DOI: https://doi.org/10.14393/REE-v39n1a2024-68264
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Exchange rate variation and non-linear effect on exports: A sectoral analysis by Technological Intensity

Variação cambial e efeito não linear nas exportações: Uma análise setorial por Intensidade Tecnológica

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Abstract: This paper aims to assess the asymmetric effect of these exchange rate variations on Brazilian sector exports to the United States, from 1999 to 2020. We assess these impacts by observing the technological intensity of the sectors analyzed. This study has applied the Non-linear Autoregressive Distributed Lag (NARDL) model to 700 sectors of the Brazilian economy. The results show that there was a long-term relationship between exports from certain sectors, foreign income, and the exchange rate. Furthermore, we observe that exchange rate variations have an asymmetric effect on exports, which can be positive or negative, depending on the sector.

Keywords: Exports; Exchange rate; Technological Intensity; Asymmetries; NARDL.
JEL Classification: F14. F49. C32

Resumo: O presente estudo teve como objetivo avaliar o efeito assimétrico das variações da taxa de câmbio sobre as exportações setoriais brasileiras para os Estados Unidos, de 1999 a 2020 por intensidade tecnológica dos setores analizados. O estudo aplicou o modelo Autorregressivo de Defasagem Distribuída Não Linear (NARDL) para 700 setores da economia brasileira. Os resultados mostraram que existe uma relação de longo prazo entre as exportações de determinados setores, a receita externa e a taxa de câmbio. Além disso, observou-se que as variações cambiais têm um efeito assimétrico sobre as exportações, positivo ou negativo, dependendo do setor.

Palavras-chave: Exportações; Taxa de Câmbio; Intensidade Tecnológica; Assimetria; NARDL.
Classificação JEL: F14. F49. C32

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1. Introduction

In a floating exchange rate regime and fierce competition in international trade, it is still important to study the effects of the exchange rate on international trade flows, as observed in the literature (see Baldwin, 1990; Reinhart, 2002; Verheyen, 2013; Bahmani-Oskooe et al., 2017; Lourenço and Vasconcelos, 2019; Wahab et al., 2020; among others).

In practice, the empirical literature has relied on the linear effect of the exchange rate on the components of the trade balance. However, as noted by Shin et al. (2014), asymmetry is endemic in human behavior. These authors argued that the assumption of linearity in the adjustment of macroeconomic variables may be insufficiently rich and overly restrictive. Thus, the asymmetry of the exchange rate effect on trade flows received considerable impetus to be modeled in the international trade literature (see Cheung and Sengupta, 2012; Verheyen, 2013; Arize et al., 2017; Shekhawat, 2018; Lourenço and Vasconselos, 2019; Wahab et al., 2020; among others).

However, this discussion has barely touched on the relationship with the technological intensity of sectors. Lall (2000) has already pointed out that the slow change in the structure of exports has implications for growth and development, which shows the importance of studying by sector given its technological intensity. Consequently, it is hypothesized that the exchange rate has different effects on sectors depending on their technological intensity. In fact, Colacelli (2009) had already shown that the real exchange rate (RER) has a more intense effect on differentiated goods than on homogeneous goods. Cimolli et al. (2013) justify this fact because the devaluation makes exports more competitive in the production of goods where the productivity difference is greater.

In this context, the paper aims to assess the asymmetric impact of these exchange rate fluctuations on Brazilian sector exports to the United States from 1999 to 2020. We assess these effects by observing the technological intensity of the sectors analyzed. In this way, the contribution to this debate was to analyze, in the long run, the asymmetric effect of the exchange rate on exports. We also examine how this result differs due to the technological intensity of the sectors, which configures a gap in the literature. Therefore, we apply the NARDL methodology to bilateral exports from Brazil to the United States in 700 sectors, observing their inherent technological intensity, from 1999 to 2020. In fact, several patterns emerge when disaggregating exports by sector. We find that asymmetry is the most common result. We also observe that when there is negative (positive) asymmetry, revaluations (devaluations) tend to benefit a particular sector. We also found that larger sectors with greater technological intensity tend to benefit from exchange rate appreciation.

The remainder of this paper is organized as follows. The second section reviews the literature and describes the empirical framework. The third section describes the methodology and data source. The fourth section presents the results. The last section provides our final thoughts on the paper.

2. Literature Review

The study of export demand equations is widespread in the international trade literature. Put simply, the relationship between the exchange rate and the components of the trade balance, such as exports, is based on the elasticity model (Bickerdike, 1920; Marshall, 1923; Lerner, 1944; Robinson, 1947; Metzler, 1948). This model predicts that domestic currency devaluations are associated with an increase in domestic supply. Consequently, appreciation (depreciation) makes exports more expensive.

In the opposite direction of the linear effect of the exchange rate, there is a growing discussion in the literature about the asymmetry of this effect (i.e., cases in which the effect of devaluations or appreciations is different). As condemned by Shin et al. (2014), it is clear that such nonlinearities are endemic in human behavior, that is, economic agents respond differently to fluctuations in the same variable. Specifically with respect to the exchange rate, there are several channels that can explain the asymmetries.

There are several reasons for this phenomenon. The first is sunk costs, where exporters do not react to the exchange rate due to large initial investments (Baldwin, 1990). The second is the fear of exchange rate fluctuations, because exporters believe that governments have made devaluations temporary and behave differently than valuations (Calvo and Reinhart, 2002).

Exchange rate asymmetry is also justified because exporters are unlikely to adjust prices to every change in the exchange rate. Instead, they incorporate these changes into their profits so as not to lose international market share. Thus, it is possible that there is a band of inaction in which exporters do not respond to exchange rate fluctuations (Verheyen, 2012, 2013). If exporters are trying to increase their market share, they can absorb some of the appreciation in their profit margins. However, in the face of devaluations, demand may increase depending on capacity constraints (Verheyen, 2013).

Cheung and Sengupta (2012) examined the effect of RER on the export share of Indian firms in the non-financial sector over the period 2000-2010. They found that there is a negative relationship between valuation and exchange rate volatility of exports. They also found an asymmetric effect, where exports are more sensitive to appreciations than to depreciations.

Cimolli et al. (2013) tested the hypothesis that the RER leads to an increase in diversification, which favors sectors with higher technological intensity. The authors analyzed how the exchange rate affects the diversification and structure of exports. They found evidence that exchange rate depreciation tends to increase the participation of more technologically intensive sectors. The authors used the dynamic panel method for 111 countries over the period 1965-2005.

Verheyen (2013) examined the asymmetries of the exchange rate effect on bilateral US exports to 12 Economic and Monetary Union (EMU) countries from 1988 to 2012. The results suggest that linearities are restrictive. They showed that exports are more sensitive to depreciations than to appreciations. Analyzing the relationship between exchange rate movements and Indian export demand from 1993-2013, Mathur and Shekhawat (2018)

showed that exports respond more intensively to appreciations than to depreciations. The authors used the approach developed by Verheyen (2013).

In assessing the relationship between the exchange rate and exports and imports in eight countries (i.e., China, Israel, Korea, Malaysia, Pakistan, Philippines, Russia, and Singapore) from 1980 to 2013, Arize et al. (2017) sought to understand the importance of the asymmetric effects of the exchange rate (appreciation and devaluation) on exports and imports. The authors used the NARDL approach, and their results showed that the short- and long-term evidence pointed to the existence of asymmetries in appreciation and devaluation. Khachatryan and Grigoryan (2020) evaluated the relationship between RER and Armenian exports during 2001-2019. The authors found that there is a positive relationship between devaluations and exports and that prolonged overvaluations may have caused a deterioration in the external competitiveness of the Armenian economy. Wahab et al. (2020) studied the trade war between China and the US by assessing the impact of devaluations on the trade balance between the two countries from 2011 to 2018, using the NARDL approach. Their results show that devaluations of the Chinese currency had a positive effect on China's trade balance (valuations were not significant) and that competitiveness was more important.

Analyzing sectors by technological intensity, Melitz and Ottaviano (2008) and Berman et al. (2012) showed that high-productivity firms with low demand elasticity increased export volumes in response to currency devaluations. Meanwhile, Chatterjee et al. (2013) showed that high-productivity firms responded to currency devaluations by increasing product diversification and prices.

