Structural changes in Brazilian industry (1995-2009)

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Abstract

This article analyses the structural changes that took place in Brazilian industry between 1995 and 2009, by considering their intersectoral relations, through input-output analysis using the structural decomposition method and the calculation of linkage indices. The results show that the expansion of final demand plays a key role in industry growth in terms of employment, value added and gross production value. Natural-resource-intensive industry has grown particularly strongly. Another finding is that intersectoral demand has weakened, particularly in scale-intensive sectors that use differentiated technology.

Keywords

Industry, industrial enterprises, structural adjustment, input-output analysis, productivity, employment, value, industrial policy, Brazil

JEL classification

L16, L60, O14

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I. Introduction

Achieving economic development in a country requires overcoming a series of obstacles, and implementing structural change to ensure that the economy's resources flow rapidly towards modern economic activities of higher productivity (Rodrik, 2013). Many recent studies focus on the different structural changes that have taken place in the Brazilian economy in recent years, focusing particularly on those that occurred in the productive sectors of the economy following the trade liberalization process of the 1990s.

Each study examines fundamental aspects that enrich that debate, such as the industrial sector's declining share in the economy,[1] the spread of outsourcing,[2] Dutch disease[3] and the regressive specialization of the industrial sector,[4] among others. Although there is no consensus on this matter, authors who emphasize the importance of industry for economic dynamics agree on the peculiarities of this sector. Hirschman (1958) claims that industry has more forward and backward linkages than the agriculture and service sectors, and that positive externalities and indirect effects are likely to be more prominent in that sector. Consequently, industry growth would have greater positive effects on the economy as a whole. Kaldor (1966) also stresses the differentiated role of industry with respect to technology and the greater potential of static and dynamic economies of scale.

With the aim of contributing to that debate, this paper seeks to analyse the structural changes that took place in Brazilian industry between 1995 and 2009, by considering its intersectoral relations. Following the trade liberalization process, Brazilian industry entered a period of structural specialization, which was premature in terms of the country's per capita income (Carvalho and Kupfer, 2011). The liberalization that took place in the 1990s favoured sectors of the economy that were already consolidated, and it led to a reduction in the industry share in value added and employment, the spread of outsourcing and the growth of the services sector. Such circumstances can imply a shift in industrial structure towards sectors of lesser technological content.[5] The study of the type of specialization occurring in Brazilian industry is an important element in the design of general economic policy.

To analyse structural change in Brazilian industry, this article uses the structural decomposition method of input-output analysis proposed by Miller and Blair (2009). This has been used in studies of both national and international scope to analyse structural changes both in the industrial sector and in the economy as a whole. Franke and Kalmbach (2005) studied structural change in industry and its effects on the service sector in Germany in the 1990s. Linden and Dietzenbacher (2000) analysed the determinants of structural change in the European Union by applying the RAS method to update the coefficients of an input-output matrix that captures variations of substitution and manufacturing effect. Guilhoto and others (2001a) compared the structural change that took place in Brazil between 1959 and 1980 with that occurring in the United States between 1958 and 1977; and they split the change in the structure of the economies into three components, inside and outside the sector (final demand, technology and intersectoral relations).

In addition to the structural decomposition, this article analyses the trend of linkages between industrial sectors according to the Rasmussen-Hirschman and Ghosh linkage indices; and it deflates

[1] See Oreiro and Feijó (2010), Marquetti (2002) and Bonelli (2005).

[2] See Araújo (2010).

[3] See Bresser-Pereira (2009) and Bresser-Pereira and Marconi (2008).

[4] See Carvalho and Kupfer (2007 and 2008).

[5] See Shafaeddin (2005).

the data from the matrices as proposed by Miller and Blair (2009).[6] The data are obtained from input-output tables based on a classification of 42 sectors,[7] estimated by Guilhoto and Sesso Filho (2010) on the basis of the national accounts produced by the Brazilian Geographical and Statistical Institute (IBGE), to analyse changes in production value, value added and employment in Brazilian industry between 1995 and 2009. The choice of period was based on criteria of data availability and quality, and comparability with other studies.

The importance of evaluating structural change in Brazilian industry is easy to justify. The pursuit of economic development requires taking account of several aspects of industrialization for policy definition. As argued by Rodrik (2007), productive specialization based on comparative advantages, particularly in commodities, is unlikely to be sufficient to achieve industrial upgrading. For that process to take place, investments are needed in other large manufacturing sectors, such as machinery, equipment and production facilities. The analysis of the type of specialization taking place in national industry is useful for evaluating public industrial development policies. This paper classifies the industrial sectors by technological level.[8]

In view of the above, this article is divided into five sections including the Introduction. Section II describes the methodology used in the study, while section III considers the source and classification of the data considered. Section IV presents the study's main findings, and section V summarizes the conclusions.

II. Methodology

This section firstly describes how the input-output matrices were deflated. The base year was 2009, and the method used, defined in Miller and Blair (2009), is referred to as double deflation, since it consists in a two-stage process. The first step involves deflating intermediate demand, final demand and gross production value (GPV), using a price index for each sector calculated based on data from the tables of uses and resources published in the IBGE national accounts. The price index by sector, with base year 1995 = 100 for the 42 sectors and the period 1996-2009, was:

$$I_{x,1995} = 100, \text{ for } x = sector\,1, \ldots, sector\,42 \tag{1}$$

$$I_{x,1996} = I_{x,1995} \cdot \textit{annual variation in prices of sector } x_{1996}$$

$$I_{x,t} = I_{x,t-1} \cdot \textit{annual variation of prices of sector } x_t, \textit{ for } t = 1997, \ldots, 2009 \tag{2}$$

The indices were re-based to 2009 as follows:

$$I_{t,base\ year\ 2009} = \left(I_{t,base\ year 1995} \big/ I_{2009,\,base\ year\ 1995}\right) \cdot 100, \text{ for } t = 1995, \ldots, 2009 \tag{3}$$

Once calculated, a vector π_t could be constructed with the price indices for the 42 sectors, and it was possible to deflate intermediate demand (Z^b), final demand (f^b) and GPV (X^b):

[6] As input-output data from different years are being compared, it is important to distinguish changes attributed to prices from those of other sources.

[7] The 42 sectors are presented in the annex.

