THE J-CURVE AND THE MARSHALL-LERNER CONDITION: EVIDENCE FOR NET EXPORTS IN THE SOUTHERN REGION OF BRAZIL

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This work analyzes the occurrence of the J-Curve and the validity of the Marshall-Lerner condition for the trade balance for the Southern region of Brazil, using monthly data between January 1999 and July 2013, and error correction vectors. In all of the considered models, the response to net exports in the south of Brazil to an exchange rate devaluation is shown to be positive and elastic, validating, thus, the Marshall-Lerner condition. This response is greater for manufactured goods. As described by the theoretical model, domestic income presents a negative and statistically robust impact on the trade balance, while foreign income presents a positive effect. The results points to the non-occurrence of the J-Curve phenomenon.

Keywords: trade balance; J-Curve; Marshall-Lerner condition; exchange rate.

CURVA J E CONDIÇÃO DE MARSHALL-LERNER: EVIDÊNCIAS PARA AS EXPORTAÇÕES LÍQUIDAS NA REGIÃO SUL DO BRASIL

O estudo analisa a ocorrência do fenômeno da curva J e a validade da condição de Marshall-Lerner para a balança comercial da Região Sul do Brasil com dados mensais entre janeiro de 1999 e julho de 2013 e vetores de correção de erros. Em todos os modelos considerados, a reposta das exportações líquidas do Sul brasileiro a uma depreciação cambial se mostra positiva e elástica, validando, portanto, a condição de Marshall-Lerner. Essa resposta é maior para os manufaturados. Como previsto pela teoria, a renda doméstica apresenta impacto negativo e estatisticamente robusto sobre o saldo comercial, enquanto que a renda externa apresenta repercussão positiva. Os resultados não apontam para a ocorrência da curva J.

Palavras-chave: balança comercial; curva J; condição de Marshall-Lerner; taxa de câmbio.

LA CURVA J Y LA CONDICIÓN DE MARSHALL-LERNER: EVIDENCIA PARA LAS EXPORTACIONES NETAS EN LA RÉGION SUR DEL BRASIL

Este estudio analiza la ocurrencia del fenómeno de la curva J y la validez de la condición de Marshall-Lerner para la balanza comercial de la Región Sur de Brasil con datos mensuales entre enero de 1999 y julio de 2013 y vectores de corrección de errores. En todos los modelos considerados, la respuesta de las exportaciones netas del Sur brasileño a una depreciación cambiaria se muestra

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positiva y elástica, validando, por lo tanto, la condición de Marshall-Lerner. Esta respuesta es mayor para los manufacturados. Según lo previsto por la teoría, la renta doméstica presenta un impacto negativo y estadísticamente robusto sobre el saldo comercial, mientras que la renta externa presenta una repercusión positiva. Los resultados no apuntan a la ocurrencia de la curva J.

Palabras clave: balanza comercial; curva J; condición Marshall-Lerner; tasa de cambio.

LA COURBE EN J ET LA CONDITION DE MARSHALL-LERNER: EVIDENCE D'EXPORTATIONS NETTES DANS LA RÉGION SUD DU BRÉSIL

L'étude examine l'apparition du phénomène courbe en J et la validité de la condition de Marshall-Lerner pour la balance commerciale dans le sud du Brésil avec des données mensuelles entre Janvier 1999 et Juillet 2013 et vecteurs de correction d'erreurs. Dans tous les modèles considérés, la réponse des exportations nettes de la région sud du Brésil à une dépréciation du taux de change positif et élastique montré, validant ainsi la condition de Marshall-Lerner. Cette réponse est plus élevée pour les produits manufacturés. Comme prédit par la théorie, le revenu des ménages a un impact négatif et statistiquement robuste sur la balance commerciale, alors que le revenu étranger a eu des répercussions positives. Les résultats ne montrent pas l'apparition de la courbe en J.

Mots-clés: balance commerciale; courbe en J; condition de Marshall-Lerner; taux de change.

JEL: F10; F31; F41.

1 INTRODUCTION

In recent years, especially after the establishment of the Bretton Woods system, where exchange rates became highly volatile due to the adoption of the floating exchange rate, several researchers have focused their efforts on analyzing how exchange rate policies influence net exports and in which way do such policies impact economic growth. In other words, in an economic environment which is progressively more globalized, better understanding these relationships is important for policy makers. In such researches and discussions, the theoretical aspects and the empirical regularity of the J-Curve and the Marshall-Lerner condition are essential concepts, and these are presented below.

The J-Curve refers to the occurrence of a reduction in net exports in the short term, followed by a long-term balance surplus in response to the exchange rate devaluation. As described by Bahmani-Oskooee and Ratha (2004), currency devaluation is said to worsen the trade balance first and improve it later, resulting in a pattern that resembles the letter J, hence the J-Curve phenomenon.

This phenomenon could be explained by the existence, in the short term, of a relative rigidity in terms of imported and exported quantum due to foreign exchange contracts (Leonard and Stockman, 2001). Krugman and Obstfeld (2008) justify the J-Curve phenomenon on the grounds that after a currency devaluation, exports and imports values still represent contracts based on the previous real exchange rate, reflecting the increase in the value of imports in terms of domestic goods. Furthermore, the persistence of habits and customs and the delay in decision making on the part of economic agents are also presented as explanatory factors of this phenomenon. Bahmani-Oskooee and Ratha (2004) argue that, when analyzing several works, which have studied the J-Curve phenomenon, the results have been, at best, ambiguous.

According to Sonaglio, Scalco and Campos (2010), the Marshall-Lerner condition stipulates that there will only be an improvement in net exports in response to an exchange rate devaluation if, and only if, the volume of exports and imports is elastic with respect to the real exchange rate.

Despite the importance of this subject and the recent increase in the number of works studying this topic, there is still no consensus on the occurrence and regularity of these phenomena in the Brazilian economy, especially from a regional perspective. In Brazil, the several exchange rate policies adopted since the 1990s and the growing trade openness offer a considerable opportunity to analyze the relationship between the trade balance and variations in the exchange rate (Sonaglio, Scalco and Campos, 2010). Therefore, this work aims to contribute in that sense by developing an analysis of the Southern region of Brazil, which is composed by three states: Paraná (PR), Santa Catarina (SC) and Rio Grande do Sul (RS).

The foreign trade data, available from the Bureau of Foreign Trade, which is a part of the Ministry of Development, Industry and Foreign Trade of Brazil (SECEX / MDIC), show that the region has, between 1999 and 2011, an average trade openness[4] rate of 25.2%, having reached 28% in 2008. This implies a significant insertion in international trade, particularly when one compares it with Brazil as a whole, since, using the same data, the average in trade openness for Brazil is 19.7% for the period. That fact alone merits a closer investigation on the characteristics of the region and the relationships regarding its exports. Furthermore, between 1991 and 2013, exports and imports of the Southern region of the country represented, on the average, 23% and 17%, respectively, of the total of exported and imported goods by Brazil.

When considering the classification using the aggregate factor[5] between 1999 and 2013, on the average, 60% of exports from the Southern region where of industrialized goods, of which 51% were manufactured goods; as for imports, this average reaches 78%, of which only 7% were semi-manufactured goods.

4. Given by the ratio between the sum of the values of exports and imports and the region's GDP.

5. In this classification, the product is classified as basic or industrialized, the latter group being divided into semi-manufactured and manufactured. The basic items are those which keep their similar characteristics to the state in which they are found in nature, i.e., with a low level of development. Examples are: minerals, agricultural products (coffee beans, soybeans, fresh beef, grain corn, wheat in grain etc.). The semi-manufactured products are those that are not yet in their final form, whether it be a final or intermediate good, because these must go through another production process to become an artifact (ex.: raw sugar => refined sugar; soybean oil gross => soybean oil into refined; semi-finished products of iron/steel => rolled; cellulose => paper etc.).

A more thorough comprehension of the economy and foreign trade of the Southern states of Brazil and the short and long-term dynamics of the net exports may provide important insights into how not only the Southern region of Brazil can continue increasing its insertion into international commerce, but also how Brazil as a whole can use economic policy to mirror the region's success in net exports. Furthermore, at times the Southern region of Brazil, particularly the state of Rio Grande do Sul, in recent years has shown a different commercial dynamic to the one observed in Brazil as a whole, as in some periods there was a positive trade balance in the Southern region of the country, while when considering the aggregate, there was a deficit in foreign trade, as argued and presented by Moraes et al. (2015).

