Income Elasticity of Imports and External Constraint in Periods of Commodity Export Boom: Evidence for the Brazilian Economy

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Abstract

The work proposal includes verifying: i) whether the increase in the income elasticity of demand for imports (IEDI) in Brazil (between 1997q1 and 2018q4) can be explained by the increase in exports; ii) whether this could have occurred as a result of the increase in commodity exports; iii) the mechanisms by which the increase in IEDI occurred, whether through final consumption goods or through intermediate goods; iv) whether this should be considered in models that explain economic growth through the performance of the balance of payments (Thirlwall's Law). Then, to test this, we propose estimates a modified version of the multi-sectoral Thirlwall Law (MSTL). The vector autoregressive (VAR) methodology and the vector error correction model (VECM) were used in the estimations. The results showed that the growth of commodity exports has a significant impact on the increase in the IEDI in the analyzed period, which limits the possibilities for the Brazilian economy to reach a balanced growth trajectory with a higher growth rate in the long term.

Keywords: Balance-of-payments-constrained growth, income elasticities of sectoral trade, technological intensity, broad economic categories.

Elasticidad del ingreso de las importaciones y restricción externa en períodos de auge en la exportación de productos básicos: evidencia para la economía brasileña

Resumen

La propuesta de trabajo incluye verificar: i) si el aumento de la elasticidad ingreso de la demanda de importaciones (EIDI) en Brasil (entre 1997 y 2018) puede ser explicado por el aumento de las exportaciones; ii) si esto pudo haber ocurrido como resultado del aumento en las exportaciones de commodities; iii) los mecanismos por los cuales se produjo el aumento de la EIDI, ya sea a través de bienes de consumo final o a través de bienes intermedios; iv) si esto debe ser considerado en modelos que explican el crecimiento económico a través del desempeño de la balanza de pagos (Ley de Thirlwall). Luego, para probar esto, proponemos estimaciones de una versión modificada de la ley multisectorial de Thirlwall. En las estimaciones se utilizó la metodología de vectores autorregresivos (VAR) y el modelo de vector de corrección de errores (VECM). Los resultados mostraron que el crecimiento de las exportaciones de materias primas tiene un impacto significativo en el aumento de la EIDI en el período analizado, lo que limita las posibilidades de que la economía brasileña alcance una trayectoria de crecimiento equilibrado con una mayor tasa de crecimiento en el largo plazo.

Keywords: Palabras clave: Crecimiento restringido por balanza de pagos. elasticidades ingreso del comercio sectorial. intensidad tecnológica. amplias categorías económicas.

Fecha de recepción: 7 de marzo 2022
Fecha de aprobación: 27 de enero de 2023

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INTRODUCTION

Considering the demand-led growth approach, two positions stand out in the debate about which would be the best growth strategy to be adopted by the Brazilian economy: i) the first, based on the Kaldorian tradition and balance-of-payments-constrained growth models, argues that exports are the variable with the ability to boost the economy (Kaldor 1957; Thirlwall 1979; Bresser-Pereira and Gala 2012; Oreiro; Punzo and Araújo 2012); ii) the second, in line with the wage-led growth models perspective1, identifies that the elements that dynamize the growth rate of the economy's output are linked to the stimulus for the internal market, especially with the increase in the consumption of workers (Bastos 2012; Freitas; Dweck 2013; Serrano; Summa 2012; 2015).

In our view, these positions are more complementary than opposing, in the sense that a sustainable strategy of output expansion with an increase in social well-being must consider the condition of economic growth with intertemporal equilibrium of the Balance of Payments and the increase in consumption of the population (especially of the less favored classes). Therefore, it is necessary to coordinate both strategies (of increasing exports and consumption) to avoid possible problems that can mitigate the expected result. From the point of view of conducting macroeconomic policy, one of these problems occurs when the expansion of exports induces a significant increase in the demand for imported final consumer goods. This will be the focus of the analysis of this paper.

Considering the Brazilian economy in perspective, it is possible to observe that the positive scenario experienced by the export sector since 2003 is associated with an increase in the total consumption demand in the national income, whose participation went from 79% to 85% between 2004 and 2014. Thus, if, on the one hand, the expansion of demand resulting from the increase in exports boosted product growth in the period, on the other, the possible effects of this process on the import coefficient cast doubt on the benefits of this expansion as a long-term growth strategy. In other words, the positive effect of the increase in exports on growth may have been dissipated in the medium term with the significant increase in the import coefficient.

However, the higher income elasticity of demand for imports (IEDI) may be a natural feature of an industrial economy in the development process or due to economic policy strategies that induce greater consumption. In the first case, imports are linked to the increase in intermediate inputs used to produce final goods. In the second, there is an increase in imports of final consumer goods, which may be indicating structural problems related to the capacity of domestic supply.

In this context, the purpose of this paper is to verify the recent evolution of IEDI in Brazil. More specifically, the work proposal includes verifying: i) whether the increase in IEDI can be explained by the increase in exports; ii) whether this could have occurred as a result of the increase in commodity exports; iii) the mechanisms by which the increase in IEDI

1 These models could have different theoretical inspirations (like Marx, Kalecki, and Sraffa, among others).

occurred, whether through final consumption goods or through intermediate goods; iv) whether this should be considered in models that explain economic growth through the performance of the balance of payments (Thirlwall's Law).

In the empirical approach, we incorporate the effect of exports on the IEDI in a modified version of the multi-sectoral Thirlwall´s Law (MSTL). We emphasize that the inclusion of this hypothesis makes the theoretical relationship proposed by the referred Law more complex imposing additional difficulties to estimate it in empirical terms. Estimates for the Brazilian economy will be made using the methodology of the vector autoregressive (VAR) and the vector error correction model (VECM2) for the period from 1997q1 to 2018q4 (quarterly). The period includes phases of rise and fall in the level of output of the economy, which eliminates the bias of the results being influenced by only one phase of the economic cycle.

Some studies showed that the increase in the import coefficient is not something essentially new in Brazil. In other words, this coefficient increased in the last decades of the 20th century (Vieira and Holland 2008), specifically after the period of trade liberalization (Azevedo and Portugal 1998; Resende 2001), and this intensified after the years 2000-2001 (Lélis et al. 2018; Nassif, Feijó, and Araújo 2015).

Nevertheless, the novelty of this study is to advance this discussion by testing different hypotheses regarding the determinants of the IEDI. In particular, the interest is in identifying whether the commodity boom has affected the structure of imports.

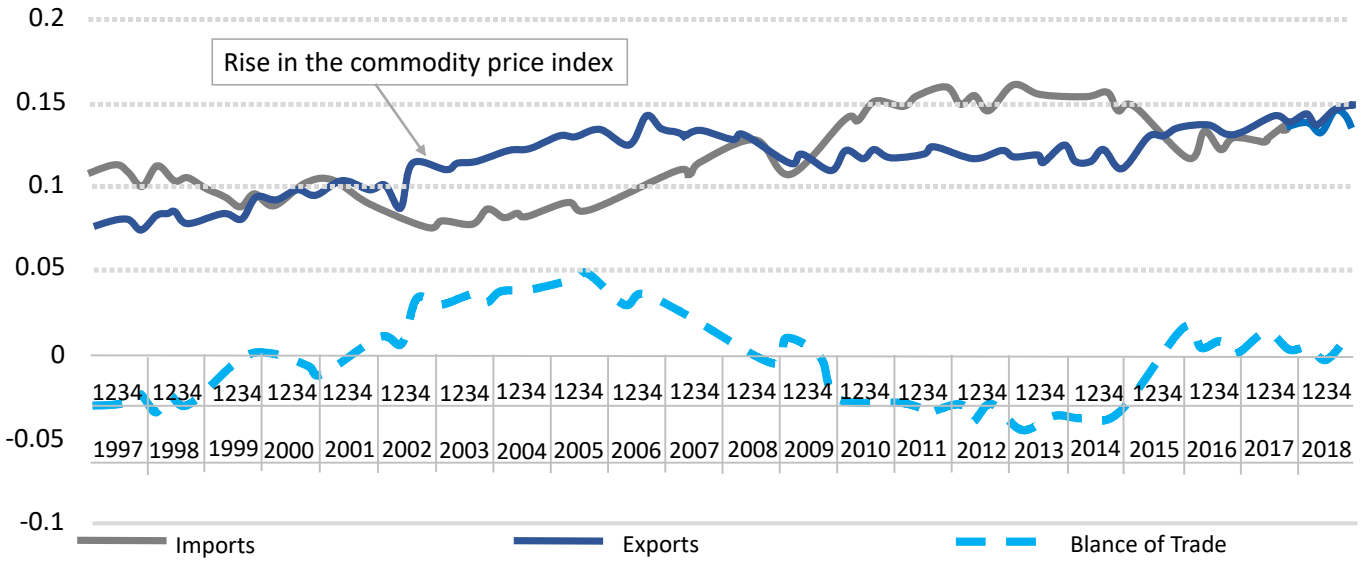
If the empirical evidence confirms this hypothesis, it is possible to argue, in line with the balance-of-payments-constrained growth models, that this expansion cycle of the Brazilian economy had effects on future growth trajectories, increasing the external constraint and limiting the achievement of higher output growth rates in the medium and long term. It will also be possible to discuss aspects of the economic policy adopted in the period, such as whether the policy of appreciating the real exchange rate had (and/or still has) negative effects on the country's economic performance.