[8] The sectors were classified by technological intensity based on Organization for Economic Cooperation and Development (OECD) (2005), which draws on Pavitt (1984). See the annex.

$$\pi_t = \begin{bmatrix} I_{agriculture,\ t} \\ I_{extractive\ mining,\ t} \\ \vdots \\ I_{non\text{-}commercial\ private\ services,\ t} \end{bmatrix},\ \text{for}\ t = 1995, \ldots, 2009 \tag{4}$$

$$Z^b = \hat{\pi}_t Z_t \tag{5}$$

$$f^b = \hat{\pi}_t f_t \tag{6}$$

$$X^b = \hat{\pi}_t X_t \tag{7}$$

The second step consists in calculating the price index to deflate the value-added data. All data are obtained at current prices, including value added. The value added (v^b) needed to ensure that the GPV is the same in both the sum of the rows and the sum of the columns, is calculated as follows:

$$\left(v^b\right)' = \left(X^b\right)' - i' Z^b \tag{8}$$

The deflator of value-added can then be calculated as,

$$\hat{r}_t = \hat{v}^b \left(\hat{v}_t\right)^{-1}, \text{ where } v_t \text{ represents value added at current prices} \tag{9}$$

According to Miller and Blair (2009), although the double deflation method is widely used, it has many disadvantages for deflating input-output tables, since all the elements of the row of the transactions matrix are deflated by the same index. The authors point out that inter-industry prices can vary considerably in many economies, so deflation by the same index could be incorrect. An alternative method is the bi-proportional adjustment algorithm or RAS. The double deflation method was chosen, because the RAS method is used mostly to update and project coefficients, rather than to deflate input-output matrices.[9]

After the deflation, the linkage indices and structural decompositions are calculated. For this purpose, a number of input-output analysis relations need to be defined. An economy is assumed to consist of n sectors; X is an $n \times 1$ vector of sectoral gross production values; A is an $n \times n$ matrix of technical coefficients; and f is an $n \times 1$ vector of final demand for the output of each sector. The sector production vector X can be expressed through the equation $X=AX+f$. The necessary algebraic manipulations give the input-output model that relates the respective sectoral outputs.

$$X = Lf \tag{10}$$

where $L=(I–A)^{-1}$, is an identity matrix of order n. $(I–A)^{-1}$ is the matrix of technical coefficients of direct and indirect inputs, or the Leontief inverse matrix, which captures the direct and indirect effects of exogenous changes in final demand in the production of the n sectors.

There are various ways of measuring sectoral linkages. This paper calculates the Rasmussen-Hirschman backward linkage indices, created by Rasmussen (1956) and subsequently developed

9 According to Miller and Blair (2009), the RAS technique requires less information and is widely used to estimate input output matrices that are not available. Using an input output matrix for a given year $\left(A_0\right)$ the RAS technique makes it possible to estimate the matrix for a later year $\left(\check{A}_1\right)$, knowing the sum of the rows $\left(\sum_{j=1}^{n} Z_{1j}\right)$, the columns $\left(\sum_{j=1}^{n} Z_{i1}\right)$ and the gross production value of all sectors of the economy in the later year.

by Hirschman (1958). According to Guilhoto and Sesso Filho (2010), the backward linkage indices indicate how much each sector demands from the other sectors of the economy. The indices in question are based on the inverse Leontief matrix ($L=(I-A)^{-1}$), so l_{ij} can be defined as an element of the matrix L, along with L^* which is the mean of all elements of L. It is also possible to calculate L_{*j}, which is the sum of the elements of a column of L, with n representing the number of sectors in the economy. Algebraically this gives:

$$L_{*j} = \sum\nolimits_{j=1}^{n} l_{ij} \quad i,j = 1,2,\dots \tag{11}$$

Thus it is possible to determine the backward linkage indices:

$$U_j = \left[\frac{L_{*j}}{n}\right] \Big/ L^* \tag{12}$$

To calculate forward linkage indices, the Ghosh model is the most suitable (Miller and Blair, 2009). These indices show how a sector is demanded by the other sectors, or how it supplies them with inputs. Instead of considering the technical coefficient ($a_{ij}=Z_{ij}/X_j$), this model considers the coefficient of allocation of production ($b_{ij}=Z_{ij}/X_i$). The indices are based on the inverse Ghosh matrix ($G=(I-K)^{-1}$), so that g_{ij} can be defined as an element of the matrix G, along with G^* which is the mean of all elements of G. In addition, G_{i*}, can be calculated as the sum of the elements of a row of G. Algebraically, this gives:

$$G_{i*} = \sum\nolimits_{i=1}^{n} g_{ij} \quad i,j = 1,2,\dots \tag{13}$$

It is thus possible to determine the forward linkage indices:

$$U_i = \left[\frac{G_{i*}}{n}\right] \Big/ G^* \tag{14}$$

The key sectors will be those that simultaneously show forward and backward linkage indices with values above one. Table 1 classifies the sectors by the value of their indices (less than or greater than one).

Table 1
Classification of intersectoral linkages

		Total forward linkage	
		Low (<1)	High (>1)
Total backward linkage	Low (<1)	(I) Independent	(II) Dependent on intersectoral demand
	High (>1)	(III) Dependent on intersectoral supply	(IV) Generally dependent (or key sector)

Source: Prepared by the authors, on the basis of R.E. Miller and P.D. Blair, *Input-Output Analysis: Foundations and Extensions*, New Jersey, Prentice-Hall, 2009.

Next, a structural decomposition is performed on GPV (ΔX), industrial employment $\Delta\varepsilon$ and value-added in industry (ΔV), assuming that there are input-output matrices for two periods (0 and 1). Then, the GPV for the two periods is obtained from equation (10), as follows:

$$X_0 = L_0 f_0;\; X_1 = L_1 f_1 \tag{15}$$

where, f_t is the final demand vector in year t; and $L_t=(I-A_t)^{-1}$ is the Leontief impact matrix in year t. The variation in GPV between the two years is:

$$\Delta X = X_1 - X_0 = L_1 f_1 - L_0 f_0 \quad (16)$$

The structural decomposition method involves several comparative statics exercises in which various coefficients are changed to be able to compare the activity levels with a benchmark (Miernyk, 1974). Considering equations:

$$\Delta f = f_1 - f_0; \quad f_1 = (f_0 + \Delta f); \quad f_0 = (f_1 - \Delta f);$$
$$\Delta L = L_1 - L_0; \quad L_1 = (L_0 + \Delta L); \quad L_0 = (L_1 + \Delta L)$$

and substituting in equation (16) gives:

$$\Delta X = L_1 (f_0 + \Delta f) - (L_1 + \Delta L) f_0 = (\Delta L) f_0 + L_1 (\Delta f) \quad (17)$$

The first part of equation (17) concerns technological change, whereas the second reflects changes in final demand. Although several combinations are possible, Miller and Blair (2009) perform the decomposition additively and develop some of those examples. Apart from that shown in equation (17) there are the following:

$$\Delta X = (\Delta L) f_0 + L_0 (\Delta f) - (\Delta L)(\Delta f) \quad (18)$$

$$\Delta X = (\Delta L) f_1 + L_1 (\Delta f) - (\Delta L)(\Delta f) \quad (19)$$

While all of the above equations are possible, Dietzenbacher and Los (1998) found that the combination of equations (18) and (19) is the most appropriate. That combination gives rise to equation (20), which is used in this study.

$$\Delta X = \left(\frac{1}{2}\right)(\Delta L)(f_0 + f_1) + \left(\frac{1}{2}\right)(L_0 + L_1)(\Delta f) \quad (20)$$

The first term on the right-hand side represents the variation in GPV if there is a change in technology (it assumes the change in the inverse Leontief matrix - ΔL), whereas the second term captures the effect of variations in final demand (Δf) on ΔX.

