Commodity Prices and the Exchange Rate in an Export-Led Growth Model

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Resumo: Este artigo tem por objetivo desenvolver um modelo de crescimento liderado pelas exportações que incorpora o impacto dos preços das *commodities* sobre o crescimento econômico dos países especializados na produção de *commodities*. Na sequência, realiza-se uma análise empírica para testar a significancia dessas duas variáveis para explicar o crescimento econômico brasileiro no período de 1996 e 2018, considerando a relação comercial do país com a China. Os resultados econométricos demonstram que essas variáveis são importantes para explicar a trajetória de crescimento econômico do Brasil.
Palavras-chave: Lei de Thirlwall; Taxa de Câmbio; Preço das *Commodities*; China; Brasil.

Abstract: This paper aims to develop a model of export-led growth that incorporates the impact of commodity prices on the economic growth of the countries specialized in the production of commodities. Following, we made an empirical analysis to test the significance of these two variables to explain the Brazilian economic growth in 1996 and 2018, considering the country's trade relationship with China. The econometric results show that these variables are essential to explain the trajectory of Brazil's economic growth.
Keywords: Thirlwall's Law; Exchange Rate; Commodity Prices; China; Brazil.
JEL Code: F43; E12

1.   Introdução

In recent decades, the Brazilian economy's growth trajectory has been "stop and go", in nature, alternating between low and medium economic growth. However, between 2003 and 2010, this growth rate demonstrated relative stability, reversing the downward trend, which may have been the result of a dramatic rise in commodity exports and increased commodity prices.

This simultaneity between an increase in growth rates and a boom in commodity exports resurrects an old question, originally presented by the Economic Commission for Latin America and the Caribbean (ECLAC), about how commodity prices and a pattern of economic specialization restricts a country's growth potential.

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In this sense, any rise in commodity prices involves reversing the trend for deteriorating terms of trade, known as the Prebisch-Singer hypothesis, causing temporary alleviation to the external constraint problem faced by commodity producing countries, to the extent that an increase in commodity prices and exports increases the importing capacity of these economies, making it possible to enhance growth rates without further pressurizing external balance.

Under these circumstances and considering the importance of this issue for the formulation of public policies aimed at economic growth and development, this article seeks to create a model that connects commodity prices to the potential output growth of an economy that specializes in commodity production.

Thus, we begin with the concept of balance of payments constrained growth developed by Thirlwall (1979), which demonstrates the limit to economic expansion provided by the ratio between income elasticities of exports and imports. The paper's contribution is to extend this model in line with the assumption that commodity prices is important in explaining long-run growth behavior.

To test this model's explanatory power, we used autoregressive vectors (VAR) to analyze the impact of a shock to the explanatory variables on Brazilian economic growth. Then, we considered the bilateral trade relationship between Brazil and China, given its importance in determining the Brazilian economy's trade flows, particularly over the past decade.

This paper is divided into five sections including this introduction. The second section provides a brief discussion of the theoretical approaches that address external demand as a key growth factor, and studies that discuss the importance of commodity prices and the exchange rate to determine GDP trajectory in countries that produce primary goods. In the third section, we present our model, which incorporates commodity prices in the equation of the balance of payments constrained growth model. In the fourth section, we discuss the methodology, database and econometric results used to test the hypothesis validity empirically. In the fifth and final section, we present our final considerations.

2. Commodity Prices, the Exchange Rate and Export-Led Growth: A Brief Review

Assuming that demand factors are key drivers of long-run economic growth is mainly based on Keynes' (1936) seminal contribution regarding the principle of

effective demand, which asserts that spending on consumption and investment determine an economy's income and employment, meaning that the real output trajectory constitutes a sequence of short-run results, which are, in turn, related to the effective use of available resources, driven by demand behavior.

When considering an open economy, exports are a fundamental component of aggregate demand, meaning that they are essential to any explanation of a country's economic dynamics. As Thirlwall (2011) points out, Harrod's (1933) foreign trade multiplier is one of the first concepts to highlight the importance of the balance of payments equilibrium and, therefore, of net exports for growth. This concept demonstrates that as well as representing a direct stimulus for aggregate demand, an increase in exports also enables an increased growth rate by alleviating the external constraint imposed by the need for the balance of trade equilibrium, allowing other components of aggregate demand (investment and consumption) to grow without pressurizing this equilibrium.

Kaldor (1968) highlights the importance of exports for a country's industrial and economic growth. From this perspective, an increase in exports primarily stimulates the growth of industrial production through a boost in demand. Soon afterward, thanks to productivity gains brought about by increased industrial production, a circular and cumulative process begin through which productivity gains are dissipated by the various economic sectors, improving competitiveness in tradable goods and, consequently, increasing export capacity. It is clear, therefore, that, for Kaldor, growth in investment rates and consumption follows growth in exports, and the latter is the limit for an economy's real domestic product. (Brito; Romero, 2011).

Structuralist Latin American thought, constructed out of Raul Prebisch's original ideas, also considers export growth to be a critical factor in maintaining sustainable growth[1]. In the 1950s, Prebisch argued that the ratio between the income elasticity of exports and the income elasticity of imports is a limiting factor for economic growth, since the trend for rising income elasticity of imports creates an imbalance in the balance of payments, which, if not solved by increased exports, requires a lower economic growth in order to close external accounts. In this case, the number of imported goods should adjust to the "capacity to import" provided by exports in reducing economic growth. Exports relax the external constraint problem presented by Latin American countries.

