Effects of higher commodity prices on exports of manufactures: the case of Brazil

André Moreira Cunha, Marcos Tadeu Caputi Lélis, Sabrina Monique Schenato Bredow and Luciane Franke

Abstract

This study seeks to determine whether the increased earnings of Brazil's trading partners that benefited from the boom in commodity prices during the 2000s spurred Brazilian exports of manufactures to those countries. It begins with the hypothesis that there is a positive link between Brazil's exports of manufactured goods and the increased revenues of its trading partners derived from the robust performance of their exports of natural resources. A two-stage hierarchical statistical model based on a panel data structure is used to estimate a crosss-section data model. To our knowledge, this strategy has not been used before to study the behaviour of Brazilian manufactured exports during the economic boom of the 2000s fuelled by the commodity supercycle.

Keywords

Commodities, commodity prices, business cycles, industrial development, international trade, manufactures, exports, econometric models, Brazil

JEL classification

F14, F44, O14

Authors

André Moreira Cunha is a Professor of the Postgraduate Economics Programme of the Federal University of Rio Grande do Sul and a Research Fellow of the National Council for Scientific and Technological Development (CNPq). Email: andre.cunha@ufrgs.br.

Marcos Tadeu Caputi Lélis is an Associate Professor of the Postgraduate Economics Programme of the University of Vale do Rio dos Sinos and a Research Fellow of the National Council for Scientific and Technological Development (CNPq). Email: mlelis@unisinos.br.

Sabrina Monique Schenato Bredow holds a Ph.D. in Economics from the Federal University of Rio Grade do Sul and is an Economic Adviser to the Credit Division of the Banco do Brasil. Email: sabrinabredow@gmail.com.

Luciane Franke is a doctoral candidate in the Postgraduate Economics Programme of the Federal University of Rio Grande do Sul. Email: luciane.franke@hotmail.com.

I. Introduction

In a departure from the trend seen in the 1980s and 1990s, the prices of agricultural, mineral and energy commodities rose sharply during much of the first two decades of the twenty-first century in what has been described in the specialized literature as a "supercycle" (Sinnot, Nash and De la Torre, 2010; IMF, 2015; Fernández, González and Rodríguez, 2015; Alberola-Ila and others, 2016; World Bank, 2009; De la Torre, Filippini and Ize, 2016; UNCTAD/FAO, 2017; ECLAC, 2017). This appears to have been attributable to a combination of several different factors, including the expansion of global demand brought about by the rapid urbanization and growth of income in emerging countries, such as, in particular, China; insufficient investment in the production and distribution of some commodities, such as oil and petroleum products; and the "financialization" of prices, against a backdrop of expanding global liquidity.

The specialized literature suggests that this supercycle's positive impact on the terms of trade is what accounts for the strong macroeconomic and social performance of commodity-producing and commodity-exporting countries during this period. Throughout the 2000s and up to at least mid-2010 —but continuing at a somewhat slower pace until 2013— there was a widespread and quite unusual combination of accelerating economic growth, improving public accounts and balance of payments results, declining monetary poverty rates and increasingly positive human development indicators in such areas as education and health (ECLAC, 2018). This economic buoyancy apparently eased the widespread external and fiscal constraints that typically hold back emerging and developing countries, thus allowing them to step up investment in physical and social infrastructure. There was a partial break in this trend in 2008 and 2009 owing to the impact of the global financial crisis, followed by a reversal when commodity prices began to fall steeply in 2014.

This study looks at some of the effects that those years of strong growth may have had on Brazilian exports. There are at least two channels through which the favourable terms-of-trade effects generated by that period of robust growth could have been transmitted to external sales of goods: a direct one, via the rising prices and export volumes of commodities and commodity derivatives; and an indirect one, via the increase in exports of manufactured goods to economies specialized in the production and exporting of natural resources. This study will focus on that second channel in an effort to determine to what extent the increased revenues of Brazil's trading partners, which also benefited from the upswing in commodity prices, spurred Brazilian exports of manufactured goods to those countries. The study departs from the hypothesis that there is a positive link between Brazil's exports of manufactured goods and the increased revenues of its trading partners derived from the robust performance of their exports of commodities and natural resource-intensive goods.

As a first step in testing this hypothesis and pursuing the study's objective, a sample of 51 national markets for Brazil's manufactured exports was selected, which includes countries in Africa and Latin America known as producers and exporters of natural resources. During the study period (2001–2015), these countries bought approximately one third, on average, of the manufactured goods sold by Brazil on international markets. In order to establish the direct income effect of the upward swing in commodity prices, we used the value of exports of commodities and of resource-intensive goods, following the taxonomy of Pavitt (1984), as a proxy. In terms of the methodology, a dynamic panel data model was used to perform the empirical exercise. To our knowledge, this strategy has not been used before to study the behaviour of Brazil's exports of manufactures in the 2000s during the boom driven by the commodity supercycle (Castilho and Luporini, 2010; Bastos, 2012; Hiratuka and others, 2012; Jenkins, 2014; Medeiros and Cintra, 2015; Lélis and others, 2018; Lin, 2018).

Apart from this brief introduction, the study is divided into three sections: a review of the literature (section II) lays the groundwork for our presentation of the econometric exercise performed to provide input for the debate around this issue (section III). Conclusions (section IV) are then provided regarding the main results and their implications.

II. The commodity supercycle and exports of manufactured goods: a brief review of the literature

The recent upswing in commodity prices had a positive impact on the terms of trade for net commodity exporters (World Bank, 2009; De la Torre, Filippini and Ize, 2016; UNCTAD/FAO, 2017; ECLAC, 2017). Although this factor alone is not enough to reduce these economies' exposure to the problems associated with the unfavourable price structure and income elasticities of demand[1] described in the seminal works of Prebisch (1950) and Singer (1950), steeply rising commodity prices and dollar-denominated export earnings can diminish or even temporarily cancel out the negative pressure on such countries' balance of payments because the increased revenues generate a disproportionately large jump in the demand for manufactured goods. In the 2000s, these factors opened up an extraordinary opportunity for countries with commodity-based production structures to step up their pace of growth without having to deal with the external constraints that generally hold them back.

