The capacity of primary sectors to promote economic development: An input-output analysis for the Brazilian economy

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Abstract

The complex relationship between the production structure and economic growth has been the subject of heated debate among economists. During the 2000s, the Brazilian economy experienced a period of growth that contrasted with the stagnation observed in the previous two decades. This period of economic growth coincided with a change in the Brazilian production structure characterized by the rise of commodity exports. This process led to interpretations that highlighted commodity exports as the engine of the country's recent growth. Therefore, with the aim of analyzing the capacity of commodity exports to generate economic growth either in the export sector itself or in its upstream supply chain, this paper seeks to assess, based on input-output tables, the performance of commodity sectors *vis-à-vis* manufacturing. Based on such analyses, this paper's main conclusion is that in order to boost economic growth the development strategy should takes into account comparative advantages in the economy without denying the advantages of a production structure oriented toward expanding manufacturing. The analysis of the Brazilian production structure showed unmistakably that sectors related to manufactured products can stimulate the economy more intensely as a result of their linkage effects on other sectors of the economy.

Key words: Commodities, manufactured products, production structure, economic growth, development, input-output model, growth models.

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1. Introduction

In the early 2000s after at least two decades of low economic growth the Brazilian economy gained momentum. The economic growth cycle that followed, especially after 2003, was characterized by income distribution, a virtually steady drop in unemployment, and increased investment in fixed capital. This scenario reflected an intense economic growth in the years that followed and, given its importance to policy-making, gave rise to a vast range of interpretations which sought to determine the factors and instruments that triggered this process. Over this decade changes in the intensity of trade flows began to be more clearly perceived. As pointed out by Canuto *et al* (2013), the Brazilian strong economic performance and intense international trade were accompanied by a boom in commodity prices that increased the country`s exports around 262 percent, almost twice of the global average of 135 percent. This new economic reality resulted in an increase of the country's gross domestic product (GDP) that raised 10% of GDP in 2000, peaking to 16.4% in 2004 and dropping to 11.2 % in 2010[4] as a consequence of the global financial crisis. Despite of it, the Brazilian commodities played a key role in the economy's dynamism which was highly associated with the Asian demand, notably the Chinese one[5] (Prates, 2006 and Rocha, 2011).

In a scenario where the international market began to demand Brazil's main export products, economic growth led by exports of primary products, especially commodities, assumed a prominent position in interpretations of the growth experienced during that period. On the one hand, some economists support the idea that the expansion based on the production and exports of commoditized sectors did not have a negative effect. According to them, besides being capable of generating income in export sectors, primary sectors have also indirect effects on other productive chains and capacity to generate additional income to consumption that would feed back the domestic production (Auty, 2000, 2001a, 2001b; Gylfason, 2001; Neumayer, 2004; Mehlum *et al*, 2006; Sachs & Warner, 2001). This line of thought have constantly sought to refute the necessity of industrial and foreign trade policies. They point out that a state interventionism in favor of industrial sectors would promote an "artificial" industrialization not compatible with international patterns based in a competitive free market. However, on the other hand, several studies have attempted to demonstrate the limitations in promoting country's productive and international trade structure based in these assumptions. Both classic Kaldorian interpretations (Kaldor, 1966, 1981; Cornwall, 1977, Thirlwall & Hussein, 1982; McCombie & Thirlwall, 1994a, 1994b; Verdoorn, 1949; Thirlwall, 1979; Dasgupta & Singh,2006; Dixon & Thirlwall, 1975, Moreno-Brid, 2003) and those based on the structuralist approach of the Latin American thinking (Prebisch 1986, Singer, 1950; Furtado, 1961 and Tavares, 1998), have emphasized the limitations in promoting economic development based on a productive and trade structure of low value-added products[6].

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[4] Considering the series at constant prices (1980), the share of exports in GDP continued to increase even after 2004 and reached a peak in 2007, the year that preceded the global crisis.

[5] About the recent rise in commodity prices, see Prates (2007).

[6] This school of thought, commonly referred to as developmental, is particularly supported by theorists who observe the negative effects of currency appreciation in the manufacturing sector caused by exports of commodities, a process known as the "Dutch Disease." In this dynamic, the existence of comparative advantages in natural resources would significantly boost exports of low value-added products such as commodities, resulting in a major inflow of dollars into the domestic economy and in the appreciation of the domestic currency in real terms. In a scenario of commodity prices on the rise, the implications would be even more serious for the domestic industry, as

The main argument of those who do not support economic growth based on primary products exports is that manufacturing is the main engine of economic development[7]. Authors such as Rosenstein-Rodan (1943), Prebisch (1949), Lewis (1954), Rostow (1956) and Furtado (1961) were some of the first intellectuals to emphasize the importance of manufacturing to the economic development. According to them, development is essentially a process of structural change. Broadly speaking, sustained economic growth is associated with the capacity to diversify the structure of domestic production, i.e. generate new activities to expand possibilities of production, linkages and higher value-added goods by providing incentives to manufacturing. According to Kaldor (1966), economic growth is brought about by shifting productive sectors with decreasing returns to those with increasing returns. This shift creates dynamic economies of scale. The author believes that manufactured goods is the one with the greatest capacity to do so and therefore its expansion plays a key role in promoting sustainable growth in the long term and consequent modernization and diversification of the production structure. Along the same lines, Chenery *et al* (1986) argue that economic development is triggered by productive transformations induced by an increasing demand for product diversity and technological progress. Such transformations would also lead to a more productive use of inputs and increased productivity. The industrialization process feeds itself and diversifies the production structure. Such changes in demand resulting from growth entail a dynamic element that transforms the production structure. They lead to a shift in the composition of production and thus in supply that requires new investments, which end up leading to technological improvements and further stimulate demand.

The impacts of stimulating a certain sector were discussed in detail by Hirschman (1958). This author argues that a development strategy should focus on ensuring investments in sectors that can generate backward and forward linkages, i.e. stimulating the production of inputs used in its production process, generating economies of scale inside the sector, or those which can be used as inputs in other sectors also leading to productivity gains and cost savings for sectors in later stages of the production chain. Thus, with the aim of evaluating the dynamic effects of a development strategy based on commodity exports such as the one adopted by Brazil in recent years, this paper compare possible production linkages that can be created by stimulating these sectors, in which Brazil enjoy comparative advantages in production, with those that could be generated by providing incentives to manufacturing, as well as to assess whether such a strategy can be successful from the point of view of production diversification and, consequently, if it can contribute to fostering economic growth.

For this purpose, this paper will use analyses based on input-output tables to empirically determine the capacity of primary sectors and their exports to leverage growth in the Brazilian economy *vis-à-vis* manufacturing. Based on the theoretical discussion above, the idea is to assess whether exports of primary goods can generate production linkages as argued by economists who support the adoption of this development model. The paper is divided into six sections, including this introduction and concluding remarks. The following section provides a brief analysis of the main features of the post-1990s Brazilian development model that replaced the

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the competitiveness of higher value-added products would be reduced, possibly triggering a process of "deindustrialization" of the economy. On this topic, see Palma (2005) and Bresser-Pereira (2008).