As the calculation is based on the changes in the Leontief matrix, the effect of the technological change shows how the linkages between the sectors vary (weakening or strengthening of the link). The factors explaining the technological changes are: innovations, import substitution, an increase in the benefits obtained from economies of scale, changes in product mix (with the adoption of new substitutes or complimentary inputs in the production process), variation in relative prices (given that the technical coefficients in the Leontief matrix arise from the monetary valuation), and changes in trade patterns (exports and also import substitution). Those factors alter the technical coefficients in the Leontief matrix, and are shown in the calculated effect of the technological changes (Schuschny, 2005).[10]

[10] Although structural decomposition makes it possible to identify the activities that recorded increases in output owing to technological change, the model does not contain information to identify and analyse its causes. In other words, this method cannot determine the increase in output of a given sector owing to the variation in each separate factor that comprises the technological change (innovation, economies of scale, changes in product mix, variation in relative prices, changes in trade patterns).

For the decomposition of employment, $(e_t)' = [e_{0,t} \ldots e_{1,t}]$ is the vector of employment coefficients representing the quantity of labour per monetary unit of production in sector i during period t. The inverse of those coefficient represents an indirect measurement of labour productivity, defined as:

$$e_{i,t} = \varepsilon_{i,t} / X_{i,t} \tag{21}$$

Thus, the sectoral employment vector in period t will be:

$$\varepsilon_t = \hat{e}_t X_t = \hat{e}_t L_t f_t \tag{22}$$

and the vector of changes in employment will be:

$$\Delta\varepsilon = \varepsilon_1 - \varepsilon_0 = \hat{e}_1 L_1 f_1 - \hat{e}_0 L_0 f_0 \tag{23}$$

Using the same relations as in the decomposition of production, equation (23) can be written as follows:

$$\Delta\varepsilon = \left(\frac{1}{2}\right)(\Delta\hat{e})(L_1 f_1 + L_0 f_0) + \left(\frac{1}{2}\right)\left[\hat{e}_0 \Delta L f_1 + \hat{e}_1 \Delta L f_0\right] + \left(\frac{1}{2}\right)(\hat{e}_0 L_0 + \hat{e}_1 L_1)(\Delta f) \tag{24}$$

The first term of equation (24) is the portion of the variation in employment caused by changes in the direct labour coefficient. The second term represents the portion of the variation in sectoral employment owing to the technological changes that altered the input requirements of the production activities. The third term captures the effect of the variation in final demand on sectoral employment.

Lastly, the decomposition of value added is similar to that of employment. The difference is that account is taken of the direct vector of coefficients of value added, which is represented by the ratio between value added and output value ($va_{i,t}$), instead of using the vector of direct employment coefficients.

$$va_{i,t} = V_{i,t} / X_{i,t} \tag{25}$$

$$V_t = \widehat{va}_t X_t = \widehat{va}_t L_t f_t \tag{26}$$

$$\Delta V = V_1 - V_0 = \widehat{va_1} L_1 f_1 - \widehat{va_0} L_0 f_0 \tag{27}$$

$$\Delta V = \left(\frac{1}{2}\right)(\Delta\widehat{va})(L_1 f_1 + L_0 f_0) + \left(\frac{1}{2}\right)\left[\widehat{va_0} \Delta L f_1 + \widehat{va_1} \Delta L f_0\right] + \left(\frac{1}{2}\right)(\widehat{va_0} L_0 + \widehat{va_1} L_1)(\Delta f) \tag{28}$$

III. Source and classification of the data

Input-output tables were used, based on a classification of 42 sectors, estimated by Guilhoto and Sesso Filho (2010) and available online at the website of the University of São Paulo Regional and Urban Economics Lab (NEREUS).

Thirty of the 42 sectors examined in this paper are industrial. The data published by the cited source adhere to an international classification criterion based on version 1.0 of the National

Classification of Economic Activities (CNAE).[11] The classification by technological intensity was done using the methodology based on the taxonomy created by Pavitt (1984) and adopted by the Organization for Economic Cooperation and Development (OECD) in various studies (OECD, 1987 and 2005), which was also used by Nassif (2006) to analyse Brazil's foreign trade, among numerous other studies.

Lall (2000) used that taxonomy in an analysis of technological change and industrialization in Asia. For that author, the main factor in the competitiveness of natural-resource-intensive sectors is access to the natural resources itself, whereas the competitiveness of labour-intensive sectors depends on the availability of low- and medium-skilled labour at a low relative cost compared with other countries. Scale-intensive sectors are those in which it is possible to gain by producing on a large scale. In sectors with differentiated technology, the products satisfy different patterns of demand; while the key competitive factor in sectors with science-based technology is rapid application of the science to the industrial technology.

A shortcoming of the Pavitt (1984) taxonomy is that the classification does not capture any of the changes that have occurred in the world economy over the last three decades. According to Dupas (1998), corporate production and distribution strategies have been reformulated, and the vertically integrated enterprise has given way to networks which incorporate different firms in a single global project. In this process, technology and capital become increasingly mobile, driven by the potential fragmentation of production chains. In this context, the oil and gas sector, which, in that taxonomy is classified as natural-resource-intensive, involves knowledge relating to oil extraction and refining, which would be technology-intensive. The same situation applies to the electronic appliances sector, classified as an industry of differentiated technology, in which the production chain includes segments with very similar characteristics to those of labour-intensive sectors. This article reconciles the sectors classified in that taxonomy by OECD (2005) and the sectors of the input-output matrix.[12]

IV. Results

1. Intersectoral relations

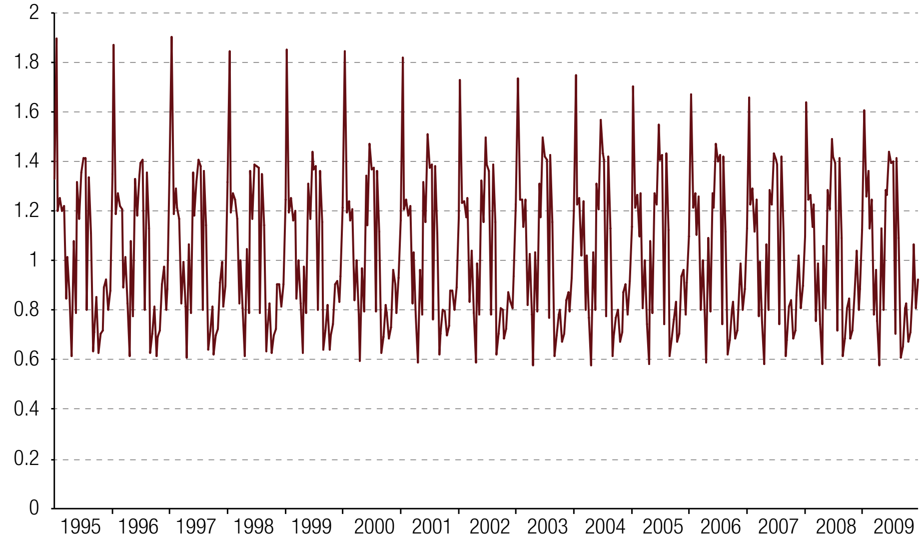
Use of the Ghosh and Rasmussen-Hirschman indices made it possible to ascertain how the production structure of the Brazilian economy has changed through time. This is shown in figures 1 and 2, which resemble encephalograms in medicine, measuring differences based on a certain standard. That analogy, originally defined in Guilhoto and others (2001a and 2001b), has been called the electro-econogram of the production structure. It can be constructed by showing the results of the indices on a linear graph. The smaller the change reflected in the dispersion of the graphs, the closer the results will be to those of the first year of the analysis (1995). In contrast, the larger the dispersion of the graphs, the larger will be the changes recorded in the productive structure over the period analysed.