The structure of the paper is divided into six sections, including this introduction. Section 2 presents an analysis of the Brazilian trade balance in the period, considering the classifications by technological intensity and broad economic categories. Section 3 presents the modified version of MSTL. Section 4 presents the source of the data and the methodology of the econometric models used; Section 5 discusses the performance of Brazilian economy in the period based on the results achieved. Finally, we present the final considerations.

ANALYSIS OF THE BALANCE OF TRADE BY CLASSIFICATIONS (TECHNOLOGICAL INTENSITY AND BROAD ECONOMIC CATEGORIES)

2 Romero et al. (2011) also used a VEC model to verify the hypothesis of the validity of Thirwall's Law for Brazil in a context of structural changes.

Figure 1 . Participation of exports and imports in GDP



Source: elaborated by the authors, based on SCN/IBGE data.

The export sector had an unsatisfactory performance in the years 1995-19983. This, in part, may have been influenced by the period´s overvalued exchange rate. In 1999, the country adopted the floating exchange rate regime. From that period onwards, the trade balance showed a significant improvement (Graph 1), with surpluses in the trade balance after 2002. The expansion of exports in the early 2000s occurred before the rise of the commodity price index4. The rise in external demand (influenced by the boom of the US economy fueled by the dot-com bubble) and low domestic growth — which reduces pressure on imports — help to explain this result. In contrast, from 2005 onwards, there was an increase in the share of imports in GDP. This increase in imports was detrimental to the trade balance, which was negative from the beginning of the crisis (2008-2009) until 2015.

The Federação das Indústrias do Estado de São Paulo (Fiesp5) data show that the import coefficient of the Brazilian economy more than doubled between 2002 and 2014. The explanations and hypotheses are diverse, which include: i) positive effects of income and the impact of this on a more sophisticated demand (Carvalho 2018); ii) a reduction in domestic supply in the face of less competitive industrial sectors and lower profitability (Oreiro and D´Agostini 2017). Thus, a detailed analysis of the dynamics of the trade balance in economic categories and technological sectors is essential to understand the factors related to the increase in imports in this period.

3 The period of estimations started in 1997 due to the lack of reliable data since 1995. However, we believe that the context after 1995 is important to introduce the analysis to be explored in the paper. Therefore, we briefly comment on the scenario of foreign trade between 1995 and 1998.

4 IMF data show that the rise in the commodity price index started in 2003.

5 Fiesp is the largest class entity in the Brazilian industry with around 130 thousand industries from various sectors.

Starting with exports, we observed that there was a significant loss of participation in sectors with higher technology and a gain in participation in the non-industrial sector (Table 1). In 2000, the share of high-tech exports accounted for 11.9%, while the share of medium-high technology accounted for 23.7% and that of products not classified by technology, which will be considered here as commodities, accounted for 16.6% of the country's export. In 2011, these values changed to 3.3%, 17.7% and 40.8%, respectively. In other words, the increase in the share of commodities in the export basket was visible, largely influenced by the increase in the price index of these products after 2003. In addition, from 2004-2005, there was a reduction in the share of consumer goods and an increase in the share of products not classified in economic categories (Petroleum products and others).
Source: elaborated by the authors, based on data from Comex Stat.

Table 1. Share of exports by Technological Intensity and by Broad Economic Categories

	Classification by Technological Intensity (TI)						Classification by Broad Economic Categories (BEC)				
YEAR	High tech	Medium-high tech	Medium-low tech	Low tech	Commodities	Total (TI)	FCG	IG	CG	Others	Total (BEC)
1997	4.40%	25.20%	17.30%	34.60%	18.60%	100%	8.70%	69.80%	19.40%	2.10%	100%
1998	5.80%	25.90%	16.30%	33.60%	18.40%	100%	9.80%	67.70%	20.60%	1.90%	100%
1999	8.00%	23.20%	16.30%	34.90%	17.60%	100%	10.00%	66.50%	20.90%	2.50%	100%
2000	11.90%	23.70%	16.80%	31.00%	16.60%	100%	12.40%	63.00%	21.10%	3.50%	100%
2001	11.40%	21.70%	15.40%	33.40%	18.10%	100%	11.40%	60.60%	22.40%	5.60%	100%
2002	9.30%	21.60%	16.50%	33.40%	19.20%	100%	9.30%	61.60%	22.40%	6.70%	100%
2003	6.50%	23.40%	16.80%	33.50%	19.80%	100%	8.10%	62.90%	22.10%	6.90%	100%
2004	6.40%	23.70%	18.40%	31.80%	19.80%	100%	11.40%	61.30%	20.80%	6.50%	100%
2005	7.00%	25.10%	17.80%	29.50%	20.60%	100%	10.30%	59.80%	21.60%	8.30%	100%
2006	6.40%	24.60%	18.60%	28.20%	22.30%	100%	9.30%	59.80%	20.40%	10.50%	100%
2007	6.00%	23.60%	18.20%	27.90%	24.30%	100%	10.40%	59.10%	19.60%	10.90%	100%
2008	5.40%	21.10%	18.00%	26.40%	29.10%	100%	9.90%	59.20%	17.90%	12.90%	100%
2009	5.50%	18.60%	14.70%	30.10%	31.00%	100%	7.30%	62.60%	18.50%	11.50%	100%
2010	4.20%	18.90%	12.70%	27.60%	36.60%	100%	7.10%	64.50%	16.30%	12.10%	100%
2011	3.30%	17.70%	13.30%	25.00%	40.80%	100%	7.10%	66.20%	13.90%	12.80%	100%
2012	3.80%	17.60%	14.20%	25.50%	38.90%	100%	8.20%	65.20%	13.70%	12.90%	100%
2013	3.70%	17.20%	15.40%	25.70%	38.00%	100%	9.90%	66.10%	14.80%	9.20%	100%
2014	4.00%	16.30%	13.70%	26.70%	39.30%	100%	7.40%	66.90%	14.50%	11.10%	100%
2015	4.80%	17.30%	14.20%	27.90%	35.70%	100%	8.10%	68.00%	15.30%	8.60%	100%
2016	5.30%	18.10%	14.60%	29.20%	32.80%	100%	9.90%	66.60%	16.20%	7.30%	100%
2017	4.60%	18.50%	12.80%	26.50%	37.60%	100%	7.80%	66.90%	15.60%	9.70%	100%
2018	4.20%	16.20%	15.20%	23.30%	41.10%	100%	8.80%	65.00%	13.00%	13.10%	100%

Source: elaborated by the authors, based on data from Comex Stat. CG – Capital Goods; IG – Intermediate Goods; FCG – Final Consumer Goods.

With regard to imports (Table 2), it is possible to observe two different phases in the period under analysis: the first comprises the beginning of the period (1997) until 2004; the second starts from 2005. In the first case and on the technological side, we observed a reduction in the share of medium-low and low technology products. By economic categories, there was an increase in the share of intermediate goods to the detriment of capital and consumer goods. In the second (2005 onwards) this relationship is reversed, and medium-low and low-tech products increase their relative share by TI classification and consumer and capital goods increase their relative share by BEC classification.

Table 2. Share of Imports by Technological Intensity and by Broad Categories in the total imported

	Classification by Technological Intensity (TI)						Classification by Broad Economic Categories (BEC)				
YEAR	High tech	Medium-high tech	Medium-low tech	Low tech	Commodities	Total (TI)	CG	IG	FCG	Others	Total (BEC)
1997	18.70%	43.10%	13.80%	11.60%	12.80%	100%	20.50%	55.00%	15.10%	9.50%	100%
1998	19.10%	44.90%	13.30%	11.60%	11.00%	100%	20.20%	56.70%	16.00%	7.10%	100%
1999	22.00%	43.30%	13.90%	9.50%	11.30%	100%	18.50%	60.80%	12.10%	8.70%	100%
2000	23.60%	39.40%	16.10%	8.60%	12.20%	100%	15.60%	62.80%	10.20%	11.50%	100%
2001	22.90%	42.60%	15.30%	7.60%	11.70%	100%	16.60%	61.60%	10.40%	11.50%	100%
2002	20.40%	43.00%	14.40%	8.00%	14.20%	100%	13.90%	62.80%	9.90%	13.30%	100%
2003	20.20%	42.20%	14.20%	7.30%	16.10%	100%	11.40%	65.60%	9.10%	13.80%	100%
2004	21.20%	40.20%	13.90%	6.90%	17.80%	100%	10.70%	64.20%	8.60%	16.40%	100%
2005	21.90%	39.40%	14.40%	6.90%	17.40%	100%	11.70%	62.80%	9.30%	16.20%	100%
2006	22.10%	37.00%	15.80%	7.30%	17.80%	100%	11.50%	61.00%	10.80%	16.60%	100%
2007	19.70%	39.20%	16.40%	7.50%	17.30%	100%	11.90%	59.80%	11.60%	16.70%	100%
2008	18.20%	40.50%	16.90%	7.10%	17.30%	100%	12.50%	57.90%	11.40%	18.20%	100%
2009	20.10%	42.50%	14.70%	8.80%	13.90%	100%	14.40%	57.30%	15.10%	13.20%	100%
2010	18.30%	41.90%	18.90%	8.40%	12.40%	100%	14.10%	57.00%	14.90%	14.00%	100%
2011	16.40%	42.20%	19.80%	8.30%	13.20%	100%	13.50%	55.10%	15.40%	16.00%	100%
2012	16.80%	42.40%	18.90%	8.90%	12.90%	100%	14.20%	55.10%	14.90%	15.80%	100%
2013	16.60%	42.10%	18.50%	8.60%	14.20%	100%	13.60%	54.90%	14.50%	17.00%	100%
2014	16.90%	40.70%	19.10%	9.10%	14.10%	100%	12.90%	55.40%	14.50%	17.30%	100%
2015	18.00%	42.70%	17.20%	10.10%	12.10%	100%	13.60%	58.00%	15.60%	12.80%	100%
2016	19.40%	44.00%	16.40%	10.40%	9.70%	100%	13.40%	61.80%	15.80%	9.10%	100%
2017	18.80%	41.60%	19.40%	10.70%	9.60%	100.00%	10.70%	62.10%	15.40%	11.70%	100%
2018	16.50%	40.30%	24.20%	9.30%	9.70%	100.00%	15.80%	57.90%	14.10%	12.30%	100%