Also, the classification, which categorizes goods by sectors,[6] reveals that, in the same period, both exports and imports from the Southern region of Brazil were focused on the industrial inputs sector, with an average share of 58.97% and 44.02%, and durable consumer goods, with an average share of 40.59% and 32.17%, respectively. Thus, the strong participation of that Brazilian region's trade, and its major operations in sectors of manufacturing and industrial inputs are also motivating factors which encourage a more elaborate analysis, such as proposed in this work.

Lastly, the analysis for Brazil's Southern region can also be justified by the fact that the data from the SECEX/MDIC show that the region's production is shown to be extremely concentrated in agricultural goods and mineral extraction. Therefore, as indicated in the literature, one would expect the Marshall-Lerner condition to be observed in such a context. For example, Carter and Pick (1989) find evidence of positive long-run responses of the trade balance of the agricultural sector to exchange rate devaluations, as do Dooroodian, Jung and Boyd (1999), but in the case of the latter, the same cannot be said for manufactured goods. In terms of Brazil, Scalco, Carvalho and Campos (2012) also find evidence of a positive long-run elasticity for net exports of the Brazilian agricultural sector.

Thus, this work aims to contribute to the literature with the empirical analysis of short and long-term relationships between the real exchange rate and net exports of Southern Brazil between January 1999 and July 2013.[7] In other words, the occurrence of the J-Curve and the Marshall-Lerner condition will be analyzed for the trade balance of Brazil's Southern region, using a vector error correction (VEC) model. In addition, this analysis will also be performed on a disaggregated level for semi-manufactured and manufactured products.

6. In this classification the products are classified as capital goods, intermediate goods, consumer goods and fuels, and lubricants.

7. This period was selected because in 1999 the Brazilian foreign exchange market came under a regime of floating exchange rates.

This work offers some new insight by presenting an investigation of this nature on a regional perspective for Brazil, as well as by making use of an aggregation technique for the construction of the domestic income proxy which reflects, on a monthly basis, the relative importance of each state in the dynamics of the Southern region of the country, as originally used in Pesaran, Schuermann and Weiner (2004).

Apart from this introduction, this work has four more sections. The next section emphasizes the theoretical and empirical aspects that concern the Marshall-Lerner condition and the J-Curve. The third section features the presentation of the database used, as well as the econometric strategy employed. The analysis and discussion of the results are on the subsequent section. Lastly, this work's concluding remarks are presented.

2 LITERATURE REVIEW

2.1 The theoretical model

To explain the relationship between the exchange rate and the trade balance, Bickerdike (1920), Robinson (1947) and Metzler (1948) developed a model for net exports based on the elasticities of the supply and demand functions. The model assumes the existence of two markets from the perspective of the domestic economy: the domestic market and the export market. In the former, the local country holds the demand for foreign goods, which are offered by the rest of the world; while in the second, the opposite occurs, that is, the local country offers the goods that will be demanded by the rest of the world.

Under these conditions, a currency devaluation causes an increase in the quantity demanded by the rest of the world, and an expansion of domestic supply driven in part by the increased foreign demand. In the domestic economy, exports tend to increase due to the cheapness of its products in foreign currency, while imports may increase or decrease depending on the price elasticity of supply, making the effect of the currency devaluation ambiguous (Moura and Silva, 2005).

Therefore, in this model, the sufficiency condition for the occurrence of a trade surplus in response to an exchange rate depreciation, called the Bickerdike--Robinson-Metzler condition (BRM), is that the derivative of this with respect to the exchange rate is positive.

Moura and Silva (2005) argue that the Marshall (1923) and Lerner (1944) condition is a special case of the BRM condition; that is, it is valid when the incomes of countries remain constant and, above all, the external supply curves and domestic supply of exports are highly elastic, and hence it follows that, for there to be an improvement in the trade balance, the sum of the price elasticities of internal and external demands is greater than one.

A complementary approach to the focus on elasticities is the one regarding absorption, which considers the effects of the devaluation not only in relative prices and the trade balance, but also on the income and the absorption.[8] Given constant domestic prices and variable external prices, it is postulated that domestic income is exogenous for exports and endogenous for imports, due to the dependence on industrial inputs of domestic products.

That said, after an exchange devaluation, the economic agents of the domestic country can: *i*) demand domestic products instead of foreign products, due to the latter becoming more expensive in domestic currency; *ii*) given an increase in domestic income, increase their demand for foreign products, the larger the marginal propensity to consume and the elasticity of foreign supply. Effect (*i*) is called the substitution effect and effect (*ii*) is the income effect. In general, the absorption approach argues that a currency devaluation tends to deteriorate the terms of trade, but this does not imply a trade deficit. For there to be an improvement in the trade balance, it is necessary that the substitution effect be greater than the income effect (Moura and Silva, 2005).

As featured in Lobo (2007), the BRM model can be constructed from the relation that explains the balance of trade balance, B:

$$B = P_x X - P_m M \tag{1}$$

where *M*, *X*: imports and exports made by the domestic economy; *PM*, *PX*: prices of imports and exports in domestic currency.

The BRM model provides a general condition[9] that determines the variation in the trade balances from the total differentiation of equation (1) and the use of the concepts of elasticities of demand for imports and of supply for exports; that is, the relation that explains the absolute change in the trade balance, starting from an initial equilibrium (*B*=0), is given by:

$$\partial B = P_X X \left[\frac{(1+\varepsilon)\,\eta^*}{\varepsilon+\eta^*} - \frac{(1-\eta)\varepsilon^*}{\varepsilon^*+\eta}\right]\frac{\partial e}{e} \tag{2}$$

In which e: nominal exchange rate; 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 supply of domestic exports; ε^*: compensated elasticity of supply of exports from the rest of the world;

8. The Keynesian absorption approach explains the relationship between domestic output and trade balance.

9. For details on these relationships and the general condition of the BRM model, see appendix A.

$\frac{\partial P_M}{P_M} = [\frac{\varepsilon^*}{\varepsilon^*+\eta}]\frac{\partial e}{e}$; $\frac{\partial P_X}{P_X} = [\frac{\eta^*}{\varepsilon+\eta^*}]\frac{\partial e}{e}$, denote, respectively, approximations of the average rates of growth in prices of imports and exports.

It can be observed that if there is no variation in the terms of trade,[10] or if there is a positive variation (i.e., when $\frac{\partial P_X}{P_X} \geq \frac{\partial P_M}{P_M}$), there is no way of occurring a deterioration of the trade balances, so that $\partial B \geq 0$. However, if there is a deterioration of the terms of trade, $\frac{\partial P_X}{P_X} < \frac{\partial P_M}{P_M}$, there is the possibility of trade deficit in response to a devaluation/depreciation of the real exchange rate. In the BRM model, the sufficiency condition for there to be a surplus in trade balances after a currency depreciation is given by:

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

The Marshall-Lerner condition is a particular case of the situation presented above, when one considers that the price elasticities of supply for exported and imported goods of the domestic economy tend to infinity. That is, in this scenario, the sum of the price elasticities of internal and external demand will be greater than one.

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

In that scenario, it is possible to identify the occurrence of the J-Curve, a phenomenon in which, after a devaluation, a trade deficit occurs in the short term, and a surplus in the long run. In other words, from the viewpoint of absorption, the income effect is dominant in the short term, while in the long run, the substitution effect is more prevalent and, consequently, the response graph of the trade balance to a currency depreciation over time has the shape of the letter J. Analytically, the three main facts which generate the J-Curve are the exchange of contracts, price rigidity and the persistence of habits and customs of economic agents.

Exchange contracts consolidate negotiations before the currency devaluation occurs, prices and quantities being fixed. After the exchange rate depreciation, because of the gap between the pass-through prices, the remaining quantities are fixed, so that exporters are able to adjust prices, but importers cannot do the same, resulting in a trade deficit in the short term. The rigidity of prices would thus be explained in three time lags; namely, the recognition, the decision period and the delivery/payment period. The first one occurs because importers and exporters are slow to notice the change in the competitive environment. The

10. Terms of trade are defined as the ratio of the prices received for exports and paid on imports of an economy; it can also be defined as the ratio between the value of exports and imports of an economic unit.

second involves the agents' expectations as to the duration of the devaluation, if it is a momentary or a lasting one, and the last is related to transport costs and logistical difficulties (Lobo, 2007; Moura and Da Silva, 2005; Sonaglio, Scalco and Campos, 2010). Also, Krugman and Obstfeld (2008) discuss the habits, preferences and customs of economic agents as an explanatory factor for the short term trade deficit.