The visual analysis shows that the Ghosh forward linkage indices (see figure 1) display decreasing variation, which indicates less intensity in intersectoral supply in the later years of the series, compared to the start of the period. That loss of intensity occurred slowly between 1995 and 2009, so the dispersion of the graphs was less than in the analysis of Rasmussen-Hirschman the backward linkage index (see figure 2). In this case, there is a clear change in the pattern of the graphs: slow change in the production structure in 1995-2000, followed by a clear change as from 2001, indicating a reduction in intersectoral demand as from that year.

[11] The 30 industrial sectors form part of section C (extractive industries) and section D (manufacturing industries) of CNAE 1.0.

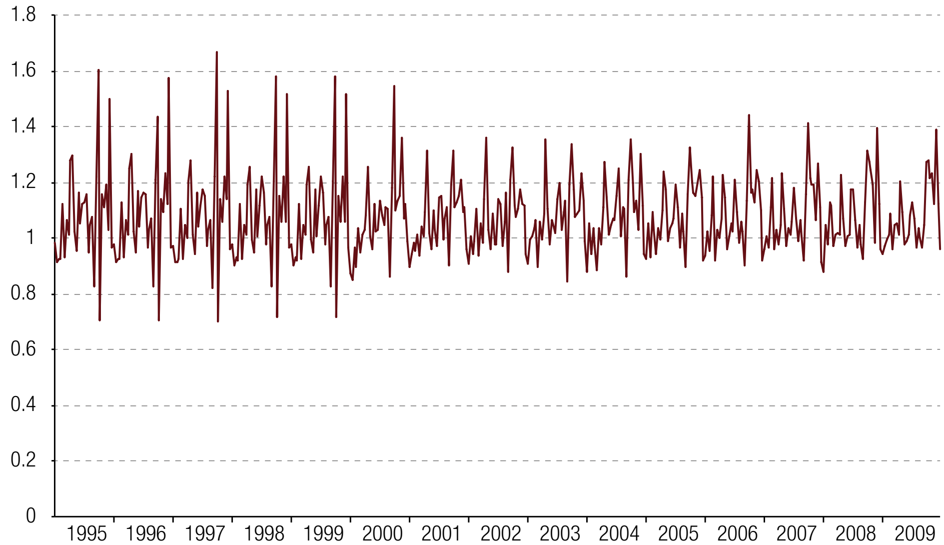
[12] See annex.

Figure 1
Electro-econogram of the Ghosh forward linkage index of the sectors of Brazilian industry, 1995-2009



Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS).

Figure 2
Electro-econogram of the Rasmussen-Hirschman backward linkage index of the sectors of Brazilian industry, 1995-2009



Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS).

A factor that may have influenced this phenomenon was the change in the macroeconomic policy regime from 1999 onwards. Between 1995 and 1998, the macroeconomic policy regime based on an exchange rate anchor was implemented, which underpinned the success of the Real Plan. In 1999, that regime was replaced by the "macroeconomic tripod," which was in force until 2005, consisting of inflation targets, primary surplus targets, and a relatively free-floating nominal exchange rate. The change since 2001 is probably related to an increase in import content; in other words, the impact of foreign trade on the structure of national production, owing to the change in the economic development model being pursued (particularly by the floating exchange rate as from 1999).[13] Although the integration of the Brazilian market into the global economy in the first decade of the twenty-first century made it possible to increase exports, many firms replaced national suppliers with foreign ones.[14] Thus, the reduction in sectoral demand relations (see figure 2) can be explained in terms of substitution by imported inputs.

Sectoral relations decline in both cases, since there was a reduction in sectoral relations in terms of input supply (captured by the Ghosh forward linkage index) and a much larger loss in sectoral demand relations (captured by the Rasmussen-Hirschman backward linkage index).

There follows a more detailed analysis of the sector linkages, in order to determine whether the intersectoral linkages were strengthened or weakened. The aim is to establish which sectors increase their linkages with the others, within the composition of manufacturing industry. Table 2 shows the backward and forward linkage indices.

Table 2
Rasmussen-Hirschman backward linkage indices and Ghosh forward linkage indices
1995 and 2009

Classification by type of technology	Sector	Ranking (highest backward linkage indices)		Backward linkage index		Ranking (highest forward linkage indices)		Forward linkage index	
		1995	2009	1995	2009	1995	2009	1995	2009
Science-based	Pharmaceutical and veterinary	24th	26th	0.95	0.97	22nd	23rd	0.81	0.8
Natural-resource-intensive	Extractive mineral	21st	30th	0.98	0.94	5th	5th	1.35	1.36
	Oil and gas	28th	25th	0.91	0.97	1st	1st	1.87	1.9
	Non-metallic mineral	27th	22nd	0.92	1	11th	10th	1.19	1.19
	Oil refining	10th	7th	1.13	1.13	3rd	2nd	1.39	1.41
	Coffee industry	1st	3rd	1.6	1.27	21st	20th	0.82	0.82
	Processing of vegetable products	30th	2nd	0.71	1.28	29th	29th	0.62	0.62
	Animal slaughter	8th	5th	1.16	1.21	27th	27th	0.69	0.7
	Dairy products industry	13th	4th	1.11	1.23	25th	25th	0.72	0.72
	Sugar manufacture	6th	8th	1.19	1.12	17th	17th	0.91	0.91
	Manufacture of vegetable oils	18th	1st	1.03	1.39	16th	15th	0.98	1
	Other products food	2nd	9th	1.5	1.12	23rd	21st	0.8	0.82
	Non-ferrous metallurgy	12th	11th	1.12	1.09	9th	9th	1.22	1.22
Labour-intensive	Other metallurgy	25th	28th	0.93	0.96	10th	12th	1.21	1.17
	Wood and furniture	23rd	24th	0.95	0.98	24th	24th	0.78	0.79
	Textile industry	14th	21st	1.07	0.99	13th	13th	1.13	1.14
	Garments	29th	27th	0.82	0.96	28th	28th	0.63	0.64
	Footwear manufacture	5th	15th	1.22	1.05	26th	26th	0.7	0.72
	Miscellaneous industries	22nd	29th	0.96	0.96	19th	18th	0.89	0.9

13 That argument is at the heart of studies on Dutch disease by Bresser-Pereira (2009) and Oreiro and Feijó (2010).

14 In his study, Magacho (2013) decomposed changes in industry between 1995 and 2008 to determine the sectors in which substitution by imported inputs was most intense. The results show that in the primary sectors the impact of replacement by imported inputs in output was 13.9%. In the high and medium-high technology sectors, replacement by imported inputs reduced the growth of output value by 18.1%, particularly in the chemical and electrical equipment sectors. The author states that the national process of replacement by imported inputs was most intense between 2003 and 2008.