Source: elaborated by the authors, based on data from Comex Stat. CG – Capital Goods; IG – Intermediate Goods; FCG – Final Consumer Goods.

The different results over the period, among other factors, can be explained by the price and income effects of imports. The price effect can be captured by changes in the exchange rate and the income effect by changes in domestic income. The fall in imports of consumer and capital goods in the first phase is possibly due to the economic crisis in the period and devaluation of the exchange rate because of the adoption of the macroeconomic tripod6 in 1999. This devaluation made imports less attractive and benefited exports of final goods and higher technology. This can explain the increase in imports of intermediate goods in this period — these products are used as raw material in production that is destined for export, which has benefited from a more devalued exchange rate since 1999.

The income effect caused by the commodities boom was essential (although not the only one)7 for the change in trajectory after 2005. The country reached high growth rates since this period and this raised a discussion about a new middle class in Brazil (Neri 2011). However, this demand for more diversified consumption basket was incompatible with the capacity of domestic supply, having real effects on the increase in the import coefficient in the period (FIESP 2020), mainly for final consumer goods.

In terms of the balance-of-payments-constrained growth model, these results seem to indicate that the period of boom in commodity exports momentarily relaxed the external constraint since 2003. On the other hand, it is possible to highlight movements that seem to go in the opposite direction, in the sense of indicating a more active constraint when considering long-term growth. This, given that the significant increase in the share of commodities in the export basket may mean a reprimarization process of the economy, with a consequent reduction in the income elasticities of exports; at the same time, the entry of foreign currencies can cause an appreciation of the nominal exchange rate - depending on the exchange rate policy - and consequently of the real exchange rate and make industrial sectors less competitive in the international market (Bresser-Pereira 2006; Bresser-Pereira, Oreiro, and Marconi 2016).

In summary, what was observed after 2003 was a reduction in the share of products with greater technology in the export basket and an increase in the import of consumer goods and the import coefficient of the Brazilian economy. However, this was reflected in greater external constraint only after the international crisis of 2008, which occurred in conjunction with the reduction in the commodity price index (IMF 2020).

MULTI-SECTORAL THIRLWALL´S LAW AND IMPORTS AS A FUNCTION OF EXPORTS

When analyzing the trade of a domestic economy with the rest of the world, Thirlwall (1979) considers that the growth rate compatible with the balance-of-payments equilibrium is equal to the ratio between the growth rate of exports and the income elasticity of imports. When considering the multisectoral version of the Thirlwall´s growth model — that is, that exports

6 Economic policy that combines floating exchange rate, inflation targeting and primary surplus.

7 Other factors were also important for the good economic performance of the period, such as favorable external conditions and the increase in consumption associated with the rise in real wages after 2003.

and imports are composed of several sectors (i) —, the equilibrium of the balance of payments (1) and the equation of exports (2) and imports (3) can be presented as follows:

$$\sum_{i=1}^{n} p_i x_i = \sum_{i=1}^{n} p^*_i \, e \, m_i \tag{1}$$

$$x_i = \bar{x}_i \left(\frac{p_i}{p^*_i e} \right)^{\psi_i} Z^{\varepsilon_i} \tag{2}$$

$$m_i = \bar{m}_i \left(\frac{p^*_i e}{p_i} \right)^{\eta_i} Y^{\pi_i} \tag{3}$$

where subscript *i* represents the sectors of an economy (*i* = 1, ..., n), *x* are the domestic country's exports; *m* are domestic country's imports; $\bar{x}$ and $\bar{m}$ are constant terms; *p* is the domestic price; *p** is the external price; *e* the nominal exchange rate; *Y* is the domestic income; *Z* is the income for the rest of the world; ψ is the price elasticity of exports ($\psi < 0$); is the income elasticity of exports ($\varepsilon > 0$); η is the price elasticity of imports ($\eta < 0$); π is the income elasticity of imports ($\pi > 0$). When considering that imports can be directly influenced by export boom periods, the import equation can be changed to:

$$m^*_i = \bar{m}_i \left(\frac{p^*_i e}{p_i} \right)^{\eta_i} Y^{\pi_i} \; x_a^{\gamma_i} \tag{4}$$

Where γ is the elasticity of imports with respect to export growth. When considering equations 2 and 4 in growth rate, we have:

$$\hat{x}_i = \psi_i (\hat{p}_i - \hat{p}^*_i - \hat{e}) + \varepsilon_i (\hat{z}) \tag{5}$$

$$\hat{m}^*_i = \eta_i (\hat{p}^*_i + \hat{e} - \hat{p}_i) + \pi_i (\hat{Y}) + \gamma_i (\hat{x}_i) \tag{6}$$

When considering the purchasing power parity hypothesis $(\hat{p}^* + \hat{e} = \hat{p})$, equations 5 and 6 can be simplified to:

$$\hat{x}_i = \varepsilon_i \hat{Z} \tag{10}$$

$$\hat{m}^*_i = \pi_i \hat{Y} + \gamma_i \hat{x}_i \tag{11}$$

Thus, it is considered here that the growth rate of imports $(\hat{m}_{i*})$ is also a function of the growth of exports $(\hat{x}_i)$. For BP to remain in equilibrium over time, we have:

$$\sum_{i=1}^{n}\left[\frac{p_i x_i\left(\hat{p}_i+\hat{x}_i\right)}{\sum_{i=1}^{n} p_i x_i}-\frac{p^*_i em^*_i\left(\hat{p}^*_i+\hat{e}+\hat{m}^*_i\right)}{\sum_{i=1}^{n} p^*_i em^*_i}\right]=0 \quad (12)$$

When considering $v_i=\frac{p_i x_i}{\sum_{i=1}^{n} p_i x_i}$ as the market share of the i-th product in the total exported $\mu_i=\frac{p^*_i em^*_i}{\sum_{i=1}^{n} p^*_i em^*_i}$ and the market share of the i-th product in the total imported, as well as that there is a parity of purchasing power in the long run $(\hat{p}^* + \hat{e}=\hat{p})$, we have:

$$\sum_{i=1}^{n} v_i \hat{x}_i=\sum_{i=1}^{n} \mu_i \hat{m}^*_i \quad (13)$$

By replacing equations (10) and (11) in equation (13) and after some algebraic operations, the balance-of-payments equilibrium equation (equation 14) is reached, with the inclusion of growth in exports over imports.

$$\hat{Y}=\frac{\sum_{i=1}^{n}(v_i-\mu_i\gamma_i)\,\varepsilon_i}{\sum_{i=1}^{n}\mu_i\pi_i}\hat{Z} \quad (14)$$

When considering that $\gamma=0$, this equation becomes identical to the multi-sectoral approach of Araujo Lima (2007). Equation (14) shows that the balance-of-payments equilibrium growth rate tends to be lower the greater the direct effect of export earnings on imports. However, despite the simplified model, $\gamma>0$ can occur through several mechanisms. This can happen when the export of final goods is intensive in imported intermediate goods, when the export of commodities is intensive in capital goods (agricultural machinery) or when the export earnings are used to purchase final consumer goods from other countries. Thus, the structural characteristics of an economy are implicit in the mechanisms by which this relationship occurs, mainly for commodity-exporting economies in which export revenue is highly dependent on external price cycles. If the demand for consumer goods imports is sensitive in periods of boom in commodity exports, for example, this will indicate low domestic supply capacity in consumer goods (structural problems) and greater constraint in the balance of payments.

METHODOLOGY

Source and database

In the present paper, the following data series were used:

- Exports and imports classified by Broad Economic Categories (BEC) — collected in the Comex Stat database through the 3-digit subdivision and later classified into final consumer goods, intermediate goods, and capital goods.
- Exports and imports classified by technological intensity — data collected on the Comex Stat website through the 6-digit subdivision. This database follows the classification of Industry Sectors by Technological Intensity

(high; medium-high; medium-low; low; products not classified in industry sectors), according to the methodology of the Organization for Economic Co-operation and Development (OECD). In this paper, unclassified products will be considered as commodities, as they are formed, for the most part, by agricultural products, livestock, and natural resources.

