

Exchange Rate and Trade Balances in Brazil: A Disaggregated Analysis by Major Economic Categories

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Abstract

This work investigates the repercussions of real devaluations in the exchange rate on the trade balance for Brazil, when considering major economic categories, i.e., capital goods, durable consumer goods, semi-durable and non-durable consumer goods, intermediate goods, and fuels and lubricants. To this end, monthly data are used for the period January 2000 and July 2019, and vector error correction (VEC) models. The results suggest that, in the long run, real devaluations in the exchange rate have positive and elastic impacts on the trade balance in all sectors, except for fuels and lubricants. Only the durable consumer goods and fuels and lubricants sectors do not show the occurrence of the J curve. Domestic income has a negative impact on the trade balance in most models analyzed, while foreign income has a positive impact on all sectors, except for fuels and lubricants.

Keywords: J-curve, Marshall-Lerner Condition, real exchange rate

1. Introduction

With the adoption of the Bretton Woods system, an increase in exchange rate volatility was observed because of the adoption of floating exchange rates. Since then, several authors have turned their studies to assess how exchange rate policies affect the balance of trade and economic growth of economies, since, in an increasingly globalized economic context, understanding these relationships is crucial for the formulation of economic policies. In this context, the J curve and the Marshall-Lerner condition (MLC) are discussed.

The J curve is a phenomenon which refers to a negative balance in net exports in the short term, followed by a surplus result in the long term, in response to a currency devaluation (Bahmani-Oskooee & Brooks, 1999). Ramos Filho and Ferreira (2016) attribute this phenomenon to a relative rigidity in terms of the quantum in exports and imports, which occurs because of short-term exchange contracts. Krugman and Obstfeld (2000) argue that, after an exchange rate depreciation, the values of exports and imports still represent contracts which were agreed upon using the former real exchange rate, and that is reflected in a relative increase in the value of imports and, also, the persistence of habits and customs and the lag of decision making by economic agents can also be presented as explanatory facts of the J curve.

The MLC argues, then, that an improvement in the trade balance in response to a real devaluation of the exchange rate occurs if, and only if, exports and imports are elastic in relation to the real exchange rate (Bahmani-Oskooee & Fariditavana, 2015; Moura & da Silva, 2005).

Considering the trade balance of the Brazilian economy, some authors have made recent contributions, such as Sonaglio, Scalco, and Campos (2010), Mortatti, Miranda, and Bacchi (2011) and Ramos and Ferreira (2016), to name a few, finding different results on the validity of the MLC and the J-curve in Brazil.

Therefore, in order to add to this literature, the present work intends to perform an empirical analysis of the short and long-term relations between the real exchange rate and the Brazilian trade balance between January 2000 and July 2019; that is, to verify the validity of the MLC and the occurrence of the J curve for the trade balance of Brazil, using vector error correction (VEC) models. The main contribution of this work is the use of an analysis which is disaggregated by major economic categories, namely, capital goods, intermediate goods, durable

consumer goods, semi-durable and non-durable consumer goods and fuels and lubricants. In addition to being unprecedented, this approach can contribute in more detail to the elaboration of policies and strategies for insertion in international trade, given that any sectoral asymmetries can be observed.

Apart from the introduction, this work has five sections. Section two presents the theory behind the MLC and the J curve, as well as the empirical evidence. Next, methodological aspects are presented, with a description of the trade balance profile of Brazil by the major economic categories, the description of the database and the econometric strategy used. Section four is reserved for the analysis and discussion of the results. Lastly, the concluding remarks.

2. Literature Review

2.1 Theoretical Model

Authors such as Bickerdike (1920), Robinson (1947) and Metzler (1948) (Note 1) laid the groundwork for the theoretical foundation of the relationship between the exchange rate and the trade balance, based on a model based on elasticities of supply and demand functions. The model known as Bickerdike-Robinson-Metzler (BRM) assumes that there are two markets: a foreign market and a domestic market. The domestic country demands foreign goods from the foreign market, which are offered by the rest of the world; also, the local economy offers goods produced domestically, which are, in turn, demanded by the rest of the world.

As featured in Arruda, Castelar, and Martins (2019), the BRM model can be analyzed from the relationship that explains the trade balance:

$$B = P_X X - P_M M \quad (1)$$

In which: M, X: imports and exports done by the domestic economy, respectively; P_M , P_X : prices of imports and exports in domestic currency, respectively; The BRM model provides a general condition (Note 2) which determines the variation in trade balances from the differentiation of equation (1) and the use of the concepts of import demand elasticity and export supply elasticity; that is, the relationship that explains the absolute variation in trade balances, starting from an initial balance ($B=0$), is given:

$$dB = P_X X \left[\frac{(1+\varepsilon)\eta^*}{\varepsilon+\eta^*} - \frac{(1-\eta)\varepsilon^*}{\varepsilon^*+\eta} \right] \frac{de}{e} \quad (2)$$

In which, e : nominal exchange rate (prices in domestic currency / price in foreign currency); η : compensated elasticity of demand for domestic imports; η^* : compensated elasticity of demand for imports from the rest of the world; ε : compensated elasticity of domestic export supply; ε^* : compensated elasticity of export supply from the rest of the world; denote, respectively, approximations of the average growth rates of the prices of imports and exports.