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[1] Medeiros e Serrano (2001).

As a result of the trade specialization in Latin American economies and in particular in the Brazilian economy, the recent rise in commodity prices has brought to the fore the debate about the importance of commodity prices for long-run growth. At the heart of this debate is the identification of several transmission mechanisms through which commodity prices may affect economic growth:

1. the greater specialization of commodity production and the more the economy depends on foreign markets to absorb this production, the higher the effect of commodity prices;

2. the impact of the terms of trade behavior: Prebisch claims that in economies that specialize in the production of primary goods, there is a structural and permanent trend for deterioration in terms of trade, which involves a loss in the real value of commodity prices compared to manufactured goods. The explanation for this phenomenon is related to the fact that the income elasticity of demand for commodities is low. Also, technical progress spreads slowly and unevenly, since increased productivity achieved by manufactured producers does not result in a relative price reduction for these goods, but in a wage increase from the center to the working class, meaning that peripheral countries do not appropriate the results of this progress. Then, the deterioration in terms of trade means a worsening of external constraint in peripheral countries, lowering their import capacity and hence their potential output growth;

3. the effect of commodity price volatility: According to Carneiro (2012), regardless of the long run price trend, this volatility impacts negatively on economic activity by increasing risk and uncertainty, therefore unsettling productive investment and output. This also creates an environment of insecurity about the realization of tax revenues from commodity exports, which affects public spending plans; and

4. the effect of commodity price changes on the exchange rate. In this case, an increase in income obtained from foreign exchange and the appearance of extraordinary profits caused by rising commodity prices creates pressure for domestic currency appreciation. This appreciation discourages activities related to the production of tradable goods as they lose international competitiveness, causing the economy to return to specializing in less dynamic activities, thus setting up the "Dutch Disease" process (Bresser-Pereira, 2012).

To describe the strategy of external insertion of these countries, it is important to remember the crucial role of the real exchange rate. The rise in the

debate about the relationship between this variable and economic growth is due to the emergence of empirical studies that relate high GDP growth rates to periods in which the real exchange rate is devalued. These empirical regularities have generated a fundamental question: through which channels are these variables connected? The answer has emerged from various theoretical formulations and different schools of economic thought.

In Brazil, we note the recent papers of "structuralist development macroeconomics", which considers the exchange rate to be the cornerstone of this theory. For Oreiro *et al*. (2013), the behavior of the real exchange rate has a decisive impact on an economy's productive structure. This structure determines external performance and the degree of technological content incorporated into household goods. In this sense, the variable is the centerpiece for the establishment of the international division of labor between countries, defining the worldwide distribution of industrial production.

According to this reasoning, a permanently overvalued exchange rate has a disincentive effect on maintaining certain industrial productive activities, triggering a process of productive specialization toward less dynamic sectors, usually related to the production of primary goods. Thus, policy makers should seek an "exchange rate of industrial equilibrium" to ensure that domestic companies close to the world technological frontier can compete in the international market.

Oreiro *et al*. (2013) demonstrate that both the exchange rate level and its volatility are critical to determining investment behavior, since the more unstable this variable is, the higher uncertainty and, consequently, the smaller entrepreneurial willingness to expand the economy's productive capacity.

Bresser-Pereira (2012) argues that economists linked to the Keynesian and Neoclassical approaches have overlooked the importance of the exchange rate in long-run growth, because they expected it to float either gently (neoclassical theory) or in a volatile manner (Keynesian theory) around a point in the current account balance, since this is only a short-run problem. For the author, the real exchange rate has demonstrated a clear trend for appreciation in recent years, hindering domestic companies' access to the international market.

This recent trend for currency appreciation may result from an excessive inflow of foreign capital into the domestic economy, which disrupts the country's industrial production. In this context, a competitive exchange rate (industrial) is

critical to reversing this situation, since it encourages investment in export manufacturing activities and increases domestic savings. Also, more competitive exchange rates modify income distribution, changing the wage share of income and thus changing the economy's dynamics for consumption, investment and savings (Bresser-Pereira, 2012).

Rodrik's (2008) theoretical position is distinct from structuralist development macroeconomics, but also states that there is a positive relationship between undervalued exchange rates and long-run growth, particularly in developing economies. According to this author, the real exchange rate has a decisive influence on the participation of tradable production activities, especially in industry. Thus, devaluation improves this sector's profitability relative to the non-tradable production sector, causing a structural change to developing economies and a process of income convergence across countries.

3.   Commodity Prices in an Export-Led Growth Model

The Thirlwall (1979) growth model was intended to analyze demand to explain why different growth rates exist between countries. In the case of an open economy, the main restriction of demand is the balance of payments. According to McCombie and Thirlwall (1994), long-run economic growth depends on the ratio between income elasticity of exports and imports, assuring the Marshall-Lerner condition and maintaining constant relative prices for tradable goods.

Thirlwall's growth model assumes that the export growth may favor economic growth, however, countries with similar export growth rates do not necessarily incur equivalent growth rates, since we need to observe the income elasticity of demand, given that the imports required by growth differ between countries and that some countries have to force demand sooner than others, in order to equilibrate the balance of payments.