- Real exchange rate — the real exchange rate was calculated based on data related to the price index and nominal exchange rate. These were collected in the database of IPEADATA and the World Bank.
- External demand — world GDP, collected in the Federal Reserve Bank of St. Louis database, was used as a proxy for external demand.
- Price index for commodity exports — collected in the International Monetary Fund (IMF).
- GDP — used as a proxy for domestic demand. It was collected in IBGE's system of quarterly national accounts.

All series are quarterly. The more detailed classification of the product groups that make up the economic categories and technological intensities can be seen in Tables A.1 and A.2, in the appendix. Traditionally, using Comtrade data, there are different proposals for aggregation by technological intensity, such as that of (Pavitt 1984)but specific to firms and applications, cumulative in development and varied amongst sectors in source and direction. Innovating firms principally in electronics and chemicals, are relatively big, and they develop innovations over a wide range of specific product groups within their principal sector, but relatively few outside. Firms principally in mechanical and instrument engineering are relatively small and specialised, and they exist in symbiosis with large firms, in scale intensive sectors like metal manufacture and vehicles, who make a significant contribution to their own process technology. In textile firms, on the other hand. most process innovations come from suppliers. These characteristics and variations can be classified in a three part taxonomy based on firms: (1, (Leamer 1985), (Lall 2000), among others. But as the purpose of this paper is to deal specifically with Brazil, through two classifications (BEC and TI), an association between the OECD classification and Pavitt's taxonomy (1984) would make it difficult to compare the two classifications used.

VAR/VEC models

The VAR/VEC models started with the seminal work of Sims (1980) and can be seen in greater detail in the works of Hamilton (1994), Johansen (1988), Lütkepohl (2005) and Becketti (2013).

For the estimation of this class of models, a series of procedures are necessary, such as: i) check if the variables have a unit root, considering the existence of a trend if necessary; ii) test whether they become stationary at first difference; iii) test which are the optimal lags of the models; iv) check if there is cointegration in the long term; v) perform the necessary specification tests, such as autocorrelation, heteroscedasticity, normality of errors and stability. Theoretical details of these models can be seen in the Appendix.

The equations to be estimated are shown below. The first two equations (3 and 4) represent the multi-sectoral Thirlwall´s model, while the last three (5, 6 and 7) include variables external to traditional equations

that capture the elasticities of imports. In equation 5, commodity exports were used for the import equations of all sectors to verify which sector was most influenced by the commodity boom. In equations 6 and 7, exports of final consumer goods and capital goods (FCG and CG) were used for the intermediate goods import equation, since there may be a direct relationship between these variables — that is, by the degree of composition of imported intermediate inputs that are used in the production of final goods.

$$lnX_{k,t} = \beta_0 + \beta_1 lnRER_t + \beta_2 lnWGDP_t + e_{k,t} \quad (3)$$

$$lnM_{k,t} = \beta_0 + \beta_1 lnRER_t + \beta_2 lnGDPBR_t + e_{k,t} \quad (4)$$

$$lnMFCG_{k,t} = \beta_0 + \beta_1 lnRER_t + \beta_2 lnGDP_t + \beta_3 lnXCOMM_t + e_{k,t} \quad (5)$$

$$lnMIG_t = \beta_0 + \beta_1 lnRER_t + \beta_2 lnGDP_t + \beta_3 lnXFCG_t + e_t \quad (6)$$

$$lnMIG_{,t} = \beta_0 + \beta_1 lnRER_t + \beta_2 lnGDP_t + \beta_3 lnXK_t + e_t \quad (7)$$

where *ln* indicates that the variable is in logarithm; *X* represents exports, *RER* the real exchange rate; *WGDP* the World Gross Domestic Product; *GDP* is the Gross Domestic Product. *MFCG* represents imports of final consumer goods, *MIG* represents imports of intermediate goods; *XCOMM* represents exports of commodities, *XFCG* represents exports of final consumer goods and XK represents exports of capital goods. The models' intercept and parameters are represented by , respectively. Time is represented by t, and k represents the division of exports and imports, which are represented by BEC and TI. As the variables are measured in logarithmic differences, the coefficients can be interpreted as elasticities. As the interest is in verifying whether commodity exports were related to the different sectors of imports in the long run, mainly imports of final goods, the VEC model becomes the most appropriate as it captures these long-term relationships between the variables.

Specification tests

The unit root tests of Dickey-Fuller and Phillips-Perron, with and without trend, did not reject, at the level of 1% of significance, the null hypothesis of unit root, because the values of the tests, in module, were lower than the critical values (Table A.3, in appendix). This is true for both trend and non-trend tests. Tests with the first difference variables showed that, without exceptions, it is possible to reject the null hypothesis of unit root. That is, the variables are not stationary in level, but become stationary after being differentiated. However, Perron (2005) considers that traditional tests may err when indicating the existence of a unit root in series that are stationary, but that present a structural break. Thus, Table A.3 also shows

the tests by Jesus Clemente et al. (1998) for unit root with structural break. Likewise, the tests indicated that the variables have a unit root in their level values but become stationary in the first difference.

Tables A.4 and A.5, in appendix, present the model specification tests. Table A.5 does not include exports of commodities. These tables show the tests used to check the optimal lags, using the Akaike (AIC), Schwarz (SBIC) and Hannan-Quinn (HQIC8) criteria, the lags that were used, as well as the Johansen test for cointegration and the Breush-Pagan test for heteroscedasticity. The lags used in the models were chosen not only based on the AIC, SBIC and HQIC criteria, but also based on the autocorrelation tests. The Johansen test9 showed, for both cases (traditional and modified test), that all models present at least one cointegration vector, which allows estimation using the error correction vector (VEC).

For the Breush-Pagan test it was necessary to follow a set of steps, such as: estimating OLS, creating the residuals, raising the residuals to the square and then estimating the square of the residuals against the explanatory variables of the model. At the 1% significance level, only a few models rejected the null hypothesis of the absence of heteroscedasticity. That is, with minor exceptions, the models did not indicate heteroscedasticity.

Tables A.6, A.7 and A.8 show the autocorrelation tests for both versions (traditional and modified). Statistics are displayed up to the limit number of lags used by the model. In the tables it is possible to verify that, with few exceptions, the tests did not reject the null hypothesis of absence of autocorrelation. Tables A.9 and A.10, in appendix, show the stability tests of the VEC models. This test provides indicators to verify that the cointegration equations are well specified and that they are stationary. It can be observed that, for all the estimated models, the roots are within the unit circle, which satisfies the conditions of stability.

RESULTS

In this section, the results of the empirical exercises will be presented and analyzed. First, we present more general results that allow us to evaluate the main determinants (elasticities) of the growth rate with intertemporal equilibrium of the balance of payments. Next, we will analyze the results of the modified import function.

Income and price elasticity of demand for exports and imports

Tables 3 and 4 show the price elasticities of demand (PED) and the income elasticities of demand (IED) of exports and imports by Broad Economic Categories (BEC) and by Technological Intensity (TI). Based on Thirlwall (1979), the PED captures the effect of terms of trade on the demand for imports and/or exports, and the IED captures the effect of changes in external (internal) income on exports (imports). For the coefficients with statistical significance of the two classifications, the values are in accordance with economic theory, with positive IED for exports and imports and positive (negative) PED for exports (imports). In other words, exports (imports) respond

8 According to Lütkepohl (2005), the SBIC and HQCI criteria offer consistent estimates of the true amount of lags that should be used.

9 We chose to estimate the models with a restricted constant.

positively to increases in external (domestic) income and the depreciation of the real exchange rate tends to increase (reduce) exports (imports) 10.

Starting with exports (Table 3) and considering the classification by BEC, we saw that the IED by exports11 was higher for the category of final consumer goods (FCG) and capital goods (CG), when compared to intermediate goods12 (IG). For the TI classification, only exports classified as low-tech and commodities showed statistical significance, the latter being quite elastic with respect to changes in world income. This may be related to the rise of the Chinese economy and the increase in demand for Brazilian primary products (Comtrade 2022).

When considering imports (Table 4), the value of the coefficient that represents the IED for imports was also higher for final consumer goods and capital goods, with elasticities of 4.04 and 3.30, when compared to intermediate goods, which presented an elasticity of 2.66. This indicates that

Table 3. Export elasticity

Classification	Dependent variable (exports)	IED	PED	Constant
Broad Economic Categories	Intermediate goods	3.578***	0.866	83.57
		(1.33)	(0.70)	
	Capital goods	5.455***	0.985	141.18
		(1.97)	(1.05)	
	Final consumer goods	11.77*	-2.71	329.87
		(4.56)	(2.40)	
Technological Intensity	High tech	1,984	-0.46	37.87
		(2.16)	(1.14)	
	Medium-high tech	-1,358	2.798***	-61.91
		(2.00)	(1.05)	
	Medium-low tech	1,309	1.859**	17.76
		(1.94)	(1.02)	
	Low tech	3.521***	0.484***	83.19
		(1.50)	(0.79)	
	Commodities	6.748***	0.593	178.91
		(0.95)	(1.80)	

Source: Elaborated by the authors, based on the results of the research. Note1: The signals of the VEC models have already been inverted. Thus, the table already shows the real relationship between the variables. Note 2: Standard errors in parentheses. Note 3: * significant at 1%; ** significant at 5%; * significant at 10%.**

10 The real effects of an exchange rate devaluation on the balance of payments will depend on the validity of the Marshall-Lerner condition (Krugman, Obstfeld, and Melitz 2015).