Thus, if the terms of trade are altered, or in the case of positive variation in them; that is, when $\frac{dP_X}{P_X} \geq \frac{dP_M}{P_M}$, there

is no way for trade balances to deteriorate, so that $dB \geq 0$. However, if the terms of trade suffer a deterioration,

$\frac{dP_X}{P_X} < \frac{dP_M}{P_M}$, a trade deficit may occur in response to a real devaluation of the exchange rate. In the BRM model,

the sufficient condition for a surplus result to occur in the trade balances, in an economy after a currency depreciation, is given by:

$$\frac{(1+\varepsilon)\eta^*}{\varepsilon+\eta^*} > \frac{(1-\eta)\varepsilon^*}{\varepsilon^*+\eta} \quad (3)$$

The MLC is a particular case of the above, when it is considered that the price elasticities of the supply of exported and imported goods from the local economy tend to be infinite. In other words, in this scenario, the sum of the price elasticities of internal and external demands will be greater than (Note 3), *i.e.*:

$$\lim_{\substack{\varepsilon \rightarrow \infty; \\ \varepsilon^* \rightarrow \infty}} \frac{(1+\varepsilon)\eta^*}{\varepsilon+\eta^*} > \lim_{\substack{\varepsilon \rightarrow \infty; \\ \varepsilon^* \rightarrow \infty}} \frac{(1-\eta)\varepsilon^*}{\varepsilon^*+\eta} \rightarrow \eta^* > 1 - \eta \rightarrow (\eta + \eta^*) > 1 \quad (4)$$

A complementary approach to that of elasticities is the absorption approach (Harberger, 1950; Alexander, 1959), which considers the effects of an exchange rate devaluation, not only on relative prices and the trade balance, but also on income and absorption. Given constant domestic prices and variable external prices, domestic income is postulated to be exogenous for exports and endogenous for imports, due to the dependence on industrial inputs in the domestic product, as well as imports being part of the total absorption.

That said, after a currency devaluation, first, domestic agents can demand local products instead of foreign products, due to the price increase in the country's own currency, and, second, given an increase in domestic income, increase demand for foreign goods, the greater the marginal propensity to consume and the supply elasticity of foreign imports. The first effect is called the substitution effect, and the second, the income effect. In general, the absorption approach explains that an exchange rate devaluation tends to deteriorate the terms of trade, but this does not imply a deficit in the trade balance. The substitution effect has to be greater than the income effect in order for the occurrence of an improvement in the trade balance (Moura & Da Silva, 2005).

In addition, the occurrence of the J curve is discussed, where after a currency devaluation, a deterioration in the trade balance occurs in the short run, and a surplus is observed in the long run. From the perspective of absorption, the J curve is manifested when the income effect is greater in the short run, while in the medium and long terms, the substitution effect predominates and, as a consequence, the response of the trade balance to a currency depreciation throughout a time period has the shape of the letter J. It is worth noting that the MLC remains valid in this process, since the surplus, although not manifested immediately, occurs in the long-term equilibrium (Lobo, 2007; Moura & Da Silva, 2005).

2.2 Empirical Evidence

In this section, we briefly summarize some of the more recent empirical evidence, for international studies and research focusing on Brazil.

Noland (1989), analyzing the Japanese economy, tests the occurrence of the J curve phenomenon and the validity of the MLC with quarterly data between 1970 and 1985 and the distributed lag model. The author finds evidence that suggests the validity of both phenomena.

Seeking to test the validity of the MLC and the occurrence of the J curve phenomenon for the five largest US trading partners with quarterly data between 1977 and 1992, Marwah and Klein (1996) confirm the validity of the MLC and the J curve in all cases analyzed.

Bahmani-Oskooee and Brooks (1999) use quarterly data, between 1973 and 1996, and Autoregressive Distributed Lag (ARDL) models to assess the validity of the J curve and the MLC in US trade with the other G-7 countries. The results suggest the validity of the MLC, but the J curve does not seem to occur.

Cambazoğlu and Güneş (2016), using monthly data from 2010.1 to 2014.12 and the ARDL framework, also confirm the MLC for the bilateral trade relationship between the countries of Turkey and Germany. The authors note that a depreciation of the domestic currency improves Turkey's trade balance in the long run.

Baba and Yazici (2016) investigate the bilateral J-curve in the short-run and the Marshall-Lerner (ML) condition in the long-run between Nigeria and European Union. The work uses data from the 1999 to 2012 period and employs the Autoregressive Distributed Lag approach. Results find no evidence of the J-curve, and the Marshall-Lerner condition appears to not occur in the bilateral case between Nigeria and the EU, but the evidence suggests the J-curve in bilateral cases between Nigeria and some specific countries, such as Austria, Denmark, Germany and Italy in the short-run, while in the long-run, the Marshall-Lerner condition exists only in the case of Luxembourg.

In a more recent work, Upadhyaya, Mixon Jr., and Bhandari (2020) investigate if there is a J-curve in the bilateral U.S. and China trade. Using error correction estimation and quarterly time series data from 1999 to 2018, results show that an increase in domestic as well as foreign income significantly improves China's trade balance with U.S., while the monetary variables have no effect on that trade balance. The authors also find that a depreciation of China's currency initially worsens its trade balance, but, over time, its trade balance improves, which supports the existence of the J-curve.

For the Brazilian economy, one of the first efforts can be found in Bahmani-Oskooee and Malixi (1992), who sought to investigate the J curve and the MLC for 13 countries, including Brazil, with data quarterly from the beginning of 1973 to the end of 1985. The authors find favorable evidence of both phenomena for Brazil.

Bahmani-Oskooee and Alse (1994) expand the discussions of the previous work to 19 developed countries and 22 developing countries (Brazil included) through quarterly data, between 1971 and 1990, and VEC models. The results confirm the validity of the MLC, but cannot observe the J curve for Brazil.

Hsing (2008) also includes Brazil in a sample of seven Latin American economies, aiming to analyze the J curve for the region, regarding its trade balance with the United States. The author uses a VECM model and generalized impulse response functions, applied on data which consists of different quarterly periods which span from 1980 to 2007, and estimates in order to measure the response of the trade balance to a shock to real

depreciation. The results suggest that the J-curve is identified for Chile, Ecuador and Uruguay. Specifically, for Brazil, the evidence finds that the trade balance is positively associated with real currency devaluation and real domestic income, but there is a negative influence from real income in the U.S. in the long term, and the occurrence of the J curve is not observed.

Moura and Da Silva (2005) investigate the MLC and the J curve for Brazil, using monthly data from January 1990 to December 2003, as well as Markov switching error correction models (MS-VECM). The authors note that, after an exchange rate depreciation, the trade balance tends to adjust rapidly, presenting an overshooting, instead of a deterioration, suggesting the validity of the MLC, but not observing the J curve.

Also examining the J curve for Brazil, with quarterly data from 1980 to 2005, and VEC models, Lobo (2007) points to the non-occurrence of this phenomenon and that the external and internal income are relevant, in determining the balance of the Brazilian trade balance.

