln\left(\frac{X_i}{M_i}\right)_{t-1}$ as in equation *(B2)*

$$ln\left(\frac{X_i}{M_i}\right)_{t-1} = -\frac{\varphi_2}{\varphi_1} lnY^i_{t-1} + -\frac{\varphi_3}{\varphi_1} lnY^{Sl}_{t-1} + -\frac{\varphi_4}{\varphi_1} ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-1} \qquad (B2)$$

Appendix C: ARDL Model used in the Analysis of Industry Level Trade

$$ln\left(\frac{X_i}{M_i}\right)_t = a + blnY^{Ind}_t + clnY^{Sl}_t + dln\left(\frac{P_{Ind} \cdot E}{P_{Sl}}\right)_t + \varepsilon_t \qquad (C1)$$

Where; X_i is the value of exports from Sri Lanka to India for sector i, M_i is the value of imports to Sri Lanka from India for sector i, Y^{Ind} is the income of India (Real GDP of India), Y^{Sl} is the income of Sri Lanka (Real GDP of Sri Lanka), P_{Ind} is the price level of India (CPI of India used as a proxy), P_{Sl} is the price level of Sri Lanka (CPI of Sri Lanka used as a proxy) and E is the Nominal Exchange rate (Sri Lankan Rupees per unit of Indian Rupee).

Engle-Granger (1987) specification in *(C2)*

$$\Delta ln\left(\frac{X_i}{M_i}\right)_t = \alpha + \sum_{k=1}^{n} \beta_{t-k} \Delta ln\left(\frac{X_i}{M_i}\right)_{t-k} + \sum_{k=0}^{n} \delta_{t-k} \Delta lnY_{t-k}^{Ind} + \sum_{k=0}^{n} \gamma_{t-k} \Delta lnY_{t-k}^{Sl} + \sum_{k=0}^{n} \pi_{t-k} \Delta ln\left(\frac{P_{Ind} \cdot E}{P_{Sl}}\right)_{t-k} + \varphi\varepsilon_{t-1} + \mu_t \quad (C2)$$

Error Correction Term in *(C3)*

$$\varepsilon_{t-1} = ln\left(\frac{X_i}{M_i}\right)_{t-1} - a - blnY_{t-1}^{Ind} - clnY_{t-1}^{Sl} - dln\left(\frac{P_{Ind} \cdot E}{P_{Sl}}\right)_{t-1} \quad (C3)$$

Equating *(C3)* into *(C2)* yields *(C4)* which is the ARDL model

$$\Delta ln\left(\frac{X_i}{M_i}\right)_t = \alpha + \sum_{k=1}^{n} \beta_{t-k} \Delta ln\left(\frac{X_i}{M_i}\right)_{t-k} + \sum_{k=0}^{n} \delta_{t-k} \Delta lnY_{t-k}^{Ind} + \sum_{k=0}^{n} \gamma_{t-k} \Delta lnY_{t-k}^{Sl} + \sum_{k=0}^{n} \pi_{t-k} \Delta ln\left(\frac{P_{Ind} \cdot E}{P_{Sl}}\right)_{t-k} + \varphi_1 ln\left(\frac{X_i}{M_i}\right)_{t-1} + \varphi_2 lnY_{t-1}^{Ind} + \varphi_3 lnY_{t-1}^{Sl} + \varphi_4 ln\left(\frac{P_{Ind} \cdot E}{P_{Sl}}\right)_{t-1} + \mu_t \quad (C4)$$

Appendix D: Cross-Correlation Function used in the Analysis of Industry Level Trade

$$\rho_k = \frac{\sum(RER_t - \overline{RER})(TB_{t+k} - \overline{TB})}{\sqrt{\sum(RER_t - \overline{RER})^2(TB_{t+k} - \overline{TB})^2}} \quad (D1)$$

The trade balance (TB) was defined as $TB = ((X_i - M_i)/GDP_{Sl})$ where X_i is the value of export from Sri Lanka to India for sector i, M_i is the value of imports to Sri Lanka from India for sector i and GDP_{Sl} is the real GDP of Sri Lanka. All terms were in Sri Lankan Rupees. RER is defined as $RER = ((P_{Ind} \cdot E)/P_{Sl})$ where P_{Ind} is the price level of India; P_{Sl} is the price level of Sri Lanka and E is the Nominal Exchange Rate (SLR per unit of Indian Rupee).