11 In the classification by BEC, only exports showed IED with statistical significance.

12 The value of IED for capital goods was lower than the value for final consumer goods, but the standard errors of the latter were higher — thus, we cannot reject the hypothesis that the elasticities of these two sectors are compatible.

Table 4. Import elasticity

Classification	Dependent variable (exports)	IED	PED	Constant
Broad Economic Categories	Intermediate goods	2.662***	-0.950***	45.86
		(0.11)	(0.14)	
	Capital goods	3.300***	-1.768***	63.27
		(0.47)	(0.61)	
	Final consumer goods	4.042***	-1.639***	83.20
		(0.38)	(0.50)	
Technological Intensity	High tech	2.620***	-1.180***	45.69
		(0.14)	(0.18)	
	Medium-high tech	3.118***	-1.344***	58.03
		(0.16)	(0.20)	
	Medium-low tech	3.374***	-1.153***	65.68
		(0.22)	(0.28)	
	Low tech	2.889***	-0.184	54.28
		(0.45)	(0.31)	
	Commodities	1.922***	0.420	29.52
		(0.82)	(1.02)	

Source: Elaborated by the authors, based on the results of the research. Note1: The signals of the VEC models have already been inverted. Thus, the table already shows the real relationship between the variables. Note 2: Standard errors in parentheses. Note 3: * significant at 1%; ** significant at 5%; * significant at 10%.**

during the analyzed period and with other constant factors, the category of import of final consumer goods and capital goods responded positively and with greater intensity to the positive variations in domestic income when compared to the intermediate goods sector. Regarding the PED, we observed that an exchange rate depreciation tends to have a negative effect on imports which is greater for imports of capital goods.

We also found that imports of low and medium-low technological intensity had a higher IED — that is, increases in domestic income tend to increase the import of products classified in these sectors. The next subsection tests the functions of modified imports and tries to see if the IED for imports can be explained by exogenous factors.

New import functions

The results in this section (Tables 5 and 6) present new import functions. The difference with the import functions of the previous subsection is in the inclusion of the effect of commodity exports on all categories of imports (both by TI and by BEC). In addition, the effects of exports of final goods (consumer and capital goods) on imports of intermediate goods were also estimated, similar to the work of Blecker and Ibarra (2013). This

Table 5. Elasticity of imports with the inclusion of other parameters (1997-2018)

Classification	Dependent Variable (Imports)	IED (GDP)	PED (RER)	Commodity exports	Export of final consumer goods	Export of capital goods	Constant
BEC	Intermediate Goods (1)	2.543***	-0.606***	0.040			42.02
		(0.46)	(0.19)	(0.12)			
	Intermediate Goods (2)	4.032***	-0.723***		-0.121 (0.07)		79.11
		(0.25)	(0.14)				
	Intermediate Goods (3)	5.084***	-0.679**			-0.459***	99.48
		(0.51)	(0.28)			(0.15)	
	Capital Goods	4.337***	-3.484***	0.035			88.60
		(0.65)	(0.28)	(0.17)			
	Final Consumer Goods	-0.433	-3.280***	1.693***			3,149
		(1.56)	(0.67)	(0.42)			
TI	High Tech	4.677***	-0.885**	-0.680***			84.42
		(0.36)	(0.80)	(0.21)			
	Medium-High Tech	0.203	-1.962***	0.983***			3.42
		(0.63)	(0.28)	(0.17)			
	Medium-Low tech	0.470	-2.624***	1.442***			3.33
		(1.14)	(0.49)	(0.31)			
	Low Tech	3.251***	-1.673***	0.153			66.20
		(0.93)	(0.81)	(0.48)			
	Commodities	4,142	2.373**	-1.156***			62.20
		(1.13)	(1.13)	(0.73)			

Source: Elaborated by the authors, based on the results of the research. Note1: The signals of the VEC models have already been inverted. Thus, the table already shows the real relationship between the variables. Note 2: Standard errors in parentheses. Note 3: * significant at 1%; ** significant at 5%; * significant at 10%.**

was done to identify in more detail the factors that caused the greatest IED for imports in recent decades. The variables in both tables are the same. However, there is a methodological difference, since in Table 6 GDP is used without the external sector. This is done to avoid possible multicollinearity problems, since exports of commodities, which is an independent variable, are included in GDP, which is also an independent variable. Thus, to ensure that there is almost no linear relationship between two independent variables, the external sector is removed from the GDP measures in Table 6.

The results in Table 5 indicated that imports of final consumer goods are strongly influenced by exports of commodities. The inclusion of commodity exports captured the effect that domestic income had on imports of final consumer goods. In other words, this indicates that the import of the latter is directly related to the commodity boom. The results also indicated: i) a negative relationship between exports of capital goods and imports of intermediate goods; ii) a non-significant relationship between exports of final consumer goods and imports of intermediate goods. This invalidates the hypothesis that the increase in the IED for imports of the Brazilian economy in recent decades has been a natural phenomenon of an economy that exports final goods and, in turn, demands a greater quantity of intermediate inputs. When considering the sectors by technological intensity, there are positive elasticities of commodity exports to the high and low technology sectors.

When we removed the external sector from the GDP measures (Table 6), some changes were seen in the results. Commodity exports started to have a positive effect on capital goods imports. The positive coefficient on capital goods was already expected since machinery and equipment used for agricultural production and extraction of natural resources are mostly imported. The effect of commodity exports on imports of final consumer goods continued to be positive. However, the coefficient that captures the effect of income (GDP) on final consumer goods has become insignificant. This indicates that the export of commodities was the main determinant of the IED for imports of this sector. As this was also the sector with the highest IED for imports in traditional estimates (subsection 5.1), this confirms the hypothesis supported in this paper — that the commodity boom influenced the largest IED for imports and that this occurred through imports of final consumer goods.

The results do not imply that imports of final goods are dependent on exports of commodities, but that the income obtained from these exports ends up going to imports of final consumer goods. In addition to the main results, Table 6 also showed that the coefficients that measure the effects of GDP on imports of intermediate goods remained positive and significant, but with less elasticity. At the same time, exports of final consumer goods

Table 6. Import elasticity with the inclusion of other parameters (GDP without external sector, 1997–2018)

Classification	Dependent Variable (Imports)	IED (GDP)	PED (RER)	Commodity exports	Export of final consumer goods	Export of capital goods	Constant
BEC	Intermediate Goods (1)	3.006***	-0.252	-0.247			49.63
		(0.46)	(0.27)	(0.14)			
	Intermediate Goods (2)	2.027***	-0.715***		0.264*** (0.06)		35.23
		(0.09)	(0.12)				
	Intermediate Goods (3)	2.187***	-0.615**			0.147**	36.85
		(0.128)	(0.15)			(0.07)	
	Capital Goods	2.290***	-3.549***	0.623***			49.89
		(0.58)	(1.06)	(0.61)			
	Final Consumer Goods	1.726***	-3.690***	1.056***			44.76
		(0.93)	(0.46)	(0.27)			
TI	High Tech	2.345***	-0.966	0.042			39.58
		(0.34)	(0.19)	(0.09)			
	Medium-High Tech	1.397***	-1.673***	0.585***			25.86
		(0.24)	(0.13)	(0.07)			
	Medium-Low tech	3.561***	-0.665***	0.155			67.21
		(0.398)	(0.22)	(0.13)			
	Low Tech	1.868***	-1.163***	0.460**			37.20
		(0.66)	(0.37)	(0.20)			
	Commodities	-1,525	-0.869	1,714			-17.33
		(7.87)	(5.17)	(2.29)			

Source: Elaborated by the authors, based on the results of the research. Note1: The signals of the VEC models have already been inverted. Thus, the table already shows the real relationship between the variables. Note 2: Standard errors in parentheses. Note 3: * significant at 1%; ** significant at 5%; * significant at 10%.**

and capital goods have had a positive effect on imports of intermediate goods — that is, part of the IED for imports of intermediate goods is due to the export of final goods.

It is also relevant to emphasize that an export boom can impact imports both by the income effect and by the price effect. The increase in exports of commodities in large quantities has direct positive effects on income. At the same time, the inflow of resources through exports (along with capital inflows and FX derivatives operations stimulated by the interest rate differential) makes the Real appreciate against other currencies. As a result, the effect on the increase in imports is twofold — both for the increase in income (GDP) and for the reduction of relative prices (appreciation of the Brazilian currency). In this way, a growth strategy through commodity exports has effects on the increase in imports both by the income effect and by the price effect.

Brazil and other Latin American countries began to benefit from the rise in commodity prices, largely influenced by the greater Chinese demand for these products. From 2004 to 2008, the Brazilian economy went through a period of expansion, with an average growth rate of 4.82% (IBGE 2022) per year and a set of favorable indicators from the macroeconomic point of view. As exports have the dynamic ability to influence other sectors — such as household consumption and investment — and these sectors demand imports, it can be said that IED for imports ends up being higher in times of export boom. However, the intensity with which these imports will increase will depend on the structural characteristics of the Brazilian economy and its production and supply capacity.