For the Brazilian case, several studies have analyzed the asymmetries of the exchange rate effect. Kannebley Jr. (2008) used a linear cointegration model to assess the possibility of hysteresis in Brazilian exports between 1985 and 2003. He found that exports behave non-linearly in the long run. However, his specification allowed only short-term analysis. Gouvêa and Schettini (2011) examined whether there was an asymmetric pattern of Brazilian imports between 1996-2010 in a Markov switching (MS) structure, which was confirmed. However, the exchange rate effect was small. Schettini et al. (2012) also used an MS structure approach and showed that there was a change in cointegration between 1995-2009. However, they did not find a significant relationship between the components of trade and the exchange rate.

De Prince and Kannebley Jr. (2013) evaluated the hysteresis hypothesis in Brazilian imports. Using cointegration techniques, they validated the hysteresis hypothesis for 17 of the 29 sectors analyzed from 1996 to 2008, mainly in sectors with traditionally high sunk costs. Moreover, Lourenço and Vasconcelos (2019), using the NARDL approach for Brazil's five largest trading partners from 1999-2015, found that overvaluation promoted exports in both the short and long run. They found that depreciations discouraged imports. However, these results varied across countries. The authors also found evidence for the hysteresis hypothesis.

This review shows that there has been an evolution in the sophistication of the analysis of the effects of the exchange rate on the components of the trade balance in the

empirical work on international trade that focuses on this issue. There has also been an increase in the importance of assessing the asymmetries of the exchange rate effect. For the Brazilian case, however, there is still a lack of empirical work on the subject, especially when the sectoral characteristics of these exports are taken into account. This paper attempts to fill this gap.

3. Identification Strategy

We follow the methodology proposed by Verheyen (2013) and Shin et al. (2014). Shin et al. (2014) highlight that little effort has been made to capture nonlinear cointegration, despite the contributions of Park and Phillips (2001), Saikkonen and Choi (2004), Escribano et al. (2006), and Bae and de Jong (2007).

This model can provide clues as to whether the appreciation or depreciation of the real against the dollar has a distinct effect on the Brazilian sector's exports to the United States. Thus, the model starts with a demand equation for standard exports, i.e:

$$\begin{aligned} x_t &= \beta_0 + \eta\,(e_t + p_t^* - p_t) + \varepsilon\, y_t^* \\ x_t &= \beta_0 + \eta\, rer_t + \varepsilon\, y_t^* \end{aligned} \tag{1}$$

where x_t, e_t, p_t^*, p_t, y_t^* and rer_t are, respectively, the demand for exports, the nominal exchange rate, the external prices, the domestic prices, the external income, and the real exchange rate, all these variables in natural logarithm and measured in the period t. ε (η) represents the income-elasticity (price) of demand for exports ($\varepsilon > 0, \eta > 0$). This is the structural model, without the presence of asymmetries, which are to be estimated.

According to Pesaran et al. (2001), the verification of the long-term relationship, cointegration, in an ARDL (p, q_1, q_2) approach for the structural model of equation (1) can be represented by:

$$\begin{aligned} \Delta x_t &= \beta_0 + \alpha_0 x_{t-1} + \alpha_1 rer_{t-1} + \alpha_2 y_{t-1}^* + \\ &+ \sum_{s=1}^{p} \gamma_1 \Delta x_{t-s} + \sum_{s=0}^{q_1} \pi_1 \Delta rer_{t-s} + \sum_{s=0}^{q_2} \pi_2 \Delta y_{t-s}^* + u_t \end{aligned} \tag{2}$$

The advantage of the ARDL (p, q_1, q_2) model, presented in eq. (2) is that it allows us to analyze the cointegration between the demand for exports and its determinants; that is, a long-term relationship[1]. The level-lagged components capture the long-term relationship of the model and the variables in difference, which are the short-term relationships arising from the error correction term.

[1] One of the limitations of the approach proposed by Pesaran et al. (2001), as the authors themselves suggest in the conclusion of their study, is that it captures only one eq. of cointegration and, "Consequently, it is inappropriate in situations where there may be more than one level relationship" (Pesaran et al., 2001, p. 315).

The limits test is used to verify the cointegration between the model variables. The null hypothesis of the test proposed by Pesaran et al. (2001) is the absence of a long-term relationship between exports and other variables; that is, ($\alpha_0 = \alpha_1 = \alpha_2 = 0$). Thus, if the calculated value is greater than the upper limit, it implies cointegration. If it is less than the lower limit, it implies the absence of cointegration. However, it is not possible to draw conclusions if the test falls between the two limits. In this case, cointegration exists if the ECM coefficient is highly significant compared to the critical values of Banerjee et al. (1998).

3.1 Nonlinearities

Note that equation (2) does not allow us to assess the asymmetries that possibly exist between the exchange rate and exports. To insert them, we extended, as suggested by Shin et al. (2014), by including the partial sum of positive and negative changes in the real exchange rate, as established by equation (2):

$$rer_t^+ = \sum_{s=1}^{t} \Delta rer_s[\Delta rer_s > 0]$$
$$rer_t^- = \sum_{s=1}^{t} \Delta rer_s[\Delta rer_s < 0] \quad (3)$$

where $\Delta rer_s[\,.\,]$ is a dichotomous variable that takes a value of 1 if the condition in the indicator function is met and is 0 otherwise. Thus, rer_t^+ (rer_t^-) refers to devaluations (appreciations) in the real exchange rate.

In this way, it would be possible to capture the distinct effects on exports of devaluations and appreciations. Here, the effect of devaluations on exports is expected to be distinct from valuations, depending on the sectoral characteristics.

Therefore, the analysis of the impact of the non-linearity of the real exchange rate on exports consists of inserting equation (3) in place of the ARDL model exchange rate presented in equation (2). The real exchange rate is now analyzed separately for its valuations and depreciations. The NARDL (p, q_1, q_2, q_3) model is formalized as follows:

$$\Delta x_t = \beta_0 + \alpha_0 x_{t-1} + \alpha_1 rer_{t-1}^- + \alpha_2 rer_{t-1}^+ + \alpha_3 y_{t-1}^* + \sum_{s=1}^{p} \gamma_1 \Delta x_{t-s} + \sum_{s=0}^{q_1} \pi_1 \Delta rer_{t-s}^- + \sum_{s=0}^{q_2} \pi_2 \Delta rer_{t-s}^+ + \sum_{s=0}^{q_3} \pi_3 \Delta y_{t-s}^* + u_t \quad (4)$$

Here, from eq. (4), the PSS boundary test has the null hypothesis $\alpha_0 = \alpha_1 = \alpha_2 = \alpha_3 = 0$. Note that currency asymmetries are tested, both in the short and in the long run,

by evaluating the disaggregated exchange rate coefficients (α_1, α_2, π_1 e π_2) of equation (3).

It is worth noting that after the estimations, exchange asymmetries are classified by the magnitude of the coefficients of the disaggregated variable. We compare the coefficients of rer_t^+ and rer_t^-. If both variables are significant, then the Wald test is performed. If only one is significant, then asymmetry is proven. Table 1 describes the tests that we performed.

Table 1: Asymmetry analysis for a limit model

Significant	Not significant	Wald test	Asymmetry
α_2 (rer_{t-1}^+)	α_1 (rer_{t-1}^-)	-	Positive
α_1 (rer_{t-1}^-)	α_2 (rer_{t-1}^+)	-	Negative
Both (α_1, α_2)	-	H_0: $\alpha_2 = \alpha_1$	Positive if $\lvert\alpha_2\rvert > \lvert\alpha_1\rvert$ Negative if $\lvert\alpha_2\rvert < \lvert\alpha_1\rvert$ Symmetric if H_0 is sustained

Source: Lourenço and Vasconcelos (2019, p. 689).

3.2 Source and processing of data

We extract 1227 sectoral exports of four digits of the Harmonized System (HS). However, the sectors were first filtered to include only those that exported in at least half of the months analyzed (130 months). After this initial filtering, the sample consisted of 700 sectors from the Comex Stat platform of the Brazilian Ministry of Economy (2020).

The classification proposed by Lall (2000) was used to analyze the technological intensity of these sectors. The author classified the sectors into five categories, namely primary products (PP), resource-based products (RB), low technology (LT), medium technology (MT) and high technology (HT). Although restrictive, the 700 selected sectors represent about 98% of Brazil's total bilateral exports to the United States during the period.