Thirlwall's (1979) model starts with an equitable balance of payments, through which the growth rate compatible with equilibrium in the balance of payments is determined, the latter being measured in terms of domestic currency:

Given that the balance of trade need not be zero, it has:

$$XP_d - P_f EM = NX \tag{1}$$

where
P_d is the price of exports in the domestic currency;
X is the volume of exports;
P_f is the price of imports in foreign currency;

M is the volume of imports;
E is the nominal exchange rate.
NX is the trade balance

Rewriting equation (1) we have:

$$\left[\frac{\hat{L}}{\hat{L}}\frac{X}{L}P_d - \frac{M}{L}EP_f\right]L = NX \tag{2}$$

Where $\hat{L}$ is the external population and L the internal one.

$$\left[\xi\frac{X}{\hat{L}}P_d - \frac{M}{L}EP_f\right]L = NX \tag{3}$$

Dividing by Pd:

$$\left[\xi\frac{X}{\hat{L}} - \frac{M}{L}\left(\frac{P_fE}{P_d}\right)\right]L = \frac{NX}{Pd} \tag{4}$$

With $x = \frac{X}{\hat{L}}$, in$= \frac{M}{L}$ and $\xi = \frac{\hat{L}}{L}$, then the trade balance can be written as follows:

$$[\xi x - me]LP_d = NX \tag{5}$$

Deriving (5) with respect to time, we have:

$$[\xi\dot{x} - \dot{m}e - m\dot{e}]LP_d + [\xi x - me][\dot{L}Pd + \dot{P}_dL] = \dot{N}X \tag{6}$$

Restricting the rate of change in the trade balance to $\dot{N}X = 0$, we achieve the rate of economic growth $\frac{\dot{y}}{y}$ compatible with equilibrium in the trade balance.

Thus, equation (6) determines dynamic equilibrium in the balance of trade:

$$[\xi\dot{x} - \dot{m}e - m\dot{e}]LP_d + [\xi x - me][\dot{L}Pd + \dot{P}_dL] = 0 \tag{7}$$

Knowing that the price elasticities of demand for exports and imports are respectively η and Ψ; and income elasticities of demand for exports and imports are ε and π, respectively.

Equation (8) is the export function:

$$X = b\left(\frac{P_fE}{P_d}\right)^{\eta} Z^{\varepsilon} \tag{8}$$

where:
b is a constant;
η é the price elasticity of demand for exports;
Z is global income;
ε is the income elasticity of demand for exports.

For convenience, equation (8) will be multiplied and divided by the domestic and foreign workforce:

$$\frac{X}{\hat{L}} = \left(\frac{P_fE}{P_d}\right)^{\eta} \frac{Z^{\varepsilon}}{\hat{L}^{\varepsilon}}\frac{\hat{L}^{\varepsilon}}{\hat{L}} \tag{9}$$

Thus, we find:

$$x = \left(\frac{P_f E}{P_d}\right)^{\eta} z^{\varepsilon} L^{\varepsilon - 1} \tag{10}$$

where $z = \frac{Z}{L}$.

Transforming the logarithm in (10) and driving with respect to time, one obtains the following expression:

$$\frac{\dot{x}}{x} = \eta \left(\frac{\dot{P}_f}{P_f} + \frac{\dot{E}}{E} - \frac{\dot{P}_d}{P_d}\right) + \varepsilon \frac{\dot{z}}{z} + (\varepsilon - 1)\hat{n} \tag{11}$$

$$\dot{x} = x\eta \left(\frac{\dot{P}_f}{P_f} + \frac{\dot{E}}{E} - \frac{\dot{P}_d}{P_d}\right) + x\varepsilon \frac{\dot{z}}{z} + x(\varepsilon - 1)\hat{n} \tag{12}$$

The same mathematical operations are conducted in the import function:

$$M = a \left(\frac{P_d}{P_f E}\right)^{\Psi} Y^{\pi} \tag{13}$$

where
a is a constant;
Ψ is the price elasticity of demand for imports;
Y is household income;
π is the income elasticity of demand for imports.

$$\frac{M}{L} = \left(\frac{P_d}{P_f E}\right)^{\Psi} \frac{Y^{\pi}}{L^{\pi}} \frac{L^{\pi}}{L} \tag{14}$$

$$m = \left(\frac{P_d}{P_f E}\right)^{\Psi} y^{\pi} L^{\pi - 1} \tag{15}$$

Transforming the logarithm and differentiating with respect to time, similar to equation (12), we obtain:

$$\frac{\dot{m}}{m} = \Psi \left(\frac{\dot{P}_d}{P_d} - \frac{\dot{P}_f}{P_f} - \frac{\dot{E}}{E}\right) + \pi \frac{\dot{y}}{y} + (\pi - 1)n \tag{16}$$

$$\dot{m} = m\Psi \left(\frac{\dot{P}_d}{P_d} - \frac{\dot{P}_f}{P_f} - \frac{\dot{E}}{E}\right) + m\pi \frac{\dot{y}}{y} + m(\pi - 1)n \tag{17}$$