[7] Rodrik (2007), Szirmai (2009, 2012) and Fagerberg & Verspagen (1999) support the same arguments.

import substitution industrialization (ISI) model and led to a shift in the country's development strategy, with its economy being oriented toward producing goods with comparative advantages and thus to the expansion of "commoditized" sectors as the main engine of economic growth. The input-output methodology that is used in this analysis is presented. Finally, production multipliers, Hirschman-Rasmussen backward and forward linkage indexes, and pure normalized backward and forward linkage indexes comprising primary sectors and manufacturing industry are calculated.

2. From the lost decade to the post-1990s Brazilian development model

The so-called "lost decade" – the 1980s – was marked by a deep economic crisis that resulted in very low rates of economic growth, low investment levels, imbalance in public accounts, and major macroeconomic instability. The pronounced instability observed in the Brazilian economy during that period, which had deep effects in public sector funding, was largely caused by the country's increasing foreign debt. The net public sector debt rose from 34.6% of GDP in 1981 to 169.5% of GDP in 1989[8]. This scenario, added to a reversal in the liquidity cycle, brought deep macroeconomic instability not only to Brazil, but also to the great majority of Latin American countries, with severe foreign exchange restrictions, rising inflation, relative price mismatches, and low economic growth.

The crisis disrupted the economic growth-promoting mechanisms adopted in Brazil in previous decades, as a result of a marked contraction in international credit markets and repatriation of capital flows to central economies. The deterioration of global macroeconomic environment, high government indebtedness in the 1970s, and the debt nationalization process – which forced the government to bear the burden of private decisions – ultimately weakened the state apparatus and exposed it to a fiscal and financial crisis, as it undermined its capacity to continue to promote investment and development as in previous decades. Fiscal deterioration and problems abroad, added to the specific structural features of the Brazilian economy and its increasing indexation, led the inflation as measured by the IPCA/IBGE to soar from 95.6% in 1981 to 1,972.9% in 1989[9].

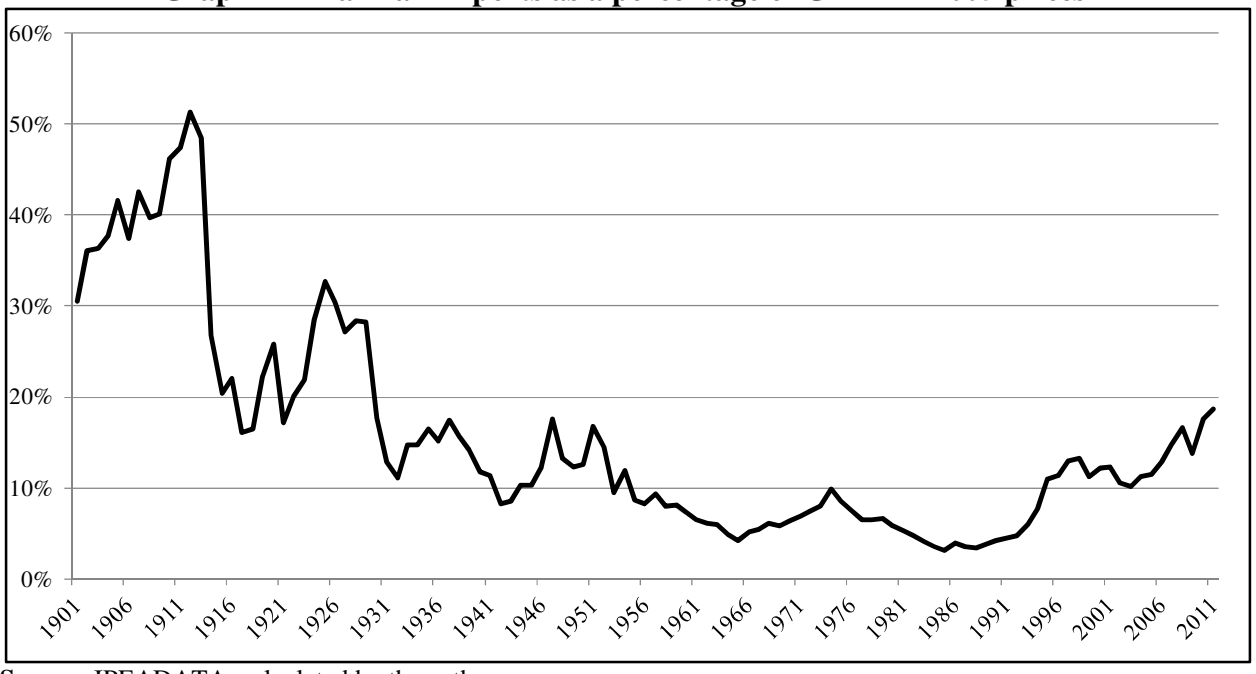
In this scenario, the Brazilian development model began to be strongly criticized. Not only the manner in which Brazil's economic policy was conducted in the previous decade, but also the limits of the model applied in the Brazilian economy since the 1930s. According to Bacha e Bonelli (2005), neoliberals saw the economic stagnation of the 1980s not only as a consequence of macroeconomic imbalances, but also as an effect of a greater structural crisis arising from the exhaustion of a development model built on a very closed economy marked by strong state intervention and based on the import substitution industrialization (ISI) model. It was therefore argued that a radical shift in Brazil's economic policy was required and that the foundations of the development model based on import substitution (ISI) should be replaced. The ISI provided a great incentive to a Chenery-style industrial development model (strengthening the industry of intermediate inputs with major linkages in the production structure), but free-market economists were of the opinion that it was based on a protectionist policies that would

[8] Total public sector net debt, BCB Boletim/Finanças Públicas (IPEADATA).
[9] As measured by the IPCA/IBGE.

give rise to distortions in relative prices and in the allocation of resources in the economy, thus causing inefficiency (Bonelli, 2005).

It is argued that the ISI process in the Brazilian economy began to show signs of exhaustion in the 1980s with the import coefficient dropping to very low levels (see Figure 1). The transformation of the Brazilian economy's production structure had reached such a level of diversification that it made domestic demand less dependent on global production, thus bringing the ISI implementation cycle to an end.

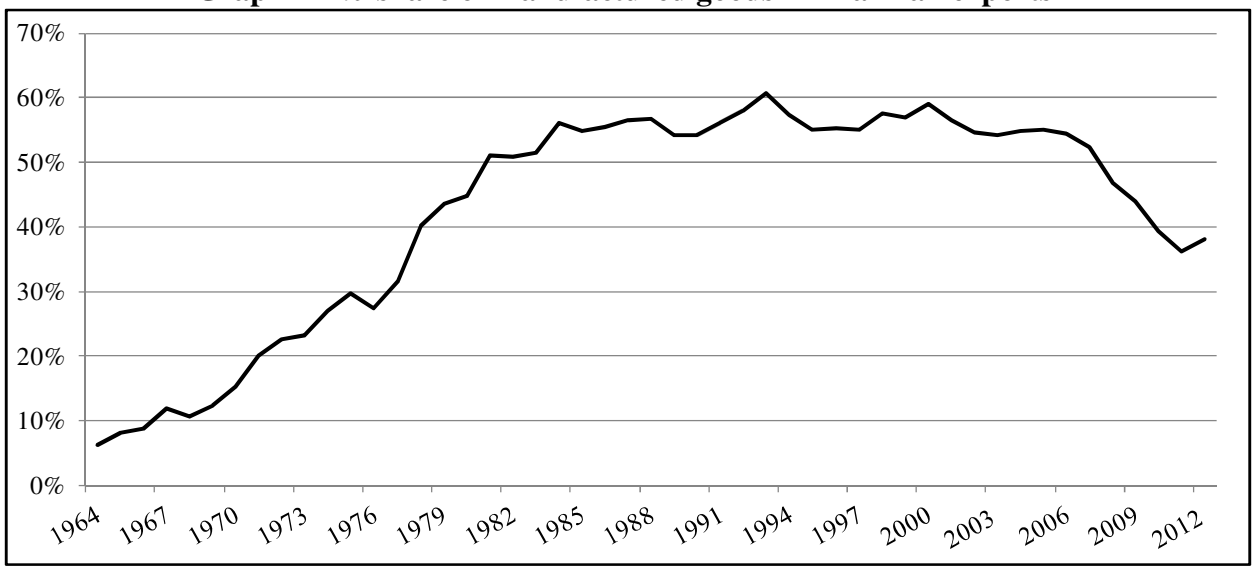
Graph 1 - Brazilian imports as a percentage of GDP - in 2005 prices