Mortatti, Miranda, and Bacchi (2011), using monthly data between 1995 and 2008, observe the J curve in the bilateral trade between China and Brazil, considering agricultural commodities and industrialized goods. The results suggest that income in Brazil and China is relevant for commerce between the two countries, in all cases considered. As for the exchange rate, however, it does not seem to be relevant for the export of commodities, but highly important for the industrialized good.

Vasconcelos (2010) uses quarterly data between 1990 and 2009 for Brazil and cointegration modeling, based on the ARDL and VEC models. The results do not favor the J curve occurring in any of the cases considered, however, the long-term effects suggest the MLC being valid for all the bilateral relationships considered.

Sonaglio, Scalco, and Campos (2010) also analyze the J curve and the MLC for twenty one sectors of manufactured goods for the bilateral trade between Brazil and the United States, for the period of 1994 to 2007, again through VEC models. The authors find evidence for the MLC for six of the considered sectors, and evidence of the J Curve was found only for two sectors.

Scalco, Carvalho, and Campos (2012) research effects in the short and long-run of an exchange rate depreciation on the agricultural trade balance in Brazil with the rest of the world, using monthly data for the period of July 1994 to December 1997, and VEC models. The results do not favor the J curve, and confirm the MLC.

Ramos Filho and Ferreira (2016) analyze the J curve in 19 industrial sectors for Brazil and its trade with the Rest of the World, with annual data between 1996 and 2012 and ARDL models. The results show that none of the sectors presents evidence for the complete J curve. However, the authors observe the so-called incomplete J curve in 5 of the sectors analyzed.

More recently, Arruda, Castelar, and Martins (2019) investigated the MLC for the trade balance of states which are located in the South region of Brazil, with data from January 1999 to July 2013, and VEC models. The results show that the response of net exports of the states in Brazil's southern region to a currency depreciation is positive and elastic, thus validating the MLC.

Thus, although there are a number of works which have been dedicated to the MLC and the J curve, and discussions on the relationship between the exchange rate and the trade balance, results still vary considerably, particularly for studies which focus on Brazil. This work intends to contribute with an analysis which is disaggregated by major economic categories; namely, capital goods, intermediate goods, durable consumer goods, semi durable and non-durable consumer goods and fuels and lubricants, an unprecedented exercise for Brazil.

3. Methodology

3.1 Classification by Major Economic Categories

In this work, the Classification by Major Economic Categories, is used, which is prepared by the Department of Foreign Trade, in Ministry of Development, Industry and Foreign Trade (*Secretaria de Comércio Exterior, Ministério do Desenvolvimento, Indústria e Comércio Exterior* - SECEX/MDIC). The products are divided into five categories; Capital goods, Intermediate goods, Durable Consumer Goods and Semi-Durable and Non-Durable Consumer Goods and Fuels and Lubricants. Chart 1 presents a summary.

Chart 1. Classification by major economic categories

Capital Goods

- Capital goods, except industrial transport equipment
- Industrial transport equipment

Intermediate Goods

- Basic foods and beverages, mainly intended for industry
- Elaborate foods and beverages, mainly intended for industry
- Basic industrial inputs
- Elaborate industrial inputs
- Parts and accessories for capital goods
- Parts and accessories for transport

Consumer goods

- **Durable consumer goods**
 - Durable consumer goods – except transport equipment
 - Passenger cars
 - Non-industrial transport equipment
- **Semi-durable and Non-Durable Consumer Goods**
 - Semi-durable consumer goods
 - Non-durable consumer goods
 - Basic foods/beverages, mainly intended for domestic consumption
 - Prepared foods/beverages, intended mainly for domestic consumption

Fuels and Lubricants

- Basic fuels and lubricants
- Elaborate fuels and lubricants
 - Gasoline for cars
 - Fuels and lubricants prepared except gasoline for automobiles

Source: Prepared by the authors using data from MDIC (2016).

3.2 Data and Descriptive Analysis of the Variables

In this research, monthly information is used between January 2000 and July 2019. Table 2 presents the variables used and sources. The trade balance indicator is constructed from the natural logarithm of the ratio between Brazilian exports and imports (Bahmani-Oskoei & Kantiapong, 2001; Moura & da Silva, 2005; Sonaglio, Scalco, & Campos, 2010; Arruda, Castelar, & Martins, 2019). This variable is compiled from data on exports and imports of Capital Goods, Durable Consumer Goods, Intermediate Goods, Semi-durable and non-durable Consumer Goods and Fuel and Lubricants. This information was acquired from the Brazilian department of foreign trade (SECEX/MDIC).

There are several advantages of using this variable: i) it remains constant, regardless of the measurement unit considered (Bahmani-Oskoei & Alse, 1994); ii) it represents net exports in real or nominal terms (Bahmani-Oskoei & Kantiapong, 2001); iii) after its registration, it is possible to extract its growth rate from the first difference (Brada, Kutan, & Zhou, 1997).

Chart 2. Description of the variables

VARIABLE	PROXY	PERIOD	SOURCE
REER	Natural logarithm of the real effective exchange rate	01/2000– 07/2019	BCB-SGS
Domestic Income	Natural logarithm of Brazil's monthly GDP	01/2000– 07/2019	BCB-SGS
Foreign Income	Natural logarithm of Brazil's monthly GDP	01/2000– 07/2019	IFS-FMI
Trade balance of capital goods	Natural logarithm of Brazil's monthly GDP	01/2000– 07/2019	MDIC/SECEX
Trade balance of durable goods	Natural logarithm of the balance of durable goods	01/2000– 07/2019	MDIC/SECEX
Trade balance of Intermediate Goods	Natural logarithm of the balance of intermediate goods	01/2000– 07/2019	MDIC/SECEX
Trade balance of semi-durable and non-durable goods	Natural logarithm of the balance of semi-durable and non-durable goods	01/2000– 07/2019	MDIC/SECEX
Trade Balance of Fuel and Lubricants	Natural logarithm of the Fuel and Lubricants balance	01/2000– 07/2019	MDIC/SECEX

Source: Prepared by the authors.