Table 2 (concluded)

Classification by type of technology	Sector	Ranking (highest backward linkage indices)		Backward linkage index		Ranking (highest forward linkage indices)		Forward linkage index	
		1995	2009	1995	2009	1995	2009	1995	2009
Scale-intensive	Iron and steel	26th	20th	0.93	1.01	8th	8th	1.27	1.29
	Automobiles trucks and buses	3rd	6th	1.3	1.21	30th	30th	0.61	0.61
	Vehicle parts	19th	10th	1.02	1.09	14th	14th	1.08	1.07
	Cellulose, paper and graphics	7th	23rd	1.16	0.99	7th	6th	1.33	1.36
	Rubber industry	16th	18th	1.05	1.01	12th	11th	1.18	1.18
	Chemical elements	11th	12th	1.12	1.08	6th	7th	1.34	1.32
	Miscellaneous chemicals	9th	13th	1.16	1.07	2nd	3rd	1.41	1.38
	Plastics	17th	17th	1.05	1.04	4th	4th	1.35	1.36
Differentiated	Machinery and equipment	15th	16th	1.06	1.05	18th	19th	0.89	0.83
	Electrical material	20th	14th	1.01	1.05	15th	16th	1.01	0.99
	Electronic equipment	4th	19th	1.28	1.01	20th	22nd	0.83	0.81

Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS).

Comparing 1995 with 2009, there is evidence that the backward linkages that increased most were those of the sectors in the natural-resource-intensive group, in other words their intersectoral demand increased. Whereas in 1995, just two of the five highest indices of backward linkage corresponded to natural-resource-intensive sectors (coffee industry, other food products), by 2009 that number had risen to five (manufacture of vegetable oils, processing of vegetable products, coffee industry, dairy product industry, and animal slaughtering). In addition, another four sectors in that group raised their positions in the ranking: oil and gas, non-metallic minerals, oil refining, and non-ferrous metallurgy. In the forward linkages of those sectors, there were not many changes between the two years, except in the case of the manufacturer of vegetable oils, which became a key sector in 2009, because its forward linkage index rose by more than one. Oil refining and non-ferrous metallurgy were key sectors in both 1995 and 2009.

In general, the group of labour-intensive sectors lost positions among the highest indices of backward linkage between 1995 and 2009, except for the clothing sector. In 1995, the textile industry and footwear manufacture displayed backward linkage indices above one, and were dynamic sectors from the standpoint of intersectoral supply.[15] In 2009, the textile industry had lost backward linkages and was no longer a dynamic sector from the supply standpoint. Moreover, although the forward sector linkages of those sectors increased, their positions among the highest forward linkage indices remained unchanged. The textile industry was the only sector in the group to record forward linkage indices greater than one in both 1995 and 2009, which means that it is dynamic from the demand perspective. The loss of backward linkages in that sector caused a change in classification from a key sector in 1995, to a sector dependent on intersectoral demand.

Among scale-intensive sectors, there has been an increase in backward sector linkages in the iron and steel industries and vehicle parts, which meant that iron and steel was classified as a key sector in 2009. The other sectors in the group suffered reductions. All sectors display backward linkage indicators above one, so they are dynamic sectors from the intersectoral supply viewpoint. Only the pulp, paper and graphics sector ceased to be dynamic in terms of supply in 2009, owing to the loss

[15] A sector that is dynamic from the supply standpoint succeeds in influencing intersectoral supply, since it is an important source of demand in other sectors of the economy. In contrast, a dynamic sector from the demand standpoint is an important supplier to other sectors and influences intersectoral demand.

of backward linkages, and thus was not classified as a key sector in that year. Moreover, despite the forward linkages remaining broadly unchanged between 1995 and 2009, the corresponding indices were greater than one in nearly all sectors of the group, which shows that they are dynamic from the demand standpoint. The automobile, trucks and bus industry is an exception, because it displayed a forward linkage index less than one in 1995, and in 2009 was not classified as a key sector because it was dependent on intersectoral supply and because it provides input to the other sectors of the economy. The scale-intensive group had the largest number of key sectors in the period.

In the pharmaceutical and veterinary sector, which uses science-based technologies, there were few changes in the backward and forward linkages. That sector was dynamic neither from the supply nor the demand standpoint, because its backward and forward linkage indices were less than one in both 1995 and 2009. Its backward linkages increased and forward linkages declined in the period analysed.

Lastly, all sectors with differentiated technology displayed backward linkage indices greater than one in 1995 and 2009, and thus represented dynamic sectors in terms of supply. Between 1995 and 2009, the backward linkages decreased in the machinery and equipment and electronic equipment sectors, and increased in the electrical material sector. In terms of forward linkages, only the electrical material sector recorded an index greater than one in 1995. Nonetheless, as it lost linkages, it ceased to be dynamic from the intersectoral demand standpoint, and was reclassified as dependent on intersectoral supply.

While there were no significant changes in forward linkages between 1995 and 2009, the situation is different when the backward linkages are analysed. In general, there was a loss of backward linkages in the Brazilian economy, which implies a weakening of intersectoral demand. The analysis of technological groups shows that while the natural-resource-intensive sectors gain importance in 2009, by increasing the demand for inputs from the other sectors (displaying higher backward linkage indices in that year), the backward linkages declined in important scale-intensive demanding sectors,[16] along with differentiated technology[17] and two labour-intensive sectors (textile industry and footwear manufacture).

The analysis of sector linkages shows that the Brazilian economy went through a process in which the intersectoral demand of natural-resource-intensive sectors increased by more than the sectors of the other groups. There was an industrial restructuring process in which the scope of the intermediate demand of natural-resource-intensive sectors increased, while that of the scale-intensive sectors and those with differentiated technology declined. The results of the structural decomposition of employment, value-added and GPV are presented next.

2. Decomposition of employment

Table 3 summarizes the results of the decomposition of employment in the industrial sectors by type of technology used. Of the 2.7 million jobs created between 1995 and 2009, 931,200 were in sectors that use natural resources-intensive technologies, and 951,980 were in labour-intensive sectors. This concurs with the claim by Nassif (2006) that sectors with natural resource-based and labour-intensive technologies have greater capacity to generate direct jobs.

[16] Except for iron and steel and vehicle parts.

[17] Except for machinery and equipment.

Table 3
Brazil: structural decomposition of industrial employment by type of technology, 1995-2009
(Thousands of jobs and percentages)

Classification of the industry by type of technology	Total variation in employment	Contribution of technological change		Contribution of change in final demand		Contribution of the change in the direct labour coefficient	
Science-based	30.24	-27.58	-91.22%	148.60	491.40%	-90.77	-300.18%
Natural-resource-intensive	931.10	-22.34	-2.40%	1 627.80	174.82%	-674.36	-72.43%
Labour-intensive	951.98	-361.43	-37.97%	802.99	84.35%	510.43	53.62%
Scale-intensive	466.08	-28.96	-6.21%	1 078.39	231.37%	-583.35	-125.16%
Differentiated	376.68	-113.58	-30.15%	527.49	140.04%	-37.24	-9.89%
Total	2 756.09	-553.90	-20.10%	4 185.28	151.86%	-875.29	-31.76%

Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS).