We use the Organization for Economic Cooperation and Development (OECD) series on total industrial production (2021) as a proxy for U.S. income. The nominal exchange rate was also obtained from the Federal Reserve (FED 2020), while domestic and foreign prices were obtained from the International Monetary Fund (IMF; 2020). Thus, the bilateral real exchange rate between Brazil and the United States was calculated as follows: $rer = EP^*/P$, where E is the nominal exchange rate and P (P^*) is the consumer price index for the Brazilian (US) economy.

The analysis period runs from January 1999 to June 2020, so the series has 258 monthly observations. The choice of 1999 as the starting period is justified because at that time Brazil had adopted the floating exchange rate regime after abandoning the fixed exchange rate regime. It is worth noting that all data have been deflated to 2015 prices using the Consumer Price Index obtained from the IMF (2020) and seasonally adjusted using the STL method (Robert et al., 1990).

4. Results and Discussion

First, we assessed the presence of unit roots in the series analyzed, the bilateral real exchange rate, US income, and Brazilian exports to the US of the 700 sectors. The explanatory variables of the export demand model given by equation (4), the exchange rate and income, were found to be stationary to the first difference. All sectoral export series also followed this pattern according to the Dickey-Fuller Augmented (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests, simultaneously.

In the single-equation approach proposed by Pesaran et al. (2001), the variables can be I(0) or I(1), otherwise the F-statistics cannot be trusted to determine the long-run relationship between exports and their determinants. Thus, the NARDL methodology is appropriate for these 700 export demand equations.

We then analyze the number of lags of variables in the NARDL model of the 700 sectors based on the Akaike Information Criterion (AIC). The lags for each of the variables (export of a particular sector, depreciation, appreciation, and U.S. income) varied according to the minimization of this selection criterion.[2]

We validated the models by evaluating the presence of serial autocorrelation using the Ljung-Box test. The presence of serial autocorrelation was observed in 46 of the 700 equations we analyzed. We capture the presence of a long-run relationship with the explanatory variables, as done by Verheyen (2013), in 358 sectors (51% of the sample) of the remaining 654 sectoral exports. By evaluating the sectors according to their technological intensity, following the classification of Lall (2000), we found that about 42%, 49%, 55%, 52%, and 44% of the high technology (HT), medium technology (MT), low technology (LT), resource-based (RB), and primary products (PP) sectors, respectively, have a long-term relationship with the model variables.

For most sectors, regardless of technological intensity, there is a long-run structural relationship between export demand and its determinants. It is clear here that the classification of the sector by technological intensity is important, since the weight of the sectors that have a long-term relationship in the relative sectoral participation in total exports decreases from the high technology sector, followed by primary products, medium technology for the other classifications. A summary of these results is presented in Table 2. The results can be seen in more detail in Table 4 in Annex A. It should be noted that this table is a summary of the 700 estimates we made.

Of the cases in which there was cointegration, we used the Wald test and rejected the hypothesis of symmetry of the exchange rate effect in 210 sectors. In this case, there is a greater frequency of asymmetric effect of the exchange rate on sectoral exports, regardless of technological intensity. However, symmetry is more frequent in sectors with high technological content. If we analyze more closely, negative (positive) asymmetry was observed in 51% (49%) of the sectors where there is asymmetry, or 107 (103) sectors. In other words, we concluded that in periods of appreciation, the effect of the exchange rate

[2] We omitted the results of the stationarity, lags and cointegration analysis because of their length.

on exports is more intense in most cases where there is an asymmetric effect of the exchange rate on exports.

Table 2: Summary of results on cointegration and asymmetry

I. T.	Part.	Qtd.	Cointegrated			Positive			Negative		
			Qtd.	%	Part.	Qtd.	%	Part.	qtd.	%	Part.
HT	13.93%	55	23	41.82%	71.15%	3	13.04%	0.09%	8	34.78%	9.88%
MT	29.30%	173	85	49.13%	48.92%	24	28.24%	9.52%	17	20.00%	14.22%
LT	8.48%	158	87	55.06%	33.81%	30	34.48%	3.94%	24	27.59%	9.19%
RB	19.48%	136	71	52.21%	27.94%	20	28.17%	11.01%	24	33.80%	8.30%
PP	18.52%	82	36	43.90%	61.35%	9	25.00%	8.28%	16	44.44%	7.40%
OU	9.13%	96	56	58.33%	38.44%	17	30.36%	1.33%	18	32.14%	29.52%
Total	98.82%	700	358	51.14%	47.98%	103	28.77%	7.02%	107	29.89%	12.14%

Source: search results.
Note: I. T.: Sectoral Technological Intensity. High-Tech (HT), Medium Tech (MT), Low Tech (LT), Resource-Based Manufactures (RB), Primary Products (PP) and Unclassified (OU).[3]

In terms of technological intensity, we find that about 13% of the 23 high technology sectors with a cointegration ratio, 28% of the 85 medium technology sectors, 34% of the 87 low technology sectors, 28% of the 71 resource-based manufacturing sectors, and 25% of the 36 primary manufacturing sectors had a positive asymmetric effect of the exchange rate on exports. In this case, we verified that the high technology sector has the smallest percentage of subsectors with this behavior. This indicates that the RER effect is more intense in periods of exchange rate depreciation than in periods of exchange rate appreciation. In turn, in 35%, 20%, 28%, 34%, and 44% of the high technology, medium technology, low technology, resource-based manufacturing, and primary products sectors, respectively, we observe that the effect of the exchange rate on exports is more intense in periods of exchange rate appreciation. Negative asymmetry of the exchange rate is not more common only in the medium and low technology sectors. Nevertheless, sectors with negative asymmetry have a larger share in total exports than sectors with positive asymmetry, except for natural resource-based manufacturing and primary products.

In assessing the direction of the effect of the exchange rate on exports in different sectors, it was found that in 66 of the 107 cases where there was a negative asymmetry, the effect of an exchange rate appreciation tended to benefit a particular sector. This shows that in the long run, regardless of technological intensity, exchange rate appreciation has a positive effect on these sectors. This result is in line with the results found by Amiti et al. (2014), where currency appreciation is positively associated with exports because large

[3] We obtained the sectoral representation percentages (%) by filters. For example, 41.82% of the 55 high technology (HT) sectors (23 sectors) showed co-integration. In turn, 13.04% of these 23 sectors (3) present positive asymmetry. Thus, 52% have a symmetry relationship. In turn, these 55 sectors had 13.93% in the share of total exports. Still, the HT sectors with co-integration represent 71.15% of the participation of these sectors, or 9.91% of the total participation in exports. Furthermore, HT sectors with positive exchange rate asymmetry represent 0.09% of the share of these sectors or 0.01% of total exports.

exporters are also large importers, and therefore an appreciation can reduce production costs. These sectors have a relative importance in sectoral participation due to technological intensity, considering sectors with negative asymmetry, except for medium technology sectors. These results are summarized in Table 3. They are also detailed in Appendix A, Table 4.

We observe that in 87.38% of the cases where there is a positive exchange rate asymmetry, devaluations lead to an increase in exports in the long run. This occurs in about 67%, 92%, 87%, 90%, 78% of the sectors that had a positive asymmetry of high, low and medium technology, resource-based manufactures and primary products, respectively. In the remaining cases, we found that the increase in exports was associated with an appreciation of the real exchange rate. Thus, in most of these cases, we seem to be able to confirm the hypothesis that currency devaluations make the export content cheaper and thus more competitive in the long run. This observation holds true in periods of currency devaluation, both for dynamic sectors with a high technological content and for less sophisticated sectors. Thus, the discussion of the "Dutch disease" widely discussed by Bresser-Pereira (2013) does not seem to be valid here.

Finally, it is worth describing the cases in which no non-linear exchange rate effect was observed. Of the 148 cases in which cointegration was observed, only 69 showed a significant long-run effect of the exchange rate on exports. Of these sectors, exports of 51 have a positive relationship with currency devaluations. Most of the cases are in the low, medium and high technology sectors (28). This shows that the arguments of Cimolli et al. (2013), Colacelli (2009), Goya (2020) and Missio and Jayme Jr. (2012) are valid, according to which a currency devaluation benefits sectors with a higher technological content, compensating for low competitiveness in terms of quality and sophistication or encouraging investment in R&D. In other cases, either no asymmetric phenomenon is observed or the decomposed components of the exchange rate are not significant.