Considering $\dot{e} = \left(\frac{\dot{P}_f}{P_f} + \frac{\dot{E}}{E} - \frac{\dot{P}_d}{P_d}\right)$ and substituting equation (7) with equations (12) and (17):

$$\left[\xi \left(x\eta \left(\frac{\dot{P}_f}{P_f} + \frac{\dot{E}}{E} - \frac{\dot{P}_d}{P_d}\right) + x\varepsilon \frac{\dot{z}}{z}\right) - \left(m\Psi \left(\frac{\dot{P}_d}{P_d} - \frac{\dot{P}_f}{P_f} - \frac{\dot{E}}{E}\right) + m\pi \frac{\dot{y}}{y}\right)e - m\dot{e}\right]LP_d + [\xi x - me][\dot{L}Pd + \dot{P}_d L] = 0 \tag{18}$$

$$LP_d \xi x\eta \left(\frac{\dot{P}_f}{P_f} + \frac{\dot{E}}{E} - \frac{\dot{P}_d}{P_d}\right) + LP_d \xi x\varepsilon \frac{\dot{z}}{z} - LP_d em\Psi \left(\frac{\dot{P}_d}{P_d} - \frac{\dot{P}_f}{P_f} - \frac{\dot{E}}{E}\right) - LP_d em\pi \frac{\dot{y}}{y} - LP_d m\dot{e} + [\xi x - me][\dot{L}Pd + \dot{P}_d L] = 0 \tag{19}$$

When the economy's export is heavily concentrated on commodity production and the comparative advantages of this sector, the internal price follows

the price of commodities (P_d^c), which are determined by international markets[2]. However, Ono (2014) points out that there is also an indirect effect, through which an increase in commodity prices generates an appreciation in the local exchange rate.

Thus, by simplifying equation (19) and assuming that $n = \hat{n} = 0$, meaning that domestic and foreign population growth are zero, we have:

$$\frac{\dot{y}}{y} = \left[\frac{\xi x \eta + m(e\Psi - 1)}{em}\right]\left(\frac{\dot{P}_f}{P_f} + \frac{\dot{E}}{E} - \frac{\dot{P}_d}{P_d}\right) + \left[\frac{\xi x \varepsilon}{em\pi}\right]\left(\frac{\dot{z}}{z}\right) + \left[\frac{(\xi x - me)}{em\pi}\right]\left(\frac{\dot{P}_d^c}{P_d^c}\right) \qquad (20)$$

Equation (20) demonstrates that growth in commodity prices relaxes an economy's external constraint. Brazil is an exporter of commodities and will benefit from an increase in international prices, increasing its export balance and creating pressure for the appreciation of the exchange rate. An appreciation can generate a pass-through from the exchange rate to prices, particularly of tradable goods, reducing inflation. However, the literature suggests that countries whose economies are highly dependent on commodity exports, such as Brazil's, have a high level of commodity price pass-through to the exchange rate, reducing the effect on their price levels.

In Brazil, commodity exports play a central role in the long-run growth model, since they account for 50% of the export, which has contributed to a relaxation of the external constraint. Countries that significantly depend on commodity exports can, therefore, benefit from a growth in their prices, which are determined by the global market.

4. Methodology, Database, and Results

4.1 Methodology

We used a Vector Autoregression (VAR) methodology. This model enabled us to determine the trajectory of the variable of interest (sectoral and aggregate growth) for future periods given a structural shock to monetary disturbances.

According to Bueno (2008), one can express a VAR of p through a vector with endogenous variables n, X_t, connected by matrix A:

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[2]The Appendix 1 contains a demonstration of this hypothesis using the Johansen test. "Recent studies about commodity prices, such as Awokuse and Yang (2003), Bhar and Hamori (2008), Cheung (2009), Hassam and Salim (2011), Ciner (2011) and Gospodinov (2013) have demonstrated that commodity prices are good indicators of record inflation [...]."(Souza, 2014).

$$AX_t = B_0 + \sum_{i=1}^{p} B_i X_{t-i} + B\varepsilon_t \qquad (21)$$

where:

-A is an *n x n* matrix that defines contemporary constraints between the variables that constitute the vector *n x 1*, X_t;

- B0 is a vector of constants *n x 1*;

- Bi are matrices *n x n*;

- B is an *n x n* diagonal matrix of standard deviations;

- ε_t is a vector *n x 1* of random disturbances not contemporary or temporally correlated, i.e. $\varepsilon_t \sim$ i.i.d. (0, *ln*).

The VAR aims to find the path for the variable of interest when a structural shock occurs, i.e. to ascertain the duration of the shock's effect on the variable, whether it changes its level and other information, to prevent the variables from being individually correlated with errors.

One requirement for time series analysis using VAR is for the series to be stationary. A stationary time series process is observed under the following conditions: 1) the second off-center point must be finite, although it may be uneven across different periods (i.e., conditional heteroscedasticity may occur); 2) the average for the whole period remains equal, even when the VAR distribution continues to change over time; and 3) autocovariance does not depend on time, but rather on the temporal distance found in the observations. These elements do not represent a restriction in terms of the correlation between variables, which may or may not be correlated with each other. Stationarity does require that the nature of any correlation between adjacent terms is the same across all periods. A process that does not follow these assumptions is known as non-stationary (Wooldridge, 2009; Bueno, 2008).

The Impulse Response Function (IRF) is used to circumvent any difficulty in interpreting the estimated coefficients in the individual VAR model. A shock in a model variable affects the variable itself and is also transmitted to other endogenous variables through the structural VAR dynamic. The purpose of the IRF is to track, in the VAR system, the dependent variable's response to shocks, in terms of error, and to ascertain the impact of these shocks on future periods.

Variance Decomposition Analysis (VDA) is related to the model's predictive power. This analysis reveals the percentage of forecast error variance that results from each endogenous variable.