The growth of the income and domestic markets of commodity-exporting countries was not brought about solely by the increase in commodity prices, however. The domestic policies[2] adopted by these countries during this period were also influential. Nonetheless, while it is true that these economic policies drove the growth of aggregate demand, the fact remains that the increase in commodity prices[3] and improvement in the terms of trade were what ensured the viability of that growth and its compatibility with a balance-of-payments equilibrium. This translated into higher employment, higher income, an upswing in productive investment, improved solvency and more ample external liquidity thanks to greater inflows of foreign currency from exports, direct investment and portfolio investments, along with a reduction in physical vulnerabilities (World Bank, 2009; De la Torre, Filippini and Ize, 2016; Sinnot, Nash and De la Torre, 2010; IMF, 2015).

In Latin America, these conditions opened the way for greater trade integration among the countries of the region (Bastos, 2011 and 2012; ECLAC, 2017). Favourable external conditions and increased profitability in the primary export sector, combined with economic policies designed to promote internal market growth and income distribution, played a fundamental role in this process (IMF, 2015; De la Torre, Filippini and Ize, 2016). Brazil wielded a great deal of diplomatic influence during this period and proved to be one of the countries that gained the most from the economic boom (Bastos, 2011 and 2012; Alberola-Ila and others, 2016; De la Torre, Filippini and Ize, 2016). During the commodity supercycle, Latin America as a whole relied on its commodity export earnings to finance its intraregional imports of manufactures, and a substantial portion of those came from Brazil, which consequently amassed hefty trade surpluses. Bastos (2012) and Castilho and Luporini (2010) therefore point out that the Brazilian

[1] A large and varied body of literature focuses on empirical evidence to back up the ideas espoused by Prebisch and Singer (Sinnot, Nash and De la Torre, 2010; UNCTAD/FAO, 2017). The empirical debate around whether or not there is a downward trend in the terms of trade for primary producers and about the normative implications of such a trend if it does exist continues to be quite animated. There is, however, a growing consensus around the outcomes of commodity price volatility. In addition, in balance-of-payments-constrained growth models such as those devised by Thirlwall (1979) —even without taking a downward trend in commodity prices into account— the structure of the income elasticity of demand for commodities and manufactured goods is enough in itself to block convergence between the economic growth of commodity exporters in the presence of the external constraints affecting them and the economic growth of exporters of manufactures (Nassif, Feijó and Araújo, 2015; Cimoli and Porcile, 2014; Lélis and others, 2018. Within a different framework, Gruss (2014) and IMF (2015) show that economies that specialize in the production and exportation of natural resources grow less over the long term.

[2] See, among others, Bastos (2011 and 2012), Castilho and Luporini (2010), Medeiros and Cintra (2015), Serrano (2013), Black (2015), World Bank (2009); De la Torre, Filippini and Ize (2016), UNCTAD/FAO (2017) and ECLAC (2017 and 2018). This literature suggests that there is no automaticity mechanism at work between variations in commodity prices and economic growth: transmission channels have to be reinforced in order for countries to tap into favourable external conditions.

[3] For further details, see Serrano (2013) and UNCTAD/FAO (2017).

economy benefited both directly (owing to the increased volume and prices of its commodity exports) and indirectly (owing to the increased volume of its manufactured exports to commodity-exporting countries) from higher commodity prices.

The competitive advantages of Brazil's industrial sector vis-à-vis other developing economies, and especially those in Latin America and Africa, enabled it to capitalize on this favourable set of conditions to expand its exports of manufactured items. Despite the difficulties experienced by the country in the 1980s (a sharp contraction of its domestic market and the breakdown of the import substitution process,[4] brought about by its external debt crisis) and 1990s (massive inflows of external capital, soaring imports and an atrophying industrial export sector), it continued to be in a different position than the rest of the Latin American countries, and a number of its economic sectors were more developed than those of the other countries in the region in terms of both scale and productivity (Medeiros and Serrano, 2001; Carvalho and Kupfer, 2011; Naudé, Szirmai and Haraguchi, 2016; Hiratuka and Sarti, 2017). As a result, even though a large part of its exports are commodities, Brazil's industrial sector is highly diversified and its production structure (especially in the case of processing industries) is technologically more complex than those of its trading partners in the region (Castilho and Luporini, 2010; Ferraz and Marques, 2014; UNIDO, 2015; ECLAC, 2017).

In the 2000s, and especially between 2003 and 2008, Brazil consolidated its position as a major exporter of commodities to China and as an important supplier of manufactured items to countries in its region, although the strength of that position was diminished somewhat by growing competition from Asian manufacturing, especially Chinese products. This competition intensified during the ensuing international economic crisis since, when developed-country demand began to slacken, China started to seek out emerging markets to sustain its export growth (Lélis, Cunha and Lima, 2012; Silva and Hidalgo, 2012; Black, 2015; Hiratuka and Sarti, 2017). Yet despite these competitive pressures and the loss of some regional market share by several Brazilian industrial sectors, the strong ties between Brazil and its resource-intensive trading partners can account for the upturn in Brazilian exports of manufactured products during the commodity price boom.

Studies by Black (2015), De la Torre, Filippini and Ize (2016), ECLAC (2017), UNCTAD/FAO (2017) and others indicate that the growth in manufactured export volume to these countries might have been a channel[5] for the positive effects of the recent upturn in commodity prices on Brazil's economic growth. This channel basically functioned through nominal price increases for commodities and improved terms of trade of commodity-exporting countries, which boosted the earnings of Brazil's trading partners and their ability to import manufactured goods to satisfy expanding aggregate demand. The gain in commodity prices in both absolute and relative terms improved the Latin American countries' terms of trade, and the more those countries exported commodities and imported manufactured items, the greater that improvement was.