Table 3: Summary of results regarding the direction of the exchange rate effect when positive asymmetry, negative asymmetry, or linearity

I. T.	Positive			Negative			Simmetric	
	$\alpha_2 > 0$	%	Part.	$\alpha_1 > 0$	%	Part.	$\alpha_1 > 1; \alpha_2 > 0$	Part.
HT	2	66.67%	0.08%	2	25.00%	1.6%	3	0.09%
MT	22	91.67%	9.26%	8	47.06%	13.4%	15	2.33%
LT	26	86.67%	3.66%	6	25.00%	2.0%	10	0.26%
RB	18	90.00%	10.56%	9	37.50%	5.9%	14	1.05%
PP	7	77.78%	1.75%	10	62.50%	1.6%	8	0.15%
OU	15	88.24%	1.02%	6	33.33%	24.5%	1	0.00%
Total	90	87.38%	5.58%	41	38.32%	8.1%	51	3.88%

Source: search results.

Note: I. T.: Sectoral Technological Intensity. High-Tech (HT), Medium Tech (MT), Low Tech (LT), Resource-Based Manufactures (RB), Primary Products (PP) and Unclassified (OU).[4]

Some patterns that we have found deserve to be highlighted and emphasized. The first is that there are losers and winners in the face of exchange rate fluctuations, and that this phenomenon can have long-term effects. In addition, large sectors seem to benefit from currency valuations, while small sectors have more intense and positive effects against exchange rate depreciation. Finally, while most of the high-tech subsectors, as well as those based on manufacturing and primary products, have a negative asymmetry, most of the medium-low-tech subsectors are more affected in periods of currency depreciation. These details provide evidence to support the hypothesis that exports are not linearly affected by the exchange rate. Therefore, these characteristics must be taken into account by the monetary authority when it is necessary to influence exchange rate fluctuations.

5. Final Considerations

This work has contributed to a gap in the international trade literature; namely, to evaluate the asymmetric effects of the exchange rate on exports from Brazil to the United States, from 1999–2020, considering the technological intensity of production in the sectors over the long term. deadline. A non-linear approach was applied to construct the model, breaking down the exchange rate between periods of exchange devaluation and periods of exchange appreciation.

We observe that there is a long-term relationship between the model variables in most cases. In most of those cases where this relationship exists, we noticed an asymmetric effect of the exchange rate. However, the exchange rate proved to be an important determinant of sectoral exports in the long run, with a distinction between positive asymmetric, negative asymmetric, and symmetric effects.

In most cases, regardless of the technological intensity of the sector, a certain pattern was observed: when there is positive asymmetry, devaluations have a positive effect on sectorial exports and, in the case of negative asymmetry, appreciations are associated with an increase in exports. This result is in line with the fact that a devalued exchange rate makes exports cheaper or even, and these valuations can reduce production costs. However, negative asymmetry was more frequent, the sectors that suffer from this phenomenon are usually larger.

It is noteworthy that the summary of the results does not cover all of the details of the various results that we found in this study. Thus, for future work, we propose to examine the sectorial characteristics and their relationship with the results found here in more detail because they are too extensive to be included in this study.

[4] The percentages refer to the sectors in which there was positive or negative asymmetry, as shown in Table. For example, we noted that in 67% (2) of the three HT sectors that had positive asymmetry currency devaluations have a positive effect on exports.

Finally, our results have important policy implications. Contrary to a linear effect of the exchange rate on exports, we observed an asymmetric phenomenon in several sectors. In addition, several sectors needed valued exchange rates to improve their costs given their high demand for imports because they are larger sectors and with greater technological content. However, certain sectors benefit from moments of exchange devaluation due to increased competitiveness. This highlights the continued weakness of the Brazilian export sector vis-à-vis exchange rates. In this case, policy makers should balance the interests of large and small manufacturers, and dynamic sectors of low technology content.

Acknowledgements

Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES and Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq by financial support.

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Appendix

Table 1: Results of export demand models that co-integrated

Code	Part.	I.T.	α_1 (rer^-_{t-1})	α_2 (rer^+_{t-1})	Wald	Ljung–Box
x8470	0.01%	HT	7.05** (2.78)	-2.45 (2.03)	8.92***	15.56
x8506	0.00%	HT	4.54*** (1.38)	2.15** (1.00)	4.16**	16.84
x2844	0.00%	HT	-3.94* (2.35)	-2.55 (1.71)	0.54	21.41
x8464	0.00%	MT	11.26*** (2.92)	6.82*** (1.99)	4.61**	8.31
x8903	0.02%	MT	10.96*** (3.15)	4.61** (1.89)	6.64***	21.67
x8457	0.04%	MT	6.44* (3.33)	1.10 (2.15)	3.93**	13.45
x8509	0.00%	MT	5.71*** (2.05)	1.69 (1.36)	5.07**	10.16
x5516	0.00%	MT	5.69*** (1.86)	2.48** (1.06)	5.15**	19.02
x3822	0.01%	MT	4.97** (2.40)	1.96 (1.73)	1.55	14.55
x8420	0.00%	MT	4.50* (2.55)	-2.18 (1.67)	9.23***	15.50
x2207	1.82%	MT	3.99** (1.81)	-1.19 (1.28)	8.62***	17.69
x8417	0.02%	MT	3.15* (1.78)	-0.43 (1.28)	6.03**	13.67
x8425	0.00%	MT	2.84** (1.29)	1.22 (0.90)	2.41	13.93
x3307	0.00%	MT	1.77*** (0.64)	0.14 (0.37)	7.71***	12.49
x7306	0.10%	MT	1.56*** (0.58)	-0.20 (0.39)	12.94***	17.10
x8479	0.09%	MT	1.02*** (0.39)	0.43 (0.30)	2.21	7.18
x8422	0.02%	MT	0.92** (0.46)	-0.45 (0.35)	8.86***	6.73
x3917	0.04%	MT	0.85** (0.37)	0.23 (0.24)	4.79**	11.28
x9001	0.01%	MT	-0.56** (0.24)	-0.17 (0.20)	4.85**	7.96
x5402	0.00%	LT	8.02*** (2.08)	2.67* (1.43)	5.75**	7.35
x3922	0.00%	LT	7.58*** (1.73)	2.31* (1.24)	11.69***	21.18
x3925	0.00%	LT	6.97*** (2.12)	2.20 (1.39)	6.05**	9.93
x7010	0.00%	LT	6.66*** (2.50)	-1.42 (1.76)	10.60***	13.35
x7214	0.05%	LT	5.78** (2.24)	1.59 (1.50)	5.37**	11.43
x9608	0.00%	LT	5.35** (2.32)	-1.14 (1.62)	6.90***	15.82
x9505	0.00%	LT	4.36** (2.05)	2.26 (1.42)	1.65	6.64
x6401	0.01%	LT	3.92* (1.99)	-1.12 (1.58)	6.32**	12.11
x6506	0.00%	LT	2.93* (1.68)	1.80 (1.35)	0.47	11.50
x8201	0.01%	LT	2.56*** (0.98)	-0.17 (0.69)	7.93***	19.75
x6205	0.00%	LT	2.52** (1.17)	0.69 (0.73)	3.53*	10.49
x6202	0.00%	LT	2.25** (1.09)	-0.76 (0.80)	5.15**	20.25
x6102	0.00%	LT	2.20** (0.85)	-0.26 (0.63)	7.61***	25.46
x7317	0.00%	LT	1.65*** (0.43)	1.06*** (0.30)	3.88**	5.11
x8215	0.01%	LT	1.01** (0.47)	0.38 (0.30)	2.10	14.90
x4202	0.01%	LT	0.55** (0.25)	0.07 (0.20)	2.90*	8.24
x7615	0.08%	LT	0.36* (0.21)	0.06 (0.15)	2.22	11.06
x3923	0.07%	LT	0.29*** (0.10)	0.10 (0.07)	6.96***	11.06
x8205	0.01%	LT	-0.42* (0.25)	-0.18 (0.17)	1.18	11.81
x2827	0.01%	RB	8.56*** (3.15)	0.56 (2.14)	7.63***	16.91
x1101	0.00%	RB	7.50*** (2.15)	4.08*** (1.35)	4.57**	12.88
x2713	0.10%	RB	6.93** (3.28)	4.35 (2.66)	0.54	17.45