4.2 Database

The variables used to estimate the VAR models may be found below:

- GYBR - Brazil's GDP Growth Rate;
- GYAGRO - Growth Rate in Brazil's Agricultural Sector;
- GYEXT - Growth Rate in Brazil's Extractive Sector;
- GYTRAN - Growth Rate in Brazil's Manufacturing Sector;
- GYIND - Growth Rate in Brazil's Industrial Sector;
- PCOMMOD – Commodity Price Growth Rate;
- GYCHI - China's GDP Growth Rate;
- GREER - Growth rate of the real effective exchange rate. Calculated by the nominal exchange rate (R$/Yuan), inflation rates in Brazil and China (IPCA and CPI), and weighted by the share of exports to China about Brazil's total exports;

Summary information about these variables can be found in the table below:

Table 1 – Variables

Variable	Code	Period	Frequency	Source
Real Effective Exchange Rate (R$/Yuan)	GREER	1996-2018	Quarterly	Calculated*
Brazil GDP Growth Rate	GYBR	1996-2018	Quarterly	IPEADATA
China GDP Growth Rate	GYCH	1996-2018	Quarterly	FMI
Growth Rate Agr. Sector	GYAGRO	1996-2018	Quarterly	IBGE
Growth Rate Ext. Sector	GYEXT	1996-2018	Quarterly	IBGE
Growth Rate Trans. Sector	GYTRAN	1996-2018	Quarterly	IBGE
Growth Rate. Ind. Sector	GYIND	1996-2018	Quarterly	IBGE

Commodity Price Growth Rate	GPCOMMOD	1996-2018	Quarterly	IFS/FMI

Source: Prepared by the Authors.
Note: *Nominal Exchange Rate (IPEADATA), Consumer Price Indices (IMF, OECD, and Eurostat), Price Commodities (IFS /IMF) and Exports (Alice Web/MDIC).

4.3   Analysis of Results for Brazil vs. China Bilateral Relationship

Initially, we subjected the variables to the unit root test to check whether they were stationary, as required by the VAR methodology; we then conducted the Augmented Dickey-Fuller (ADF) test. All variables were stationary at a significance level of 5%, except for the GYBR variable.[3] These variables were therefore used at level, and it was therefore not necessary to differentiate between them. The ADF test results are summarized in the table below:

Table 2 – Augmented Dickey-Fuller Test (ADF) for Stationarity

Discrimination	Lag	Constant	Trend	T Statistic	Critical Value 5%
GYBR	8	No	No	-1.516351	-1.944811
GYAGRO	8	No	No	-3.223230*	-1.944811
GYEXT	1	Yes	No	-9.796840*	-1.944487
GYTRAN	3	No	No	-4.759181*	-1.944574
GYIND	3	No	No	-3.772335*	-1.944574
PCOMMOD	1	No	No	-6.341586*	-1.944487
GYCHI	5	Yes	No	-5.111028*	-2.896346
GREER	0	No	No	-7.891161*	-1.944445

Source: Prepared by the Authors from Eviews 10.
* Significant at 5%
** Significant at 10%

We used Akaike (AIC), Schwarz (SC) and Hannan-Quinn (HQ) information criteria to set the number of lags in the model. When the criteria indicated different lag numbers, we chose the number provided by the majority.

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[3]According to KPSS and Phillips-Perron Tests Statistics, the GYBR is a stationary variable. More details see Appendix 2.

To avoid arbitrariness, we used the Block Exogeneity Wald Test in order to define a statistically consistent ordering of the variables. This statistical test showed the join significant of the lagged explanatory variables for each equation from VAR.

We applied the Impulse Response Function (IRF) and Variance Decomposition Analysis (VDA) to the bilateral relationship between Brazil and China, given that China is Brazil's main trading partner. We also used these tools to analyze effects on sectoral economic growth relating to this trading partner. Forecasts were made for the next six periods, from 2019/01 to 2020/02.

Figure 1 shows the impulse response function for the GDP growth rate variables and selected sectors, arising from shocks to variables such as the real effective exchange growth, China's GDP growth and commodity prices growth.