The largest increases in employment in the period analysed took place in the sectors of vegetable product processing (360,000 jobs created) and garments (357,000 jobs). As the first of these is natural-resource-intensive and the second is labour-intensive, their contributions were important for the results of those groups.

Technological change resulted in job losses in the industry, particularly in labour-intensive sectors (361,430 fewer jobs). The garment sector made a big contribution to that result, because it was the manufacturing industry sector that suffered the largest job loss for that reason. Despite the negative technological effect, the second largest increase in employment occurred in that same sector. This was because the contributions of the change in final demand and direct labour coefficient together outweighed the contribution made by technological change. The same happened in the other sectors of the labour-intensive group.

Final demand increased industrial employment, particularly in natural-resource-intensive sectors (creation of 1.62 million jobs) and in scale-intensive sectors (1.07 million new jobs). The sectors recording the largest increases in employment as a result of final demand were, respectively, other food products, and pulp, paper and graphics.

The direct labour coefficient reduced employment in all of the groups analysed, except for the labour-intensive group. The coefficient measures the amount of labour per monetary unit of production, and its inverse can be interpreted as an indirect measure of labour productivity. Thus, the largest increase in labour productivity (with a reduction of 674,360 jobs owing to the change in the coefficient) occurred in the natural-resource-intensive sectors. In the labour-intensive sectors, labour productivity declined (with an increase of 510,430 jobs), because the garment and footwear manufacturing sectors lost productivity during the period analysed.

The restructuring of industrial employment between 1995 and 2009 occurred with the largest job growth in the technology and natural-resource-intensive sectors. Those sectors suffered a reduction owing to the technological effect, but, while the labour-intensive sectors lost productivity, the natural-resource-intensive sectors displayed the largest increase in employment owing to increases in final demand and labour productivity in the period analysed.

3. Decomposition of value added

In terms of the decomposition of value added, the industrial sectors with natural-resource-intensive technology recorded the largest share in the total variation of industry value-added (41.07%), followed by the scale-intensive sectors (35.26%), sectors using differentiated technology (15.40%), science-based sectors (5.62%) and, lastly, the labour-intensive sectors (2.65%) (see table 4).

Table 4
Brazil: structural decomposition of industrial value added by type of technology, 1995-2009
(Millions of reais at 2009 prices and percentages)

Industry classification by type of technology	Total variation in value-added		Variation in value added attributable to each effect					
			Technological change		Change in final demand		Change in the direct coefficient of value-added	
Industry	161 915.17	100.00%	-7 103.70	100.00%	199 620.03	100.00%	-30 601.15	100.00%
Science-based	9 099.46	5.62%	-2 653.79	37.36%	14 706.55	7.37%	-2 953.30	9.65%
Natural-resource-intensive	66 496.22	41.07%	12 767.17	-179.73%	76 979.45	38.56%	-23 250.40	75.98%
Labour-intensive	4 288.48	2.65%	-7 977.85	112.31%	22 625.39	11.33%	-10 359.06	33.85%
Scale-intensive	57 088.73	35.26%	-3 804.19	53.55%	60 025.71	30.07%	867.21	-2.83%
Differentiated	24 942.29	15.40%	-5 435.04	76.51%	25 282.93	12.67%	5 094.39	-16.65%

Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS) and the national accounts published by the Brazilian Geographical and Statistical Institute (IBGE).

The technological changes that occurred in the Brazilian economy and the period examined, contributed to the increase in value-added only in the natural-resource-intensive sectors, but declined in the other sectors (see table 4). Thus, the contribution of the effect of technological changes to the change in value added in the different groups was negative in the industrial sectors that use science-based technology (-29.16%), and also in labour-intensive sectors (-186.03%), scale-intensive sectors (-6.66%), and sectors using differentiated technologies (-21.79%). Only in the sectors using natural-resource-intensive technology was an increase in value added owing to technological change, which accounted for 19.20% of the variation in value added of that group (see table 5). The contribution made by the effect of the change in final demand was the factor explaining most of the growth in value added in all of the groups analysed. In particular, the change in final demand is the only factor explaining the increase in value added of the labour-intensive sectors, since the contributions made by the other factors were negative (see table 5).

Table 5
Brazil: contributions made by the different the effects to the variation in value added, 1995-2009
(Percentages)

Industry classification by type of technology	Contributions of the different effects		
	Technological change	Change in final demand	Change in the direct coefficient of value-added
Industry	-4.39%	123.29%	-18.90%
Science-based	-29.16%	161.62%	-32.46%
Natural-resource-intensive	19.20%	115.77%	-34.96%
Labour-intensive	-186.03%	527.59%	-241.56%
Scale-intensive	-6.66%	105.14%	1.52%
Differentiated	-21.79%	101.37%	20.42%

Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS) and the national accounts published by the Brazilian Geographical and Statistical Institute (IBGE).

The effect of the direct coefficient of value added implied reductions in all of the groups except for the sectors with scale-intensive and differentiated technology. In other words, the ratio between value added and production value increased only in those two groups. This result shows that the sectors that require skilled labour, such as sectors using scale-intensive and differentiated technology, are those that succeeded in increasing their capacity to generate greater income or value added for the economy. In contrast, the sectors that carry out standardized or codified tasks, requiring little skilled labour, do not achieve that result, as is the case with several natural resource- and labour-intensive sectors. In the maquila industries[18] for example, the ratio between value added and production value is small.

The analysis of value added reveals a process of re-primarization or backward specialization in Brazilian manufacturing industry, which is reflected in the greater share of sectors with natural-resource-intensive technology in the total variation in industry value added. Backward specialization means a change in the composition of industry, such that natural-resource-intensive sectors become relatively more important.

In an analysis of "deindustrialization" from the standpoint of value added at the sector level between 2000 and 2008, Morceiro (2012) obtained interesting results. Most of the sectors of manufacturing industry analysed by the author recorded a positive performance. The largest reductions occurred in the sectors of electronics material and communications equipment, clothing and accessories, wood products and leather articles and footwear. According to that author (p. 109):

> Thus, although deindustrialization (real downsizing) proceeded in those four sectors, it can be considered localized or concentrated in a few sectors that are more exposed to international competition, particularly Asian (characterized by countries that are strong in the labour-intensive sectors and in the electronics industry). Nonetheless, other labour-intensive sectors such as the textiles, furniture, articles of rubber and plastic, and basic metallurgy, performed poorly compared to the manufacturing industry; and, if no measures adopted, they could be susceptible to deindustrialization.

The sectors identified by Morceiro (2012) as being exposed to international competition, especially Asian, are labour-intensive sectors (such as wood and furniture, clothing and footwear manufacture), and those with differentiated technology (such as electronics equipment). The only one of those four sectors in which value added decreased between 1995 and 2009 was the garment industry, with a contraction of R$ 14,143.35 million at 2009 prices, owing to the negative contribution of final demand. The sector was responsible for the low share of the labour-intensive group in the total variation in industry value added (see table 4).