x2712	0.01%	RB	5.17*	(2.63)	2.82	(1.84)	1.23	11.38
x4811	0.01%	RB	4.76***	(1.40)	1.52	(0.93)	8.47***	21.15
x2903	0.03%	RB	4.27*	(2.32)	-1.91	(1.56)	10.07***	18.89
x6809	0.00%	RB	4.22*	(2.24)	1.22	(2.13)	1.18	18.02
x2005	0.00%	RB	3.67***	(1.21)	1.39*	(0.74)	5.87**	19.84
x3302	0.01%	RB	1.81*	(0.97)	-0.54	(0.67)	7.34***	16.08
x2208	0.01%	RB	1.16*	(0.68)	0.33	(0.42)	2.36	3.94
x1102	0.00%	RB	0.81**	(0.32)	-0.52**	(0.25)	12.83***	9.50
x2009	1.55%	RB	0.65**	(0.31)	-0.29	(0.24)	8.86***	13.00
x3301	0.28%	RB	0.56***	(0.17)	0.00	(0.15)	11.32***	9.57
x2103	0.00%	RB	0.45*	(0.25)	0.19	(0.21)	1.29	12.77
x2106	0.08%	RB	-0.45**	(0.20)	0.08	(0.18)	5.53**	6.37
x7404	0.01%	RB	-5.60**	(2.73)	0.95	(1.82)	8.19***	16.75
x0206	0.00%	PP	4.02*	(2.43)	-0.36	(1.78)	3.49*	14.30
x0506	0.00%	PP	3.40**	(1.33)	-0.59	(1.03)	7.86***	13.83
x1804	0.23%	PP	3.11**	(1.23)	0.80	(0.80)	4.51**	16.93
x1805	0.06%	PP	0.41***	(0.15)	-0.02	(0.14)	11.86***	11.05
x7502	0.14%	PP	-5.34**	(2.31)	-1.51	(1.58)	4.07**	23.32
x6210	0.00%	OU	10.77***	(2.23)	5.17***	(1.45)	9.76***	10.07
x2921	0.01%	OU	5.01**	(2.31)	-0.25	(1.64)	5.17**	9.52
x8311	0.00%	OU	4.96**	(2.35)	2.07	(1.84)	1.46	10.26
x5602	0.00%	OU	4.75***	(1.81)	1.62	(1.21)	4.39**	19.36
x5910	0.00%	OU	4.05*	(2.30)	-0.40	(1.52)	4.92**	8.21
x6801	0.00%	OU	3.98**	(1.86)	-1.67	(1.32)	8.07***	15.78
x5903	0.00%	OU	3.75**	(1.57)	1.83	(1.19)	1.22	17.40
x5211	0.00%	OU	3.70**	(1.49)	-0.87	(1.06)	6.56**	16.07
x6101	0.00%	OU	3.42*	(1.87)	0.92	(1.26)	2.65	18.69
x0811	0.01%	OU	2.87**	(1.33)	-0.92	(0.99)	7.98***	5.94
x4901	0.02%	OU	1.21***	(0.38)	-0.37	(0.24)	15.18***	11.44
x6112	0.02%	OU	0.29*	(0.16)	-0.08	(0.13)	7.43***	17.46
x8471	0.18%	HT	0.13	(0.13)	0.27**	(0.13)	2.94*	12.05
x8543	0.04%	HT	0.36	(0.30)	0.71***	(0.22)	1.91	11.34
x8473	0.11%	HT	-0.03	(0.10)	-0.17*	(0.09)	4.76**	14.11
x2939	0.01%	HT	-0.63	(2.85)	-3.73*	(2.00)	1.60	10.83
x9030	0.01%	HT	-0.15	(0.39)	-0.67*	(0.35)	3.03*	24.94
x3004	0.20%	HT	0.07	(1.47)	-2.32*	(1.18)	2.28	8.85
x8503	0.82%	HT	0.03	(0.14)	-0.26**	(0.13)	5.52**	18.64
x9017	0.01%	HT	-0.48	(0.34)	-0.93***	(0.26)	2.06	8.87
x3911	0.01%	MT	1.23	(0.78)	1.65**	(0.74)	0.77	19.82
x9004	0.00%	MT	0.15	(1.70)	3.46**	(1.41)	3.50*	12.09
x3824	0.03%	MT	0.26	(0.17)	0.43***	(0.17)	2.33	11.66
x7207	3.88%	MT	0.32	(0.55)	1.29***	(0.49)	3.44*	20.72
x9002	0.00%	MT	1.71	(1.64)	3.39***	(1.29)	1.55	19.21
x9028	0.01%	MT	0.81	(1.86)	-2.25*	(1.33)	3.86**	21.13
x8478	0.00%	MT	2.03	(2.46)	-3.92**	(1.91)	4.69**	10.29
x8458	0.03%	MT	-2.02	(2.47)	-3.79**	(1.74)	0.83	11.82

x8441	0.02%	MT	-0.68	(1.36)	-2.83**	(1.28)	3.08*	14.54
x8460	0.00%	MT	-3.25	(2.76)	-5.18**	(2.33)	0.42	11.55
x8607	0.15%	MT	-0.30	(0.26)	-0.58**	(0.25)	2.74*	21.18
x9019	0.00%	MT	-2.28	(2.23)	-4.16**	(1.77)	1.01	12.93
x8714	0.01%	MT	0.48	(0.66)	-1.55**	(0.61)	7.04***	21.03
x7227	0.00%	LT	2.10	(2.65)	4.08*	(2.15)	0.51	14.94
x7308	0.04%	LT	1.90	(1.72)	2.51**	(1.18)	0.19	25.24
x3926	0.06%	LT	0.12	(0.13)	0.26**	(0.12)	0.83	24.51
x7212	0.00%	LT	3.06	(2.22)	3.90**	(1.58)	0.23	19.28
x4820	0.11%	LT	-0.12	(0.20)	-0.30*	(0.18)	0.83	14.72
x5807	0.00%	LT	-0.97	(0.69)	-0.90*	(0.54)	0.01	16.66
x5007	0.00%	LT	3.33*	(1.93)	-3.85*	(2.27)	6.56**	6.98
x6106	0.01%	LT	-0.13	(0.24)	-0.29*	(0.16)	0.75	15.72
x6203	0.02%	LT	-0.54	(0.48)	-0.64*	(0.35)	0.06	11.40
x7616	0.03%	LT	-0.02	(0.11)	-0.23**	(0.10)	3.21*	12.54
x7219	0.16%	LT	0.52	(0.56)	-1.03**	(0.40)	7.59***	6.30
x3406	0.00%	LT	1.29	(2.09)	-4.78***	(1.83)	8.17***	5.22
x6217	0.00%	LT	0.43	(0.48)	-1.00***	(0.36)	10.19***	15.23
x7226	0.00%	LT	0.11	(2.50)	-6.44***	(2.01)	6.60**	23.68
x7312	0.03%	LT	-0.10	(0.24)	-0.84***	(0.20)	8.99***	13.80
x7418	0.00%	LT	1.52	(1.75)	-7.76***	(1.80)	14.47***	9.58
x5705	0.00%	LT	-1.18	(1.98)	-6.47***	(1.50)	8.71***	19.76
x4413	0.01%	RB	-0.02	(2.18)	2.80*	(1.66)	2.30	6.96
x4806	0.00%	RB	2.66	(2.74)	3.67*	(2.07)	0.13	11.71
x4504	0.00%	RB	1.35	(1.32)	2.51**	(1.12)	0.74	7.33
x4414	0.15%	RB	-0.01	(0.08)	0.20***	(0.07)	9.82***	13.81
x6903	0.01%	RB	0.72	(0.68)	-0.77*	(0.47)	5.72**	23.24
x1516	0.01%	RB	0.69	(1.89)	-2.92**	(1.48)	4.01**	17.39
x8104	0.01%	RB	-1.85	(1.88)	-3.19**	(1.61)	0.44	14.43
x4013	0.00%	RB	-0.47	(1.31)	-1.97**	(0.93)	1.98	13.23
x4417	0.05%	RB	0.11	(0.09)	-0.17**	(0.08)	7.95***	9.48
x3507	0.00%	RB	1.21	(2.58)	-4.20**	(1.92)	5.81**	12.19
x4006	0.00%	RB	0.07	(1.32)	-3.26***	(1.09)	8.14***	9.27
x1702	0.02%	RB	-2.57	(2.06)	-4.98***	(1.57)	2.07	13.82
x6804	0.01%	RB	-0.21	(0.15)	-0.52***	(0.15)	6.56**	8.84
x6805	0.06%	RB	-0.31	(0.62)	-2.18***	(0.60)	8.34***	23.49
x2934	0.02%	RB	-4.24	(2.74)	-10.55***	(1.97)	7.52***	11.89
x0803	0.00%	PP	3.78	(2.35)	2.87*	(1.73)	0.25	11.39
x7603	0.01%	PP	3.38	(2.68)	3.17*	(1.86)	0.01	13.66
x7411	0.02%	PP	1.89	(1.92)	2.35*	(1.28)	0.07	8.13
x0903	0.01%	PP	0.91	(0.60)	1.18**	(0.58)	0.54	20.43
x0101	0.01%	PP	2.05	(1.48)	2.93***	(1.05)	0.46	11.67
x0604	0.00%	PP	1.41	(1.75)	3.94***	(1.29)	2.31	17.91
x0801	0.51%	PP	-0.08	(0.07)	-0.16**	(0.07)	3.32*	17.15
x1209	0.01%	PP	-0.84	(1.51)	-3.12***	(1.10)	3.38*	18.41
x0602	0.01%	PP	-0.16	(0.13)	-0.36***	(0.11)	1.77	10.31