Figure 1 - Impulse Response Functions for Commodity prices on Aggregate and Sectoral Growth in the Brazilian Economy arising from Bilateral Relations with China
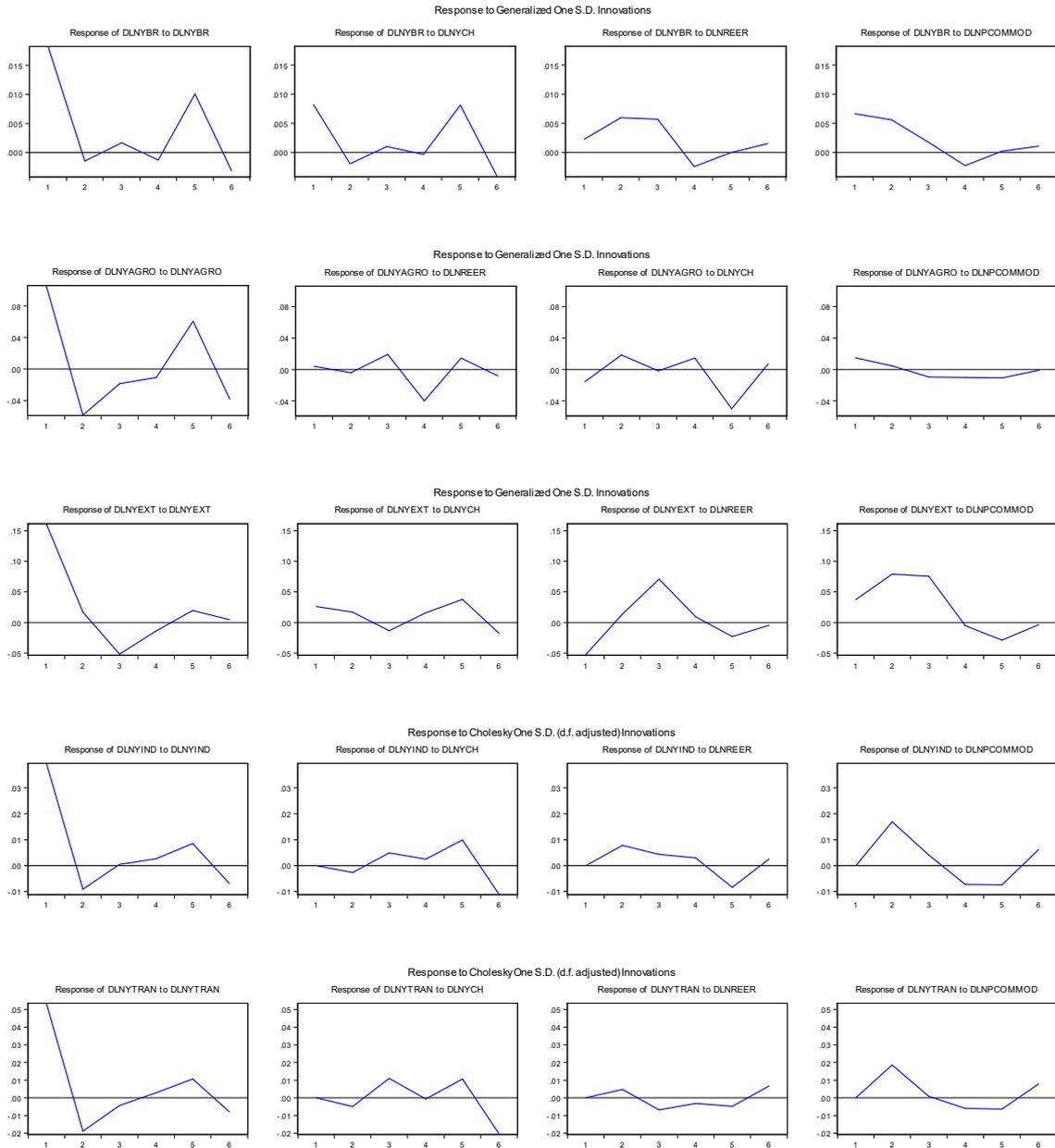
Source: EViews 10 Output.

The forecasts show that all the variables contributed to sectoral and aggregate growth in the Brazilian economy, but the Chinese economic growth contributed little with Brazilian economic growth in this period.

Note also that the tendency of the exchange rate contributed to the Brazilian economic growth. The main sector that benefited the most from the exchange rate

was the extractive industry. The results show that the Brazilian economy and the industrial sectors also benefited from the commodity price trajectory, except for the agricultural sector.

The Variance Decomposition Analysis (VDA) more clearly demonstrates both aggregate and sectoral growth peculiarities, enabling a better understanding of the role that variables such as commodity prices, Chinese economic growth, and the real exchange rate, when investigating the Brazil-China bilateral relationship.

The table 3 shows the predictions for the next periods. The results indicated that commodity prices are an important determinant of aggregate and sectoral growth in the Brazilian economy, but explained little of the economic performance of the agricultural sector.

Note that the manufacturing sector demonstrated a specific feature within this bilateral relationship since it was the sector that presented the higher dependence about Chinese economic growth.

Although all sectors demonstrated some dependence on the exchange rate and commodity prices to grow, the extractive sector was most affected by this variable. In this case, of the extractive sector, Chinese economic growth has lost importance in the current period.

Table 3 – Variance Decomposition Analysis (VDA)

ENDOGENOUS VARIABLE	PERIOD	S.E.	COMMODITY PRICES	GYCHI	GREER	OWN VARIABLE
GYBR	6	0.024863	10.53630	4.462529	**12.60864**	72.39253
GYAGR	6	0.157885	**1.957153**	8.499216	8.681135	80.86250
GYEXT	6	0.227781	**27.48005**	**1.663385**	**17.76997**	53.08659
GYIND	6	0.051212	**17.05498**	9.734024	6.293616	66.91738
GYTRAN	6	0.068716	10.30168	**14.37485**	**3.100343**	72.22313

Source: EViews 10 Output.

Since this paper is positioned within the literature related to export-led growth, our analysis should include some data regarding Brazilian exports to China. In Graph 1, we note that the participation of China in Brazilian exports has increased significantly in recent years, from 2% to 27% of total exports, making China Brazil's main trading partner.