Bearing in mind this overall context and the main objective of this study, the following discussion will address research that helps to explain what factors influenced Brazilian exports in the 2000s. This review, which is by no means exhaustive, will primarily focus on possible transmission channels between climbing commodity prices and trends in exports of manufactures. These studies have used differing approaches and theoretical frameworks to examine micro- and macroeconomic factors associated with export supply and/or demand on the basis of sector-specific or aggregate data. Increasing attention is

[4] For Medeiros and Serrano (2001), the more favourable levels of commodity prices relative to those of manufactured products, ample international liquidity and active public policies made it possible to intensify the import substitution process in the 1970s. This quickly led to the expansion and diversification of Brazil's industrial base that brought it to the fore among developing countries and enabled the country to increase its manufactures exports.

[5] Black (2015) identifies five such channels: (i) the price effect on commodity exports; (ii) the volume effect on exports of manufactures to commodity-exporting countries; (iii) increased employment in the commodity sector; (iv) the opportunity to boost imports to meet domestic demand; and (v) increased tax revenues.

being paid to the competitive position of Brazilian manufactured exports, especially in markets where Brazil has traditionally enjoyed advantages that are now being challenged more forcefully by China (Silva and Hidalgo, 2012; Lélis, Cunha and Lima, 2012; Pereira, 2014; Jenkins, 2014; Bichara and others, 2016).

In an effort to calculate the impact of the exchange rate on Brazilian exports and imports between 1996 and 2012, Carneiro (2014) estimated the elasticities of Brazil's exports using two different models: first, through cointegration tests to analyse both export supply and export demand variables at the same time; second, through a uniequational model with separate estimations of export demand and supply functions, although that method could risk biases in parameter estimates. In addition to analysing the determinants of aggregate exports, the author estimated models with the dependent variable of export volumes broken down into the categories of basic, semi-manufactured and manufactured products. In this case, the following explanatory variables were used: index of mean wages in the industrial sector (proxy for costs); total world imports (proxy for external income); relative export prices, calculated by dividing the Brazilian export price index by the global import index; the price of exports as calculated by dividing the real-denominated Brazilian export price index by the extended national consumer price index (IPCA); the industrial production index for estimates of manufactured items (a proxy for installed capacity), and the installed capacity utilization rate for the other categories; the London Inter-Bank Offered Rate (LIBOR) (a proxy for the financial cost); and dummies to control for the effects of the steep devaluation of the real in 1999, the 2002 elections and the failure of Lehman Brothers in 2008.

In general, over both the short and long term, the results for aggregate exports reflect a substantially greater response to external income (parameters between 1.024 and 1.049), while the price elasticity of demand is negative (-0.3). Supply-side factors proved to be insignificant. The results are similar to those obtained for semi-manufactured and manufactured items, except that, in the latter case, relative price variations also displayed a strong potential for influencing the demand for Brazil's exports. In sum, the main statistically significant parameters for the different models are as follows: income elasticity for semi-manufactures of between 0.409 and 0.817, with a greater potential for influencing exports than the other variables have, especially in the short run; an income elasticity for manufactured items of between 1.153 and 2.159; and a price elasticity of demand of between -0.93 and -1.819.

Using a similar econometric tool, Castilho and Luporini (2010) look into the income elasticity of Brazilian exports by country of destination, including Argentina, Chile and Mexico. These authors' research covers the period from 1986 to 2007 and is based on a single-equation distributed-lag model. The following variables were used: volume and price indices for Brazilian exports, by sector of activity; relative prices of exported products; GDP of the country of destination; the exchange rate for the Brazilian real and the currency of the destination market; and Brazil's installed capacity utilization rate. Their findings indicate that Brazilian exports of manufactured goods are more sensitive to demand conditions, especially in terms of variations in the incomes of their Latin American neighbours, particularly Argentina. The cointegration tests run as part of this study of Brazil's regional trade performance point to a long-standing link between Brazilian exports of manufactured products and domestic economic conditions in the various countries. They also indicate that all of these countries, including Brazil, rely on commodity price cycle upswings to spur economic growth.

A study conducted by Kawamoto, Santana and Fonseca (2013) that does not focus on the region is nonetheless useful for comparing the influence exerted by changes in prices and income on the demand for Brazilian exports. Their findings indicate that exports were more sensitive to changes in export earnings than to price changes between 2003 and 2010. Interestingly, they also find a negative and apparently spurious relationship between export volumes and the exchange rate. These authors used panel data and various estimators to gauge the scale of possible dynamic effects. They show that these effects were robust using a least-squares dummy variable corrected (LSDVC) estimator, with an increase of 10% in current exports leading to a 6.1% increase in exports in the following period. The dependent variables are indices of export volumes for 20 different processing industries. Among

the explanatory variables, external earnings were calculated using industrial production indices for the United States, Japan, Canada, Mexico, the United Kingdom, France, Italy and the Republic of Korea and weighted by these countries' share of Brazil's exports of manufactured products.

In order to determine if Brazil's economic growth is constrained by its balance of payments, the estimates calculated by Lélis and others (2018) of the demand function of exports indicate that total external sales were highly sensitive to global income and to commodity price fluctuations between 1995 and 2013. The results for the real exchange rate, on the other hand, were spurious. One of the important contributions made by this study is its use of the general commodity price and the world income index as explanatory variables, which were estimated on the basis of the GDP of 46 countries representing 90% of world GDP. The authors of this study use vector auto regression (VAR), vector error correction (VEC) and structural state of space models, the latter being applied specifically to the estimated period of strong commodity prices (2001–2013).