The domestic income variable used is the monthly GDP made available by the Brazilian Central Bank (BACEN). The proxy for foreign income, or foreign demand, is represented by the value of imports from the rest of the world, compiled by the International Financial Statistics (IFS), and published by the International Monetary Fund (IMF). The values were deflated by the price index of total imports from the rest of the world, which is also available in the IFS-IMF. It is worth mentioning that, despite being traditionally used in works that research the dynamics of the trade balance with the rest of the world (Moura & Da Silva, 2005; Scalco, Carvalho, & Campos, 2012; Arruda, Martins, & Castelar, 2019), in the period analyzed, there was an expansion in the integration of global trade chains, which calls for caution in inferring the elasticity of this indicator, since the strong increase in external demand in the period may inflate its effect. However, future studies that use non-linear techniques can attest whether there are in fact asymmetries in this elasticity, considering an indicator of global integration as a threshold variable, for example. Lastly, the exchange rate used here is the real effective exchange rate (REER), available in the Central Bank of Brazil Time Series Generator System (BCB-SGS).

Figure 1 shows the evolution of Brazilian exports by major economic categories. The sectors of intermediate goods and durable consumer goods presented the highest and the lowest volume of exports, respectively. In all sectors, it is possible to observe a decrease between 2007 and 2009, and 2015 and 2016, reflecting the impacts of the subprime crisis and the strong recession and political crisis that culminated in the impeachment of Brazilian President Dilma Rousseff, respectively.

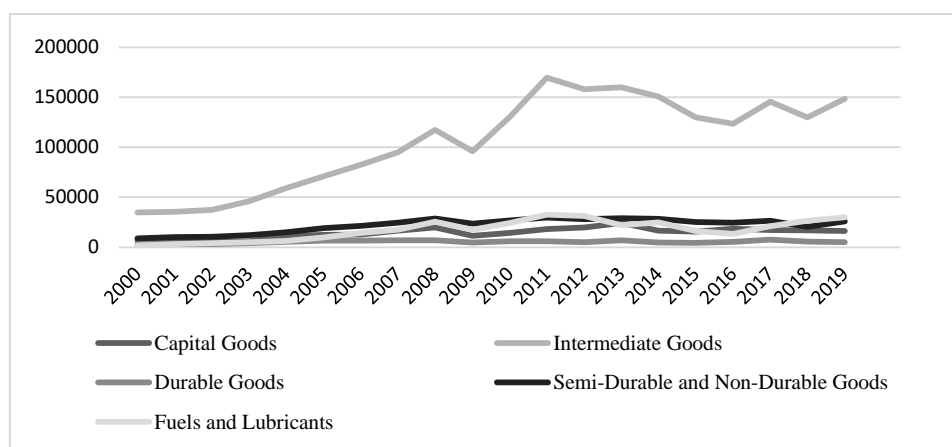


Figure 1. Evolution of FOB Exports (US\$ Millions)

Figure 2 shows a similar analysis for Brazilian imports. As in exports, the intermediate goods sector presented a higher volume of imports in the entire period under investigation. Capital goods and fuels and lubricants have alternated over the years as the second most relevant sector in imported volume. The retractions in exports in the previous Figure, between 2007-2009 and 2015-2016, were also observed in imports.

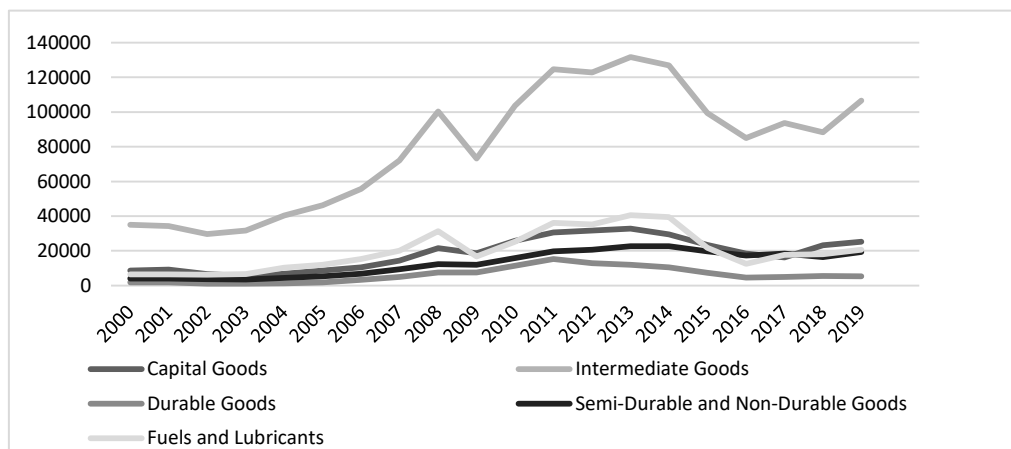


Figure 2. Evolution of FOB Imports (US\$ Millions)

Table 1 presents a summary of the participation of each sector in the composition of exports and imports from Brazil. Considering exports, the sectors with the highest average participation were Intermediate Goods, Semi-durable and non-durable Consumer Goods and Fuels and Lubricants, with averages of 63.57%, 13.97% and 9.61%, respectively. Under similar conditions, intermediate goods, fuels and lubricants and capital goods stood out with 59.67%, 14.17% and 13.33%, respectively, in imports from Brazil. Therefore, there is an important concentration of Brazilian commercial interactions in the sector of intermediate goods.