Lastly, authors such as Grimwade (1996) and Yeats (1987) argue that prices of primary commodities and semi-manufactured goods have a tendency to fall relative to those of manufactured goods. Such a tendency has shown mixed results in terms of empirical evidence, but nevertheless, if the elasticity of demand for the finished product is higher than for the semi-finished product or raw material, then the same rate of nominal tariff will have a greater effect on the demand for the finished product than for the semi-finished product or raw material. According to those authors, there is some evidence that demand elasticities increase with production, so nominal tariffs would need to be lower at the final stages of processing to avoid any distortion to trade. Therefore, one would expect a greater impact of manufactured goods.

2.2 Empirical evidence

As mentioned in the introduction, Bahmani-Oskooee and Ratha (2004) present a detailed literature review on the J-Curve phenomenon and its empirical validity, and find that results about the J-Curve have been ambiguous. For example, Bahmani-Oskooee and Brooks (1999) analyze the possibility of the J-Curve occurring by studying the relationship between the United States of America and six of its trading partners, Canada, France, Germany and the United Kingdom, and find that there is no evidence of the phenomenon in the short run, but there is some empirical evidence in the long run. As for Bahamni-Oskooee and Ratha (2004), the authors analyze the same conjecture, but for 18 of the United States' trading partners, and using a longer sample period, and find a relationship between a currency devaluation and an improvement of the balance of trade in the long run.

Bahmani-Oskooee and Goswami (2003), on the other hand, while investigating the flow of commerce between Japan and nine of its trading partners, find empirical support for the J-Curve phenomenon in the short run for only two of the twenty analyzed cases. But in the long run, the authors find that there is evidence of a positive relationship between currency devaluation and the trade balance in six of the twenty trade partnerships for the United Kingdom, three out of nine when analyzing Japan, and four out of seven when considering India and its trading partners.

The literature investigating the occurrence and the empirical regularity of the theoretical predictions mentioned earlier evolved in recent years, with several authors presenting contributions regarding Brazil. One of the first efforts in that sense can be found in Moura and Da Silva (2005), investigating the validity of the Marshall-Lerner condition and the occurrence of the J-Curve phenomenon for the Brazilian trade balance, using data spanning from January 1990 to December 2003, and error correction vectors with a change of regime (MS-VECM). The author notes that, after a currency depreciation, the trade balance tends to adjust quickly, with the occurrence of an overshooting rather than an initial deterioration, thus providing positive evidence for the Marshall-Lerner condition, and negative evidence for the J curve.

Lobo (2007) investigates the occurrence of the J-Curve phenomenon for the Brazilian economy using quarterly data from 1980 to 2005, and a vector error correction (VEC) model. The results indicate that the J-Curve phenomenon seems not to occur when using Brazilian data for that time period. The author further argues that the external and internal revenues are shown to be strongly relevant in determining the trade balance, and therefore a deterioration in the trade balances would be possible with the slowdown in domestic economic activity and/or external economic activity.

Analyzing the short and long-term relationships between the trade balance and exchange rate depreciations under a bilateral perspective between Brazil and the United States, Mercosur, EU and the rest of the world, Vasconcelos (2010) makes use of quarterly data from 1990 to 2009 and cointegration modeling from the autoregressive distributed lag model (ARDL) and the error correction model (EMC) as proposed by Pesaran, Shin and Smith (2001). The results appear to not support the occurrence of the J-Curve phenomenon in any of the cases considered, however, the long-term effects point to the occurrence of the Marshall-Lerner condition in all bilateral analysis.

Sonaglio, Scalco and Campos (2010) conducted an empirical investigation of the occurrence and empirical regularity of the J-Curve and the Marshall--Lerner condition for 21 sectors of manufactured goods in bilateral trade between Brazil and the United States during the 1994 to 2007 period, using VEC models. The authors find evidence of that point to the existence of J-Curve in 2 of the 21 sectors analyzed and in 6 sectors they do not register the short run effects, although the commercial balance answers positively in the long run to shocks of exchange depreciation. The Marshall-Lerner condition, in turn, was present in six sectors, namely rubber, footwear, electronic equipment, wood and furniture, industrial parts and other vehicles, and clothing.

Mortatti, Miranda and Bacchi (2011), highlight the importance played by China in Brazilian foreign trade as it becomes Brazil's largest trading partner in the mid-2000s, and investigate the determinant variables in exports from Brazil to China analyzing the exports of agricultural commodities, minerals and exports of industrial products using monthly data from January 1995 to December 2008 with, again, VEC models. The authors show that both the Brazilian, as well as Chinese income, is important for trade between these two countries in all cases considered. The exchange rate, on the other hand, was of little relevance for the exports of commodities, but strongly determinant for industrialized products. The authors also verified the occurrence of the J-Curve phenomenon in Brazil--China bilateral trade for agricultural commodities and manufactured goods.

Investigating the short and long-term effects of currency devaluations on the commercial agricultural balance of Brazil/rest of the world with the use of monthly data from July 1994 to December 2007 and VEC models, Scalco, Carvalho and Campos (2012) reject the hypothesis of the occurrence of the J-Curve phenomenon and confirm the validity of the Marshall-Lerner condition which states that, in the long run, exchange rate depreciation has a positive effect on net exports.

In short, despite the above mentioned contributions, one can observe the lack of works with evidence on the occurrence of the J-Curve phenomenon and the validity of the Marshall-Lerner condition in a regional context. This work aims to contribute in this direction by analyzing the short and long-term effects of exchange rate depreciation on net exports of the Southern region of Brazil,[11] considering the total and disaggregated levels for the semi-manufactured and manufactured goods sectors.

3 METHODOLOGICAL ASPECTS

3.1 Data

In order to study the validity of the Marshall-Lerner condition and the occurrence of the J-Curve phenomenon for the Southern region of Brazil, monthly data is used, from January 1999 to July 2013, and a vector error correction (VEC) model.

The trade balance in Southern Brazil is constructed from data on exports and imports by aggregate factor acquired from the Department of Foreign Trade, a part of the Ministry of Development, Industry and Foreign Trade (SECEX/MDIC).[12] This variable is used considering total values and the balance of the semi-manufactured and manufactured goods sectors.

11. This work focuses on Brazil's Southern region because of the characteristics of its trade balance, as described in the introduction, and also because of the fact that the properties of the series for the other regions of the country were not suitable for using the methodology proposed here.

12. Available at: <http://www.mdic.gov.br/>.

In this classification, the product is categorized as basic or industrialized, the latter group being divided into semi-manufactured and manufactured. The basic items are those which keep their similar characteristics to the state in which they are found in nature, i.e., with a low level of elaboration. Examples are minerals and agricultural products, such as coffee beans, soybeans, fresh beef, grain corn, wheat in grain etc. The semi-manufactured products are those that are not yet in their final form, whether it be a final or intermediate good, because these must go through another production process to become an artifact (for example: raw sugar => refined sugar, soybean oil gross => soybean oil into refined; semi-finished products of iron/steel => rolled; cellulose => paper etc.).

Due to the absence of regional accounts indicators by states or regions on a monthly frequency, this work opted for the use of the Industrial Production Index (IPI) because the industry represents a significant share of GDP in the region and, also, because of its use in other works such as Tatiwa and Arruda (2011), and Martins and Arruda (2015).

Thus, a weighted average of the Industrial Production Index (IPI) of each state in the Southern region of the country was used as a proxy[13] for regional accounts, similar to what is presented in Pesaran, Schuermann and Weiner (2004). This weighing aims to incorporate possible changes in the economic cycles of regional industrial production over time and treat the states according to the representativeness of their dynamism in regional industrial activity. The state IPI is calculated and made available by the Brazilian Institute of Geography and Statistics (IBGE). This proxy was constructed from a weighted average of the specific series of each state *l* in the Southern region of Brazil,[14] as it is shown:

$$IPI_{Southt} = \sum_{l=1}^{3} w_{lt} IPI_{lt} \tag{5}$$

It is worth nothing that the weights w_{lt} vary monthly, given the share of industrial output of each unit l federation in month *t*. The weights can be described as:

$$w_{lt} = \frac{IPI_{lt}}{\sum_{l=1}^{3} IPI_{lt}} \tag{6}$$

13. Various proxies were tested to try and analyze the effect of domestic income of the South region of Brazil on its net exports, such as the monthly national GDP, however these models were not well adjusted and the long-term relationships were not shown to be statistically significant. Thus, the methodology presented in Pesaran, Schuermann and Weiner (2004) was adopted to construct a proxy for regional economic activity. Even though the industrial production index does not capture in its entirety the effect of a region's domestic income on its net exports, the models were shown to be well-adjusted and the elasticities were statistically significant and consistent with the literature.