In summary, the results of the estimates indicated that exports of commodities influenced the increase in the IED for imports, mainly through final consumer goods. This direct relationship between commodity exports and imports does not necessarily indicate greater external constraint13 — that is, if the latter is due to the former, reductions in commodity exports also reduce imports and the balance of payments tends to remain in equilibrium. However, a system with these characteristics tends not to present trade surpluses for long periods and this has negative effects on investment and reduces the effectiveness of a growth strategy aimed at the domestic market.

In other words, the country tends to never pass an average income level and increases in consumption and welfare levels tend to occur only in periods of higher commodity exports. This partly explains why policies to encourage domestic demand during the period of falling commodity prices (after 2010) did not have the expected effects14.

13 Blecker and Ibarra (2013)but instead rose in the post-liberalization period, so this model cannot account for the country's growth slowdown. Instead, the analysis points to the need to consider the real exchange rate as well as internal obstacles and policies.","container-title":"Structural Change and Economic Dynamics","DOI":"10.1016/j.strueco.2013.02.001","ISSN":"0954349X","journalAbbreviation":"Structural Change and Economic Dynamics","language":"en","page":"33-47","source":"DOI.org (Crossref showed that part of the elasticities of imports of intermediate goods from Mexico was due to their exports of final goods. In other words, the authors found that the increase in import elasticities was due to a natural growth process generated by exports. It is considered that this does not represent a greater external constraint, as imports of intermediate goods are directly offset by higher exports of final goods.

14 The higher level of income of the population, combined with a poorly diversified productive structure, made the population's demand higher than the domestic supply, which negatively impacted economic growth.

Finally, at the criterion of testing the validity of the estimates of what was proposed in this paper, the next subsection presents the comparison of the GDP growth rate and the growth by MSTL in the traditional and modified versions.

Growth rate and MSTL

Following Mccombie (1989), we consider that the validity of the Thirlwall Law is given by comparing the growth rate predicted by the model with the real growth rate observed in the country. The procedure carried out consists of multiplying the growth rate of world income by the ratio between the IED for exports (weighted by each sector15) and the IED for imports (weighted by each sector), as also done by Gouvea and Lima (2010). This procedure was performed for the two classifications (BEC and TI) and for the traditional and modified versions of MSTL considered in this paper.

Data with inflation and seasonality adjustment showed that the quarterly growth rate (between 1997q1 and 2018q4) in Brazil was 0.55%. Through the traditional version16 of the MSTL, the results showed that the quarterly growth rate was 1.17% for exports classified in TI and 0.77% for exports classified by BEC. The modified version17, on the other hand, presented a quarterly growth rate of 0.58% for the classification by TI and 0.39% by BEC. When comparing the growth rate over time of the traditional and modified versions of MSTL by TI and by BEC (Figures 2 and 3), we saw that both the traditional and the modified approach tend to follow the economic cycle.

Thus, the modified version considered in this work proved to be more compatible with the growth observed in the country, which reinforces the hyphotesis of this paper. In other words, a significant part of the income from the commodity price boom went to imports of final consumer goods, which constrained the balance of payments, as well as economic growth in the last decades (1997-2018).

15 The weighting was done based on the categories that presented statistical significance.

16 The calculation method for the traditional version can be presented as: $\frac{\sum_{i=1}^{n}(GRE_{it}\times SE_{it})}{\sum_{i=1}^{n}(IED\,IMP_{it}\times SI_{it})}$

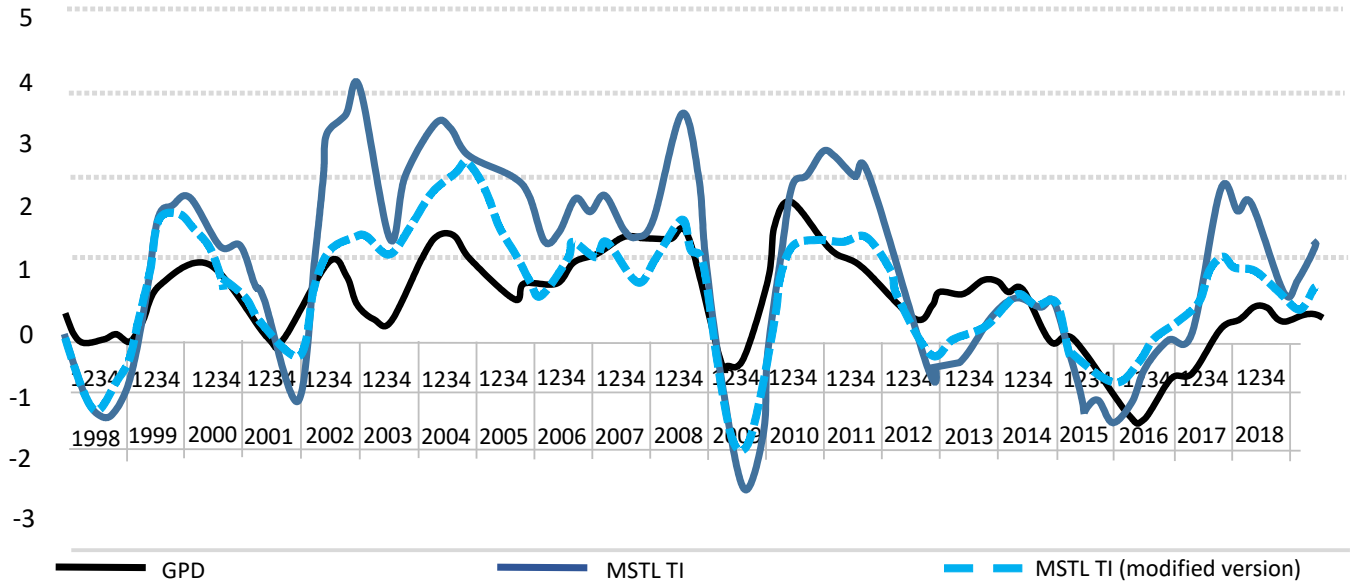
Where i represents the sectors of both classifications (TI and BEC), t is time (in quarter), GRE is the growth rate of exports, SE is the share of exports in total, IED IMP is the income elasticity of demand for imports and SI is the share of imports in the total imported.

17 The calculation method for the modified version considered in this work can be presented as:

$$\frac{\sum_{i=1}^{n}\{(GRE_{it}\times PE_{it})-\left[(ICE_{i}\times GRCE_{it})\times SI_{it}\right]\}}{\sum_{i=1}^{n}IED\,IMP_{it}\times SI_{it}}$$

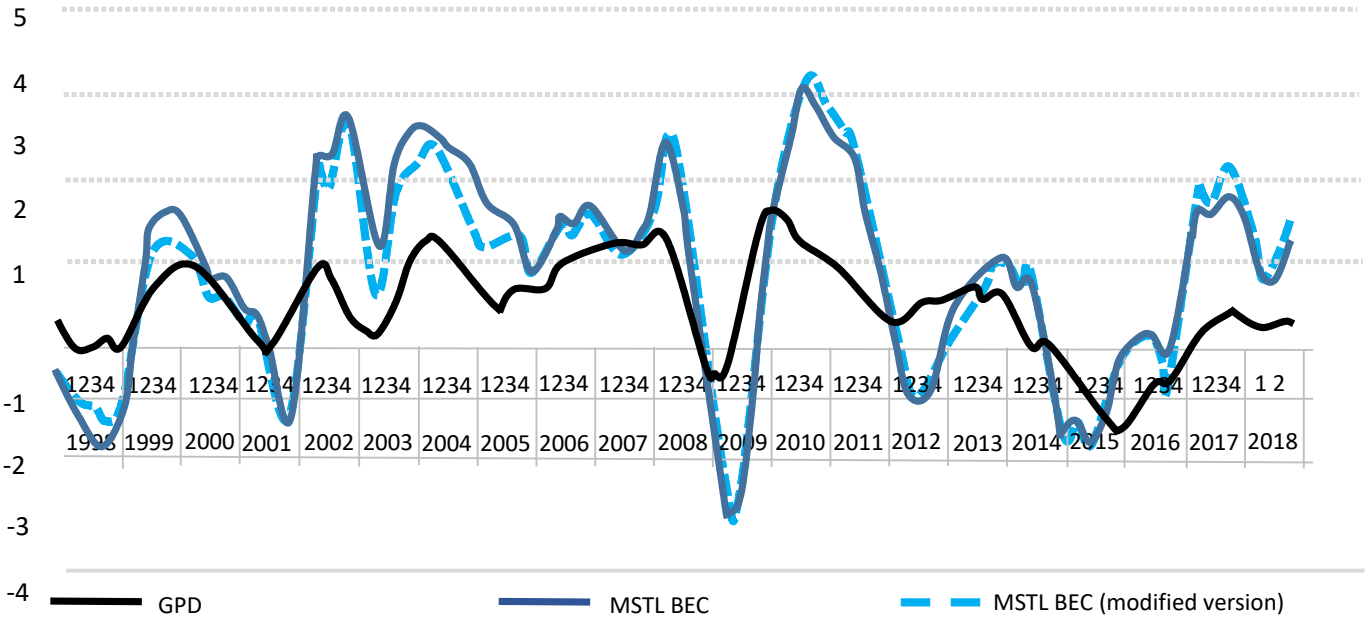
Where IEC represents imports in relation to commodity exports and GREC represents the growth rate of commodity exports.