Appendix E: SITC Revision 1 Commodity Categories

Sector Code	**Sector/Industry**
0	Food and live animals
1	Beverages and tobacco
2	Crude materials, inedible, except fuels
3	Mineral fuels, lubricants and related materials
4	Animal and vegetable oils and fats
5	Chemicals
6	Manufacture goods classified chiefly by material
7	Machinery and transport equipment
8	Miscellaneous manufactured articles
9	Commodities & transactions not classified according to kind

Appendix F: Unit Root Test

Appendix F1: Bilateral Trade

Variable	Level	Critical Values			First Difference	Critical Values		
		1%	5%	10%		1%	5%	10%
ln_y_srilanka	0.533	-3.562	-2.920	-2.595	-9.908	-3.563	-2.920	-2.595
ln_xm_india	-2.500	-3.567	-2.923	-2.596	-15.188	-3.569	-2.924	-2.597
ln_y_india	-0.906	-3.567	-2.923	-2.596	-8.397	-3.569	-2.924	-2.597
ln_rer_india	-2.162	-3.567	-2.923	-2.596	-5.387	-3.569	-2.924	-2.597
ln_xm_japan	-3.025	-3.562	-2.920	-2.595	-9.826	-3.563	-2.920	-2.595
ln_y_japan	-1.352	-3.562	-2.920	-2.595	-5.709	-3.563	-2.920	-2.595
ln_rer_japan	-1.545	-3.562	-2.920	-2.595	-6.708	-3.563	-2.920	-2.595
ln_xm_uk	-2.457	-3.562	-2.920	-2.595	-10.872	-3.563	-2.920	-2.595
ln_y_uk	-3.693	-3.562	-2.920	-2.595	-3.042	-3.563	-2.920	-2.595
ln_rer_uk	0.046	-3.562	-2.920	-2.595	-5.629	-3.563	-2.920	-2.595
ln_xm_usa	-6.547	-3.562	-2.920	-2.595	-14.22	-3.563	-2.920	-2.595
ln_y_usa	-4.257	-3.562	-2.920	-2.595	-4.637	-3.563	-2.920	-2.595
ln_rer_usa	0.720	-3.562	-2.920	-2.595	-5.452	-3.563	-2.920	-2.595

Appendix F2: Industry Level Trade

Variable	Level	Critical Values			First Difference	Critical Values		
		1%	5%	10%		1%	5%	10%
ln_y_srilanka	-1.212	-3.702	-2.890	-2.622	-4.887	-3.709	-2.983	-2.623
ln_y_india	1.430	-3.702	-2.890	-2.622	-5.453	-3.709	-2.983	-2.623
ln_rer	0.683	-3.702	-2.890	-2.622	-4.462	-3.709	-2.983	-2.623
ln_xm_0	-3.824	-3.702	-2.890	-2.622	-6.297	-3.709	-2.983	-2.623
ln_xm_1	-1.575	-3.750	-3.000	-2.630	-2.929	-3.750	-3.000	-2.630
ln_xm_2	-3.911	-3.702	-2.890	-2.622	-7.668	-3.709	-2.983	-2.623
ln_xm_3	-2.501	-3.750	-3.000	-2.630	-5.538	-3.750	-3.000	-2.630
ln_xm_4	-2.428	-3.736	-2.994	-2.628	-5.621	-3.743	-2.997	-2.629
ln_xm_5	-3.300	-3.709	-2.983	-2.623	-6.932	-3.716	-2.986	-2.624
ln_xm_6	-1.748	-3.702	-2.890	-2.622	-5.734	-3.709	-2.983	-2.623
ln_xm_7	-3.280	-3.702	-2.890	-2.622	-11.085	-3.709	-2.983	-2.623
ln_xm_8	-1.994	-3.702	-2.890	-2.622	-7.218	-3.709	-2.983	-2.623
ln_xm_9	-2.107	-3.750	-3.000	-2.630	-5.929	-3.750	-3.000	-2.630