The study conducted by Hiratuka and others (2012), which focuses on the effects of China's increasing economic power on Latin American trade between 2000 and 2009, is perhaps the one that is most closely aligned with the present study. In addition to investigating the possible crowding-out effect of stronger Chinese competition on regional trade in manufactured goods, the authors analyse the impact of the region's increased commodity exports to China on intraregional trade in manufactures among the member countries of the Latin American Integration Association (LAIA). The demand effect is investigated using a gravity model whereby the manufactured imports of country i from country j, which is a member of ALADI, are explained on the basis of the aggregate exports of country i to China and the GDP and per capita GDP of country i. The possible endogeneity between the exports of country i to China and GDP-related variables is controlled for by the independent variables traditionally used in models of this type, such as the geographic distance between China and country i. Another problem resolved by the study is the presence of null values for sectoral trade, which are replaced by a value close to zero (0.0001). The study's findings show that intraregional trade in manufactured goods was positively influenced by the increase in the region's commodities exports to China during the study period and that Brazil was the country that benefited the most from this demand effect.

In summary, the above studies of the sensitivity of Brazilian exports to price and income variations provide empirical support for the hypothesis that external revenue, and possibly the external revenue of Brazil's trading partners in the Latin American and Caribbean region as well, may have played an influential role in fuelling Brazil's exports of manufactures during the commodity price boom. Taking these contributions into account, the following section presents the econometric model used for the present study and our research findings.

III. Empirical evaluation of the link between the boom in commodity prices and Brazilian exports of manufactured goods

This section presents the sources, data treatment and estimated results for the statistical exercise undertaken in an effort to determine what impact commodity prices have had on Brazil's exports of manufactured products. To this end, the direct income effect of trading partners' commodity exports is analysed. The point of departure is the proposition that variations in commodity prices influence the income levels of the countries covered in this research by altering the value of their exports. The model we employ does not deal with the indirect or induced income effect, which is presumed to be the result of increases in private and public investment and domestic expenditure stemming from terms-of-trade shocks generated under the conditions analysed in the specialized literature (IMF, 2015;

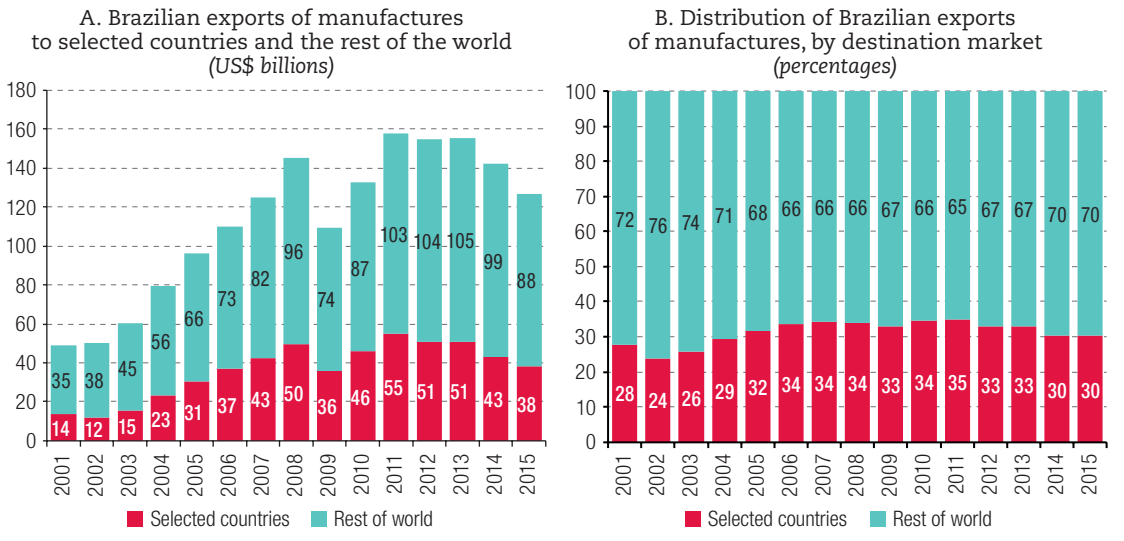
World Bank, 2009; De la Torre, Filippini and Ize, 2016; UNCTAD/FAO, 2017). The estimated model is used to establish the relationship between Brazil's exports of manufactured goods and their relative degree of dependence on trading-partner sales of natural resources and/or resource-intensive goods.

This exercise covers 51 African and Latin American trading partners.[6] These regions are heavily specialized in the development and exportation of natural resources and are major buyers of Brazilian manufactured items (purchasing five times more than the international average). More specifically, from 2001 to 2015,[7] an average of 3.8% of those countries' imports of manufactured goods came from Brazil, which accounted for only 0.7% of global exports of these products. Moreover, during that period, these markets absorbed a third, on average, of Brazil's total exports of manufactured goods.

This information is mapped out in figure 1, which shows, for example, that exports of manufactured items to the countries in the sample more than trebled between 2003 and 2008, jumping from US$ 15 billion to US$ 50 billion and then remaining at that level until 2013 (panel A). During that same period, total exports of manufactures doubled, and then rose to the equivalent of US$ 100 billion over the next five years. The share of those exports bought by the trading partners in the sample therefore climbed from 26% (2003) to 34% and then to 35% (2015) (panel B).

In 2014 and 2015 —when the upward phase in the supercycle of commodity prices gave way to a downturn, triggering a sudden slowdown in the growth of emerging and developing economies, especially those specializing in the development and exportation of natural resources— exports of manufactured goods to the markets in the sample and to the rest of the world plunged by 20% (De la Torre, Filippini and Ize, 2016; UNCTAD/FAO, 2017). While Brazil accounted for around 3.0% of the imports of manufactured products for the countries in the sample before the supercycle, that figure rose to 4.5%, on average, during the years when prices were booming (up to 2011). In other words, Brazil expanded its market share in those markets (panel C). This stands in contrast to what was occurring in the rest of the world, where its market share shrank (panel D).