Table 1. Share of Brazilian exports and imports by major economic categories (%)

Year	Capital Goods		Intermediate Goods		Durable Consumer Goods		Semi-Durable and Non-Durable Consumer Goods		Fuels and lubricants	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
2000	12,48	15,67	63,01	62,65	5,34	3,01	15,77	7,28	3,40	11,39
2001	11,61	16,68	60,51	61,5	5,33	3,3	17,07	7,19	5,49	11,34
2002	9,47	14,03	61,6	62,74	5,17	2,35	17,15	7,7	6,61	13,18
2003	8,27	11,65	62,79	65,47	5,59	1,99	16,49	7,27	6,85	13,62
2004	11,49	10,72	61,29	64,18	5,5	1,89	15,36	6,82	6,37	16,38
2005	10,36	11,69	59,85	62,72	5,48	2,32	16,08	7,11	8,23	16,16
2006	9,37	11,52	59,83	60,93	4,82	3,53	15,56	7,43	10,41	16,59
2007	10,44	11,86	59,13	59,81	4,23	4,03	15,36	7,71	10,83	16,6
2008	9,97	12,48	59,23	57,99	3,54	4,32	14,42	7,06	12,85	18,14
2009	7,43	14,55	62,64	57,31	3,1	5,79	15,39	9,29	11,43	13,06
2010	7,18	14,18	64,5	57,02	2,98	6,26	13,3	8,64	12,03	13,89
2011	7,15	13,53	66,22	55,11	2,27	6,7	11,62	8,71	12,73	15,96
2012	8,26	14,21	65,19	55,07	2,12	5,73	11,58	9,23	12,85	15,76
2013	10,01	13,68	66,09	54,94	2,85	5,01	11,92	9,46	9,12	16,91
2014	7,49	12,94	66,89	55,38	2	4,56	12,58	9,89	11,04	17,23
2015	8,21	13,69	67,95	58,01	2,26	4,21	13,08	11,43	8,51	12,67
2016	10,11	13,43	66,61	61,75	2,94	3,23	13,18	12,56	7,17	9,02
2017	7,88	10,77	66,88	62,13	3,53	3,26	12,10	12,17	9,61	11,66
2018	8,51	15,38	65,16	58,35	2,83	3,61	10,21	10,76	13,28	11,91
2019	7,21	13,84	65,98	60,28	2,24	3,6	11,18	10,9	13,39	11,94
Mean	9,15	13,33	63,57	59,67	3,71	3,94	13,97	8,93	9,61	14,17
Δ%	-42,23	-11,68	4,71	-3,78	-58,05	19,60	-29,11	49,73	293,82	4,83

Source: Prepared by the authors using data from SECEX/MDIC.

Note. Average annual growth of participation of referred sector for the period 2000-2019, defined by $\{[\ln(t_f) - \ln(t_0)]/T\}100$, in which t_f and t_0 indicate the participation of the Categories in the last and the first period of the sample, respectively, and $T = 20$.

Analyzing the evolution of participation in exports, it can be observed that only the sectors of fuels and lubricants (293.82%) and intermediate goods (4.72%) presented growth in the period. Durable consumer goods (-58.05%), semi-durable and non-durable goods (-29.11%) and capital goods (-42.23%) suffered retraction in their participation. A similar assessment of imports reveals that consumer goods showed the highest growth in the period (semi-durable and non-durable, 49.73%, durable, 19.60%), while the capital goods sector suffered the greatest drop (-11.68%).

3.3 Econometric Strategy

The usual definition of the trade balance is adopted in this work, that is, the ratio between the values of exports and imports for the balance of the sectors being a function of the domestic income (Y_t), of foreign income (Y_t^*), and the real effective exchange rate ($REER_t$) in a log-log model, i.e.:

$$\ln\left(\frac{X_t}{M_t}\right) = \alpha + \beta_1 \ln(REER_t) + \beta_2 \ln(Y_t) + \beta_3 \ln(Y_t^*) + \varepsilon_t \quad (5)$$

In which, $\ln\left(\frac{X_t}{M_t}\right)$ is the natural logarithm of the exports / imports ratio, or net exports of each of the sectors employed in the study (capital goods, intermediate goods, durable consumer goods, semi-durable and non-durable consumer goods and fuels and lubricants, making a total of five models); $\ln(Y_t)$ is the natural log of the domestic income proxy; $\ln(REER_t)$ is the natural logarithm of the Brazilian real effective exchange rate;

$\ln(Y_t^*)$ is the natural logarithm of world imports, used here as a proxy for foreign income; α is the intercept; $\beta_1, \beta_2, \beta_3$ are the elasticities to be estimated; ε_t is the error term.

Hence, in order to study the dynamics in the short and long term, a multivariate cointegration analysis is used, as suggested by Johansen (1988). When two (or more) series are co-integrated, it can be said that, between them, there is a long-term relationship, and, furthermore, that their differences are stationary, even though each individual series is non-stationary. As such, observing cointegration suggests that there is a balance in the relationship between these variables, in the long run. Thus, the cointegration analysis proves to be an adequate mechanism to verify the relationships of the variables present in equation (5).

In verifying the cointegration among the variables, an improved version of the vector autoregression (VAR) is used, along the lines of Lütkepohl and Kräzig (2004), in the form of a vector error correction model, VEC(p), as presented by equation (6) below:

$$\Delta Y_t = v_0 + \Pi Y_{t-1} + \sum_i^p \Gamma_i \Delta Y_{t-1} + \varepsilon_i \quad (6)$$

Behavior in the long-run is represented by matrix Π , which is a linear combination of the error correction vector and the cointegration vector, *i.e.*, $\Pi = \alpha\beta'$; while matrix Γ_i represents the short-run dynamics.

Therefore, the initial econometric strategy consists of analyzing the order of integration of the series. For this, we use the augmented Dickey-Fuller (ADF) test, where the null hypothesis is the presence of a unit root, and the KPSS test, proposed by Kwiatkowski, Phillips, Schmidt, and Shin (1992), which has stationarity as a null hypothesis. In addition, the tests proposed by Elliot et al. (1996), the Dickey Fuller - GLS test (DF-GLS), and by Ng and Perron (2001), are used, both featuring the presence of a unit root as the null hypothesis. This is in order to mitigate eventual weaknesses of the ADF test.

If the series prove to be non-stationary, the cointegration analysis suggested by Johansen (1988) is carried out using the trace and maximum eigenvalue tests that indicate the existence of a long-term relationship between the variables and the number of vectors of cointegration. After identifying the cointegration vectors, the VEC is estimated.

The analysis of the occurrence of the J curve is carried out by examining the impulse response functions of the estimated VAR model, and the estimated long-term relationships are used to establish the validity of the MLC.