In the period under analysis, value added also declined in the vegetable product processing sectors (- R$ 15,781.08 million at 2009 prices) and vegetable oil manufacture (- R$ 9,413.70 million at 2009 prices), both of which are natural-resource-intensive sectors. Despite the reduction in those sectors, the substantial results of the oil and gas industries (variation of R$ 22,001.17 million in value added) and oil refining (total variation of R$ 20,159.69 million in value added), meant that the natural-resource-intensive sectors generated the largest share of the total variation of industry value added (see table 4).

The results obtained partially confirm the study by Morceiro (2012). It was found that labour-intensive sectors were those that participated least in the growth of industry value added in the period analysed, because they suffer from international competition. The discrepancies observed are due to methodological differences between the studies. The structural decomposition was used to analyse the total variation in value added between 1995 and 2009, and the factors explaining that variation (technological changes, changes in final demand, and changes in the direct coefficient of value-added). Morceiro (2012) compared the growth rates of value added of 2000 and 2008 by industry sector, and used a different industrial sector classification than that used in this paper.

[18] The maquila industries were originally labour-intensive manufacturing enterprises set up on the border between Mexico and the United States to exploit cheap labour. The production process that was transferred to Mexico was very simple and did not require skilled labour, nor did it contribute to technological change. See Bresser-Pereira, Marconi and Oreiro (2009). As those industries also involve product assembly based on imported components, they generate little value added.

4. Decomposition of gross production value

Table 6 shows the results of the decomposition of industry GPV by type of technology. Between 1995 and 2009, industrial GPV increased by R$ 722,743.92 million at 2009 prices. The largest share in the total increase in industry GPV corresponds to the natural-resource-intensive sectors (51.08%), followed by the scale-intensive sectors (31.28%), and then those with differentiated technology (8.75%), labour-intensive sectors (5.05%), and those using science-based technology (3.84%).

Technological change in the economy reduced industry GPV by R$ 12,770.66 million, and the sectors using differentiated technology were those that contributed in most to that result. In addition, technological change reduced industry GPV in all groups analysed, except for natural-resource-intensive sectors, where GPV increased by R$ 47,447.81 million as a result of technological change (see table 6).

Table 6

Brazil: structural decomposition of industrial gross production value (GPV) by type of technology, 1995-2009

(Millions of reais at 2009 prices and percentages)

Industry classification by type of technology	Total variation in GPV		Variation in GPV owing to the effects			
			Technological change		Change in final demand	
Industry	722 743.92	100.00%	-12 770.66	100.00%	735 514.57	100.00%
Science-based	27 771.54	3.84%	-6 010.14	47.06%	33 781.68	4.59%
Natural-resource-intensive	369 201.13	51.08%	47 624.88	-372.92%	321 576.25	43.72%
Labour-intensive	36 474.48	5.05%	-17 116.81	134.03%	53 591.29	7.29%
Scale-intensive	226 064.67	31.28%	-12 580.79	98.51%	238 645.46	32.45%
Differentiated	63 232.10	8.75%	-24 687.80	193.32%	87 919.89	11.95%

Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS) and the national accounts published by the Brazilian Geographical and Statistical Institute (IBGE).

The contribution made by the effect of technological change to the variation in value added of the different groups was negative for the industry sectors that use science-based technology (-21.64%), and also for labour-intensive sectors (-46.93%), scale-intensive sectors (-5.57%) and those using differentiated technology (-39.04%). It was positive only for the natural-resource-intensive sectors (12.90%) (see table 7).

Table 7

Brazil: contribution of the different effects to the variation in gross production value (GPV), 1995-2009

(Percentages)

Industry classification by type of technology	Contribution of the effects	
	Technological change	Change in final demand
Industry	-1.77%	101.77%
Science-based	-21.64%	121.64%
Natural-resource-intensive	12.90%	87.10%
Labour-intensive	-46.93%	146.93%
Scale-intensive	-5.57%	105.57%
Differentiated	-39.04%	139.04%

Source: Prepared by the authors, on the basis of data from the University of São Paulo Regional and Urban Economics Lab (NEREUS) and the national accounts published by the Brazilian Geographical and Statistical Institute (IBGE).

The technical changes that occurred in the Brazilian economy increased value added and GPV only in the natural-resource-intensive industrial sectors, whereas the other sectors suffered reductions. Those changes could reflect innovations, import substitution, economies of scale, changes in product mix, variations in relative prices, and changes in trade patterns.

Growth of final demand was the main factor driving an increase in industry GPV. Although that increase was greater in the natural-resource-intensive sectors (see table 6), the labour-intensive sectors were those displaying the largest contribution of the effect of the change in final demand (146.93% —see table 7). It was the impulse generated by the increase in final demand that caused science-based, labour-intensive, scale-intensive and differentiated technology sectors to record GPV growth in 1995-2009.

The analyses of industry GPV and value added confirm the hypothesis of a process of industrial re-primarization or backward specialization, because the largest increase in GPV corresponded to natural-resource-intensive sectors, followed by the scale-intensive sectors, those using differentiated technology, science-based technology, and labour-intensive sectors. The sectors that contributed most to the increase in GPV in the natural-resource-intensive group were oil refining and oil and gas.

The second largest increase in GPV occurred in the scale-intensive sectors, thanks to the contribution of the automobile, truck and bus sector, which had the largest increase in GPV within this group. In sectors using differentiated technology, the machinery and equipment sector achieved the highest GPV growth, which, by contrast, declined in the electronic equipment sector. The latter was affected by external competition, mainly from Asia. GPV growth in the labour-intensive sector was less than in the natural-resource-intensive sectors, and also in the scale-intensive and differentiated-technology sectors, owing to the reduction in GPV in the clothing sector, which is also affected by external competition.

V. Conclusions and final thoughts

This study analysed the structural changes that occurred in Brazilian industry between 1995 and 2009, considering its intersectoral relations. Empirical evidence showed that the structural changes weakened intersectoral demand in Brazilian industry. It was also found that an industrial restructuring process took place, as the scope of the intersectoral demand expanded in natural-resource-intensive sectors, but shrank in the scale-intensive and differentiated-technology sectors.

The restructuring of industrial employment between 1995 and 2009 occurred with the largest increases in the number of jobs in technology-intensive and natural-resource-intensive sectors. Although those sectors suffered a reduction owing to the technological effect, they displayed the largest increase in employment owing to growth in final demand in the period analysed.

The analyses of value added and GPV confirm the hypothesis of a process of industry re-primarization and backward specialization, because the largest increases in value-added and GPV corresponded to the natural-resource-intensive group.

An important conclusion of the study was that the technological changes made a negative contribution to employment growth, value added and GPV in Brazilian industry. The technological changes that took place in the economy contributed to reductions of 20.10% in employment, 4.39% in value added and 1.77% in GPV of Brazilian industry between 1995 and 2009. The labour-intensive sectors were the most affected from the standpoint of loss of jobs and value added, while sectors using differentiated technology with the most affected with respect to the reduction in GPV. Those changes could be due to technological innovations, an increase in the benefits obtained from economies of scale, changes in product mix, variation in relative prices or changes in trade patterns. One of the technological changes that seems to be most important is the replacement of national inputs with imported ones, since this could be one of the causes of the reduction in the sectors' backward linkage indices, reflecting a weakening of the intersectoral demand of industry. In contrast, the contributions of final demand were responsible for most of the positive results of the structural decompositions.