x0601	0.00%	PP	-1.86	(2.24)	-7.47***	(1.67)	7.64***	18.31
x0301	0.00%	PP	-0.63**	(0.24)	-1.03***	(0.22)	2.97*	4.96
x6304	0.00%	OU	-1.43	(1.29)	2.02**	(0.93)	10.88***	10.37
x7508	0.01%	OU	-0.07	(0.88)	1.58**	(0.68)	3.21*	21.37
x5608	0.00%	OU	2.46	(1.62)	3.14***	(1.12)	0.27	23.39
x2710	2.22%	OU	-0.05	(0.96)	1.97***	(0.68)	5.69**	9.56
x6303	0.00%	OU	3.23*	(1.81)	5.83***	(1.53)	3.64*	14.20
x7320	0.03%	OU	0.03	(0.09)	-0.14*	(0.09)	9.58***	5.65
x4908	0.00%	OU	-0.03	(0.31)	-0.44*	(0.25)	2.04	12.33
x6212	0.01%	OU	-0.21	(0.25)	-0.40*	(0.21)	0.56	10.20
x5209	0.01%	OU	-0.89	(1.02)	-1.56**	(0.74)	0.69	8.82
x8309	0.03%	OU	0.74	(0.84)	-1.50**	(0.70)	5.91**	11.88
x5210	0.00%	OU	0.99	(2.19)	-4.15**	(1.65)	5.90**	10.46
x9205	0.00%	OU	-2.62	(1.93)	-4.77**	(1.86)	1.03	20.34
x9206	0.00%	OU	-1.17	(2.18)	-4.00**	(1.55)	2.06	10.36
x4821	0.00%	OU	-0.02	(0.42)	-0.80***	(0.28)	4.66**	20.41
x5208	0.01%	OU	0.18	(0.18)	-0.61***	(0.18)	14.83***	17.26
x2938	0.01%	HT	5.75**	(2.64)	7.32***	(2.00)	0.65	7.99
x8518	0.02%	HT	0.55***	(0.21)	0.36*	(0.18)	1.68	5.06
x8532	0.06%	HT	0.31**	(0.14)	0.36***	(0.12)	0.16	11.62
x8504	0.27%	HT	-0.61***	(0.23)	-0.62***	(0.22)	0.01	14.16
x8502	0.10%	HT	0.86	(2.39)	1.17	(1.76)	0.02	14.85
x8545	0.03%	HT	0.25	(0.18)	0.12	(0.17)	1.27	9.43
x9033	0.00%	HT	0.24	(1.45)	-0.35	(0.98)	0.24	10.28
x9013	0.01%	HT	0.02	(1.17)	0.31	(0.83)	0.08	20.94
x9026	0.08%	HT	0.00	(0.10)	0.07	(0.08)	0.38	7.97
x8542	0.07%	HT	-0.16	(0.33)	0.00	(0.24)	0.27	18.20
x8802	7.85%	HT	-0.33	(0.49)	0.19	(0.45)	2.85*	3.72
x8410	0.02%	HT	-3.95	(3.05)	-1.37	(2.18)	1.09	14.72
x8514	0.00%	MT	8.61***	(2.72)	6.33***	(1.91)	1.37	13.14
x3809	0.00%	MT	6.90***	(2.49)	5.90***	(1.72)	0.29	12.40
x3207	0.00%	MT	6.28**	(2.60)	5.91***	(2.15)	0.02	16.80
x9102	0.00%	MT	5.96***	(2.17)	3.71**	(1.55)	1.76	23.87
x8462	0.06%	MT	5.76*	(2.98)	3.92*	(2.03)	0.66	7.54
x3405	0.00%	MT	5.09**	(2.29)	2.63*	(1.54)	1.88	11.24
x8907	0.00%	MT	4.32*	(2.20)	3.05*	(1.64)	0.32	8.95
x3903	0.05%	MT	3.71*	(2.10)	2.99*	(1.52)	0.21	13.74
x3909	0.01%	MT	2.81***	(0.97)	1.23*	(0.66)	2.67	21.34
x8477	0.02%	MT	1.46***	(0.54)	1.80***	(0.51)	1.16	18.73
x8484	0.05%	MT	1.01***	(0.20)	1.05***	(0.20)	0.20	12.29
x8438	0.04%	MT	0.92***	(0.24)	0.73***	(0.20)	1.35	20.84
x8429	1.71%	MT	0.26*	(0.15)	0.24**	(0.11)	0.03	4.73
x8536	0.15%	MT	0.15**	(0.08)	0.20***	(0.07)	1.26	7.25
x8448	0.01%	MT	-1.98**	(0.88)	-1.41**	(0.62)	0.64	8.64
x7201	3.05%	MT	-2.72***	(1.04)	-2.03***	(0.76)	0.55	21.88
x3805	0.01%	MT	3.13	(2.34)	1.69	(1.69)	0.52	8.91