**Graph 1 – China's Participation in Brazilian Exports (%)**

Years
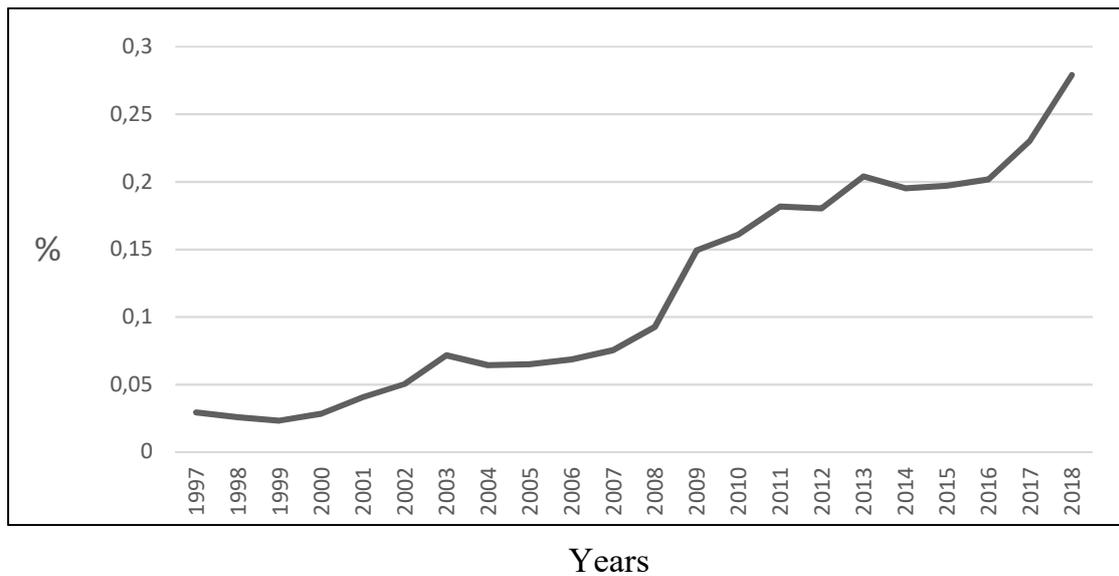
Source: AliceWeb – MDIC/Secex.

According to MDIC/Secex, over this period, Brazilian exports to China mainly consisted of commodities, derived from both the agricultural and extractive sectors. Currently, these products represent approximately 85% of the total, compared to 15% of industrialized products (semi-manufactured and manufactured), with the former presenting an upward trend from 2003 onwards.

Since 2001, there has been a substantial increase in international commodity prices, significantly benefiting growth in the Brazilian economy, as demonstrated by the variance decomposition, but commodity price suffered a decrease in the recent period, which reduced the importance of this variable in the trade with China.

Graph 2 – Commodity Price Index (2005 = 100)
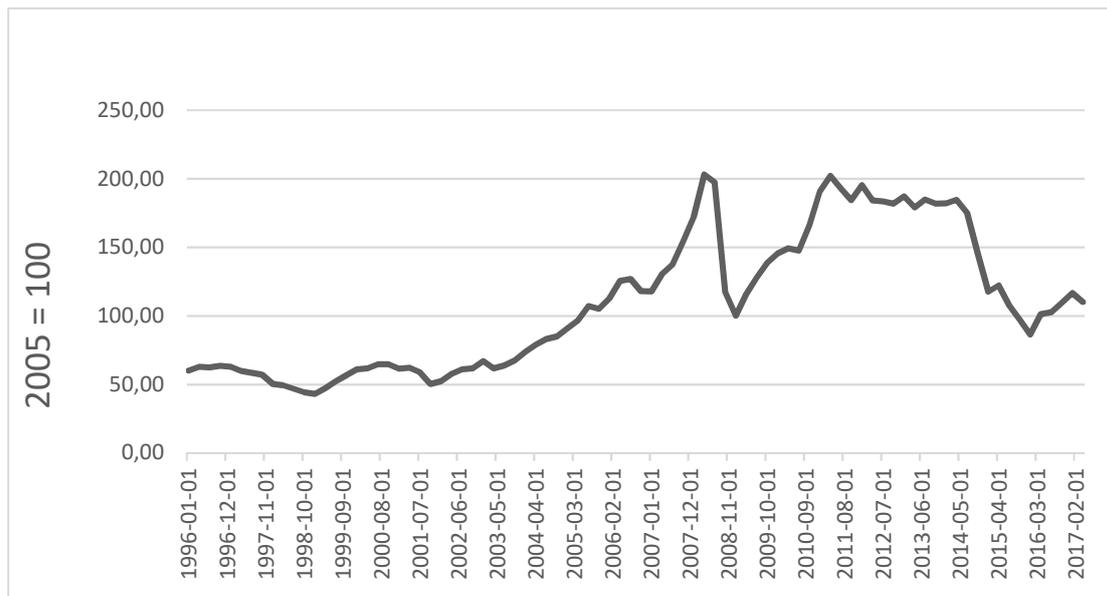
Source: International Financial Statistics – IFS/FMI

In short, in recent years, Brazil's economic growth has followed growth in the Chinese economy, based on the current pattern of trade specialization, focused on commodity exports. Brazil is benefiting from high international commodity prices and high demand for its products in China.

According to the World Bank, in 1996, Brazil exported more commodities from the agricultural sector than the extractive one. From 2005 onwards, this proportion was reversed, due to high Chinese demand for commodities from the extractive sector, such as iron ore and oil. Although exchange rate appreciation over this period hurt the extractive industry, growth in this sector was ensured by a sharp increase in demand from China, which became Brazil's main trading partner in 2009, with a 15% share of total Brazilian exports.

Overall, these econometric results suggest that the extractive sector isn't more sensitive to China's income, but it is the sector that most responds to commodity price and exchange rate. The Brazil-China commercial relationship has grown in recent years, due to high Chinese demand for commodities.