4. Analysis of the Results

To examine the aspects related to the validity and regularity of the MLC and the J curve, the stationarity of the series used was verified from the unit root tests. The Dickey Fuller Augmented (ADF), Dickey Fuller - GLS (DF-GLS) and Ng and Perron tests evaluate the null hypothesis of there being a unit root, while the KPSS test verifies the null hypothesis that the series is stationary. Table 2 features the results, which suggest that the variables chosen for this work are all integrated in order one, that is, I (1).

Table 2. Unit Root Tests

VARIABLE	TEST	ADF	KPSS	DF - GLS	Ng-Perron	
					$M_{Z_{\alpha}}^{GLS}$	$M_{Z_t}^{GLS}$
$\ln(REER_t)$	Level	-1.75 [-2.87]	1.17 [0.46]	-1.4 [-1.94]	-2.6 [-8.10]	-1.1 [-1.98]
	First	-12.1	0.08	-8.9	-87.33	-6.45
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
$\ln(Foreign\ Income_t)$	Level	-1.86 [-2.87]	1.85 [0.46]	0.4 [-1.94]	0.76 [-8.10]	0.67 [-1.98]
	First	-3.52	0.28	-2.8	-39.55	-4.35
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
$\ln(Domestic\ Income_t)$	Level	-1.62 [-2.87]	0.71 [0.46]	-1.62 [-2.87]	-6.18 [-8.10]	-1.72 [-1.98]
	First	-2.99	0.2	-2.99	-17.45	-2.95
	Difference	[-2.87]	[0.46]	[-2.87]	[-8.10]	[-1.98]
$\ln(Capital\ Goods_t)$	Level	-1.72 [-2.87]	0.51 [0.46]	-1.4 [-1.94]	-3.09 [-8.10]	-1.27 [-1.98]
	First	-11.65	0.14	-2.2	-17.48	-2.95
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]

$\ln(Durable\ Goods_t)$	Level	-2.83	0.85	0.68	-1.25	-0.73
		[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
	First	-16.18	0.11	-2.18	-13.31	-2.58
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
$\ln(Intermediate\ Goods_t)$	Level	-1.13	1.04	-0.8	-2.03	-0.86
		[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
	First	-16.45	0.13	-3.53	-24.68	-3.5
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
$\ln(Non - Durable\ Goods_t)$	Level	-0.65	1.63	-0.59	-0.9	-0.48
		[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
	First	-13.44	0.21	-2.46	-26.29	-3.48
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
$\ln(Fuels\ and\ Lubricants_t)$	Level	-2.36	0.93	-1.43	-4.91	-1.34
		[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]
	First	-6.54	0.21	-14.07	-127.53	-7.98
	Difference	[-2.87]	[0.46]	[-1.94]	[-8.10]	[-1.98]

After this procedure, the analysis of the trace and maximum eigenvalue tests as seen in Johansen (1988) was carried out to establish the presence of cointegration among the variables. Table 3 features the results, and suggests the presence of a cointegration vector (or a long-term relationship), in all of the five models, at a significance level of 5%, showing the existence of an equilibrium relationship in between these variables. Therefore, five VEC models are estimated. Table 4 presents a summary of the selected lags, according to Schwartz's criteria, as well as the results of the Lagrange Multiplier (LM) test of serial correlation. All models were estimated with 6 lags, except for the model for intermediate goods, in which the information criterion pointed to 7 lags. The LM tests do not reject the hypothesis of the absence of a serial correlation in the residues in all the estimated models.

Table 3. Trace and Maximum Eigenvalue tests

Test Structure		Eigenvalue	Trace Statistic	Trace – Critical Value	P-value	Max. Eigenvalue -Statistic	Max Eingenvale - Critical. Value	P-value
H0	H1							
Capital Goods Model								
$r = 0$	$r \geq 1$	0.12	54.39	54.39	0.01	30.89	27.58	0.01
$r \leq 1$	$r \geq 2$	0.07	23.50	23.50	0.22	16.62	21.13	0.19
Durable Consumer Goods Model								
$r = 0$	$r \geq 1$	0.13	56.67	47.85	0.00	32.53	27.58	0.01
$r \leq 1$	$r \geq 2$	0.06	24.13	29.79	0.19	16.47	21.13	0.19
Intermediate Goods Model								
$r = 0$	$r \geq 1$	0.15	58.36	47.85	0.00	37.33	27.58	0.00
$r \leq 1$	$r \geq 2$	0.06	21.03	29.79	0.35	14.70	21.13	0.31
Semi-Durable and Non-Durable Consumer Goods Model								
$r = 0$	$r \geq 1$	0.13	58.79	47.85	0.00	32.36	27.58	0.01
$r \leq 1$	$r \geq 2$	0.07	26.43	29.79	0.11	17.26	21.13	0.15
Fuels and Lubricants Model								
$r = 0$	$r \geq 1$	0.15	63.68	47.85	0.00	36.55	27.58	0.00
$r \leq 1$	$r \geq 2$	0.08	27.12	29.79	0.09	18.68	21.13	0.10

Source: Prepared by the authors.

Table 4. LM test of serial correlation and selection of lags for each model

Model	LM Serial Autocorrelation Test	Schwartz's Criterion Lags
Capital Goods	23.47 (0.10)	6
Durable Consumer Goods	10.84 (0.81)	6
Semi-Durable and Non-Durable Consumer Goods	14.86 (0.43)	6
Intermediate Goods	21.73 (0.15)	7
Fuels and lubricants	17.81 (0.33)	6

Source: Prepared by the authors.

Note. P-value in parentheses.

4.1 The Marshall-Lerner Condition (MLC)

The cointegration vectors represent the results of the estimated coefficients for the long-term relationships in equation 5, making it possible to analyze the validity of the MLC. It is worth mentioning that the values of the estimated coefficients are normalized and their signs have already been adjusted in table 5.