In short, while the expansion of final demand played an important role in industry growth in terms of employment, value added and GPV, there was also a weakening of intersectoral demand in Brazilian industry. This was characterized by an increase in imported inputs for production, while that production is being financed above all by the growth of final demand.

Moreover, the importance gained by the natural-resource-intensive sectors, from the growth of their intersectoral demands or significant increases in employment, value added and GPV, do not seem sufficient for industry to promote dynamism in the Brazilian economy as argued by Rodrik (2007).

If public policy-makers want to balance the contributions made by the increase in final demand with stimulus for technological change to promote industry growth, incentives need to be provided for those changes to take place. In this context, industrial policy becomes the key public policy mechanism for creating favourable conditions for the survival of the industrial sector, mainly for the sectors with greater technological intensity.

Over the last decade, the government put the topic of industrial development policy back on the public policy agenda, and sought to implement an industrial policy, despite various obstacles, such as changes in international conditions after the crisis, the overvaluation of the real and the sudden emergence of China as a global economic force.

The economic liberalization of the 1990s and the complex process of productive and financial globalization decisively influenced business and corporate strategies and are still doing so today. That process seriously compromises government's capacity to develop national policies to strengthen industrial competitiveness.

The challenge is that this context requires the State to play a central role in mobilizing and coordinating the productive, technological, financial and organizational-institutional resources needed to make investments viable. In addition to guaranteeing coordination capacity, industrial policy must take account of the specifics of reality in its various dimensions (sectoral, technological, financial, organizational, institutional and regional), based on a long-term dynamic perspective.

This study contributes to the analysis of the sectoral dimension of industry by showing the trend of those sectors in terms of employment, value added, GPV and linkages. Nonetheless, the research agenda on industry needs to take account of the other dimensions of the industry policy consolidation; and the economic debate needs to deepen its study of cohesion between industrial and macroeconomic policies, following a strategy for long-term national development.

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Annex A1
Classification of the sectors by type of technology, according to OECD

The sectors are classified by type of technology based on the classification published by OECD (2005). As some of those sectors form part of the group of 56 categories used by the IBGE System of National Accounts since 2000, the weight of production of each sector in the group of 56 categories was calculated for the corresponding sector in the group of 42. Those with the heavier weights determined how the sectors were classified in the latter group.

For example, the sectors "Wood products, excluding furniture" and "Furniture and products of miscellaneous industries" of the group of 56 categories correspond to "Wood and furniture and miscellaneous industries" in the group of 42. The sector "Wood products, excluding furniture" is natural-resource-intensive, whereas "Furniture and products of miscellaneous industries" is labour-intensive. As the weight of the sector "Furniture and products of miscellaneous industries" was greater (69.71%), "Wood and furniture and miscellaneous industries" were classified as labour-intensive.

Table A1.1
Classification of the sectors by type of technology, according to OECD

Group of 42 categories	Group of 56 categories	Weight of production of the sector of the group of 56 categories in the group of 42	OECD classification of the sector of the group of 56 categories	OECD classification of the sector of the group of 42 categories
Pharmaceutical and veterinary	Perfumery hygiene and cleaning	40.57%	Scale-intensive	
	Pharmaceutical products	59.43%	Science-based	Science-based
Extractive mineral	Iron ore	22.60%	Natural-resource-intensive	Natural-resource-intensive
	Other products of the extractive industry	14.92%	Natural-resource-intensive	
Oil and gas	Oil and natural gas	62.48%	Natural-resource-intensive	Natural-resource-intensive
Non-metallic mineral	Other non-metallic mineral products	77.25%	Natural-resource-intensive	Natural-resource-intensive
	Cement	22.75%	Natural-resource-intensive	
Oil refining	Oil refining and coke	58.05%	Natural-resource-intensive	Natural-resource-intensive
	Alcohol	8.68%	Natural-resource-intensive	
Chemical elements	Chemicals	24.93%	Scale-intensive	Scale-intensive
	Resin and elastomer manufacture	8.34%	Scale-intensive	
Coffee industry	Food and beverages	96.92%	Natural-resource-intensive	Natural-resource-intensive
Processing of vegetable products	Tobacco products	3.08%	Natural-resource-intensive	Natural-resource-intensive
Animal slaughtering				Natural-resource-intensive
Dairy products industry				Natural-resource-intensive
Sugar manufacture				Natural-resource-intensive

Table A1.1 (concluded)

Group of 42 categories	Group of 56 categories	Weight of production of the sector of the group of 56 categories in the group of 42	OECD classification of the sector of the group of 56 categories	OECD classification of the sector of the group of 42 categories
Vegetable oil manufacture				Natural-resource-intensive
Other food products				Natural-resource-intensive
Wood and furniture	Wood products, excluding furniture	30.29%	Natural-resource-intensive	Labour-intensive
Miscellaneous industries	Furniture and products of miscellaneous industries	69.71%	Labour-intensive	Labour-intensive
Textile industry	Textiles	100.00%	Labour-intensive	Labour-intensive
Garments	Garments and clothing accessories	100.00%	Labour-intensive	Labour-intensive
Footwear manufacture	Leather articles and footwear	100.00%	Labour-intensive	Labour-intensive
Iron and steel	Manufacture of steel and derivatives	100.00%	Scale-intensive	Scale-intensive
Other metallurgical Non-ferrous metallurgical	Metal products except machinery and equipment Non-ferrous metallurgy	67.30% 32.70%	Labour-intensive Natural-resource-intensive	Labour-intensive Natural-resource-intensive
Automobiles, trucks, buses	Automobiles, trucks and utility vehicles	79.96%	Scale-intensive	Scale-intensive
	Trucks and buses	20.04%	Scale-intensive	
Vehicle parts	Automobile parts and accessories	66.12%	Scale-intensive	Scale-intensive
	Other transport equipment	33.88%	Scale-intensive	
Rubber industry	Articles of rubber and plastic	100.00%	Scale-intensive	Scale-intensive
Plastics				
Miscellaneous chemicals	Miscellaneous chemical products and preparations	33.70%	Scale-intensive	Scale-intensive
	Pesticides	38.14%	Scale-intensive	
	Paints, varnishes, enamels and lacquer	28.16%	Scale-intensive	
Machinery and equipment	Machinery and equipment, including maintenance and repair	100.00%	Differentiated	Differentiated
Electrical material	Household electrical appliances	11.94%	Differentiated	Differentiated
Electronic equipment	Office machinery and information technology equipment	16.70%	Science-based	Differentiated
	Electrical machines, apparatus and materials	35.92%	Differentiated	
	Electronic materials and communication equipment	23.16%	Differentiated	
	Medical-hospital apparatus and instruments, of measurement and optics	12.28%	Differentiated	

Source: Prepared by the authors, on the basis of Organization for Economic Cooperation and Development (OECD), *Science, Technology and Industry Scoreboard 2005*, Paris, 2005; and K. Pavitt, "Sectoral patterns of technical change: towards a taxonomy and a theory", *Research Policy*, vol. 13, No. 6, Amsterdam, Elsevier [online] http://www.sourceoecd.org/scienceIT/9264010556.