5.   Concluding Remarks

This paper aims to demonstrate the importance of both commodity prices and the exchange rate in determining growth in economies that specialize in commodity production, which has intensified over the last decade. The resumption of the debate on this topic begins with an observation of the simultaneous

commodity boom and increased growth rates in economies specialized in such products.

To explain the relationship between these two phenomena, we designed a model of growth under external constraint, which incorporated the impact of both commodity prices and the exchange rate on the growth potential of a commodity-producing country.

The main results obtained through empirical analysis support the hypothesis that commodity prices and the exchange rate are important in explaining the Brazilian economy's growth trajectory when analyzing its commercial relationship with China. In other words, we could say that expansion in external demand, promoted by significant growth in the Chinese economy, raised commodity prices, relaxing external constraint to the growing problem faced by the Brazilian economy. Moreover, the impact of exchange rate valuation caused by the increase in commodity prices was not enough to reverse the positive effect of this price increase on Brazilian growth.

In the light of these results, there appears to be significant evidence that the growth dynamics of the Brazilian economy can largely be explained by elements external to it, such as the behavior of global income, the exchange rate and movements in commodity prices, which are determined exogenously. It is therefore important to draw up a growth strategy that ensures that the domestic economy is less dependent on the behavior of prices of commodities traded on the world market; one that neither involves the extinction of this sector nor disregards the comparative advantages for Brazil in producing these goods. Any such proposal, however, must include the diversification and expansion of export opportunities, by changing the production structure, and maintaining and strengthening existing industrial activities in Brazil.

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Appendix 1

Sample: 1996Q1 2018Q4
Included observations: 89
Series: LNIPCA LNPCOM
Lags interval: 1 to 2

Selected (0.05 level*) Number of Cointegrating Relations by Model

Data Trend:	None	None	Linear	Linear	Quadratic
Test Type	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend
Trace	1	1	1	0	1

| Max-Eig | 1 | 1 | 1 | 0 | 1 |

*Critical values based on MacKinnon-Haug-Michelis (1999)

Information Criteria by Rank and Model

Data Trend:	None	None	Linear	Linear	Quadratic
Rank or No. of CEs	No Intercept No Trend	Intercept No Trend	Intercept No Trend	Intercept Trend	Intercept Trend

Log Likelihood by Rank (rows) and Model (columns)

0	-32.13751	-32.13751	-31.76329	-31.76329	-31.59929
1	-22.70362	-22.57827	-22.22995	-22.16178	-21.99796
2	-22.46461	-21.34206	-21.34206	-20.91825	-20.91825

Akaike Information Criteria by Rank (rows) and Model (columns)

0	0.901966	0.901966	0.938501	0.938501	0.979759
1	0.779857*	0.799512	0.814156	0.835096	0.853887
2	0.864373	0.884091	0.884091	0.919511	0.919511

Schwarz Criteria by Rank (rows) and Model (columns)

0	1.125664	1.125664	1.218123	1.218123	1.315306
1	1.115403*	1.163020	1.205627	1.254529	1.301282
2	1.311769	1.387411	1.387411	1.478755	1.478755

Source: EViews 10 Output

Appendix 2

Null Hypothesis: DLNYBR is stationary
Exogenous: Constant
Bandwidth: 16 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.176755
Asymptotic critical values*:	1% level	0.739000
	5% level	0.463000
	10% level	0.347000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.001850
HAC corrected variance (Bartlett kernel)	0.000781

KPSS Test Equation
Dependent Variable: DLNYBR
Method: Least Squares
Date: 04/01/19   Time: 08:29
Sample (adjusted): 1996Q2 2018Q4
Included observations: 91 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.009638	0.004534	2.125762	0.0363

R-squared	0.000000	Mean dependent var	0.009638
Adjusted R-squared	0.000000	S.D. dependent var	0.043251
S.E. of regression	0.043251	Akaike info criterion	-3.432649
Sum squared resid	0.168361	Schwarz criterion	-3.405057
Log likelihood	157.1855	Hannan-Quinn criter.	-3.421517
Durbin-Watson stat	2.573088		

Source: EViews 10 Output

Null Hypothesis: DLNYBR has a unit root
Exogenous: Constant
Bandwidth: 24 (Newey-West automatic) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-13.57024	0.0001
Test critical values:	1% level	-3.504727	
	5% level	-2.893956	
	10% level	-2.584126	

*MacKinnon (1996) one-sided p-values.

Residual variance (no correction)	0.001687
HAC corrected variance (Bartlett kernel)	0.001207

Phillips-Perron Test Equation
Dependent Variable: D(DLNYBR)
Method: Least Squares
Date: 04/01/19   Time: 08:33
Sample (adjusted): 1996Q3 2018Q4
Included observations: 90 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLNYBR(-1)	-1.300890	0.101890	-12.76761	0.0000
C	0.011966	0.004477	2.672995	0.0090

R-squared	0.649419	Mean dependent var	9.00E-05
Adjusted R-squared	0.645435	S.D. dependent var	0.069767
S.E. of regression	0.041543	Akaike info criterion	-3.502190
Sum squared resid	0.151874	Schwarz criterion	-3.446639
Log likelihood	159.5986	Hannan-Quinn criter.	-3.479789
F-statistic	163.0118	Durbin-Watson stat	2.149378
Prob(F-statistic)	0.000000		

Source: EViews 10 Output