The evidence observed suggests that the MLC is valid in most of the models considered, *i.e.*, the long-term effect of a real exchange depreciation is positive on net exports, with the exception of the model for fuels and lubricants. In addition, this effect was shown to be elastic in most models, with the exception of intermediate goods, where the impact was positive, but inelastic. This result corroborates with the main evidence found for the Brazilian economy concerning the Marshall-Lerner condition (Moura & Da Silva, 2005; Vasconcelos, 2010; Scalco, Carvalho, & Campos, 2012; Arruda, Castelar, & Martins, 2019).

The exchange rate elasticities indicate that a real devaluation of this indicator by 1% leads to an increase in the trade balance of 5.78% in semi-durable and non-durable consumer goods, 4.48% in durable goods, 4.09% in capital goods, 1.02% in intermediate goods and a decrease of 3.87% in fuels and lubricants. The negative result for fuels and lubricants seems to be influenced both by the greater participation of these in imports and by showing itself to be a very volatile and sensitive sector due to its quotations in the global markets.

From the perspective of absorption, in line with Harberger (1950) and Alexander (1959), this evidence appears suggest that the substitution effect seems to surpass the long-term income effect, given the occurrence of a trade surplus in all of the analyzed cases. Thus, the results expose the importance of monetary authority in conducting exchange rate policy, in order to maintain the real exchange rate at competitive levels, in order to increase the insertion of exported products, since, in most cases considered, the balances showed positive and elastic responses to the exchange rate.

Table 5. Long-term results

	REER	Domestic Income	Foreign Income
Capital Goods Balance	4.09 [5.79]	0.74* [1.13]	1.48 [5.51]
Durable Goods Balance	4.48 [7.06]	-0.39 [-2.07]	0.77 [2.91]
Intermediate Goods Balance	1.02 [3.20]	0.12* [1.04]	0.73 [6.00]
Semi-durable and Non-Durable Goods Balance	5.78 [6.82]	1.72 [4.80]	1.15 [3.20]
Fuels and Lubricants Balance	-3.87 [5.72]	-1.90 [6.61]	-0.22* [0.79]

Source: Prepared by the authors.

Note 1. (*) Not significant at the 5% level

Note 2. T statistic in brackets.

Likewise, foreign income shows the expected sign in all of the models; that is, an increase in foreign income leads to greater demand for domestic exports, thus, improving the trade balance, confirming the theoretical forecast. It is worth noting that this impact was greater for capital goods, that is, net exports of capital goods increased 1.48%, in response to increases of 1% in external demand. Under similar conditions, in the sectors of durable, intermediate and semi-durable and non-durable goods, the increase would be 0.77%, 0.73% and 1.15%, respectively, while for the fuel and lubricants sector the result was statistically insignificant.

Lastly, the domestic income is shown to have a negative impact on the trade balance of durable goods and fuels and lubricants, with elasticities of the order of -0.39% and -1.90%, respectively, confirming the theoretical expectation. For the semi-durable and non-durable sector, this effect is positive and elastic, with an improvement of 1.72% in the trade balance of this sector, in response to increases of 1% in domestic income, a result that seems to be influenced by associated peculiarities. validity of these goods.

In view of the above, it is possible to observe the importance of a greater insertion of Brazil in international trade, since Brazil still has very discreet rates of trade opening. The information available from SECEX/MDIC indicates that the Brazilian economy had an average opening rate (measured by the sum of exports and imports divided by GDP) around 20% in the analyzed period; that is, there is still room to expand this participation in order to benefit from greater external demand.

4.2 The J Curve

As the results suggest that the MLC cannot be rejected in most of the cases considered, it now remains to test for the J curve; that is, to examine the short-term effects.

The J curve hypothesis is analyzed from the impulse-response functions (IRF), which assess how the trade balance responds to a shock in the exchange rate, in this case, a real depreciation in the exchange rate. The analysis was carried out in the following order: capital goods, durable goods, intermediate goods, semi-durable and non-durable goods and fuels and lubricants.

Figure 3 shows that a shock in the exchange rate initially negatively affects the trade balance of capital goods in the Brazilian economy, recovering after the first month until it becomes a surplus after the sixth month, characterizing the occurrence of the phenomenon.

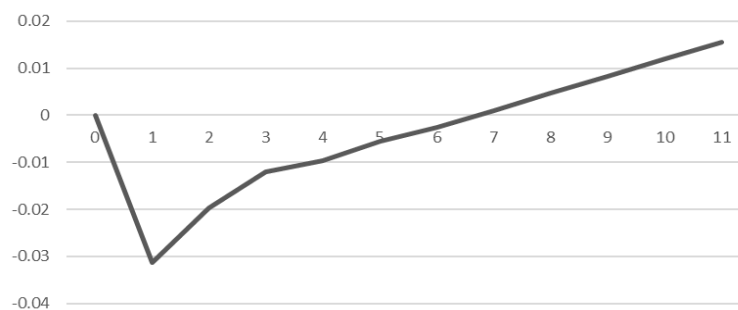


Figure 3. Impulse Response Functions - Capital Goods

Then, the IFR is analyzed in a similar way for the balance of durable goods. As can be seen in Figure 4, the J curve phenomenon is not sustainable, given that for the trade balance of durable goods, the response appears to be positive in all of the periods after a shock.

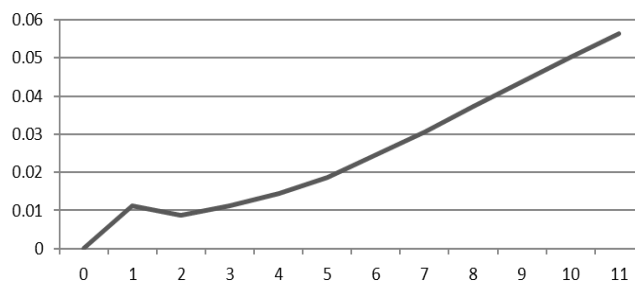


Figure 4. Impulse Response Functions - Durable Consumer Goods

Figure 5 suggests that there is evidence of the J curve for the trade balance of intermediate goods. The response to the exchange rate devaluation appears to be initially negative, recovering afterwards, presenting a surplus result after the eighth month.