Source: IPEADATA, calculated by the authors

From the mid-1960s, the development strategy applied to the Brazilian economy led to a marked increase in exports of manufactured goods supported by a foreign trade tariff and subsidization system. The graph 2 shows the evolution in the share of exports of manufactured goods in total Brazilian exports. A significant increase in this percentage can be observed up to the early 1980s, which only dropped recently when the production started to be oriented to meet the external demand for commodities.

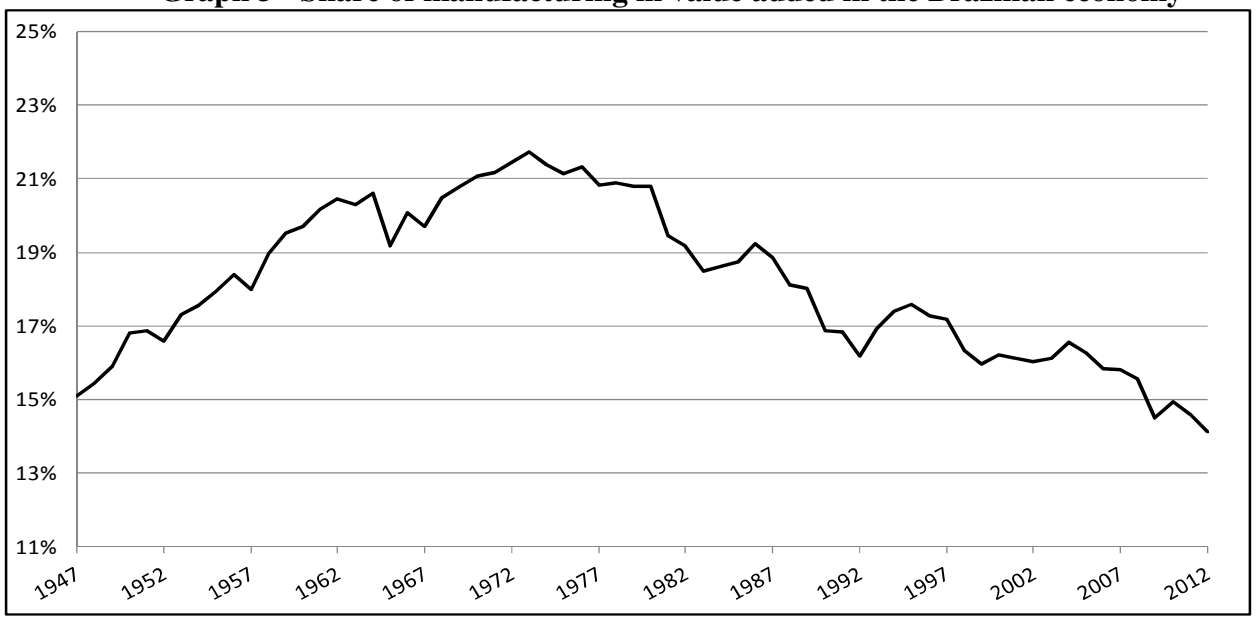
Graph 2 - % share of manufactured goods in Brazilian exports



Sources: Department of Planning and Development of Foreign Trade – DEPLA (Brazil)

The combination between this import substitution process and a subsequent increase in exports of manufactured products (always supported by industrial policies that favored both a managed exchange rate and public spending scheme promoted the development of strategic sectors) appear to have contributed significantly to foster the Brazilian industrialization process, as shown in figure 3. The share of manufacturing in value added rose up to the mid-1970s, i.e. during the import substitution phase, and remained high while the relative share of exports of manufactured goods increased.

Graph 3 - Share of manufacturing in value added in the Brazilian economy



Source: IPEADATA. The share was estimated based on value added calculated at 2011 constant prices.

Therefore, as far back as in the 1970s, Brazil's economic development process already indicated that it was geared to foreign trade, associated with the end of the import substitution process. It did not appear, therefore, that production conditions were deteriorating or that the production structure was inefficient because, among other factors, a substantial percentage of manufacturing production was facing the international competition. However, the country's deteriorating fiscal situation and external accounts, which can be partly attributed to the need to finance all this strategy, and the weakening capacity of the state to continue to lead this process contributed to the revival of arguments in favor of the free market ideology in line with the Washington Consensus.

The new model to be established was intended to reduce the participation of the state in the economy and promote competition as the main engine of productivity growth. For this purpose, countries would have to follow ten basic propositions, which also formed the basis of the neoliberal strategy. Such propositions ranged from making fiscal and monetary adjustments to adopting an openness policy in the trade and financial areas, and also promoting economic deregulation [10] (Williamson, 1989), in order to install a market economy that would promote greater productivity through specialization in production and by targeting investments to sectors in which Brazil enjoyed comparative advantages. Thus, policies designed to promote the manufacturing sector lost strength during this period and were virtually abandoned as a result of the maxim prevailing then that "the best industrial policy is no industrial policy" (Stallings & Peres, 2000). Therefore, as a result of market forces, the 1990s were marked by major economic changes that resulted in a productive restructuring of the Brazilian economy. In addition, following the neoliberal logic, a rapid process of trade liberalization and property restructuring began to take place in Brazil – especially through the privatization of state enterprises – leading the country on the path of a new development model. According to Franco (1998), this model would spearhead a process of industrial restructuring that would enhance competitiveness in the Brazilian economy, as it would eliminate less efficient companies and sectors and induce the adoption of new technologies for the country to be able to compete in the international arena.

In the Brazilian case, this strategy took material form through reductions in quantitative controls and import tariffs and the absence of public policies focused on promoting growth in strategic sectors for the country's development. The trade liberalization process strongly focused on stepping up imports (see graph 1) without providing incentives to exports, combined with a scenario of currency appreciation, resulted in a second large wave of reductions in the share of manufacturing in value added in the second half of the 1990s (see graph 3)[11]. Therefore, the trade liberalization process virtually eliminated non-tariff barriers to trade [12] and custom tariffs were

[10] The ten prepositions were the following ones: (1) fiscal discipline, (2) reduction of public spending, (3) tax reform (4) interest rates determined by the market, (5) exchange rates determined by the market, (6) liberalization of imports, (7) liberalization of foreign direct investment flows, (8) privatization of state enterprises, (9) economic and labor deregulation, and (10) respect for intellectual property.