14. Where *l* = 1, 2 and 3 denote the states of Paraná, Santa Catarina and Rio Grande do Sul, respectively.

The proxy for the income of the rest of the world used in this work was the value of world imports disclosed in the International Financial Statistics (IFS) dataset published by the International Monetary Fund (IMF). These values were deflated by the US Wholesale Price Index (IPA), which is also available at the same source.

The exchange measure used in this research is the real effective exchange rate, which is calculated from a weighted geometric mean of the largest trading partners of an economy. This study makes use of the real effective exchange rate of the Wholesale Price Index - Internal Availability (IPA-DI) available in the Time Series Generator System of Brazil's Central Bank (BCB-SGS).

3.1.1 The balance of trade in the Southern region

The data from SECEX / MDIC show that between 1999 and 2011, the balance of trade in the Southern region of Brazil featured a surplus predominantly, as can be observed in table 1. In addition, one can note a strong sensitivity of the degree of trade openness of the Southern region to currency devaluations, reaching its highest level in 2004, 30.23%.

TABLE 1
Foreign trade of Brazil's Southern region – general data (1999-2011)

Year	Exports (US$ thousand)	Imports (US$ thousand)	Trade flow (US$ thousand)	GDP (US$ thousand)[1]	Trade liberalization rate ((X+M)/GDP)[1] 100 (%)	Exchange rate[2]
1999	11,498,649	7,853,110	19,351,759	96,439,809	20.07	1.81
2000	12,883,736	9,660,261	22,543,997	106,151,572	21.24	1.83
2001	14,691,267	9,839,129	24,530,396	92,541,201	26.51	2.35
2002	15,232,710	7,796,674	23,029,384	85,488,286	26.94	2.92
2003	18,862,285	8,670,403	27,532,688	97,681,406	28.19	3.08
2004	24,128,643	10,828,283	34,956,926	115,636,076	30.23	2.92
2005	26,060,478	13,407,944	39,468,422	146,588,996	26.92	2.43
2006	27,742,040	17,398,645	45,140,685	177,334,128	25.46	2.18
2007	34,752,371	24,186,454	58,938,825	227,087,065	25.95	1.95
2008	41,963,528	37,064,617	79,028,145	274,338,606	28.81	1.83
2009	32,886,550	26,379,124	59,265,674	269,176,923	22.02	1.99
2010	37,140,483	39,207,365	76,347,848	353,553,757	21.59	1.76
2011	45,872,411	49,270,680	95,143,091	402,424,514	23.64	1.67

Sources: SECEX/MDIC; IBGE.
Authors' elaboration.
Notes: [1] Converted by the free exchange rate for annual sales - period average, obtained from IPEADATA.
[2] Exchange rate - R$ / US$ - commercial - sale - average. – R$ - Central Bank of Brazil.

Table 2 provides a description of the evolution of exports and imports of Brazil's Southern region according to the level of elaboration of the product (called Aggregate Factor by the SECEX/MDIC database). Overall, it can be observed that the majority share belongs to the manufactured goods in both exports and imports in the whole period. Considering the average annual growth rate of these sectors, it can be noted that the participation of semi-manufactured and manufactured exports shrank, on average, 3.87% and 0.89% per annum, respectively. Under the same conditions, imports of semi-manufactured and manufactured goods increased by 0.42% and 0.26% per annum, respectively.

TABLE 2
Evolution of exports and imports of composition by "aggregate factor" in the Southern region of Brazil (1999-2013)
(In %)

Year	Exports		Imports	
	Semimanufactured	Manufactured	Semimanufactured	Manufactured
1999	12.42	52.98	5.96	74.84
2000	9.75	58.86	5.82	71.71
2001	9.39	52.45	5.07	74.08
2002	10.69	52.42	5.55	69.87
2003	10.73	51.45	5.52	67.00
2004	8.91	53.42	7.13	68.62
2005	8.19	58.58	6.21	65.31
2006	9.10	58.17	6.55	65.45
2007	8.65	54.02	6.65	67.62
2008	8.28	51.54	8.06	66.29
2009	7.17	47.16	7.11	72.35
2010	8.68	46.87	7.59	76.39
2011	9.37	42.82	7.62	77.10
2012	8.78	42.44	7.04	77.52
2013	6.95	46.36	6.35	77.86
Δ% *per annum*[1]	-3.87	-0.89	0.42	0.26

Sources: SECEX/MDIC; IBGE.
Authors' elaboration.
Note: [1] Average annual growth rate of participation of the referred sector between 1999-2013, defined by: $\{[ln(t_f) - ln(t_0)\,]/T\}100$, in which t_0 and t_f indicate the participation of the sector in the first and last period of the sample, respectively, and T = 15.

TABLE 3
Participation of Brazil's Southern region's exports and imports by the National Accounts Sectors (average 1999-2013)
(In %)

National account sector		Exports	Imports
Capital goods	Capital goods	13.78	27.92
	Industrial use transport equipment	8.97	25.69
Intermediate goods	Food and beverage for the industry	4.81	2.24
	Industrial inputs	58.97	44.02
	Parts and accessories of transport equipment	12.25	3.45
Consumer goods	Durable consumer goods	40.59	32.17
	Non-durable goods	6.05	8.32
Fuels	Fuels and lubricants	0.07	0.08

Source: SECEX/MDIC.
Authors'elaboration.

The participation of exports and imports by sectors on a national level[15] was also analyzed, those sectors being: capital goods, intermediate goods, consumer goods and fuels and lubricants. Information is summarized in table 3 above. In terms of exports of the southern region of Brazil, a considerable participation of industrial inputs can be perceived (58.97%), of durable consumer goods (40.59%) and of capital goods (13.78%). On the other hand, imports are shown to be more diverse among the national accounts sectors, with important participation featured by industrial inputs (44.02%), durable consumer goods (32.17%), capital goods (27.92%) and industrial use transport equipment (25.69%).

TABLE 4
Evolution of the participation of the Southern region of Brazil in Brazilian exports and imports (1991-2013)

Year	Exports			Imports		
	Semimanufactured	Manufactured	Total	Semimanufactured	Manufactured	**Total**
1991	10.45	20.61	20.91	35.27	10.23	**12.48**
1992	13.09	20.29	23.02	30.86	10.94	**12.15**
1993	13.17	23.92	25.57	34.43	11.60	**13.62**
1994	18.19	23.60	25.12	36.37	10.25	**14.44**
1995	17.17	23.54	24.52	26.28	10.24	**13.22**
1996	16.15	23.75	26.28	26.99	10.15	**13.21**
1997	16.62	23.57	26.29	26.64	11.57	**14.26**
1998	18.67	21.87	24.37	27.93	14.79	**16.75**
1999	17.89	22.26	23.95	29.98	14.14	**15.96**
2000	14.78	23.02	23.39	26.78	14.93	**17.32**

(Continues)

15. Percentage share in the total exports and imports in the region. The average of the 1999-2013 period was used.

(Continued)

Year	Exports			Imports		
	Semimanufactured	Manufactured	Total	Semimanufactured	Manufactured	**Total**
2001	16.73	23.04	25.23	26.33	15.54	**17.71**
2002	18.17	23.91	25.24	25.69	14.09	**16.51**
2003	18.50	24.43	25.81	24.79	15.20	**17.95**
2004	16.00	24.29	25.01	27.39	15.39	**17.25**
2005	13.38	23.33	22.03	26.29	15.43	**18.22**
2006	12.94	21.50	20.18	26.46	16.30	**19.04**
2007	13.79	22.28	21.63	28.43	17.55	**20.05**
2008	12.83	23.28	21.20	33.62	18.55	**21.40**
2009	11.51	22.97	21.50	36.75	18.38	**20.65**
2010	11.43	21.82	18.39	41.91	19.87	**21.58**
2011	11.93	21.24	17.92	40.01	20.56	**21.78**
2012	11.69	20.55	18.14	38.46	20.68	**22.10**
2013	11.84	25.71	21.48	39.49	20.00	**21.24**
Δ% per annum[1]	0.54	0.96	0.12	0.49	2.91	**2.31**

Sources: SECEX/MDIC; IBGE.
Authors' elaboration.
Note: [1] Average annual growth rate of participation of the referred sector between 1999-2013, defined by: $\{[ln(t_f) - ln(t_0)]/T\}100$, in which t_0 and t_f indicate the participation of the sector in the first and last period of the sample, respectively, and T = 15.