x8451	0.00%	MT	3.09	(2.35)	-0.65	(1.58)	3.68*	17.49
x8450	0.02%	MT	2.87	(1.86)	-0.45	(1.23)	4.29**	19.40
x8515	0.00%	MT	2.60	(1.70)	-0.49	(1.25)	2.76*	15.32
x3819	0.00%	MT	2.49	(1.71)	1.24	(1.23)	0.90	25.74
x3810	0.01%	MT	2.23	(1.99)	0.63	(1.29)	0.58	3.44
x8442	0.00%	MT	2.09	(2.41)	-0.01	(1.94)	0.64	19.93
x3404	0.00%	MT	1.78	(2.51)	0.39	(1.72)	0.47	15.42
x3802	0.01%	MT	1.74	(2.34)	1.05	(1.53)	0.15	17.69
x3814	0.00%	MT	1.55	(1.60)	1.37	(1.10)	0.02	15.75
x3904	0.01%	MT	1.46	(2.60)	-0.72	(1.89)	0.70	9.33
x8707	0.00%	MT	1.32	(2.76)	-0.43	(1.97)	0.55	9.36
x8434	0.00%	MT	1.16	(2.47)	2.44	(1.78)	0.41	12.95
x8423	0.00%	MT	0.98	(2.03)	-1.74	(1.46)	2.74*	11.42
x8513	0.00%	MT	0.88	(1.95)	0.36	(1.40)	0.11	19.98
x9020	0.00%	MT	0.84	(1.08)	1.24	(0.82)	0.18	16.89
x8465	0.01%	MT	0.80	(0.88)	0.01	(0.58)	1.15	16.92
x3906	0.01%	MT	0.65	(1.08)	0.34	(0.72)	0.12	20.77
x3403	0.00%	MT	0.42	(1.73)	-0.13	(1.23)	0.13	10.23
x7315	0.02%	MT	0.35	(0.59)	-0.44	(0.58)	4.49**	17.91
x8480	0.03%	MT	0.32	(0.28)	-0.04	(0.22)	2.86*	15.57
x3808	0.05%	MT	0.28	(1.71)	-1.56	(1.18)	1.63	4.11
x8424	0.04%	MT	0.28	(0.18)	0.02	(0.14)	3.42*	13.09
x3919	0.02%	MT	0.26	(0.25)	-0.09	(0.20)	1.57	15.70
x8418	0.09%	MT	0.18	(0.12)	-0.04	(0.10)	6.35**	7.80
x8516	0.00%	MT	0.13	(0.34)	0.02	(0.26)	0.15	14.54
x8538	0.02%	MT	0.11	(0.14)	-0.02	(0.11)	1.35	14.57
x8439	0.04%	MT	0.05	(0.43)	0.23	(0.32)	0.20	13.24
x8544	0.17%	MT	0.04	(0.07)	0.02	(0.07)	0.17	11.78
x8466	0.04%	MT	0.02	(0.16)	-0.08	(0.14)	0.33	21.12
x8482	0.18%	MT	-0.02	(0.07)	-0.06	(0.06)	0.50	19.11
x3603	0.01%	MT	-0.02	(1.54)	0.24	(1.15)	0.03	21.62
x2905	0.07%	MT	-0.16	(0.22)	-0.15	(0.20)	0.00	23.82
x3815	0.06%	MT	-0.18	(2.37)	2.77	(1.78)	1.42	14.56
x8521	0.00%	MT	-0.35	(2.00)	-1.39	(1.36)	0.39	17.91
x7304	0.35%	MT	-0.74	(0.51)	-0.50	(0.48)	0.60	6.75
x9306	0.09%	MT	-0.88	(1.13)	0.61	(0.84)	1.82	21.11
x3701	0.03%	MT	-0.99	(1.14)	-1.53	(0.93)	0.25	22.94
x7224	1.44%	MT	-1.22	(1.74)	1.42	(1.29)	3.28*	21.36
x7218	0.00%	MT	-2.65	(2.40)	-0.03	(1.57)	1.73	8.75
x9602	0.00%	LT	5.70***	(2.07)	3.57**	(1.39)	1.57	19.92
x7020	0.00%	LT	5.63***	(2.02)	4.63***	(1.38)	0.36	23.99
x4602	0.00%	LT	4.07**	(1.93)	2.98**	(1.46)	0.50	11.68
x6201	0.00%	LT	3.93**	(1.71)	3.42***	(1.24)	0.16	15.80
x5702	0.00%	LT	3.06**	(1.48)	2.03*	(1.03)	0.78	12.27
x9601	0.00%	LT	1.67**	(0.73)	1.48**	(0.74)	0.22	4.45
x9609	0.14%	LT	1.51***	(0.51)	1.49***	(0.50)	0.00	6.08

x8202	0.02%	LT	0.38**	(0.18)	0.30**	(0.14)	0.23	6.83
x6406	0.01%	LT	-0.34*	(0.17)	-0.30*	(0.17)	0.13	8.81
x4104	0.17%	LT	-0.61***	(0.20)	-0.68***	(0.19)	0.74	10.59
x5703	0.00%	LT	-0.92**	(0.46)	-0.67*	(0.38)	0.27	8.42
x9606	0.00%	LT	-3.85**	(1.92)	-5.47***	(1.72)	1.18	12.80
x7208	0.24%	LT	-4.35***	(1.41)	-2.68***	(0.94)	2.67	4.88
x7209	0.29%	LT	-4.89**	(2.08)	-6.41***	(1.90)	0.45	12.06
x7215	0.00%	LT	2.94	(2.22)	0.74	(1.56)	1.51	14.35
x7310	0.00%	LT	2.34	(1.77)	-1.58	(1.20)	6.68***	18.96
x7302	0.00%	LT	2.29	(2.08)	-1.93	(1.41)	5.82**	14.23
x7220	0.00%	LT	2.11	(2.50)	2.87	(1.77)	0.14	15.80
x7313	0.01%	LT	1.95	(1.54)	1.26	(1.04)	0.29	12.33
x7223	0.00%	LT	1.93	(2.01)	2.06	(1.62)	0.00	15.52
x7114	0.01%	LT	1.92	(1.76)	-1.34	(1.18)	4.19**	14.30
x9607	0.00%	LT	1.92	(1.82)	-1.25	(1.42)	2.22	15.14
x5801	0.00%	LT	1.87	(1.18)	0.03	(0.74)	2.75*	18.05
x9506	0.00%	LT	1.30	(1.54)	-0.25	(0.98)	1.43	18.47
x4107	0.66%	LT	1.26	(1.34)	0.78	(0.90)	0.11	15.75
x7213	0.32%	LT	1.17	(1.91)	-1.99	(1.35)	3.36*	17.85
x4203	0.00%	LT	0.87	(0.70)	-0.51	(0.54)	3.06*	10.38
x7324	0.00%	LT	0.84	(2.15)	0.02	(1.64)	0.16	18.85
x4303	0.01%	LT	0.84	(0.59)	0.15	(0.40)	2.11	17.99
x6214	0.00%	LT	0.71	(1.10)	0.10	(0.71)	0.44	22.95
x6117	0.00%	LT	0.63	(0.77)	-0.28	(0.67)	1.53	17.61
x9615	0.00%	LT	0.52	(1.46)	-0.34	(1.05)	0.42	9.82
x9612	0.00%	LT	0.51	(2.37)	-0.16	(1.80)	0.08	20.76
x3924	0.01%	LT	0.29	(0.21)	-0.15	(0.18)	3.86**	7.67
x6405	0.02%	LT	0.25	(0.23)	-0.29	(0.21)	8.57***	13.19
x5309	0.01%	LT	0.20	(0.34)	-0.20	(0.23)	2.08	10.88
x7415	0.00%	LT	0.14	(0.38)	0.36	(0.28)	0.51	18.22
x7217	0.03%	LT	0.10	(0.24)	-0.23	(0.23)	4.37**	10.04
x8211	0.03%	LT	0.07	(0.38)	0.21	(0.33)	0.12	7.26
x7314	0.00%	LT	0.06	(1.24)	-0.42	(0.86)	0.22	15.09
x4813	0.04%	LT	-0.11	(0.48)	-0.02	(0.31)	0.04	17.44
x7323	0.03%	LT	-0.16	(0.60)	0.29	(0.47)	0.53	11.01
x8214	0.00%	LT	-0.29	(1.26)	-0.44	(0.93)	0.01	5.81
x7225	0.05%	LT	-0.44	(2.98)	-1.52	(2.02)	0.19	15.41
x8208	0.00%	LT	-0.63	(0.59)	0.38	(0.43)	2.88*	11.39
x7016	0.00%	LT	-0.80	(2.47)	-0.12	(1.82)	0.09	6.08
x8213	0.00%	LT	-0.88	(1.15)	-0.23	(0.78)	0.48	10.91
x7612	0.01%	LT	-0.94	(0.93)	0.46	(0.70)	2.48	6.76
x9618	0.00%	LT	-1.01	(0.76)	-0.59	(0.50)	0.46	12.39
x9503	0.00%	LT	-1.48	(1.49)	-0.31	(1.14)	0.60	7.80
x6001	0.00%	LT	-1.74	(1.97)	1.40	(1.38)	3.34*	21.05
x4805	0.00%	RB	10.75***	(2.43)	12.17***	(1.79)	0.54	21.91
x2001	0.00%	RB	8.07***	(2.62)	6.17***	(1.86)	0.90	13.69