[11] The first phase of the Brazilian deindustrialization process was in the 1980s and it might be associated with significant macroeconomic imbalances – fiscal crisis, high foreign debt and inflation – observed in that period.

[12] According to Carneiro (2002), nontariff barriers to trade, which many saw as the main protectionist instrument, were completely done away with after Annex C (a list of 1,300 products whose imports were forbidden because similar domestic products were available) was abolished.

rapidly reduced based on the country's structure of comparative advantages[13]. According to the neoliberal logic, trade liberalization was also the basis for price stabilization in Brazil, which only became a reality in the country when the Real Plan was launched. These two processes were closely related, as it was argued. On the one hand, trade liberalization could only produce positive effects once the economy was stabilized, as this would be a necessary condition to stimulate investment and thus increase the competitiveness of domestic companies. On the other hand, the exposure of the private sector to foreign competition would be one of the main mechanisms to ensure price stabilization while exposing domestic products to foreign competition, thus imposing a natural price cap on them.

However, the trade liberalization process only brought about stabilization partially. Although prices stabilized, this was done at the expense of a very restrictive monetary and fiscal policy and of the appreciation of the domestic currency. This ensured that the prices of domestic products would not increase, as they would be replaced by imported products (and trade liberalization fulfilled its main role in this regard), but it also restricted aggregate demand, as imports were stimulated at the expense of exports and productive investment was depressed as a result of the appreciation of the domestic currency in real terms. As mentioned above, policies to stimulate exports had been abandoned. Thus, investments increased much less than expected both in the public and in the private sector during that period, reducing from a rate of 19.4% on average between 1990 and 1994 to 17.1% between 1995 and 1999[14]. This reflected in an average growth of 2.9% a year in the 1990s, significantly contrasting with the average growth rate registered in the decade of 1970, of 8.7% a year[15].

Thus, contrary to what one might think, price stability did not stimulate investments. It was argued that due to the approach adopted to control inflation – via trade liberalization, an overvalued exchange rate, extremely high interest rates, and privatization measures – investments and economic growth were undermined, revealing an antithesis between macroeconomic and microeconomic elements. This resulted in negative effects on investment rates of return, frustrating the expectations of companies in terms of growth and capacity utilization. On top of this, companies began to take strict adjustment measures during the 1990s to rationalize their production with the aim of facing the challenges of the new economic environment. With no market reserve and not being able to rely on subsidies and incentives any longer, less productive companies that failed to modernize themselves were absorbed by other companies or went bankrupt (Barros and Goldstein, 1997). The restrictive monetary policy adopted as part of the *Plano Real* ended up making the adjustment process of companies more difficult and painful for the economy. Although this new dynamic led to an increase in the productivity of industry, this increase was much more due to changes in production processes through cost reductions, especially in labor costs, than to higher production rates.

[13] Nominal import tariffs were reduced by 55.3% between 1990 and 1994, with the maximum tariff not exceeding 40%.

[14] There was a 7.4% a year reduction in investment in the Productive State Sector between 1981 and 1989; and the Private Sector kept the same investment rates in real terms (data extracted from Carneiro, 2002).

[15] The data presented here were estimated by SCN/IBGE.

Production was mainly rationalized by replacing imported inputs with local inputs[16]. Import penetration coefficients increased significantly between 1990 and 1998. Thus, as argued by Belluzzo & Almeida (2002), there was a "shrinking" of supply chains – which were also affected by "predatory" imports. Industrial companies began to look for ways to quickly improve their competitiveness, upgrading local products by using more imported inputs in their manufacture and modernizing their equipment without a corresponding restructuring of supply in the economy, thus generating an asymmetric insertion across sectors due to the fact that their linkages were still under development (Rocha, 2011). According to the Brazilian Institute for Geography and Statistics (IBGE)[17], the penetration coefficient for intermediate goods rose from 2.7% in 1990 to 10.5% in 1998. In the case of manufactured intermediate goods, the substitution process was even more pronounced: while in 1990 the penetration coefficient was 6.1%, in 1998 it soared to 21.9%. Thus, as local inputs were largely replaced with imported ones, the process of stepping up domestic production required an increasing amount of foreign currency, creating increasing difficulties to keep on using the same growth strategy[18]. As argued by Laplane and Sarti (2006, p. 276), from a trade balance perspective this process "turned the surplus in the trade in manufactured goods registered in the first half of the decade into a deficit from 1995 on, clearly indicating that it would be difficult to keep the economy on a growth path. The trade balance was more significantly negative precisely in 1997, when industrial production was growing at the highest rates, reinforcing the interpretation that the increasing imported contents of local products were generating an even more pronounced deficit."

The production and export of primary products was extremely limited due to a deflation in commodity prices in international markets caused by an excessive supply resulted from technological advances in agriculture and metal mining. While domestic demand for manufactured goods and primary products was compressed by the stabilization plan, demand in foreign markets was constrained by successive international crises, such as those registered in Mexico in 1995, in Asia in 1997 and in Russia in 1998, which affected demand for industrial goods and induced liquidations that further depressed the prices of Brazilian commodities.

Exports of manufactured products recovered late in the last decade and beginning of the present one, but this movement was interrupted by changes in the global commodity market. As a result of an extremely weakened production structure resulting from over a decade of neoliberal policies, production and exports of primary products became the engine of Brazil's growth in a new cycle of economic expansion that began in 2002 with the so-called boom of commodity prices. In mid-2004, global demand began to rise more intensely due to the Asian economies growth, particularly in China. This shift resulted (along with a monetary policy that led to a significant increase in the differential between domestic and external interest rates) in a strong appreciation of the domestic currency and a consequent increase in imports of

[16] On imported input coefficients, see Rocha (2011), Marconi and Rocha (2012).

[17] Extracted from Carneiro (2002).

[18] As pointed out in Rocha (2011, p. 55), "substituting local inputs with imported ones was seen as the easiest way to meet demand and revealed the contradiction between striving for efficiency gains at the microeconomic level and the sustainability of the process at the macroeconomic level, i.e. the contrast between competitive pressure and the weakening of industrial chains."

manufactured goods, which grew by 155% between 2002 and 2008[19] at constant prices and contributed to reduce the share of manufacturing in value added[20].

This scenario contributed to the third phase of reductions in the share of manufacturing in value added in the Brazilian economy after 2002 (see graph 3), when the local currency appreciated once again, undermining the competitiveness of Brazilian manufactured products abroad and leading to an increase in exports of Brazilian primary products to Asia, which also pushed commodity prices up. The trend of rising commodity prices was only reversed in 2009, due to the 2008/2009 international financial crisis, but it should be stressed that such prices remained at fairly high levels. As a result of this new dynamic, many questions emerged as to the composition of the domestic production structure, more specifically as to the sectors that boosted the economy. This study sought to check whether a commodity-based growth strategy can actually support development in the long term by analyzing the linkage effects that commodity sectors can generate as compared to those that sectors linked to manufactured products can create.

3. Theoretical foundations of the input-output model

With the aim of analyzing the capacity of commodity production to boost the Brazilian economy *vis-à-vis* manufactured goods, input-output analyses were used in this study. The decision to use the input-output methodology was based on the fact that these models can incorporate inter-relationships between various industries in the Brazilian economy. Using this methodology, it is possible to empirically investigate the economic role of a productive sector without restricting the analysis to its "direct effects" on the economy in terms of generating production, employment, value added, tax revenue, exports, etc., but also its "indirect effects", i.e. those that a sector can bring about on other sectors through channels established by input/output transactions between different economic sectors.