Figure 1
Brazilian merchandise exports in selected countries and worldwide, 2001–2015[a]

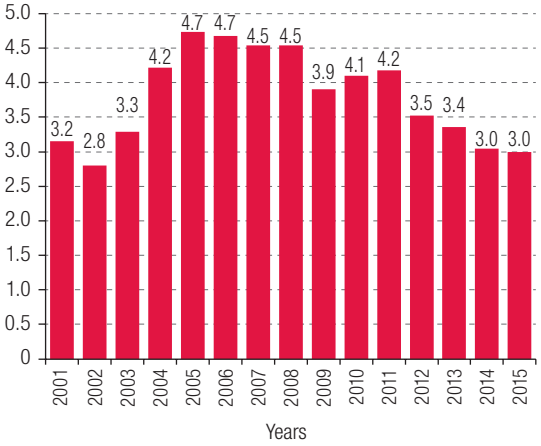


[6] Information was unavailable for the following countries, which are therefore not included in the figures shown: the Sudan, South Sudan, Cameroon, Eritrea and Cuba. Most of the countries in the sample are generally classified as low-income, middle-income or upper-middle-income countries.

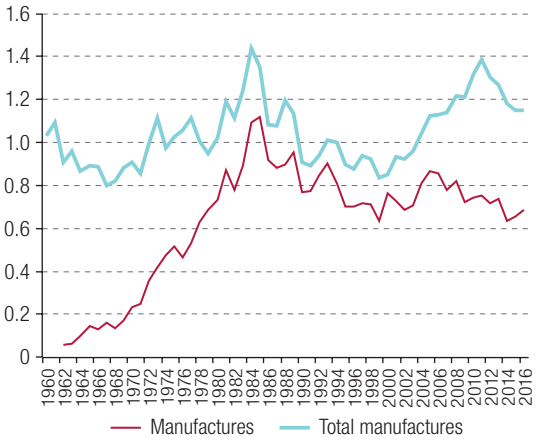
[7] The study period starts with the first year of the upward cyclical trend in commodity prices and ends with the latest year for which information was available at the time of writing.

Figure 1 (concluded)

C. Brazil's share of the market for imported manufactures in selected countries
(percentages)



D. Brazil's share of world exports



Source: Prepared by the authors, on the basis of World Bank (2018 and United Nations, UN Comtrade Database, 2018.
[a] The data in panel D correspond to 1960–2016.

The use of 51 countries for the period 2001–2015 yielded 765 observations. The exercise was based on the following variables:

- **Brazilian exports of manufactured goods** – $\left(EX_{i,t}^{BR}\right)$: This is the main variable of interest for this study. The data source was the UN Comtrade Database.[8] The category of manufactured products corresponds to the category used in the National Classification of Economic Activities, version 2.0 (CNAE 2.0).[9]
- **Trading-partner commodity exports** – $\left(EX_{i,t}^{P-COM}\right)$: This is the main control variable for the direct income effect. The data source was the UN Comtrade Database.[10] The category of manufactured products corresponds to the classification developed by Pavitt (1984)[11] based on product specifications for primary and resource-intensive products.
- **Exchange rate for the Brazilian real against trading-partner currencies** – $\left(CA_{i,t}\right)$: Euromonitor[12] was the source for the gross data. To construct this variable, the nominal exchange rate for the currency of each country was converted into an index with 2001 as the base year. The index for Brazil was then divided by the index for the trading partner in question. An increase in the resulting ratio indicates a decline in value of the Brazilian real relative to the trading partner's currency.

[8] These data are for exports of manufactures in current dollars. Current values are preferred when working with volume indices for three reasons. The first is that there was little upward pressure on the prices of manufactures during the study period, owing mainly to the size of the exportable supply from Asian countries. The second has to do with the construction of the deflator for Brazilian exports of manufactures. A deflator would have to be used for each individual trading partner, since using a single deflator would skew the gross data. The third and final reason, which has been referred to previously, is that the commodity exports of Brazil's trading partners are measured in current dollars, so it is more logical for the comparison between this aggregate and Brazilian exports of manufactures to be made in current dollars as well. Thus, the estimated parameter for this ratio will partly capture the volume and partly the terms of trade. Accordingly, we chose to use the original data denominated in current United States dollars.

[9] The CNAE 2.0 classification is similar to the International Standard Industrial Classification of All Economic Activities (ISIC), Revision 4. The categories that were used were codes 10 to 33 of section C, which basically corresponds to processing industries.

[10] See [online] https://comtrade.un.org/.

[11] The classification developed by Pavitt (1984), as adapted by Guerrieri (1998), is used because this taxonomy provides a clearer picture of the competitiveness of the product itself as opposed to the corresponding technological standards.

[12] See [online] https://www.euromonitor.com/.

- **Brazil's gross domestic product** – $\left(GDP_t^{BR}\right)$: The International Monetary Fund (IMF) was the source for the gross data for this variable,[13] which denotes the size of the Brazilian economy as measured in terms of purchasing power parity (PPP) in United States dollars. This was used as a proxy for the economies of scale of Brazilian export production.
- **Trading-partner per capita gross domestic product** – $\left(GDPP_{i,t}^{P}\right)$: IMF was the source of the gross data. The $GDPP_{i,t}^{P}$ is measured in terms of purchasing power parity (PPP) in United States dollars and is used to gauge the standard of living in the region.
- **Share of commodities in trading partners' export profile** – $\left(COM_{i,t}^{P}\right)$: This measures the ratio between a trading partner's total exports and its commodity exports $\left(EX_{i,t}^{P-COM}\right)$, which ranges from 0 to 1.

All of these variables are expressed as natural logarithms. Trading partners' GDPs are not used in the model, however, because of the multicollinearity between this variable and $EX_{i,t}^{P-COM}$. Thus, as noted earlier, the model will only capture the direct effect through Brazil's trading partners' commodity exports.

Table 1 gives the descriptive statistics for the data.