Figure 2. Moving averages of the GDP growth rate and of the traditional and modified versions of MSTL by IT classification



Source: Elaborated by the authors.

Figure 3. Moving averages of the GDP growth rate and of the traditional and modified versions of MSTL by BEC classification



Source: Elaborated by the authors.

CONCLUSIONS

Based on the section that analyzes the evolution of the trade balance, it was visible, through the classification by TI, the reduction in the share of exports from sectors with higher technology and the increase in the share of non-industrial products after the 2000s. This has become more intense with the increase in demand and in the commodity price index since 2003. In general, the boom in commodity exports has led to a lower external constraint on the balance of payments. However, the loss of share of some sectors — mainly those with higher technology — creates a warning signal for the risk of reprimarization and greater external vulnerability, due to the concentration of productive activities in some specific sectors.

The MSTL tests showed that the modified version proposed in this paper, which considers the elasticity of imports in relation to the variation in commodity exports, adjusted better to the country's real growth rate. Regarding trade elasticities, it is necessary to separate the results of traditional MSTL and modified MSTL. By traditional MSTL, we saw that the income elasticities of demand (IED), both for exports and imports, showed higher values for consumer goods and capital goods, when compared to intermediate goods. In general, the coefficients with statistical significance showed that the values are in accordance with economic theory, with positive IED for exports and imports and negative (positive) PED for imports (exports).

The sector considered as commodities showed a high IED for exports — that is, it proved to be quite elastic with respect to changes in world GDP. We believe that this may be related to the rise of the Chinese economy and the increase in demand from that country for Brazilian primary products. For imports classified in TI, the results showed that the sectors of low and medium-low technology presented greater IED — increases in domestic income tend to increase the import of products classified in these sectors.

The results of the modified version indicated that imports of final goods and capital goods were significantly influenced by exports of commodities. On the one hand, the effect on capital goods may be reflecting the import of machinery and equipment used for agricultural production. On the other hand, the effect on final consumer goods indicates that the economy used the greatest income effect from commodity exports to increase the population's consumption patterns. The latter, in turn, was intensified with the overvaluation of the currency and the inflow of dollars resulting from the export of commodities, which made foreign products even more attractive. The results also indicated that there is a positive relationship between exports of final goods and imports of intermediate goods — however, elasticities were relatively low for the latter case.

Thus, the results of the present paper showed that the increasing import elasticity in the last decades18 was influenced by the boom in commodity exports and that this is mainly due to imports of final consumer goods. We argue that this was intensified by two main factors: i) first, due to the lack of a productive structure capable of supporting a more diversified demand from the population, which caused an outflow of income for imports of final consumer goods; ii) second, and complementary to the first,

18 See Resende (2001), Azevedo and Portugal (1998), Nassif, Feijó and Araújo (2015); Lélis et al. (2018).

overvalued exchange rates have made foreign consumption cheaper and more attractive since the rise in commodity prices.

Thus, policies that aim to mitigate the negative and direct effect that the increase in the level of income has on imports would have the capacity to alleviate restrictions on the balance of payments, as well as guarantee greater effectiveness of policies to encourage domestic demand. Through the income effect, this would be possible if the internal productive structure were able to supply the greater demand of a middle class with higher levels of income. Through the price effect, we consider that in the period of boom in commodity exports, a policy should have been put in place to correct the overvaluation of the Brazilian currency (Real). This policy would have had effects through two different mechanisms: on the one hand, it could have corrected relative prices and restricted the outflow of income for imports; on the other, it would guarantee that some strategic sectors would remain competitive in the international market. Greater competitiveness, in addition to reducing idle capacity, guarantees gains in scale in the production process and reduces production costs, making these sectors even more productive.

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APPENDIX

Table A.1. Classification by Technological Intensity

High-tech industry products
Aircraft;
Computer equipment, electronic and optical products;
Pharmochemical and pharmaceutical products
Products of the medium-high technology industry
Machines and equipment;
Electrical machines and materials;
Chemicals;
Motor vehicles and parts;
Railway vehicles;
Military combat vehicles.
Products of the medium-low technology industry
Petroleum products and biofuels;
Naval vessels;
Metallurgy;
Rubber and plastic products;
Metal products, except machinery and equipment;
Non-metallic mineral products.
Low-tech industry products
Other manufactures;
Clothing and accessories;
Drinks;
Cellulose and paper products;
Leathers, leather goods, travel goods and footwear;
Computer equipment, electronic and optical products;
Printing and reproduction of recordings;
Wood and its products;
Furniture;
Food products;
Tobacco products;
Textile products
Unclassified products (commodities)
Agriculture and Livestock;
Electricity and gas;
Extraction of mineral coal;
Extraction of metallic minerals;
Extraction of non-metallic minerals;
Extraction of oil and natural gas;
Not allocated in other sectors;
Fisheries and aquaculture;
Forest production;
Editing products.

Source: Elaborated by the authors, based on the classification by broad economic categories.

Table A.2. Classification by Broad Economic Categories

Intermediate Goods
Industrial inputs;
Food and beverages, mainly intended for industry;
Basic industrial inputs;
Transport equipment parts;
Parts and accessories for capital goods.
Consumer Goods
Semi-durable and non-durable consumer goods;
Durable consumer goods.
Capital Goods
Capital goods, except industrial transport equipment;
Industrial transport equipment.
Others
Basic fuels and lubricants;
Elaborated fuels and lubricants;
Goods not otherwise specified.

Source: Elaborated by the authors, based on the classification by broad economic categories

Table A.3. Unit Root Tests

VARIABLES	-1	-2	-3	-4	-5	-6	-7	-8
World GDP	-1,409	-3,158	-1,935	-1,296	-4,647	-7.54	-1.79/-4.27	-15.5/-4.27
RER	-0.236	-2,128	-0.320	-1,623	-6,211	-6,066	-1.93/-4.27	-9.12/-3.56
GDP	-1,093	-1,445	-1,167	-1,982	-9,600	-12,664	-2.95/-3.41	-9.42/-3.56
X_FCG	-1,788	-0.859	-1,976	-0.878	-6,094	-8,505	-3.91/-4.27	-7.26/-3.56
X_K	-1,601	-2,350	-1,939	-3,609	-8,742	-16,312	-3.68/-3.56	-9.32/-3.56
X_IG	-0.666	-1,655	-0.877	-1,610	-7,591	-9,531	-3.06/-3.56	-8.05/-3.56
X_High-tech	-3,353	-2,689	-3,057	-2,924	-6,919	-14,657	-3.27/-3.56	-15.9/-4.27
X_Medium-high-tech	-1,374	-1,618	-1,522	-1,237	-5,185	-6,565	-3.76/-3.56	-6.59/-3.56
X_Medium-low-tech	-1,003	-1,829	-1,128	-2,292	-8,246	-12,970	-3.39/-4.27	-9.38/-3.56
X_Low-tech	-0.973	-0.974	-1,365	-1,017	-7,677	-9,875	-3.37/-3.56	-8.44/-3.56
X_Commodities	-0.564	-1,866	-0.790	-1,974	-8,351	-11,013	-3.33/-3.56	-8.82/-3.56
M_FCG	-0.590	-1,729	-0.638	-1,139	-4,460	-7,241	-3.40/-3.56	-5.17/-3.56
M_K	-0.477	-1,529	-0.922	-3,158	-4,653	-12,132	-2.94/-3.56	-5.33/-3.56
M_IG	-0.895	-1,828	-1,230	-1,394	-5,459	-7,230	-3.25/-3.56	-6.50/-3.56
M_High-tech	-1,007	-1,593	-1,637	-1,412	-6,323	-8,414	-3.55/-3.56	-8.66/-3.56
M_Medium-high-tech	-0.774	-1,453	-1,014	-1,209	-5,027	-8,367	-3.26/-3.56	-5.61/-3.56
M_Medium-low-tech	-0.669	-1,914	-0.910	-1,962	-5,238	-10,218	-3.32/-3.56	-5.68/-3.56
M_Low-tech	-0.408	-2,084	-0.536	-1,367	-4,296	-8,227	-3.15/-3.56	-5.24/-3.56
M_Commodities	-1,246	-1,308	-1,505	-1,379	-6,184	-9,777	-2.90/-3.56	-7.10/-3.56

Source: Elaborated by the authors. Note 1: X = exports; M = imports; RER = real exchange rate; FCG = final consumer goods; IG = intermediate goods; K = capital goods. Note 2: Dickey Fuller test; 2 - Dickey Fuller test (with trend); 3 - P. Perron test; 4 - P. Perron test (with trend); 5 - Dickey Fuller test in 1st difference; 6 - P. Perron test in 1st difference; 7 - Clemente-Montanes-Reyes test for structural breakdown (T-statistic / critical value); 8 - Clemente-Montanes-Reyes test for structural breakdown (T-statistic / critical value), in 1st difference. Note 3: In module, the critical values for the Phillips – Perron (PP) and Dickley-Fuller (DF) tests are approximately -3,530 (1%), -2,901 (5%), and -2,586 (10%).