To calculate these indexes, input-output matrices from 2000 to 2008 were used (at the level of 55 sectors), based on the National Accounts published annually by the Brazilian Institute for Geography and Statistics (IBGE). Due to the non-linear periodicity of the information contained in that publication, Brazilian matrices were estimated for each year of the period according to the methodology presented by Guilhoto & Sesso Filho (2005)[21], based on preliminary data of Brazil's National Accounts. This methodology consists in a procedure for combining information from the Table of Resources (V) and the Table of Use of goods and services at consumer prices (U) published by IBGE for the Brazilian economy. Next, to reduce the number of sectors to carry out the comparison between manufactured products and commodities, the matrix was aggregated into 13 sectors of tradable goods distributed in these two groups based on the proximity of their production structures. The correspondence between the sectors of the initial matrix (55 sectors) and of the resulting matrix (13 sectors) is shown in Annex 1. Sectors that produce non-tradable goods were not included in the analysis, as the

[19] Calculated by the authors based on information from FUNCEX (Foreign Trade Study Center Foundation).

[20] Exports of manufactured products increased by 80.5% on the same comparison basis, with nearly half the variation observed for imports.

[21] The input-output matrices were estimated based on the work of Guilhoto and Sesso Filho (2005.)

objective here is to discuss the capacity of a strategy strongly focused on the production and export of primary goods to promote economic growth in relation to an alternative based on the production of manufactured goods.

3.1.Theoretical foundations

Based on the pioneer analysis developed by Leontief (1951), the theoretical approach adopted in this study is based on the input-output model, where the economy's total production (X) is the result of the sum of the production intended for intermediate consumption by different sectors (Z) and demand, which represents to what extent sector j used goods produced by sector i in its total production. That is, it shows the percentage of inputs sold to industry j by sector i in relation to the total production of sector j.

$$a_{ij} = \frac{Z_{ij}}{X_j} \tag{1}$$

Where z_{ij} expresses the inter-sectoral sales of sector i to sector j and x_j expresses the total production of sector j. Relationship (2) can thus be demonstrated:

$$X = AX + Y \tag{2}$$

By solving this equation, the total output required to meet the final demand can be determined, i.e. (3):

$$X = (I - A)^{-1} Y \tag{3}$$

Where $(I - A)^{-1} = L$ is the inverse of Leontief's matrix.

Using Leontief's model, various analyses can be carried out to assess the impact of demand variation on production, employment and value added, among other variables. Based on the ratio between the used value of the variable K one intends to analyze in total production and total production of the corresponding sector, the direct coefficient (k) is calculated for each variable (such as: employment, value added, wages, etc....):

$$k_j = \frac{K_j}{X_j} \tag{4}$$

Once this is calculated, along with Leontief's inverse matrix (L), one can calculate, by sector, the amount directly and indirectly generated from variable K for each monetary unit produced for final demand. This is the generator notion, which relates production for final demand with a given variable of the economy. Thus, the generator of a variable K for each sector can be calculated by summing each column of matrix GK obtained in (5).

$$GK = \sum_{i=1}^{n} \hat{k}_i \cdot L_{ij} \tag{5}$$

With the quotient between the generator and respective direct coefficient, one can obtain the multiplier of variable K, which associates the direct effect of a variable on its total (direct and indirect) effect on the economy, as represented in equation (6).

$$MK_j = GK_j / k_i \tag{6}$$

Multipliers for employment and production can thus be obtained[22]. In addition, the input-output methodology allows for other indicators of economic importance to be calculated. Following the seminal works of Hirschman (1958) and Rasmussen (1956), one can define the interrelationships between the sectors and the power of each sector in the economy to establish linkages. The so-called Hirschman-Rasmussen backward linkage (BL) indexes determine how much a sector demands from other sectors and the rates of forward linkages (FL) determine how much this sector is demanded by other sectors. To calculate the Hirschman-Rasmussen backward linkage index, one defines l_{ij} as the elements of matrix L, L^* as the average of all the elements of L and L_{*j} as the sum of a column of L. The equation may be represented as:

$$BL_j = \left(L_{*j}/n\right) / L^* \tag{7}$$

As for the Hirschman-Rasmussen forward linkage index, it is calculated from the matrix of coefficients in row (F) obtained from the intermediate consumption matrix (Z), as represented in (8).

$$F = \hat{x}^{-1} \cdot Z \tag{8}$$

As in Leontief's inverse matrix, the matrix of Ghost is deduced with g_{ij}:

$$G = (I - F)^{-1} \tag{9}$$

Considering G^* as the average of all elements of G and G_{i*} as the sum of the elements in each row, the Hirschman-Rasmussen forward linkage index is obtained[23]:

$$FL_i = \left(G_{i*}/n\right) / G^* \tag{10}$$

[22] In this paper, type I multipliers were used, which only take into account multiplicative effects restricted to demand for intermediate inputs, that is, without making household demand endogenous to the model. If household demand were endogenized in the system, the induced effect would be taken into consideration and we would have the type II multiplier (Guilhoto, 2009).

[23] For more details see Miller and Blair (2009).

Depending on the result of the indexes, sectors can be classified into four groups, namely (i) independent from (or not very related to) other sectors, if both linkage indexes are less than 1; (ii) dependent from (or strongly related to) other sectors, if both linkage indexes are greater than 1, denoting sectors that are seen as playing a key role in the economy; (ii) dependent from intersectoral supply, if only the backward linkage index is greater than 1; (iv) dependent from intersectoral demand, if only the forward linkage index is greater than 1. However, as first observed by Cella (1984) and Clements (1990), these indexes don't take into account the production levels of each analyzed sector.

As an attempt to correct and refine the solutions presented by these authors, Guilhoto et al. (1994) introduced a first version of what would be referred to as pure linkage indexes, which later became known as the GHS methodology. In Guilhoto, Sonis and Hewings (1996), some decompositions of Leontief's inverse matrix are made that consist in integrating the main techniques used in analyses of input-output structures with the aim of decomposing and distinguishing the impact of a sector of the economy on its various components. The consolidated GHS methodology is based on a block matrix of technical coefficients (A):

$$A = \begin{bmatrix} A_{jj} & A_{jr} \\ A_{rj} & A_{rr} \end{bmatrix} \tag{11}$$

where it is composed of square and rectangular matrices. A_{jj} and A_{rr}represent square matrices of direct technical coefficients of sector j and of the rest of the economy (economy as a whole less sector j), respectively, while A_{jr} and A_{rj}represent rectangular matrices of direct inputs purchased by sector j from the rest of the economy and direct inputs purchased by the rest of the economy from sector j.