Appendix G: AIC, HQIC and SBIC (Information Criterion) Values at Different Lags

Appendix G1: Bilateral Trade

Trading Partner	Number of Lags								
	0	1	2	3	4	5	6	7	8
AIC									
India	-3.90	-4.05	-4.12	-4.18	-4.19	-4.17	-4.18	-4.19	-4.20
Japan	-3.36	-3.33	-3.39	-3.49	-3.46	-3.49	-3.46	-3.43	-3.41
United Kingdom	-3.74	-3.78	-3.77	-3.74	-3.73	-3.71	-3.67	-3.65	-3.63
USA	-4.59	-4.74	-4.70	-4.68	-4.64	-4.61	-4.60	-4.56	-4.53
HQIC									
India	-3.79	-3.92	-3.98	-4.02	-4.02	-3.98	-3.97	-3.97	-3.97
Japan	-3.25	-3.21	-3.25	-3.34	-3.29	-3.31	-3.26	-3.22	-3.18
United Kingdom	-3.63	-3.65	-3.63	-3.58	-3.56	-3.52	-3.47	-3.44	-3.40
US	-4.48	-4.61	-4.56	-4.52	-4.47	-4.43	-4.40	-4.35	-4.30
SBIC									
India	-3.60	-3.71	3.75	-3.76	-3.74	-3.68	-3.65	-3.62	-3.60
Japan	-3.07	-3.01	-3.03	-3.09	-3.02	-3.02	-2.88	-2.88	-2.82
United Kingdom	-3.45	-3.45	-3.4	-3.33	-3.3	-3.23	-3.16	-3.11	-3.04
US	-4.30	-4.41	-4.34	-4.28	-4.20	-4.14	-4.00	-4.00	-3.94

Appendix G2: Industry Level Trade

Number of Lags	Commodity Code									
	0	1	2	3	4	5	6	7	8	9
AIC										
0	-2.29	-2.3	-2.07	-1.76	-2.35	-2.2	-2.07	-2.22	-2.17	-1.38
1	-2.30	-2.51	-2.07	-1.67	-2.35	-2.13	-2.05	-2.24	-2.14	-1.44
2	-2.24	-2.39	-2.01	-1.58	-2.28	-2.07	-2.00	-2.18	-2.08	-1.43
3	-2.17	-	-2.01	-	-2.30	-2.16	-2.00	-2.12	-	-
HQIC										
0	-2.18	-2.37	-1.95	-1.66	-2.24	-2.08	-1.95	-2.11	-2.05	-1.31
1	-2.17	-2.59	-1.94	-1.56	-2.23	-2.00	-1.92	-2.11	-2.01	-1.37
2	-2.09	-2.48	-1.86	-1.46	-2.15	-1.92	-1.85	-2.03	-1.93	-1.34
3	-2.01	-	-1.84	-	-2.16	-2.00	-1.84	-1.96	-	-
SBIC										
0	-1.92	-1.95	-1.69	-1.36	-1.96	-1.82	-1.69	-1.85	-1.80	-0.98
1	-1.88	-2.12	-1.65	-1.22	-1.91	-1.70	-1.63	-1.81	-1.72	-0.99
2	-1.77	-1.96	-1.53	-1.08	-1.79	-1.59	-1.53	-1.71	-1.61	-0.93
3	-1.65	-	-1.49	-	-1.76	-1.63	-1.48	-1.61	-	-