Table A.4. Specification tests (traditional model)

DEPENDENT VARIABLES	Lags (AIC)	Lags (SBIC)	Lags (HQIC)	Lags used in the model	Johansen test (cointegration vectors)	Breusch-Pagan test (Prob> F)
X_FCG	4	4	4	3	1	0.990
X_K	4	4	4	3	1	0.998
X_IG	4	4	4	2	1	0.009
X_High	4	4	4	2	1	0.000
X_Medium-high-tech	4	4	4	2	1	0.677
X_Medium-low-tech	4	4	4	1	1	0.806
X_Low-tech	4	1	1	2	1	0.119
X_Commodities	4	4	4	2	2	0.004
M_FCG	4	1	1	5	1	0.000
M_K	4	1	4	5	1	0.000
M_IG	4	1	4	5	1	0.390
M_High	4	1	4	5	1	0.028
M_Medium-high-tech	4	1	1	5	1	0.288
M_Medium-low-tech	4	1	1	5	1	0.108
M_Low-tech	4	1	1	5	1	0.000
M_Commodities	1	1	1	5	1	0.942
M_IG (2)	4	1	1	5	1	0.022
M_IG (3)	4	1	4	5	1	0.051

Source: Elaborated by the authors. Note 1: X = exports; M = imports; FCG = final consumer goods; IG = intermediate goods; K = capital goods.

Table A.5. Specification tests (modified models and GDP with external sector)

DEPENDENT VARIABLES	Lags (AIC)	Lags (SBIC)	Lags (HQIC)	Lags used in the model	Johansen test (cointegration vectors)	Breusch-Pagan test (Prob> F)
M_FCG	4	1	1	5	2	0.002
M_K	4	1	2	4	1	0.018
M_IG	4	1	1	6	1	0.015
M_High	4	1	1	5	1	0.001
M_Medium-high-tech	4	1	1	5	1	0.007
M_Medium-low-tech	4	1	2	6	1	0.175
M_Low-tech	4	1	1	5	2	0.001
M_Commodities	1	1	1	6	1	0.013

Source: Elaborated by the authors. Note 1: X = exports; M = imports; FCG = final consumer goods; IG = intermediate goods; k = capital goods.

Table A.6. Autocorrelation test (traditional models)

DEPENDENT VARIABLES	Lag(1) Prob > chi2	Lag(2) Prob > chi2	Lag(3) Prob > chi2	Lag(4) Prob > chi2	Lag(5) Prob > chi2	Lag(6) Prob > chi2
X_FCG	0.049					
X_K	0.261	0.959	0.188			
X_IG	0.639	0.513				
X_High	0.322	0.271				
X_Medium-high-tech	0.148	0.182				
X_Medium-low-tech	0.420					
X_Low-tech	0.288	0.334				
X_Commodities	0.609	0.506				
M_FCG	0.565	0.273	0.812	0.118	0.477	
M_K	0.601	0.400	0.765	0.144	0.387	
M_IG	0.665	0.304	0.680	0.190	0.345	
M_High	0.858	0.384	0.216	0.076	0.168	
M_Medium-high-tech	0.671	0.288	0.686	0.051	0.280	
M_Medium-low-tech	0.321	0.110	0.701	0.031	0.238	
M_Low-tech	0.350	0.809	0.185	0.005	0.940	
M_Commodities	0.352	0.898	0.976	0.032	0.075	
M_IG (2)	0.000	0.170	0.949	0.800		
M_IG (3)	0.000	0.513	0.942	0.933		

Source: Elaborated by the authors. Note 1: X = exports; M = imports; FCG = final consumer goods; IG = intermediate goods; K = capital goods.

Table A.7 - Autocorrelation tests (model of imports and GDP with external sector)

DEPENDENT VARIABLES	Lag(1) Prob > chi2	Lag(2) Prob > chi2	Lag(3) Prob > chi2	Lag(4) Prob > chi2	Lag(5) Prob > chi2	Lag(6) Prob > chi2
M_FCG	0.816	0.779	0.414	0.115	0.966	
M_K	0.000	0.171	0.145	0.492		
M_IG	0.442	0.582	0.012	0.204	0.277	0.142
M_High	0.632	0.694	0.818	0.294	0.454	
M_Medium-high-tech	0.307	0.473	0.314	0.596	0.340	
M_Medium-low-tech	0.419	0.189	0.375	0.157	0.359	0.227
M_Low-tech	0.166	0.151	0.809	0.245	0.254	
M_Commodities	0.807	0.588	0.116	0.122	0.449	0.765

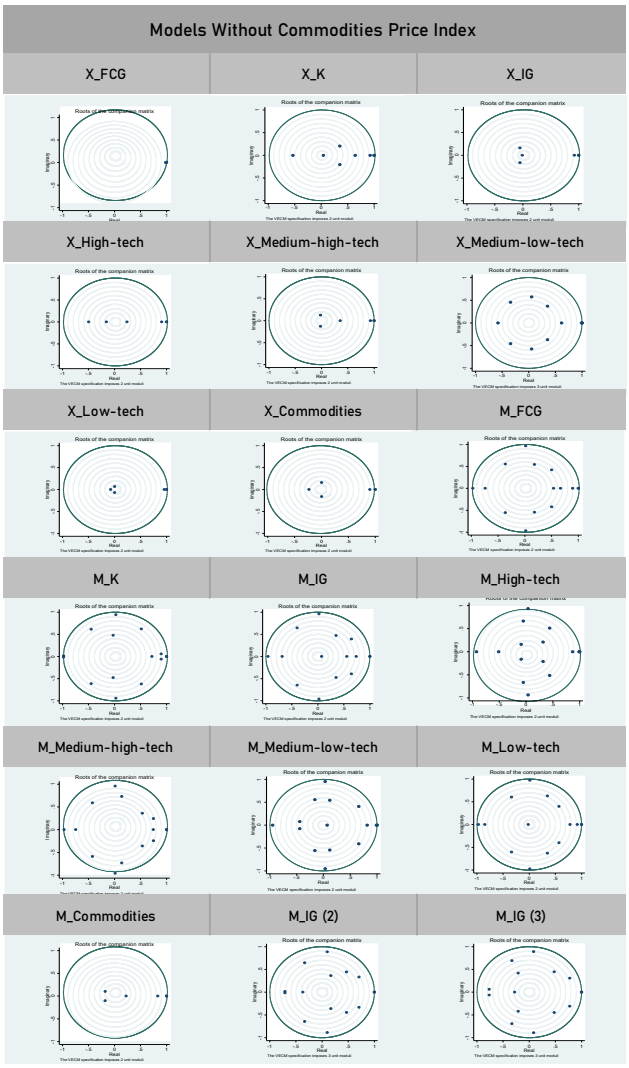
Source: Elaborated by the authors. Note 1: X = exports; M = imports; FCG = final consumer goods; IG = intermediate goods; k = capital goods.

Table A.8. Autocorrelation tests (import model and with GDP without external sector)

VARIÁVEIS DEPENDENTES	Lag(1) Prob > chi2	Lag(2) Prob > chi2	Lag(3) Prob > chi2	Lag(4) Prob > chi2	Lag(5) Prob > chi2	Lag(6) Prob > chi2	Lag(7) Prob > chi2
M_IG (1)	0.442	0.582	0.012	0.204	0.277	0.142	
M_IG (2)	0.101	0.378	0.145	0.323	0.663		
M_IG (3)	0.313	0.475	0.230	0.106	0.600		
M_K	0.000	0.366	0.231	0.026			
M_FCG	0.000	0.860	0.672	0.388			
M_High	0.357	0.033	0.107				
M_Medium-high-tech	0.856	0.941	0.449	0.216	0.935	0.293	
M_Medium-low-tech	0.069	0.201	0.021	0.018	0.607	0.349	0.144
M_Low-tech	0.453	0.750	0.297	0.349	0.819		
M_Commodities	0.006						

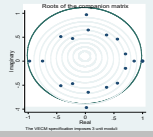
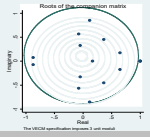
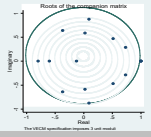
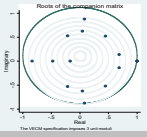
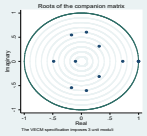
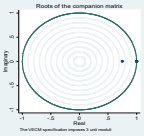
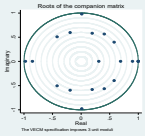
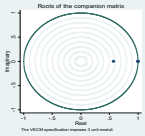
Source: Elaborated by the authors. Note 1: M = imports; FCG = final consumer goods; IG = intermediate goods; K = capital goods.

Table A.9. Stability tests of VAR / VEC models (traditional model)



Source: Elaborated by the authors. Note 1: M = imports; FCG = final consumer goods; IG = intermediate goods; K = capital goods.

Table A.10. Stability tests of the VAR/VEC models for the modified version

Modified Models			
M_FCG	M_K	M_IG	M_High
			
M_Medium-high-tech	M_Medium-low-tech	M_low-tech	M_Commodities
			

Source: Elaborated by the authors. Note 1: M = imports; FCG = final consumer goods; IG = intermediate goods; K = capital goods.