Based on this matrix A, expressed in (11) a triple multiplicative decomposition of Leontief's inverse matrix can be made as follows:

$$L = (I - A)^{-1} = \begin{bmatrix} L_{jj} & L_{jr} \\ L_{rj} & L_{rr} \end{bmatrix} = \begin{bmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} \Delta_{j} & 0 \\ 0 & \Delta_{r} \end{bmatrix} \begin{bmatrix} I & A_{jr}\Delta_{r} \\ A_{rj}\Delta_{j} & I \end{bmatrix} \tag{12}$$

where,

$$\Delta_{j} = (I - A_{jj})^{-1} \tag{13}$$

$$\Delta_{r} = (I - A_{rr})^{-1} \tag{14}$$

$$\Delta_{jj} = (I - \Delta_{j} A_{jr} \Delta_{r} A_{rj})^{-1} \tag{15}$$

$$\Delta_{rr} = (I - \Delta_{r} A_{rj} \Delta_{j} A_{jr})^{-1} \tag{16}$$

From Leontief's model expressed in (3) and equation (12), the following results:

$$\begin{pmatrix} X_j \\ X_r \end{pmatrix} = \begin{pmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{pmatrix} \begin{pmatrix} \Delta_j Y_j + \Delta_j A_{jr} \Delta_r Y_r \\ \Delta_r A_{rj} \Delta_j Y_j + \Delta_r Y_r \end{pmatrix} \tag{17}$$

Through this process, pure backward linkage (PBL) and forward linkage (PFL) indexes can be deduced in their new definition, namely:

$$PBL = \Delta_r A_{rj} \Delta_j Y_j \tag{18}$$

$$PFL = \Delta_j A_{jr} \Delta_r Y_r \tag{19}$$

In Equation (18), the index shows the impact of the value of the total output of sector j on the rest of the economy, net of demand for inputs that sector j produces for itself and of the returns of the rest of the economy for sector j and vice versa. In turn, the PFL in equation (19) indicates the impact of the value of the total production of the rest of the economy on sector j. For calculating the pure index for all linkages (PTL) in each sector in the economy, all one has to do is add up the PBL and the PFL, expressed in current values:

$$PTL = PBL + PFL \tag{20}$$

However, since these indexes don't take into account the size of the sectors, which is an important aspect for identifying key sectors of the economy, a "normalization" procedure should be applied to their indexes based on the approach of normalized pure linkage indexes. For this purpose, the pure indexes of each sector are divided by the average of pure indexes for the economy as a whole. Thus, the normalized pure backward linkage index (PBLN), the normalized pure forward linkage index (PFLN) and the total index (PTLN) can be represented by:

$$PBLN_i = PBL_i \Big/ \left(\sum_{i=1}^{n} PBL_i \Big/ n \right) \tag{21}$$

$$PFLN_i = PFL_i \Big/ \left(\sum_{i=1}^{n} PFL_i \Big/ n \right) \tag{22}$$

$$PTLN_i = PTL_i \Big/ \left(\sum_{i=1}^{n} PTL_i \Big/ n \right) \tag{23}$$

4. Results

In this section, the results obtained using the proposed methodology based on the input-output analysis are presented in the following order: output multipliers, value-added generator, Rasmussen-Hirschman indexes, pure normalized backward linkage indexes (PBLN), and pure normalized forward linkage indexes (PFLN).

The first one to be presented is the output multiplier, which indicates how much is produced for each monetary unit spent on final consumption. In other words, these multipliers

incorporate direct and indirect effects to measure the impacts of a demand shock on the economy. For the purposes of the proposed analysis, type I multipliers are used, which only consider linked effects restricted to demand for intermediate inputs, that is, without making household demand endogenous to the model [24]. The greatest multipliers that were calculated for the Brazilian economy (greater than 2.0 for most years) were identified in six sectors: food/beverages, transportation equipment, chemical products, apparel/leather/footwear, petroleum, and metal products. Two of these sectors stand out more prominently, namely, the food/beverages and the transportation equipment sectors, the latter of which comprises the auto industry. An increase in the level of output multipliers was observed in both as of 2003, especially in the transportation equipment sector. Another sector that stood out was that of chemical products, which ranked third as a result of its rather high output multipliers, particularly in the 2003-2008 period. The apparel, leather and footwear sector also deserves special mention due to its high multiplier effect, especially at the regional level, making it a key sector for the development of productive chains that employ large numbers of people. The two lowest multipliers are those calculated for the paper/printing and agricultural commodity sectors, which in turn are associated with the strong bias toward Brazil's comparative advantages. An interesting phenomenon was observed in the 2004-2006 period, during which the multipliers calculated for virtually all sectors peaked.

Table 1 - Output Multipliers: 2000-2009

Sectors	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average	Ranking
Agricultural Commodities	1.86	1.81	1.81	1.87	1.91	1.98	1.92	1.92	1.92	1.93	1.89	12
Petroleum	1.98	2.05	2.11	2.03	2.05	2.06	2.03	2.00	2.02	2.03	2.04	5
Mineral Commodities	1.98	1.98	1.99	2.04	1.90	2.00	2.03	2.07	1.92	1.95	1.99	8
Food and beverages	2.32	2.25	2.28	2.36	2.35	2.41	2.36	2.38	2.42	2.38	2.35	1
Textiles	1.98	1.94	2.02	2.07	2.03	1.98	1.96	1.95	1.94	1.93	1.98	9
Apparel, leather and footwear	2.07	2.04	2.08	2.14	2.12	2.11	2.07	2.05	2.03	1.95	2.07	4
Paper and Printing	1.84	1.86	1.84	1.85	1.81	1.83	1.82	1.79	1.75	1.74	1.81	13
Chemical Products	2.12	2.02	2.04	2.17	2.12	2.15	2.13	2.12	2.11	2.05	2.10	3
Non-metallic Minerals	1.93	1.87	1.83	1.89	1.86	1.99	1.92	2.04	2.04	1.99	1.94	10
Metal Products	2.00	1.98	2.01	2.06	1.94	2.02	2.04	2.04	1.98	1.92	2.00	6
Electr. Mat. and Communic. Equip.	1.96	1.92	1.95	2.03	2.00	2.06	2.02	2.03	2.00	1.98	1.99	7
Transportation equipment	2.08	2.06	2.12	2.27	2.28	2.35	2.31	2.28	2.24	2.23	2.22	2
Miscellaneous	1.92	1.87	1.86	1.99	1.96	1.95	1.93	1.93	1.92	1.89	1.92	11

Source: Elaborated by the authors based on the estimated Brazilian input-output tables.