As can be seen in table 4, data from the SECEX/MDIC show that, in 1991, Brazil's Southern region accounted for 20.6% of exports of manufactured goods in the country, and in 2013, accounted for 25.7%. Under the same conditions, imports from that region represented 10% of the total of imported manufactured goods to Brazil, in 1991, reaching a participation of 20% in 2013. Considering the participation in the totals, it can be observed that imports and exports of Brazil's Southern region represent, on average, 23% and 17% of Brazilian exports and imports, respectively. Such data is summarized in the table above. Thus, it can be said that the South has an important share of the Brazilian foreign trade, justifying, therefore, this present work.

Lastly, a disaggregated analysis of the main exports and imports for each state of the Southern region of Brazil, again using data from the SECEX/MDIC, shows the following:

TABLE 5
Disaggregated analysis of main exported products by state (2004 and 2014)

Rio Grande do Sul							
2004				2014			
Position	Products	Value (US$ FOB)	Part (%)	Position	Products	Value (US$ FOB)	Part (%)
1	Tobacco	946,219,763	9.58	1	Soy	3,985,547,562	21.32
2	Natural leather shoes	872,918,916	8.84	2	Tobacco	1,510,969,482	8.08
3	Crushed soybeans	630,501,003	6.38	3	Solid residue	1,157,888,457	6.19
4	Solid residue	397,208,465	4.02	4	Chicken meats	717,516,492	3.84

(Continues)

(Continued)

Rio Grande do Sul							
2004				2014			
Position	Products	Value (US$ FOB)	Part (%)	Position	Products	Value (US$ FOB)	Part (%)
5	Edible pieces of chicken meat and offal	393,412,864	3.98	5	Edible pieces of chicken meat and offal	539,200,627	2.88
Santa Catarina							
1	Edible pieces of chicken meat and offal	637,808,567	13.14	1	Edible pieces of chicken meat and offal	1,380,044,410	15.36
2	Hermetic compressors	284,723,300	5.7	2	Soy	832,176,991	9.26
3	Frozen pork meats	193,263,700	3.98	3	Frozen pork meats	522,406,964	5.81
4	Wood furniture for bedrooms	171,848,776	3.54	4	Tobacco	476,619,608	5.30
5	Other Wooden furniture	171,795,953	3.54	5	Cylinder blocks and cylinder heads for engines	429,436,021	4.78
Paraná							
1	Crushed soybeans	1,270,637,873	13.52	1	Soy	3,331,444,205	20.40
2	Solid residue	1,081,929,015	11.51	2	Solid residue	1,404,039,010	8.60
3	Soy oil	460,220,149	4.90	3	Edible pieces of chicken meat and offal	1,310,263,317	8.02
4	Corn grains	443,851,561	4.72	4	Other cane sugars	978,209,342	5.99
5	Plywood	423,847,130	4.51	5	Chicken meats	774,990,379	4.75

Source: SECEX/MDIC.
Authors' elaboration.

TABLE 6
Disaggregated analysis of main imported products by state (2004 and 2014)

Rio Grande do Sul							
2004				2014			
Position	Products	Value (US$ FOB)	Part (%)	Position	Products	Value (US$ FOB)	Part (%)
1	Gross oil	1,624,827,476	30.70	1	Gross oil	3,270,929,182	21.88
2	Naphtha for the petroche-mical industry	447,455,565	8.45	2	Naphtha for the petrochemical industry	1,450,582,206	9.70
3	Chloride Potassium	135,260,199	2.56	3	Other vehicles with Diesel Engine	1,243,533,718	8.32
4	Urea with a nitrogen content	96,563,581	1.82	4	Chloride Potassium	429,158,001	2.87
5	Ammonium dihydrogen phosphate	94,168,648	1.78	5	Urea with a nitro-gen content	415,126,685	2.78
Santa Catarina							
1	Refined copper cathodes	111,218,879	7.37	1	Refined copper cathodes	816,080,749	5.09
2	Ethylene polymers	105,403,420	6.99	2	Vehicles with internal combustion engine	407,716,108	2.55
3	Other polyethylenes	80,190,074	5.31	3	Other polyethylenes	277,764,527	1.73
4	Unroasted malt, whole or broken	44,446,493	2.95	4	Ethylene polymers	229,147,970	1.43
5	Sodium potassium nitrate	31,256,894	2.07	5	Artificial fiber yarns	201,236,688	1.26

(Continues)

(Continued)

Rio Grande do Sul							
2004				2014			
Position	Products	Value (US$ FOB)	Part (%)	Position	Products	Value (US$ FOB)	Part (%)
Paraná							
1	Gross oil	330,217,708	8.20	1	Gross oil	1,968,876,259	11.38
2	Chloride Potassium	215,975,891	5.36	2	Brazilian Volswagen branch	1,312,188,868	7.59
3	Ammonium dihydrogen phosphate	137,060,879	3.40	3	Brazilian Renault Branch	1,302,473,608	7.53
4	Parts and accessories for vehicle bodywork	121,659,836	3.02	4	Brazilian Volvo Branch	633,449,091	3.66
5	Parts and accessories for Tractors and other vehicles	100,911,067	2.51	5	Cnh Industrial Latin America	386,012,188	2.23

Source: SECEX/MDIC.
Authors' elaboration.

As can be perceived from these figures, agricultural goods are the bulk of exports in the Southern region of Brazil. This is relevant because according to the literature, for agricultural commodities, the Marshall-Lerner condition is expected to be observed. Considering the imports, these mostly feature industrial inputs, semi-manufactured and manufactured goods. In such a case, one would expect the J-Curve phenomenon to be observed.

3.2 Econometric strategy

For the analysis of the impact of an exchange rate devaluation on net exports, that is, the investigation of the occurrence of the J-Curve phenomenon and the Marshall-Lerner condition for Southern Brazil, this work uses the definition of trade balance/terms of trade commonly used in such studies,[16] i.e., $\left(\frac{X_t}{M_t}\right)$ for those sectors considered as a function of domestic income (Y_t), of foreign income $(Y^*{}_t)$, and the effective real exchange rate $(TXCER_t)$ in a log-linear model, as presented below:

$$\ln\left(\frac{X_t}{M_t}\right) = \beta_0 + \beta_1 \ln(TXCER_t) + \beta_2 \ln(Y_t) + \beta_3 \ln(Y^*{}_t) + \varepsilon_t \qquad (7)$$

Where: $\ln\left(\frac{X_t}{M_t}\right)$ = natural logarithm of the exports / imports ratio (for total goods, the semi-manufactured goods and, lastly, the manufactured goods); $\ln(TXCER_t)$ = natural logarithm of the effective real exchange rate; $\ln(Y_t)$ = natural logarithm of the real domestic income; $\ln(Y^*{}_t)$ = natural logarithm of the real rest of the world income; $\beta_0, \dots, \beta_{11}$ = parameters to be estimated; ε_t = error term.

16. See Moura and Silva (2005), Sonaglio, Scalco and Campos (2010), Vasconcelos (2010) and Scalco, Carvalho and Campos (2012).

Chart 1 below provides a descriptive overview of the variables used and their respective sources.

CHART 1
Description of the variables used

Series used	Series period	Data source
Natural logarithm of the real effective exchange rate LN(TXCER) (deflated by the IPA-DI)	01/1999 – 07/2013	BCB-SGS
Natural logarithm of world imports (Foreign Income *Proxy*) $\ln({Y^*}_t)$	01/1999 – 07/2013	IFS-FMI
Natural logarithm of the aggregate industrial production index for Southern Brazil (Southern Brazil Income *Proxy*) $\ln(Y_t)$	01/1999 – 07/2013	IBGE
Natural logarithm of the trade balance / terms trade of total goods for Southern Brazil ($\ln\left(\frac{XT_t}{MT_t}\right)$)	01/1999 – 07/2013	MDIC/SECEX
Natural logarithm of the trade balance / terms of trade – Southern Brazil's semi-manufactured goods ($\ln\left(\frac{XSM_t}{MSM_t}\right)$)	01/1999 – 07/2013	MDIC/SECEX
Natural logarithm of the trade balance / terms of trade – Southern Brazil's manufactured goods – $\ln\left(\frac{XM_t}{MM_t}\right)$	01/1999 – 07/2013	MDIC/SECEX

Authors' elaboration.