Appendix H: Short-Run Coefficient Estimates

Appendix H1: Trade Balance for Bilateral Trade

	Trading Partner			
	India	United Kingdom	Japan	United States
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-1}$	-0.4573** (2.70)	0.0753 (0.53)	0.2486 (1.15)	0.9559* (1.98)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-2}$	-	-	0.4019** (2.11)	1.0032** (2.37)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-3}$	-	-	0.4873** (2.43)	0.9398** (2.20)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-4}$	-	-	0.4275** (2.17)	0.8917** (2.28)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-5}$	-	-	0.3290* (1.84)	0.8477** (2.49)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-6}$	-	-	0.2684* (1.77)	0.7740** (2.64)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-7}$	-	-	-	0.2248 (0.83)
$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-8}$	-	-	-	0.2420 (1.31)

Appendix H2: Trade Partners Real Income for Bilateral Trade

	Trading Partner			
	India	United Kingdom	Japan	United States
ΔlnY_t^i	4.0068 (1.05)	2.2092 (0.41)	-1.5107 (0.53)	12.6168 (1.19)
ΔlnY_{t-1}^i	-4.8068 (1.28)	-5.4746 (1.12)	-8.2455** (2.52)	-0.3737 (0.04)
ΔlnY_{t-2}^i	-4.9626 (1.32)	-	-	2.7058 (0.28)
ΔlnY_{t-3}^i	-2.9380 (0.70)	-	-	-
ΔlnY_{t-4}^i	-3.1373 (0.79)	-	-	-
ΔlnY_{t-5}^i	-3.9148 (1.00)	-	-	-
ΔlnY_{t-6}^i	-1.5023 (0.47)	-	-	-
ΔlnY_{t-7}^i	-4.2538 (1.38)	-	-	-
ΔlnY_{t-8}^i	-5.0243 (1.53)	-	-	-

Appendix H3: Sri Lanka's Real Income for Bilateral Trade

	Trading Partner			
	India	United Kingdom	Japan	United States
ΔlnY_t^{Sl}	-1.4677 (1.10)	-0.9528 (1.31)	-0.1537 (0.19)	0.4542 (0.27)
ΔlnY_{t-1}^{Sl}	-	-1.9453** (2.27)	-1.1068 (1.37)	2.2370 (1.56)
ΔlnY_{t-2}^{Sl}	-	-1.6189* (1.96)	0.3276 (0.38)	2.0839 (1.46)
ΔlnY_{t-3}^{Sl}	-	-1.4821** (2.04)	-1.3377 (1.53)	-0.8869 (0.07)
ΔlnY_{t-4}^{Sl}	-	0.3443 (0.52)	0.0264 (0.03)	2.8287** (2.17)
ΔlnY_{t-5}^{Sl}	-	-	0.9665 (1.14)	-0.5035 (0.42)
ΔlnY_{t-6}^{Sl}	-	-	0.2798 (0.36)	0.5739 (0.48)
ΔlnY_{t-7}^{Sl}	-	-	-	1.7432 (1.47)
ΔlnY_{t-8}^{Sl}	-	-	-	0.1702 (0.12)

Appendix H4: Trade Balance for Industry level Trade

SITC Code	Sector	$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-1}$	$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-2}$	$\Delta ln\left(\frac{X_i}{M_i}\right)_{t-3}$
0	Food and live animals	0.8353** (2.24)	0.6222* (1.95)	0.4787* (1.84)
1	Beverages and tobacco	0.1353 (0.21)	-	-
2	Crude materials, inedible, except fuels	0.9406*** (3.76)	0.3142* (1.94)	-
3	Mineral fuels, lubricants and related materials	-	-	-
4	Animal and vegetable oils and fats	0.2300 (0.77)	0.6737** (2.68)	-
5	Chemicals	-0.0711 (0.31)	-0.3628 (1.71)	-
6	Manufacture goods classified chiefly by material	-	-	-
7	Machinery and transport equipment	0.2031 (0.68)	0.5761** (2.23)	0.3920** (2.50)
8	Miscellaneous manufactured articles	-	-	-
9	Commodities & transactions not classified according to kind	1.0672 (1.71)	1.2863** (2.56)	-