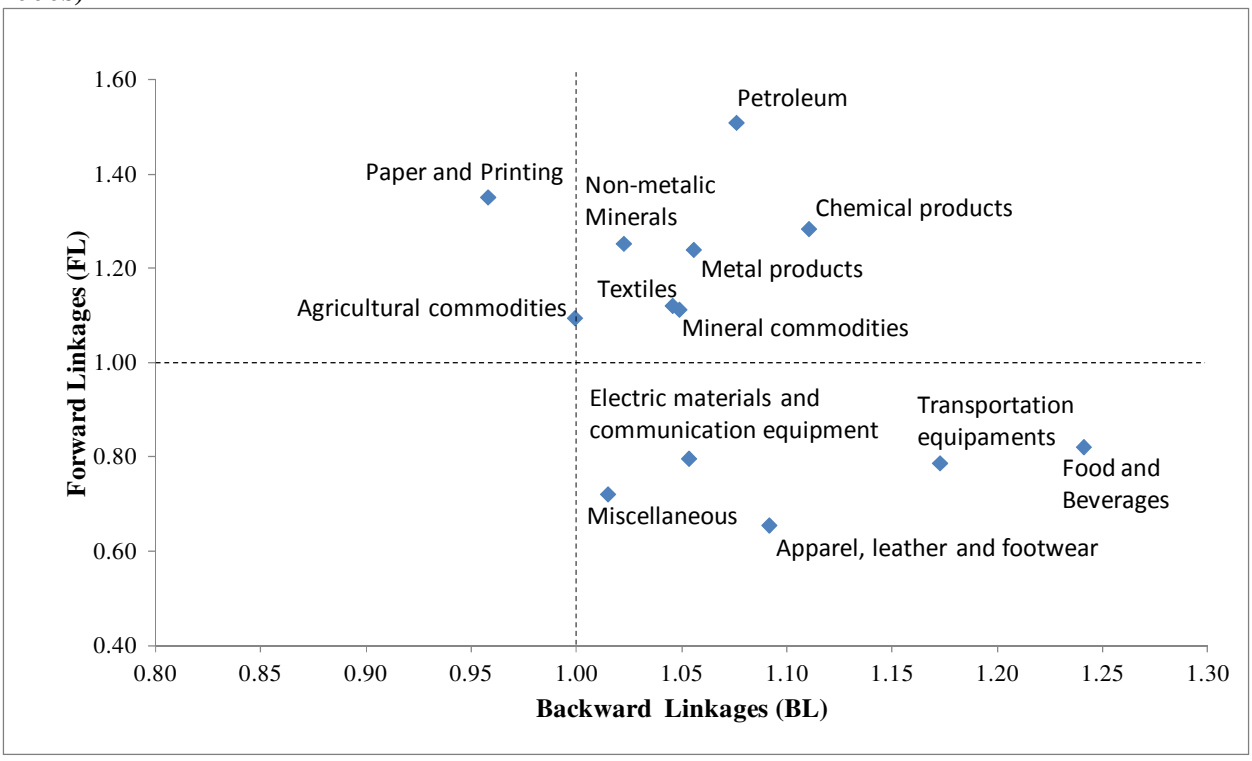
In addition, the results of the analysis of multipliers can be complemented by Hirschman-Rasmussen forward and backward linkage indexes. As highlighted by Guilhoto (2009) the Hirschman-Rasmussen linkage index analyzes the relationship between each sector and the remaining sectors of the economy. The backward linkage index was used to assess the degree of linkage in sector *j* in relation to the degree of linkage of the economy as a whole. Based on the results, one can infer to what extent the output of a particular sector stimulates the production of its inputs. The forward linkage index, in turn, makes it possible to analyze the importance of that sector as an input supplier. Through these indicators, the behavior of the economy's internal

[24] For obtaining a type II output multiplier, it would suffice to endogenize household demand, thus incorporating the induced effect or income effect into the model (Guilhoto, 2009).

structure can be studied and one can identify its key sectors that depend on inter-industrial supply, on inter-industrial demand, or are relatively independent from the others.

The key sectors that were identified in the Brazilian economy in the 2000s, located in the right upper quadrant, were petroleum, chemical products, non-metallic minerals , metal products, textiles and mineral commodities, which have a high potential to boost other sectors of the economy, besides being major input suppliers. Interestingly, there is no sector of the Brazilian economy in the group that is relatively independent from the others (lower left quadrant), indicating that there is a significant degree of dependence between several sectors of the economy. This result may have been caused by the development process of Brazilian industry during the ISI period, when input production and inter-industrial demand were strongly stimulated. As sectors strongly dependent on inter-industrial supply, located in the lower right quadrant, special mention should be made of those of food/beverages, electrical materials/ communications equipment, transportation equipment, and apparel/leather/footwear. The most prominent sectors in this quadrant are those of food/beverages and transportation equipment, which are highly dependent on inter-industrial supply. This datum contributes to evince the importance of this sector in its linkages with other sectors on which it is dependent and possibly its capacity to pull the other ones up. In the upper left quadrant, it can be observed that the paper/printing and agricultural commodities sectors are the ones that depend on inter-industrial demand the most, but they are also the ones with the lowest capacity to boost other sectors of the economy.

Graph 4 - Hirschman-Rasmussen backward and forward linkage indexes (average in the 2000s)



Source: Elaborated by the authors based on the estimated Brazilian input-output tables.

However, it should be stressed that the Hirschman-Rasmussen index does not consider the size of sectors in the economy, an important aspect for identifying key sectors, which is done through the normalized pure linkage indexes. For this reason, Table 2 shows these backward indexes, which assess the pure impact of a sector on those supplying the same inputs. In the first five positions, the food/beverages, transportation equipment, miscellaneous, petroleum and apparel/leather/footwear sectors stand out. The food/beverages sector stands out as the one with the highest index among the rest of them not only because of the importance of its demand from other industrial complexes, but also due to its size as compared to the other sectors. In addition, a special observation should be made for the transportation equipment sector, whose output has a rising and high pure impact and has demanded inputs from the other sectors of the economy over the years. Another sector whose demand from the other sectors has grown over the years is that of electrical materials/communications equipment, which ranked 6th. The levels of the indexes registered for both the agricultural and mineral commodity sectors were similar over the decade. The indexes observed for most sectors declined in 2009 probably due to the effects of the 2008 international crisis, which led to a marked decrease in demand in the economy. The sharpest drop in 2009 was the one observed in the metal products industry, which ranked 7th. The indexes for the textiles, chemical products, and paper/printing sectors varied little over the years, and their levels were similar. The last two sectors, which ranked 11th and 12th, were not the only ones for which no drop was observed and whose indexes remained constant as compared to the previous year.

Table 2 - Normalized pure backward linkage indexes (PBLN): 2000-2009

Sectors	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average	Ranking
Agricultural Commodities	0.41	0.40	0.42	0.50	0.49	0.47	0.44	0.43	0.48	0.44	0.45	9
Petroleum	0.68	0.84	0.82	0.79	0.81	0.96	1.01	0.89	0.93	0.78	0.85	4
Mineral Commodities	0.35	0.38	0.43	0.47	0.46	0.53	0.57	0.55	0.51	0.33	0.46	8
Food and beverages	6.47	6.66	6.72	7.42	7.42	7.04	6.58	6.52	6.82	6.80	6.85	1
Textiles	0.37	0.36	0.33	0.32	0.35	0.28	0.29	0.29	0.28	0.26	0.31	10
Apparel, leather and footwear	0.99	0.98	0.94	0.88	0.86	0.80	0.75	0.75	0.70	0.68	0.83	5
Paper and Printing	0.30	0.32	0.28	0.28	0.25	0.26	0.24	0.22	0.21	0.21	0.26	11
Chemical Products	0.27	0.23	0.22	0.26	0.27	0.24	0.25	0.26	0.24	0.24	0.25	12
Non-metallic Minerals	0.08	0.08	0.05	0.07	0.07	0.08	0.10	0.09	0.09	0.05	0.08	13
Metal Products	0.46	0.50	0.53	0.58	0.59	0.62	0.58	0.59	0.64	0.35	0.54	7
Electr. Mat. and Communic. Equip.	0.60	0.59	0.56	0.60	0.66	0.69	0.70	0.72	0.72	0.61	0.64	6
Transportation equipment	0.85	0.93	0.95	1.04	1.18	1.22	1.17	1.25	1.28	1.13	1.10	2
Miscellaneous	1.00	0.98	0.90	0.98	0.96	0.91	0.89	0.88	0.87	0.81	0.92	3

Source: Elaborated by the authors based on the estimated Brazilian input-output tables.