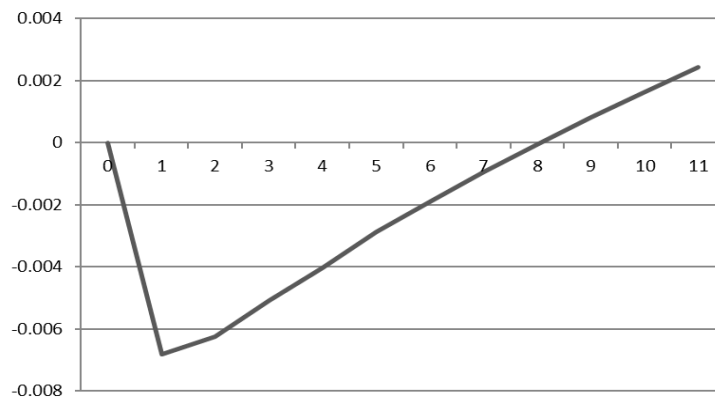


Figure 5. Impulse Response Functions - Intermediate Goods

Likewise, J curve is present for the trade balance of semi-durable and non-durable goods. Figure 6 indicates a slightly negative initial response, recovering quickly afterwards.

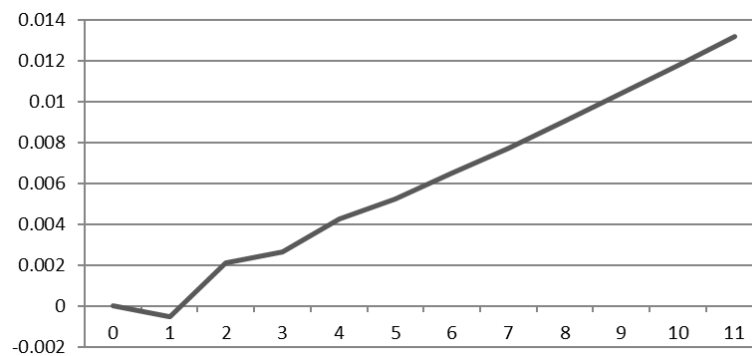


Figure 6. Impulse Response Functions - Semi-Durable and Non-Durable Goods

Lastly, the relationship between an exchange rate devaluation and the commercial balance of fuels and lubricants is analyzed. Figure 7 indicates a negative effect that persists in the long run, as seen by the previous analysis. Therefore, there does not seem to be evidence of the J curve for this sector.

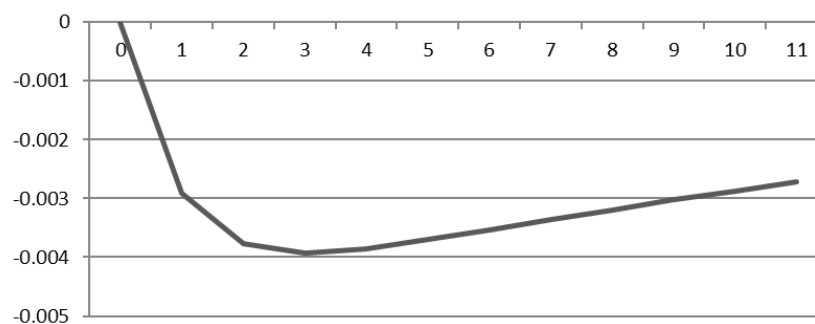


Figure 7. Impulse Response Functions - Fuels and Lubricants

Thus, in general, the J curve is observed in only three of the five sectors considered; that is, capital goods, intermediate goods and semi-durable and non-durable consumer goods; in other words, there seems to be a

decrease in the trade balance because of a real depreciation of the exchange rate initially, in the first few months, followed by a recovery until the effect becomes positive. In addition, there is a positive and immediate effect on the balance of durable goods, and permanently negative on the balance of fuels and lubricants.

It is worth mentioning that the level of sectorial disaggregation used in this work makes it difficult to compare directly with the other results obtained by the literature that investigates the occurrence of the J curve, since, to date, there are no studies for the sectors analyzed here. However, for Brazil, evidence in favor of the J phenomenon is present in some works, such as Sonaglio, Scalco, and Campos (2010), for the trade balance of manufactured goods, and in Mortatti, Miranda, and Bacchi (2011), for the agricultural and mineral commodities.

5. Concluding Remarks

The present work empirically analyzed the short and long-term relationships between the real effective exchange rate (REER) and the trade balance of Brazil between January 2000 and July 2019 in order to verify the Marshall-Lerner condition (MLC) and the J Curve. Vector Error Correction (VEC) models are used as an econometric strategy.

The potential contribution of this work is the disaggregated examination of these relationships by major economic categories, namely, capital goods, intermediate goods, durable consumer goods, semi-durable and non-durable consumer goods and fuels and lubricants. This exercise can contribute to the elaboration of more accurate policies and strategies for insertion in international trade.

The long-term elasticities indicate the MLC is valid in the cases analyzed, with the exception of fuels and lubricants. Thus, real devaluations in the exchange rate have positive and elastic impacts on the trade balance of most sectors.

The analysis of the impulse response functions also suggests the J curve being observed in most sectors considered. However, this was not the case in the sectors of durable consumer goods and fuels and lubricants.

This work can be extended both to a panel approach for Brazilian states that takes into account, in addition to a higher level of sectorial disaggregation, regional heterogeneities, as well as to econometric exercises that allow the evaluation of possible non-linearities in these relationships.

Lastly, based on these results, some policy recommendations can be made. First, the need for greater commercial openness in Brazil, given that the evidence points to positive impacts in terms of commercial results and the country is still relatively closed. Furthermore, special attention is suggested to the exchange rate policy, in order to keep the real exchange rate at competitive levels, with a view to increasing exports, since, in most of the estimated models, the balances presented positive and elastic responses to the exchange rate.

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Notes

Note 1. It should be added that Marshall (1923) and Lerner (1944) also had pioneering contributions.

Note 2. To verify these relations and the derivation of the general condition of the BRM model, see, for example, Arruda, Castelar and Martins (2019).

Note 3. In these circumstances, the estimated coefficient of the effect of the real exchange rate on net exports is expected to be positive and statistically significant to confirm the validity of the Marshall-Lerner condition.

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