Table 1
Descriptive statistics

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
$EX_{i,t}^{BR}$ (US$/millions)	765	710.65	1 981.65	0.12	21 116.37
$EX_{i,t}^{P-COM}$ (US$/millions)	765	12 313.33	21 621.92	2.32	149 019.80
$GDP_{i,t}^{BR}$ (US$/millions)	765	2 495 180	572 684	1 638 286	3 306 570
$CA_{i,t}$	765	1.08	0.50	0.01	2.21
$GDPP_{i,t}^{P}$ (US$)	765	7 439.02	7 690.80	377.20	51 187.15
$COM_{i,t}^{P}$ (percentages)	765	67.37	26.24	5.58	99.80

Source: Prepared by the authors, on the basis of StataCorp, *Stata Statistical Software: Release 15*, College Station, StataCorp LLC, 2017.

The methodology is based on an estimated model represented by equation (1). This equation estimates the parameters for the variables exhibiting changes in dimensions i and t in a dynamic panel data model:[14]

$$Y_{i,t} = \left(\beta_0 + \mu_i\right) + \beta_1 + Y_{i,t-1} + \sum_{k=1}^{K} \gamma_k X_{k,i,t} + v_{i,t} \quad (1)$$

In equation (1), $Y_{i,t}$ represents the dependent variable of the hierarchical model, in this case $EX_{i,t}^{BR}$; the $X_{k,i,t}$ component indicates the regressors observed in country i in time t: $EX_{i,t}^{P-COM}$, $CA_{i,t}$, $GDP_{i,t}^{BR}$, $GDPP_{i,t}^{P}$, $\left\{COM_{i,t}^{P} + \left(COM_{i,t}^{P}\right)^2\right\}$. This defines a quadratic relationship between the trading partner's degree of commoditization and the $EX_{i,t}^{BR}$. This option was characterized by the units for each variable. The $EX_{i,t}^{BR}$ are measured in United States dollars and may vary between 0 and ∞.

[13] See [online] https://data.imf.org.

[14] For further details on the panel data methodology, see Baltagi (2005), Hsiao (2003) and Wooldridge (2002). On dynamic panels, see Arellano and Bover (1995), Blundell and Bond (1998) and Bond (2002). In choosing to work with a dynamic model, consideration was given to the time trend components of the dependent variable in the proposed model.

The $COM_{i,t}^{P}$ variable denotes a given share and so will vary only between 0 and 1.[15] In equation (1), μ_i and $v_{i,t}$, refer, respectively, to the individual effect of sectional units and the random residual $IID{\sim}N(0,\sigma^2)$.

As is usual, unit root tests —in the formalizations of Im, Pesaran and Shin (2003); Levin, Lin and Chu (2002); and Harris and Tzavalis (1999)[16]— and cointegration tests —Kao (1999) and Pedroni (1999 and 2004)— were performed. As shown in table 2, with the exception of the $EX_{i,t}^{BR}$ variable, which displayed a stationary pattern in all the tests, the other variables were non-stationary in at least one of the tests.

Table 2
Panel data unit root tests

Variables	Im, Pesaran and Shin test		Levin, Lin and Chu test		Harris and Tzavalis test	
	Statistical *W-t-bar*	*p*-value	Adjusted *t* statistic	*p*-value	*Rho statistic*	*p*-value
$EX_{i,t}^{BR}$	-8.5854	0.0000	-12.5917	0.0000	0.6700	0.0000
$EX_{i,t}^{P-COM}$	-3.2107	0.0007	-10.3147	0.0000	0.7719	0.1640
$GDP_{i,t}^{BR}$	-2.0505	0.0202	-12.8689	0.0000	0.9386	1.0000
$CA_{i,t}$	-4.3814	0.0000	-7.1470	0.0000	0.8878	0.9989
$GDPP_{i,t}^{P}$	-0.7701	0.2206	-10.8212	0.0000	0.9344	1.0000
$COM_{i,t}^{P}$	-0.8910	0.1865	0.9046	0.8172	0.6205	0.0000

Source: Prepared by the authors, on the basis of StataCorp, *Stata Statistical Software: Release 15*, College Station, StataCorp LLC, 2017; K. S. Im, M. H. Pesaran and Y. Shin, "Testing for unit roots in heterogeneous panels", *Journal of Econometrics*, vol. 115, No. 1, July 2003; A. Levin, C. Lin and C. J. Chu, "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, vol. 108, No. 1, May 2002; R. D. F. Harris and E. Tzavalis, "Inference for unit roots in dynamic panels where the time dimension is fixed", *Journal of Econometrics*, vol. 91, No. 2, August 1999.

Given the results of the tests run by Kao (1999) and Pedroni (1999 and 2004) (table 3), the alternative cointegration hypothesis cannot be rejected in the five tests shown.

Table 3
Statistics of the tests applied by Kao and Pedroni for autocorrelation in panel data

Kao test	Statistic	*p*-value
Modified Dickey-Fuller test	-4.8740	0.0000
Dickey-Fuller test	-7.3621	0.0000
Augmented Dickey-Fuller test	-3.4027	0.0003
Unadjusted modified Dickey-Fuller test modificada no ajustada	-8.0738	0.0000
Unadjusted Dickey-Fuller test	-8.6640	0.0000
Pedroni test	**Statistic**	***p*-value**
Modified Phillips-Perron test	9.7229	0.0000
Phillips-Perron test	-9.1938	0.0000
Expanded Dickey-Fuller test	-7.5571	0.0000

Source: Prepared by the authors, on the basis of StataCorp, *Stata Statistical Software: Release 15*, College Station, StataCorp LLC, 2017; C. Kao, "Spurious regression and residual-based tests for cointegration in panel data", *Journal of Econometrics*, vol. 90, No. 1, May 1999; P. Pedroni, "Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis", *Econometric Theory*, vol. 20, No. 3, June 2004.