x2835	0.00%	RB	6.77**	(2.68)	3.61**	(1.82)	2.10	12.39
x6810	0.00%	RB	5.45**	(2.67)	3.04*	(1.75)	1.44	10.69
x3202	0.00%	RB	4.78*	(2.54)	3.37*	(1.83)	0.48	14.00
x1104	0.00%	RB	4.70***	(1.39)	4.60***	(1.13)	0.01	18.99
x2002	0.00%	RB	4.50**	(2.23)	7.78***	(1.73)	2.59	9.52
x2932	0.01%	RB	3.77*	(2.17)	4.06**	(1.68)	0.03	5.29
x3816	0.01%	RB	3.42**	(1.71)	4.43***	(1.27)	0.37	10.48
x1106	0.01%	RB	3.15***	(1.14)	3.23***	(0.93)	0.01	7.86
x2836	0.00%	RB	2.06*	(1.06)	1.38*	(0.74)	0.65	18.19
x4411	0.20%	RB	0.20**	(0.09)	0.16*	(0.08)	0.58	20.48
x2931	0.02%	RB	-7.19***	(2.75)	-8.00***	(1.94)	0.13	20.40
x3203	0.01%	RB	2.18	(1.72)	0.01	(1.18)	1.67	10.78
x1701	0.61%	RB	1.88	(1.32)	0.61	(0.82)	1.43	24.23
x2912	0.00%	RB	1.82	(2.12)	0.93	(1.42)	0.26	23.73
x1511	0.01%	RB	1.19	(1.20)	-0.29	(0.78)	2.16	12.08
x6814	0.01%	RB	1.17	(1.30)	0.24	(0.95)	0.59	25.85
x2104	0.00%	RB	0.94	(1.20)	0.25	(0.81)	0.49	8.71
x7102	0.02%	RB	0.83	(2.52)	1.40	(1.73)	0.08	22.43
x2707	0.06%	RB	0.67	(3.37)	-1.71	(2.51)	0.53	12.30
x0405	0.00%	RB	0.52	(2.15)	2.26	(1.49)	1.04	21.51
x1902	0.00%	RB	0.52	(0.63)	0.36	(0.43)	0.09	7.77
x8108	0.01%	RB	0.46	(0.35)	-0.37	(0.30)	6.01**	8.84
x2821	0.04%	RB	0.44	(0.55)	0.30	(0.37)	0.09	5.20
x4009	0.05%	RB	0.27	(0.23)	-0.11	(0.17)	4.12**	7.42
x2804	0.52%	RB	0.21	(0.15)	-0.02	(0.12)	3.71*	7.79
x4415	0.02%	RB	0.19	(0.23)	0.26	(0.18)	0.15	8.14
x4008	0.05%	RB	0.07	(0.12)	0.00	(0.10)	0.30	16.62
x1704	0.14%	RB	0.06	(0.12)	0.16	(0.10)	0.41	9.17
x3201	0.01%	RB	-0.01	(1.19)	-0.71	(0.84)	0.44	18.60
x7002	0.02%	RB	-0.19	(0.67)	0.12	(0.44)	0.33	7.01
x7009	0.01%	RB	-0.23	(0.24)	0.05	(0.20)	1.16	8.22
x2203	0.00%	RB	-0.29	(1.80)	-0.19	(1.45)	0.00	6.77
x7006	0.00%	RB	-0.40	(1.75)	-0.04	(1.21)	0.06	14.88
x2825	0.16%	RB	-0.41	(0.94)	0.87	(0.74)	1.53	11.59
x1602	0.92%	RB	-0.68	(0.50)	-0.32	(0.47)	1.32	25.67
x1515	0.01%	RB	-1.03	(0.78)	0.14	(0.65)	1.46	14.33
x1603	0.01%	RB	-2.52	(3.06)	0.08	(2.20)	0.98	18.75
x8105	0.01%	RB	-3.85	(2.71)	-1.98	(1.80)	0.73	13.34
x0713	0.00%	PP	4.78**	(2.08)	2.93**	(1.48)	1.12	7.71
x0907	0.00%	PP	4.24*	(2.50)	4.09**	(1.72)	0.01	22.83
x0401	0.00%	PP	3.91*	(2.14)	3.75**	(1.53)	0.01	15.86
x1202	0.00%	PP	3.49*	(2.10)	3.08*	(1.59)	0.04	6.17
x4402	0.00%	PP	3.21**	(1.44)	1.68*	(0.92)	1.74	15.09
x0910	0.02%	PP	3.11**	(1.54)	3.72***	(1.21)	0.21	10.35
x7407	0.05%	PP	1.52***	(0.53)	1.25**	(0.51)	0.66	10.14
x0902	0.01%	PP	-1.76**	(0.79)	-1.05*	(0.56)	1.29	4.56

x0510	0.00%	PP	4.34	(2.78)	0.12	(2.02)	2.59	4.48
x7403	0.13%	PP	3.89	(3.19)	2.88	(2.44)	0.09	17.17
x7901	0.07%	PP	2.34	(3.01)	-1.15	(2.07)	2.05	16.63
x2508	0.00%	PP	2.01	(2.10)	-0.46	(1.71)	1.03	16.92
x1404	0.00%	PP	1.84	(2.23)	2.22	(1.55)	0.04	15.26
x0507	0.00%	PP	1.81	(2.02)	-0.11	(1.38)	1.28	9.60
x0714	0.01%	PP	1.17	(0.71)	0.76	(0.48)	0.48	8.74
x0207	0.00%	PP	-0.04	(2.88)	-1.88	(2.19)	0.38	9.44
x0807	0.02%	PP	-0.09	(0.09)	-0.10	(0.08)	0.00	7.63
x0904	0.21%	PP	-0.38	(0.28)	0.04	(0.20)	2.82*	16.26
x0504	0.01%	PP	-0.59	(0.80)	-0.08	(0.54)	0.60	9.61
x2709	9.79%	PP	-0.71	(2.35)	1.14	(1.74)	0.60	9.21
x5212	0.00%	OU	7.61***	(2.00)	7.52***	(1.46)	0.00	19.81
x4902	0.00%	OU	-0.98*	(0.52)	-1.72***	(0.52)	1.52	15.70
x6908	0.29%	OU	-1.58***	(0.48)	-1.31***	(0.44)	0.38	5.82
x6306	0.00%	OU	-5.45**	(2.27)	-5.08***	(1.75)	0.04	20.28
x7806	0.00%	OU	-5.99***	(1.99)	-3.17**	(1.34)	2.60	9.27
x6209	0.00%	OU	3.54	(2.17)	0.43	(1.42)	2.94*	14.38
x2841	0.00%	OU	3.34	(2.32)	-0.89	(1.66)	4.90**	12.18
x7907	0.00%	OU	2.91	(1.90)	1.87	(1.30)	0.45	12.11
x7204	0.02%	OU	2.64	(2.93)	1.09	(2.18)	0.27	13.82
x8307	0.01%	OU	1.50	(1.08)	0.43	(0.74)	1.38	18.32
x5909	0.00%	OU	1.44	(1.82)	0.80	(1.28)	0.20	6.74
x9701	0.12%	OU	1.05	(0.80)	1.14	(0.78)	0.04	16.86
x2924	0.05%	OU	0.90	(1.28)	0.06	(0.87)	0.63	14.69
x3506	0.01%	OU	0.84	(0.62)	0.76	(0.57)	0.04	3.87
x6307	0.01%	OU	0.79	(0.49)	-0.09	(0.33)	4.62**	18.94
x3505	0.02%	OU	0.68	(0.52)	0.42	(0.35)	0.40	4.14
x4911	0.01%	OU	0.65	(0.42)	-0.20	(0.26)	5.20**	9.02
x6105	0.01%	OU	0.17	(0.84)	0.35	(0.60)	0.07	11.78
x2008	0.07%	OU	0.15	(0.11)	0.12	(0.10)	0.16	19.83
x6103	0.00%	OU	0.12	(0.63)	-0.51	(0.42)	1.42	7.18
x2202	0.01%	OU	0.08	(0.29)	0.11	(0.19)	0.02	20.38
x9209	0.01%	OU	0.06	(0.40)	0.15	(0.36)	0.05	3.51
x1211	0.01%	OU	0.04	(0.34)	0.14	(0.23)	0.12	17.45
x4909	0.00%	OU	-0.13	(1.95)	-1.81	(1.42)	0.93	15.61
x7325	0.04%	OU	-0.20	(0.14)	-0.10	(0.12)	1.01	5.09
x5607	0.17%	OU	-0.23	(0.23)	-0.31	(0.21)	0.29	19.36
x8704	0.26%	OU	-0.61	(1.65)	1.55	(1.20)	2.34	7.17
x6107	0.00%	OU	-1.61	(1.58)	-1.09	(1.15)	0.17	12.70
x5609	0.00%	OU	-1.76	(1.97)	1.12	(1.51)	2.13	15.64

Source: research results.

Note: High-Tech (HT), Medium Tech (MT), Low Tech (LT), Resource-Based Manufactures (RB), Primary Products (PP) and Unclassified (OU). *** sig. at 1%, ** sig. at 5% and * sig. to 10%. Standard deviations are in parentheses. Sectors in which there was no cointegration and those with serial autocorrelation were omitted.