The forward linkage indexes, as shown in Table 3, indicate the sectors that are the most important suppliers of others in the economy for their production. The petroleum sector stands out as the one with the greatest capacity to supply inputs to the remaining sectors. Although it falls under the commodity category, petroleum is characterized by a high production rate for each monetary unit spent on final consumption. This is so because this sector is a supplier of inputs for manufacturing the main industrialized products of the chemical products and synthetic materials sector and of the apparel sector. The highest increase in linkage indexes in this sector

was registered in the 2004-2006 period, during which Brazil became self-sufficient in oil production[25].

Another prominent sector in the table is the food/beverages one, which is a major supplier of the other sectors, as well as the metal products industry, which once again ranked 3rd as the one with the greatest capacity to supply inputs to the domestic industry, followed by the agricultural commodities, paper/printing, textiles and mineral commodities sectors. As would be expected, this index was higher for sectors with a lower degree of processing. The transportation equipment and electrical materials/communications equipment sectors, whose degree of processing is higher and whose chain is closer to final goods, ranked 10th and 11th, respectively.

Table 3 - Normalized pure forward linkage indexes (PFLN): 2000-2009

Sectors	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average	Ranking
Agricultural Commodities	1.03	1.01	1.04	1.11	1.08	0.97	0.92	0.93	0.93	0.93	0.99	4
Petroleum	1.87	1.98	2.04	2.31	2.24	2.49	2.63	2.36	2.46	2.14	2.25	2
Mineral Commodities	0.61	0.61	0.69	0.75	0.84	0.86	0.83	0.88	0.91	0.74	0.77	7
Food and beverages	1.83	1.76	1.73	1.73	1.70	1.73	1.74	1.72	1.67	1.79	1.74	1
Textiles	0.99	0.96	0.96	0.91	0.86	0.79	0.75	0.71	0.65	0.65	0.82	6
Apparel, leather and footwear	0.08	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.04	0.05	13
Paper and Printing	1.13	1.03	0.93	0.85	0.84	0.76	0.74	0.73	0.71	0.74	0.85	5
Chemical Products	0.69	0.67	0.64	0.74	0.80	0.73	0.67	0.65	0.66	0.59	0.68	8
Non-metallic Minerals	0.61	0.62	0.59	0.66	0.58	0.52	0.56	0.53	0.58	0.65	0.59	9
Metal Products	1.12	1.22	1.29	1.30	1.52	1.58	1.40	1.52	1.59	1.37	1.39	3
Electr. Mat. and Communic. E	0.30	0.29	0.29	0.28	0.28	0.28	0.28	0.28	0.27	0.27	0.28	11
Transportation equipment	0.25	0.25	0.26	0.29	0.35	0.40	0.40	0.38	0.39	0.41	0.34	10
Miscellaneous	0.32	0.27	0.30	0.28	0.28	0.24	0.23	0.23	0.23	0.25	0.26	12

Source: Elaborated by the authors based on the estimated Brazilian input-output tables.

Concluding remarks

The Brazilian development model adopted in the early 1990s was based on replacing the model that had been applied since the 1930s through the introduction of neoliberal policies. As discussed here, this model failed to promote economic growth during the 1990s, as despite a scenario of price stabilization and productivity and competitiveness gains, the rates of productive investment were low, unemployment rose, and Brazil faced high trade deficits. It was only in the early 2000s that, along with improvements in external demand for Brazilian products, the national economy resumed a growth path. Given this joint process, most interpretations of the recent expansion of the Brazilian economy identified commodity production and exports as the main engines of this growth.

With the aim of assessing this phenomenon, this study was intended to analyze the capacity of commodity production to boost the Brazilian economy *vis-à-vis* manufacturing.

[25] In 2006, the production of 1.8 million barrels a day represented self-sufficiency in terms of oil production thanks to a Petrobras platform (P-50) that became operational in April 2006, which added about 180,000 barrels/day to the producing capacity of the Brazilian state enterprise.

Input-output matrices were used to quantify the potential of the sectors to leverage demand from other sectors and to identify key input-supplying sectors. As expected, exports of agricultural and mineral commodities, as well as the paper/printing sector, showed little capacity to boost the economy. Besides their low multipliers, the backward linkage indexes for these sectors were low, as their supply chains are not very large. It is worth noting, however, that although it also falls under the commodity category, the petroleum sector has very different characteristics in relation to the other ones. In addition to the relative importance of petroleum as a demanding sector and therefore as a booster of other supply chains, this sector is the leading supplier of inputs for the economy; Besides being a provider of inputs used for manufacturing the main industrialized products produced by the chemical products sector and the synthetic materials produced by the apparel sector, it is also an indirect supplier of the transportation equipment and electrical materials/communications equipment sectors and of several other industries. Thus, the opposite behavior of the petroleum sector in relation to the other ones clearly evinces the importance of trying to add value to commodities rather than just exporting raw or semi-manufactured goods.

The analysis of multipliers and linkage indexes also highlighted the importance of transportation equipment, chemical products, and apparel, leather and footwear as sectors that are very dependent on inter-industrial supply. These sectors have a high potential to turn final demand into production both within themselves and in their upstream chain. These results highlight the importance of focusing the development strategy on consolidating a production structure in which supply chains are structured in such a way that final demand can boost the rest of the economy.

Therefore, the analysis of the Brazilian production structure clearly showed that sectors related to manufactured products can still boost the economy more intensely as a result of their linkage effects on other sectors of the economy. Efforts to boost the Brazilian production structure must be associated with a development strategy that takes into account comparative advantages in the economy, but without denying the advantages of a production structure oriented toward expanding manufacturing. Interpretations of the recent growth path of the economy in Brazil that explain it based on the expansion of “commoditized” sectors and on the country’s comparative advantages limit the understanding of the complex set of factors that play a role in boosting the economy. Recognizing these factors is as relevant, if not more, as acknowledging exports as a dynamic element of economic growth, which constitutes an important line of research for studying Brazil’s development.

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Appendix 1 - Translator of types of Commodities and Manufactured Goods

Agricultural Commodities
Agriculture, forestry, extractive products
Livestock and fishing activities
Tobacco products
Wood products - excluding furniture
Pulp and paper products
Alcohol
Mineral Commodities
Manufacture of steel and steel products
Iron ore
Metallurgy of non-ferrous metals
Other extractive products
Petroleum
Petroleum refining and coking
Oil and natural gas
Chemical Products
Manufacture of resins and elastomers
Pharmaceutical products
Agrochemicals
Perfumes, hygiene and cleaning products
Paints, varnishes, enamels and lacquers
Various chemical products and preparations
Chemical products
Rubber and plastic items
Electric Materials and Communication Equipment
Machines and equipment, including maintenance and repairs
Household appliances
Office machines and IT equipment
Electrical machines, appliances and equipment
Electronic materials and communications equipment
Medical-hospital equipment/instruments for measurement and optical purposes
Transportation equipment
Cars, vans and off-road vehicles
Trucks and buses
Parts and accessories for motor vehicles
Other transportation equipment
Textile
Textiles
Clothing, leather and footwear
Articles of apparel and accessories
Leather products and footwear
Food and beverages
Food and beverages
Non-metallic minerals
Other non-metallic mineral products
Metallurgy
Metal products - except machinery and equipment
Paper and Printing
Newspapers, magazines, CDs
Miscellaneous
Furniture items and products of different industries