[15] A number of comments are called for regarding the possibility of multicollinearity in the polynomial function. According to Gujarati and Porter (2011, p. 225), the polynomial models do not, strictly speaking, violate the multicollinearity assumption, since and are not perfectly linear. These same authors also state (2011, p. 330) that the potential estimation problem lies in the likelihood of incurring a large number of standard errors, which makes it more probable that the null hypothesis cannot be rejected. However, as we will see when examining our results, the purpose of the polynomial is to determine the relationship between the estimated parameters associated with . In other words, we apply a joint hypothesis test to these parameters, imposing that both are statistically significant at the same time. In addition, according to Hsiao (2003 and 2005), panel data involve at least two dimensions: a cross-sectional dimension and a time series dimension. This makes linear dependence between the regressors unlikely and minimizes the multicollinearity. Lokshin, Belderbos and Carree (2008), confirming Hsiao's suggestion, estimate a dynamic panel data model (with the same structure as proposed in equation (1)) using polynomial relations between the model's independent variables.

[16] Generally speaking, the difference between the proposed tests lies in the asymptotic assumptions made with respect to the number of cross-sections in the dataset and the number of periods in each panel.

The statistical structure proposed in equation (1) can therefore be used to define a model with level variables. The Hausman test (table 4) for differentiating between fixed effects and random effects indicates that we must reject the null hypothesis and therefore can specify a fixed-effect model.

Table 4
Hausman test (fixed effects versus random effects):
within estimators and generalized least squares (GLS) estimators

Estimators	$\chi^2(5)$	*p*-value
Within and GLS	40.79	0.0000

Source: Prepared by the authors, on the basis of StataCorp, *Stata Statistical Software: Release 15*, College Station, StataCorp LLC, 2017.

Table 5 shows the results of the following tests: (i) the Wooldridge test for autocorrelation in panel data;[17] (ii) the modified Wald test for heteroskedasticity for fixed-effect panel data models;[18] and (iii) the Hausman statistical endogeneity test[19] for the $GDP_{i,t}^{BR}$[20] variable. We observe that the proposed fixed-effect model displays autocorrelation and heteroskedasticity in the estimated residuals. However, based on the Hausman test, the statistical exogeneity of $GDP_{i,t}^{BR}$ is not rejected. This last result is corroborated by the fact that exports of manufactures represent such a small share of Brazil's GDP. This external component therefore does not play a significant role in determining Brazil's national income. The autocorrelation in the estimated residuals may be the result of the time trend in $EX_{i,t}^{BR}$. This opens up the possibility of working with a dynamic panel data model.

Table 5
Autocorrelation, heteroskedasticity and endogeneity tests

Test	F (1, 50)	*p*-value
Wooldridge test for autocorrelation in panel data	79.629	0.0000
	$\chi^2(51)$	*p*-value
Modified Wald test for heteroskedasticity in fixed-effect panel data models	7361.62	0.0000
	$\chi^2(7)$	*p*-value
Hausman test for statistical endogeneity of $GDP_{i,t}^{BR}$ – Arellano and Bond	0.98	0.9852

Source: Prepared by the authors, on the basis of StataCorp, *Stata Statistical Software: Release 15*, College Station, StataCorp LLC, 2017.

Table 6 shows the statistics calculated using the robust Arellano–Bond estimator (AB).[21] As the AB estimator specifies a dynamic panel data model (equation (1)),[22] it can be seen that the $EX_{i,t-1}^{BR}$ variable is statistically significant, since the Arellano and Bond (AB-AR) autocorrelation tests point to the presence of first-order autocorrelation, thereby rejecting the second-order autocorrelation hypothesis. This provides statistical corroboration of the dynamic panel specification. In addition, the Hansen test does not reject the hypothesis that the instruments are valid for the AB estimator.

[17] See Wooldridge (2002) and Drukker (2003).

[18] For further details, see Baum (2001).

[19] For the Hausman test, we estimated a fixed-effect model versus a model with a static Arellano and Bond estimator, where $GDP_{i,t}^{BR}$ is treated as endogenous.

[20] The possibility of the statistical endogeneity of $GDP_{i,t}^{BR}$ is determined on the basis of observations using the GDP demand approach, where exports of goods and services are treated as a component of this macroeconomic indicator.

[21] A dynamic panel data model was estimated on the basis of the approach espoused by Blundell and Bond (1998 and 2000). However, based on the statistical results and their economic interpretation, the Arellano and Bond estimator was selected for use in the presentation of our findings.

[22] For the dynamic panel data models, a robust two-step estimator was used.

Table 6
Estimated statistics: Arellano and Bond, Blundell and Bond, and fixed-effect estimators

Variables	Arellano and Bond	
$EX_{i,t}^{BR}$	Coefficients	*p*-value
$EX_{i,t-1}^{BR}$	0.5555822	0.000
$EX_{i,t}^{P-COM}$	0.3708294	0.004
GDP_{t}^{BR}	-0.2683318	0.515
$CA_{i,t}$	-0.2412565	0.075
$GDPP_{i,t}^{P}$	-0.0596441	0.877
$COM_{i,t}^{P}$	-6.0768460	0.015
$(COM_{i,t}^{P})^{2}$	0.8977919	0.013
_cons	-	-
Statistical test	m_1 - m_2	*p*-value
AB - AR (1)	-3.86	0.000
AB - AR (2)	0.09	0.928
	χ^2(89)	*p*-value
Hansen test	49.17	1.000
Variables	Coefficients	*p*-value
$[COM_{i,t}^{P} + (COM_{i,t}^{P})^{2}]$	3.384329	0.000

Source: Prepared by the authors, on the basis of StataCorp, *Stata Statistical Software: Release 15*, College Station, StataCorp LLC, 2017, R. Blundell and S. Bond, "GMM estimation with persistent panel data: an application to production functions", *Econometric Reviews*, vol. 19, No. 3, 2000; R. Blundell and S. Bond, "Initial conditions and moment restrictions in dynamic panel data models", *Journal of Econometrics*, vol. 87, No. 1, November 1998.