To analyze the short and long-term dynamics, a multivariate cointegration analysis is performed, as proposed by Johansen (1988). From the perspective of economic relationships, two or more series are said to be cointegrated if they present a co-movement over time and their differences are stationary, although each particular series is not stationary. In other words, the cointegration points to the existence of a balanced long-term relationship between these variables. Therefore, the cointegration analysis is an appropriate tool for examining the relationships contained in equation (7). On operational terms, two or more series which are, for example, integrated of order 1, I (1), and therefore non-stationary, are considered to be cointegrated if there exists a linear combination of those series which is stationary, I (0), and the vector that provides that I (0) series is called the cointegration vector.

Therefore, when the variables are not $I(0)$, the residual vector can be stationary and the least squares estimation can lead to spurious results. Thus, one must ensure that the residues from the system of equations to be estimated are stationary or even if they can be stationarized, in order for the estimation to be possible. If a vector of variables Y_t presents a long-run equilibrium,[17] it is possible to find a linear combination between such vector and a β vector, named the cointegration vector, in such a way that the system residues are stationary.

17. The variables are cointegrated.

In short, cointegration exists if it is possible to find the $Z_t = \beta' Y_t$ variables in which Z_t is $I(0)$.

In checking whether the cointegration between variables exists, use is made of an enhanced version of the vector autoregressive (VAR) model, so that the long-term deviations are corrected at an adequate rate, represented by the correcting errors vector α; hence the reason why the method is known as the vector error correction (VEC) model, represented by equation (11) below. With this technique it is possible to analyze the short and long-term dynamics of the system variables. The long-term behavior is represented by the matrix Π, which is a linear combination of the error correction vector and the cointegration vector,[18] i.e., $\Pi = \alpha\beta'$, and the short run dynamics is represented by the matrix Γ_i. Thus, as featured in Lütkepohl and Krätzig (2004), a VEC(p) can be represented as:

$$\Delta Y_t = v_0 + \Pi Y_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta Y_{t-i} + u_t \tag{8}$$

Therefore, the initial econometric strategy is to analyze the integration order of the series. For that purpose, using the Augmented Dickey-Fuller test (ADF) is performed, the null hypothesis being the presence of a unit root, and to complement the result of the ADF test and provide robust results, the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test is also used, which has stationarity as its null hypothesis.[19] If the series are deemed non-stationary, one proceeds to the cointegration analysis suggested by Johansen (1988), using the trace test and the maximum eigenvalue indicating the existence of a long-term relationship between the variables and the amount of vector cointegration. After the identification of the cointegration vectors, the estimation of the VEC is performed. The analysis of the occurrence of the J-Curve phenomenon will be held from the examination of the generalized impulse response functions[20] of the estimated VAR model, and the Marshall-Lerner condition is verified in the long-term relationships estimated.

In short, the econometric strategy employed in this work can be summarized as follows: after a careful review of the order of integration of the series and checking the existence of cointegration between the variables of the model (7),

18. Note that in the results are featured the estimated cointegration vectors which have been normalized to the variable net exports. Therefore, it is important to observe that the signs of long-term relationships should be interpreted in reverse.

19. In virtue of the low power of the ADF test.

20. The main justification for the use of this feature is the fact that the generalized FIR may not vary if there is a reordering of variables in the VAR. Lütkepohl (1991) argues that the traditional method for the analysis of FIR applies the "hypothesis of orthogonality", which consequently makes the result depend on the ordering of the series in the VAR. Koop, Pesaran and Potter (1996), and Pesaran and Shin (1998) developed the generalized impulse response function as a way to eliminate the problem of ordering of the variables in the VAR. For Ewing, Forbes and Payne (2003), the main potential advantages in the application of this method are: i) the generalized FIR provides more robust results than the orthogonalized method; and ii) due to the fact that the orthogonality is not imposed, the generalized FIR allows a more accurate interpretation of the initial response to each shock caused by a variable on the other.

the objective is to estimate a VEC for each case considered; that is, for the trade balance considering total goods, the semi-manufactured goods and, lastly, the manufactured goods.

4 DISCUSSION AND ANALYSIS OF RESULTS

Firstly, an analysis of the order of integration of the series used was performed. The ADF and KPSS tests were applied in level and first differences, and their results are shown in table 7. It is worth noting that the ADF test has the presence of a unit root as the null hypothesis and the KPSS test has stationarity as its null hypothesis. In the case of the ADF test, the criterion for the selection of the number of lags was the one featured in Campbell and Perron (1991), beginning with 8 lags. The results indicate that all variables used in this study are shown to be integrated in order one, that is, I (1).

TABLE 7
Unit root tests results

Variable		ADF		KPSS	
		Intercept	Intercept and trend	Intercept	Intercept and trend
$\ln(TXCER_t)$	Level	-2.00 [-2.86]	-2.30 [-3.41]	5.14* [0.46]	0.45* [0.15]
	First difference	-11.51* [-2.86]	-11.54* [-3.41]	0.09 [0.46]	0.07 [0.15]
$\ln(Y_t)$	Level	-0.99 [-2.86]	2.69 [-3.41]	1.69* [0.46]	0.21* [0.15]
	First difference	-5.11* [-2.86]	-5.09* [-3.41]	0.26 [0.46]	0.01 [0.15]
$\ln({Y^*}_t)$	Level	-1.31 [-2.86]	-1.35 [-3.41]	1.47* [0.46]	0.20* [0.15]
	First difference	-13.48* [-2.86]	-13.56* [-3.41]	0.14 [0.46]	0.09 [0.15]
$\ln\left(\frac{XT_t}{MT_t}\right)$	Level	-2.11 [-2.86]	-3.12 [-3.41]	1.01* [0.46]	0.32* [0.15]
	First difference	-18.54* [-2.86]	-18.50* [-3.41]	0.16 [0.46]	0.07 [0.15]
$\ln\left(\frac{XSM_t}{MSM_t}\right)$	Level	-1.78 [-2.86]	-1.93 [-3.41]	1.38* [0.46]	0.22* [0.15]
	First difference	-11.80* [-2.86]	-7.50* [-3.41]	0.04 [0.46]	0.04 [0.15]
$\ln\left(\frac{XM_t}{MM_t}\right)$	Level	-0.43 [-2.86]	-1.70 [-3.41]	1.07* [0.46]	0.38* [0.15]
	First difference	-17.91* [-2.86]	-17.95* [-3.41]	0.30 [0.46]	0.12 [0.15]

Authors' elaboration.
Note: * Significant at 5%.
Obs.: Test critical value at the 5% significance level in brackets.

After this finding, one proceeds to the analysis of the trace test and maximum eigenvalue to verify the existence of cointegration between the variables. The results are distributed among table 8, and point out the existence of a cointegration vector, or a long-term relationship in each of the three models considered. In addition, the criterion of Schwarz indicated 2 as the optimal number of lags of the VAR; i.e., the three models discussed will be represented as a VEC (1).

TABLE 8
Trace test and maximum eigenvalue

Test Structure H0	Test Structure H1	Eigenvalue	Trace test statistic	Trace test critical value	P-value	Maximum eigenvalue statistic	Maximum eigenvalue critical value	P-value
Total goods balance model								
$r = 0$	$r \geq 1$	0.23	69.76	47.86	0.00	46.55	27.58	0.00
$r \leq 1$	$r \geq 2$	0.07	23.21	29.80	0.23	13.16	21.13	0.44
$r \leq 2$	$r \geq 3$	0.03	10.05	15.49	0.28	5.60	14.26	0.66
Semi manufactured goods model								
$r = 0$	$r \geq 1$	0.18	58.49	47.86	0.00	33.76	27.58	0.00
$r \leq 1$	$r \geq 2$	0.07	24.72	29.80	0.17	12.24	21.13	0.52
$r \leq 2$	$r \geq 3$	0.04	12.47	15.49	0.13	7.77	14.26	0.40
Manufactured goods model								
$r = 0$	$r \geq 1$	0.24	72.20	47.86	0.00	47.92	27.58	0.00
$r \leq 1$	$r \geq 2$	0.08	24.29	29.80	0.19	14.57	21.13	0.32
$r \leq 2$	$r \geq 3$	0.03	9.72	15.49	0.30	5.69	14.26	0.65

Authors' elaboration.
Obs.: *r* is the cointegration rank.