Appendix H5: Trade Partners Real Income for Industry level Trade

SITC Code	Sector	ΔlnY_t^{Ind}	ΔlnY_{t-1}^{Ind}	ΔlnY_{t-2}^{Ind}	ΔlnY_{t-3}^{Ind}
0	Food and live animals	-5.1300 (0.44)	5.2165 (0.92)	-	-
1	Beverages and tobacco	45.0072 (1.30)	-0.8125 (0.03)	-	-
2	Crude materials, inedible, except fuels	3.2451 (0.60)	2.9353 (0.86)	-	-
3	Mineral fuels, lubricants and related materials	44.7943 (1.07)	-36.2316 (1.45)	-42.1697* (2.20)	-
4	Animal and vegetable oils and fats	-9.5891 (0.44)	-22.9949 (1.27)	-	-
5	Chemicals	19.1358** (2.25)	-2.5660 (0.41)	-	-
6	Manufacture goods classified chiefly by material	6.1273 (0.53)	-0.1898 (0.03)	2.8064 (0.44)	-
7	Machinery and transport equipment	1.1551 (0.14)	0.6922 (0.15)	-	-
8	Miscellaneous manufactured articles	-6.5289 (0.68)	2.3768 (0.41)	-	-
9	Commodities & transactions not classified according to kind	81.0262* (2.44)	9.1611 (0.36)	2.9515 (0.27)	-

Appendix H6: Sri Lanka's Real Income for Industry level Trade

SITC Code	Sector	ΔlnY_t^{Sl}	ΔlnY_{t-1}^{Sl}	ΔlnY_{t-2}^{Sl}	ΔlnY_{t-3}^{Sl}
0	Food and live animals	14.1808 (1.00)	-10.3150 (1.02)	3.3383 (0.68)	2.2879 (0.50)
1	Beverages and tobacco	-55.8470 (1.46)	9.8578 (0.27)	-	-
2	Crude materials, inedible, except fuels	-2.0973 (0.29)	-2.3808 (0.52)	1.5202 (0.50)	-
3	Mineral fuels, lubricants and related materials	-52.2905 (0.99)	60.6010 (1.60)	53.6405 (1.64)	-
4	Animal and vegetable oils and fats	2.3167 (0.09)	24.0251 (1.06)	-	-
5	Chemicals	-20.4604* (1.88)	6.5380 (0.77)	2.5666 (0.58)	-
6	Manufacture goods classified chiefly by material	-4.8842 (0.31)	-4.4904 (0.49)	-7.1200 (0.81)	-
7	Machinery and transport equipment	2.5289 (0.24)	-1.0852 (0.14)	-0.2228 (0.05)	-
8	Miscellaneous manufactured articles	15.9953 (1.31)	-4.8960 (0.59)	6.8118 (1.25)	-
9	Commodities & transactions not classified according to kind	-136.5941* (2.35)	6.5149 (0.21)	-	-

Appendix I: Formal Derivation of the Error Correction Term

Using equation *(B2)* in Appendix B, an error correction term was formed as in equation *(I1)*.

$$\varepsilon_{t-1} = ln\left(\frac{X_i}{M_i}\right)_{t-1} + \frac{\varphi_2}{\varphi_1} lnY_{t-1}^{i} + \frac{\varphi_3}{\varphi_1} lnY_{t-1}^{Sl} + \frac{\varphi_4}{\varphi_1} ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-1} \quad (I1)$$

Lagged level variables in equation *(21)* were replaced by ε_{t-1} as specified in equation *(I2)*.

$$\Delta ln\left(\frac{X_i}{M_i}\right)_t = \alpha + \sum_{k=1}^{n} \beta_{t-k} \Delta ln\left(\frac{X_i}{M_i}\right)_{t-k} + \sum_{k=0}^{n} \delta_{t-k} \Delta ln Y_{t-k}^{i} + \sum_{k=0}^{n} \gamma_{t-k} \Delta ln Y_{t-k}^{Sl} + \sum_{k=0}^{n} \pi_{t-k} \Delta ln\left(\frac{P_i \cdot E}{P_{Sl}}\right)_{t-k} + \theta \varepsilon_{t-1} + \mu_t \qquad (I2)$$

If θ is negative and significant, cointegration is affirmed.