The estimated statistics for the variables of interest in this study $\left(EX_{i,t}^{P-COM}, \left\{COM_{i,t}^{P} + \left(COM_{i,t}^{P}\right)^{2}\right\}\right)$ indicate that the direct income effect of commodity prices $\left(EX_{i,t}^{P-COM}\right)$ is statistically significant at 5%. The elasticity between $EX_{i,t}^{BR}$ and that income effect is low, however, which means that Brazil's exports of manufactures to countries in Africa and Latin America were not dynamic enough to take full advantage of the direct income effect of the changes in $EX_{i,t}^{P-COM}$.

The estimated results for the degree of specialization of trading partners in commodity exports $\left(COM_{i,t}^{P}\right)$ over $EX_{i,t}^{BR}$ were statistically significant at 5%. With the AB estimator, a quadratic relationship is obtained with at least one point. The AB estimator is characterized by at least one point where commodity exports represent a 29.5% share of the total exports of a Brazilian trading partner. The AB estimator yields a positive relationship between $EX_{i,t}^{BR}$ and the export specialization profile of Brazil's trading partners starting from that percentage and on up.

In summary, the statistical responses indicate that Brazil's exports of manufactures to countries in Latin America and Africa were buoyed by the recent cyclical rise in commodity prices. There were two possible channels for the transmission of these benefits. One of those channels would be the commodity exports of trading partners (a direct income effect). However, the elasticity for that relationship has been estimated at less than unit value, which means that it is quite low. The other channel is created by the degree of specialization in commodities of the trading partners' export profiles. Thus, the more specialized in commodities the Latin American and African countries are, the higher the level of Brazil's exports of manufactures will be (with a minimum point of between 24.7% and 29.5%). These positive effects notwithstanding, the share of Brazil's exports represented by commodities expanded rapidly during the recent upswing in commodity prices, perhaps owing to two different factors that are somewhat interrelated. One has to do with the fairly small impact on total demand of the Latin American and African countries when compared to that of advanced economies and China. The other stems from the competitive position of Brazilian industry in the international market, where it trades mainly with the emerging or developing economies analysed in the models used in this study.

IV. Conclusions

This study focuses on identifying the effects that the commodity supercycle had on exports of manufactured items produced in Brazil. Its point of departure is the hypothesis that Brazil's trading partners that develop and export natural resources benefited from those higher prices and that the resulting increase in their national income enabled them to expand their imports in general and their imports of manufactured products in particular. It also seeks to contribute to the literature on the determinants of Brazilian exports and especially its exports of manufactured goods, and to add to that literature by analysing Brazil's trade relations with low-, middle- and upper-middle-income countries in Latin America and Africa (Baumann, 2013; Medeiros and Cintra, 2015).

The study uses a sample of 51 countries, which purchased, on average, approximately one third of Brazil's exports of manufactures between 2001 and 2015. The econometric strategy adopted, which, to the knowledge of the authors, had not been used before in the literature, enabled the conclusion that the proxy used to determine the income effect of higher commodity prices was statistically significant and had the expected positive impact. In other words, the higher level of commodities exported by Brazil's trading partners was associated with an expansion of Brazil's exports of manufactures to those same markets. The effect tended to be stronger when the share of commodities in trading partners' export profiles passed a certain threshold. These findings dovetail with the conclusions of earlier, more general studies on this subject, such as those of the World Bank (2009), De la Torre, Filippini and Ize (2016), Sinnot, Nash and De la Torre (2010), Alberola-Ila and others (2016), UNCTAD /FAO (2017), ECLAC (2017), and with studies focusing on Brazil, notably those of Castilho and Luporini (2010), Bastos (2012), Hiratuka and others (2012), Medeiros and Cintra (2015) and Lélis and others (2018).

The data used in this econometric exercise and its results indicate that Brazil's total and manufactured exports were buoyed by both the direct effect of the commodity price supercycle (higher volume and prices for commodities and natural resource-intensive goods exported by Brazil) and the indirect effect associated with the more rapid economic growth of its trading partners. Thus, in the 2000s, Brazil regained part of the global market share that it had lost during years of economic decline. To provide some perspective, between 1981 and 1985, Brazil's exports represented, on average, 1.5% of the global total, and its exports of manufactured goods accounted for 0.8% of the total. In the second half of the 1990s, when the country's monetary stabilization process was anchored in the overvaluation of its currency, the corresponding figures were, respectively, 0.9% and 0.7%. But with the advent of the supercycle in the 2000s, its total exports rebounded to some extent, peaking at between 1.2% and 1.3% of the global total, while the market share of manufactured exports remained between 0.6% and 0.7%.

These indicators, which are graphed in panel D of figure 1, show the general outlines of one of the Brazilian economy's structural problems, which is its regressive pattern of specialization (Nassif, Feijó and Araújo, 2015; Naudé, Szirmai and Haraguchi, 2016; Gala, Rocha and Magacho, 2018). From the time of the external debt crisis onward, the economy's growth consistently fell below the world average (by one percentage point per year); its production structure, and especially its processing industries, began to decline in terms of density and complexity; and its export profile began to reflect an increasing reliance on sales of commodities and natural resource-intensive manufactures. Thus, although the rise in commodity prices helped to drive the relative improvement of Brazil's total and manufactures exports, it did not significantly alter the country's position in the international market. Furthermore, the weak income elasticity detected in our study suggests that the greater economic buoyancy of Brazil's trading partners was not enough to bring about a lasting or robust increase in the market share of Brazilian manufactures in those countries. The subsequent decline in commodity prices was enough to cause the market share of Brazilian manufactures in those countries to retreat once again. Future studies may look into the reasons for its loss of competitiveness on external markets. The existing literature suggests that, to some degree, this may be the result of various structural determinants, including the following:

(i) the long-standing decline in the dynamism of processing industries in Brazil; (ii) China's ascendancy to its present position as the world's leading producer and exporter of manufactures; and (iii) the difficulties encountered by the country in establishing robust, long-lasting development strategies (Jenkins, 2014; Nassif, Feijó and Araújo, 2015; Hiratuka and Sarti, 2017; Lélis and others, 2018; Lin, 2018).

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