In addition to the forecast of the theoretical model and the confirmation of the existence of a long run relationship between these variables from the cointegration tests, an analysis of how the short run imbalance adjustments occur was performed. The trade balance variable presents a negative and significant adjustment coefficient, being statistically significant at the 5% level, at the values of -0.18, -0.38 and -0.31, respectively for manufactured goods, semi-manufactured goods and the total number of goods. In other words, the negative values require that the balance of trade be decreased as time passes, so it will eventually re-establish the long-run equilibrium. In the case of the manufactured goods, for example, the -0.18 coefficient indicates that, given a short run shock which unbalances the trade balance variable in its long run relationship with the other variables, approximately 18% of these imbalances are corrected from one period to another until the long-run equilibrium is re-established. As for the semi-manufactured goods, the -0.38 coefficient indicates that, given a short term shock which unbalances the trade balance variable in its long run relationship with the other variables, approximately 38% of these imbalances are corrected from one period to another until the long-run equilibrium is re-established.

The Lagrange Multiplier test of serial correlation in the residue was applied in the three models used. The results indicate the absence of serial correlation. Furthermore, the multivariate version of the Jarque-Bera normality test does not reject the null hypothesis of multivariate normality of the residue.

4.1 Long-run dynamics

The cointegration vectors represent the results of the estimated coefficients for the long-term relationships, making it possible to analyze the validity of the Marshall-Lerner condition. It should be noted that, as the values of the estimated coefficients are normalized, their signs are altered, being inverted accordingly in the table. The results are summarized in table 9.

TABLE 9
Long-term relationships

	Real exchange rate	Southern region income	Foreign income
Total goods balance model	5.55 [5.08]	-6.07 [-5.77]	0.90* [1.87]
Semi manufactured goods model	2.76 [5.85]	-1.75 [-3.85]	0.58 [2.78]
Manufactured goods model	3.17 [4.14]	-5.54 [-7.52]	1.61 [4.76]

Authors' elaboration.
Note: * Significant at the 10% level.
Obs.: T statistic in brackets.

In general terms, the evidence found points towards the validity of the Marshall-Lerner condition in all of the considered models. In other words, the results indicate that the long-run effect of a currency devaluation is positive and is shown to be elastic on the trade balance of the Southern region of Brazil. Therefore, the South of Brazil seems to reproduce the evidence found for the Brazilian economy as a whole on the Marshall-Lerner Condition (Moura and Silva, 2005; Vasconcelos, 2010; Scalco, Carvalho and Campos, 2012).

Furthermore, the long-run elasticity of net exports in relation to the real exchange rate was found to be greater when considering manufactured goods when compared to semi-manufactured goods. That is, a 1% increase in the real exchange rate produces an increase of 3.17% in the trade balance of manufactured goods in Southern Brazil, while under the same conditions; the increase would be 2.76% in the semi-manufactured sector. As argued by Grimwade (1996), prices of primary commodities and semi-manufactured goods have a tendency to fall relative to those of manufactured goods. Such a tendency has shown mixed results in terms of empirical evidence, but nevertheless, if the elasticity of demand for the finished product is higher than for the semi-finished product or raw material, then the same rate of nominal tariff will have a greater effect on the demand for the finished product than for the semi-finished product or raw material. According to the author, there is some evidence, such as Yeats (1987) apud Grimwade (1996), that demand elasticities increase with fabrication, so nominal tariffs would need to be lower at the final stages of processing to avoid any distortion to trade.

Foreign income was also statistically significant in all models considered and featured the expected signal; i.e., an increase in foreign income can lead to an increase in demand for exports which, ceteris paribus, improves the trade balance. Note that the results were more elastic for the manufactured goods, as net exports of the Southern region of Brazil increased 1.61% in response to an increase of 1% in foreign income.

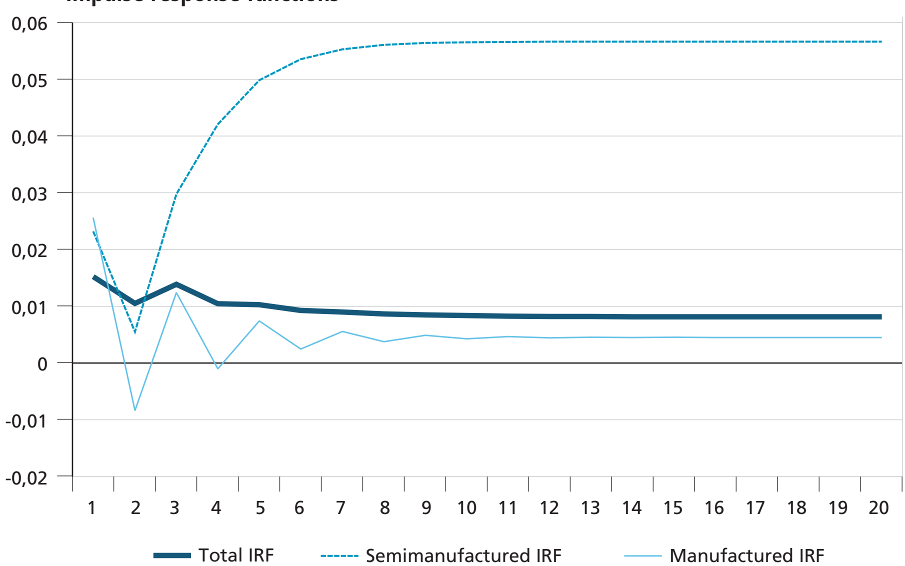
Lastly, domestic income showed a negative and statistically significant impact on net exports, since an increase in this indicator points to an increase in demand for imports which, ceteris paribus, produces deterioration in the trade balance. And yet, these results are more elastic when considering manufactured goods when compared to the semi-manufactured goods; i.e., 1% increments in income in Brazil's Southern region cause reductions of 5.54% in the trade balance; whereas, under similar conditions, the reductions would be 1.75% in the semi-manufactured sector.

With these results, one can observe the importance of the monetary authority's role in maintaining a competitive real exchange rate in order to increase the insertion of products exported by the South region of Brazil in the international market, since the real exchange rate had a positive and elastic impact on the net exports of the region. In addition, a policy of greater trade openness, which can be practiced both at the regional and national levels, is suggested, since the external demand for the products of the Southern region of Brazil has proved to be positive and statistically significant, especially for manufactured goods. Data from the SECEX/MDIC show that the average openness rate of the region between 1999 and 2011 is of 25.2%, somewhat high considering Brazil as a whole, which presented an average openness rate for the equivalent period of 19.7%, but considering the international context of trade treaties, there is still considerable room for expansion.

4.2 Short term dynamics

As the validity of the Marshall-Lerner condition is not rejected at all levels of the trade balance, i.e., the long-term effect of an exchange rate devaluation on net exports of Brazil's Southern region is a positive one, what remains to be done now is to test the J-Curve hypothesis. The analysis is performed using the impulse-response functions (IRF), which investigate what the estimated path (response) of the trade balance is, given a shock (an impulse) in the real exchange rate, in this case, a currency depreciation/devaluation. The analysis was conducted in the following order: first it was examined such effects for total net exports, followed by an analysis for the sectors of semi-manufactured and manufactured goods. The results are summarized in graph 1. It shows that a shock in the real exchange rate, initially reflected positively on total net exports of Brazil's Southern region, and that impact tends to dissipate about eight months later. Therefore, considering the total trade balance, there is no evidence of the occurrence of the J-Curve phenomenon, since the response of the overall trade balance of Brazil's Southern region to exchange rate devaluation is also shown to be positive in the short term.

GRAPH 1
Impulse response functions



Authors' elaboration.

A similar analysis for semi-manufactured goods is also featured. The evidence does not point to the occurrence of the J-Curve phenomenon, the observed initial response is an improvement in the trade balance of the semi-manufactured goods sector. Lastly, an analysis of the responses of net exports of manufactured goods to exchange rate devaluation was performed. The graph shows that the balance of trade for manufactured goods for Brazil's Southern region initially responds positively, with the shock dissipating afterwards. To summarize, the short-term evidence found in this work does not indicate the occurrence of the J-Curve phenomenon for the Southern region of Brazil, corroborating the main evidence found for Brazil (Moura and Silva, 2005; Lobo, 2007; Vasconcelos, 2010; Scalco, Carvalho and Campos, 2012).

5 CONCLUDING REMARKS

This work aimed to perform an analysis of the occurrence of the J-Curve phenomenon and test the validity of the Marshall-Lerner condition for the Southern region of Brazil, using monthly data between January 1999 and July 2013 and VEC models. The research was carried out considering the impact of a currency devaluation on total net exports and for the sectors of semi--manufactured and manufactured goods. The examination of the long-term relationships has shown that in all the models considered, the response of net exports of the Brazilian South to an exchange rate devaluation is shown to be positive and elastic, therefore validating the Marshall-Lerner condition. Furthermore, as expected, the response proved to be more elastic in the manufactured goods sector. Note that Moura and Silva (2005), Vasconcelos (2010) and Scalco, Carvalho and Campos (2012) found similar evidence using aggregate data for Brazil.

The proxy for domestic income of Brazil's Southern region used in this work proved robust in capturing the impact of this variable in the trade balance, since this was statistically significant and the signal was as predicted by the theory in all models used, i.e., an increase in this indicator promotes a deterioration in net exports, as it increases the demand for imports.

The evidence also indicates that, when foreign income increases, the trade balance of the Southern region will respond positively, since this increase will present an increased demand for its exports. The impacts proved potentially higher for manufactured goods, with net exports of the Brazilian South increasing 1.61% in response to an increase of 1% in external demand. Thus, one can highlight the robustness of foreign and domestic income proxies adopted in this study, since these have proved to be significant and showed the sign usually featured in the literature.

Therefore, such evidence reinforces the importance of policies which maintain a competitive real exchange rate for the increase of net exports of the region, as well as an effort towards more trade openness to increase participation in the international market.

Lastly, the analysis of the short-term relationships points to the non-occurrence of the J-Curve phenomenon in net exports of the Southern region of Brazil. These results corroborate the studies of Moura and Silva (2005), Lobo (2007), Vasconcelos (2010) and Scalco, Carvalho and Campos (2012), all of which did not find evidence of this phenomenon for Brazil.

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APPENDIX A

The BRM model is derived from the following equations:

$$B = P_x X - P_m M \tag{1}$$

$$M = X^* \tag{2}$$

$$X = M^* \tag{3}$$

$$P_m = P_m^* e \tag{4}$$

$$P_x = P_x^* e \tag{5}$$

Where:

- M , X: imports and exports made by the domestic economy to the world;
- M^*, X^*: imports and exports made by the rest of the world to the domestic economy;
- P_m , P_x: prices in domestic currency of imports and exports;
- P_m^* , P_x^*: prices in foreign currency of imports and exports;
- e : nominal exchange rate on domestic / foreign currency;
- B: Balance of trade and net exports of the domestic economy;

Differentiating the equation of the balance of trade (1):

$$dB = dP_x X + P_x dX - dP_m M - P_m dM \tag{1.1}$$

By differentiating the expressions (2) to (5), one gets:

$$dM = dX^* \tag{2.1}$$

$$dX = \partial M^* \tag{3.1}$$

$$dP_m = dP_m^* e + P_m^* de \tag{4.1}$$

$$dP_x = dP_x^* e + P_x^* de \tag{5.1}$$

Now, define:

I) $\eta = -\frac{dM}{dP_m}\frac{P_m}{M}$: compensated elasticity of demand for domestic imports;

II) $\eta^* = -\frac{dM^*}{dP_x^*}\frac{P_x^*}{M^*}$: compensated elasticity of demand for imports from the rest of the world;

III) $\varepsilon = \frac{dX}{dP_x}\frac{P_x}{X}$: compensated elasticity of supply of domestic exports;

IV) $\varepsilon^* = \frac{dX^*}{dP_m^*}\frac{P_m^*}{X^*}$: compensated elasticity of supply of exports from the rest of the world.

From (i):

$$\frac{dM}{M} = -\eta\,\frac{dP_m}{P_m} \quad \text{(A)}$$

From (ii):

$$\frac{dM^*}{M^*} = -\eta^*\,\frac{dP_x^*}{P_x^*} \quad \text{(B)}$$

From (iii):

$$\frac{dX}{X} = \varepsilon\frac{dP_x}{P_x} \quad \text{(C)}$$

From (iv):

$$\frac{dX^*}{X^*} = \varepsilon^*\,\frac{dP_m^*}{P_m^*} \quad \text{(D)}$$

Replacing dP_m^* from (D) into (4.1):

$$dP_m = \frac{dX^*}{X^*}\frac{P_m^*}{\varepsilon^*}e + P_m^* de$$

Replacing dX^* and X^* from (2) and (2.1) in the equation above:

$$dP_m = \frac{dM}{M}\frac{P_m^*}{\varepsilon^*}e + P_m^* de$$

Replacing $\frac{dM}{M}$ from (A) in the equation above:

$$dP_m = -\eta \frac{dP_m}{P_m}\frac{P_m^*}{\varepsilon^*}e + P_m^* de \Rightarrow \left(1 + \frac{\eta}{P_m}\frac{P_m^*}{\varepsilon^*}e\right) dP_m = P_m^* de$$

From (4), one has that $P_m^* = \frac{P_m}{e}$. Replacing in the equation above:

$$\left(1 + \frac{\eta}{P_m}\frac{P_m}{e}\frac{e}{\varepsilon^*}\right) dP_m = \frac{P_m}{e} de \Rightarrow \left(1 + \frac{\eta}{\varepsilon^*}\right)\frac{dP_m}{P_m} = \frac{de}{e} \Rightarrow \frac{dP_m}{P_m} = \frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right) \qquad (6)$$

In which $\frac{dP_m}{P_m}$ represents the average rate of growth in import prices. Replacing dP_x^* from (B) in (5.1):

$$dP_x = -\frac{dM^*}{M^*}\frac{P_x^*}{\eta^*}e + P_x^* de$$

Replacing dM^* and M^* from (3) and (3.1) in the equation above:

$$dP_x = -\frac{dX}{X}\frac{P_x^*}{\eta^*}e + P_x^* de$$

It is known, from (C), that $dX = \varepsilon \frac{dP_x}{P_x} X$. Replacing in the equation above:

$$dP_x = -\frac{\left(\varepsilon \frac{dP_x}{P_x} X\right)}{X}\frac{P_x^*}{\eta^*}e + P_x^* de \Rightarrow \left(1 + \frac{\varepsilon}{P_x}\frac{P_x^*}{\eta^*}e\right) dP_x = P_x^* de$$

Replacing $P_x^* = \frac{P_x}{e}$ de (5) in the equation above:

$$\left(1 + \frac{\varepsilon}{P_x}\frac{P_x}{e}\frac{e}{\eta^*}\right) dP_x = \frac{P_x}{e} de \Rightarrow \frac{dP_x}{P_x} = \frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right) \qquad (7)$$

In which $\frac{dP_x}{P_x}$ is the average rate of growth of export prices. Replacing dP_x and dP_m from (6) and (7) into (1.1):

$$dB = \left[\frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right)\right] P_x X + P_x dX - \left[\frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)\right] P_m M - P_m dM \qquad (8)$$

It is known, from (C), that $dX = \varepsilon \frac{dP_x}{P_x} X$. Replacing P_x , from (7):

$$dX = \varepsilon \frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right)\frac{P_x}{P_x} X \Rightarrow dX = \varepsilon \frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right) X \qquad (9)$$

It is known, from (A), that $dM = -\eta \frac{dP_m}{P_m} M$. Replacing P_m, from (6):

$$dM = -\eta \frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)\frac{P_m}{P_m} M \Rightarrow dM = -\eta \left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)\frac{\partial e}{e} M \qquad (10)$$

Replacing dX and dM from (9) and (10) in (8):

$$dB = \left[\frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right)\right] P_x X + P_x \left[\varepsilon \frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right) X\right] - \left[\frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)\right] P_m M + P_m \left[\eta \frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right) M\right]$$

From expression (1), it is known that:

$$B - P_x X = -P_m M \text{ and } P_x X - B = P_m M$$

Replacing $P_m M$ in the expression above:

$$dB = \left[\frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right)\right] P_x X + \left[\varepsilon \frac{de}{e}\left(\frac{\eta^*}{\eta^* + \varepsilon}\right)\right] P_x X + \left[\frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)\right](B - P_x X) +$$
$$\left[\eta \frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)\right](P_x X - B)$$

Placing $B\frac{de}{e}\left(\frac{\varepsilon^*}{\varepsilon^* + \eta}\right)$ and $\frac{de}{e}P_x X$ in evidence:

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

That is, starting from a trade balance in equilibrium, i.e., B = 0 we have:

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

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