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Decomposing Brazilian manufacturing industry dynamics in the mid-2000s: Macroeconomic factors and their sectoral impacts☆

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Abstract

The manufacturing industry's loss in participation, phenomena called "deindustrialization", has been observed for the Brazilian economy for a while and seems to have intensified from mid-2000s. However, the literature has not developed a consistent or integrated analysis of this process. We have used a detailed simulation model to identify how macroeconomic factors (such as exchange rate, labor costs, and household consumption) have contributed to manufacturing dynamics. Our results indicate that the macroeconomic scenario explains a large portion of the manufacturing industry's participation loss. The rise in households consumption and investment, important factors in this period, were responsible for dampening of the pressures coming from the currency appreciation and the workforce costs, benefiting some industrial sectors, but not avoiding the manufacturings participation loss.

Keywords: Manufacturing; Growth; Development; Simulations

JEL classification: O14; C68; D58

1. Introduction

One of the most important structural modifications in the Brazilian economy throughout its history can be observed in the sectoral composition of the economic activity. The division of economic sectors in farming, manufacturing and services show, especially since the early 90s, manufacturings relative loss in participation in the economy (excluding mineral extraction).[1] Numerically, this is the result of lower growth rates compared to those from other sectors, or due to negative grow rates (which were observed in few periods and subsectors of the economy). However, it is harder to evaluate the effect of relative prices, which can lead to a loss of participation even with strong production growth rates

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[1] According to Bonelli et al. (2013), the participation of manufacturing in the GDP reached 44% in 1980, retreating to 42% in 1990, and 41% in 2000.

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Table 1
Value and participation of sectors in the Brazilian economy, 2005–2011.

	Gross Output (BR$ million at current prices)		Participation in Gross Output		Change in share of Gross Output
	2005	2011	2005	2011	2005–2011
Agricultural	194,477	331,755	5.1	4.5	−0.7
Manufacturing	1,421,514	2,457,618	37.5	33	−4.5
Services	2,170,692	4,647,017	57.3	62.5	5.2

Source: Prepared by the authors from IBGE (2014).

A sector can lose participation even with strong production growth rates, if the price of its products rises less than the average price of the economy.[2]

Recent data made available by Brazilian Institute of Geography and Statistics (IBGE, 2014) about the sectoral Gross Output illustrates the recent changes. Between 2005 and 2011, a relatively short period, manufacturing lost 4.5 percentage points of participation and services gained 5.2 points (Table 1). The loss in participation was greater in the manufacturing industry group than in the extraction industry, but the importance of the latter is still minor (3.5% of the total Gross Output or 12% of the industrial Gross Output).

During this period, in the manufacturing segment, participation declined from 34.7% to 29.5% of the economy's Gross Output. The unbundled analysis of the manufacturing industry (Table 2) shows that 20 sectors, which represent 65% of it, lost 6.45 percentage points of participation in the economy (with emphasis on Chemicals, Computer Equipment, Food, and Steel Products); while 6 sectors, which represent 35% of the manufacturing industry obtained 1.95 percentage points of participation, with higher gains in Machines and Equipment, Automobiles Fabrication and Oil Refining.

Differently from what is observed in the 90s, for which the effect of commercial opening is considered the decisive factor for this phenomenon, there is no agreement in literature about its causes in recent periods. As it will be discussed in the next section, scholars associate this movement to some macroeconomic and structural elements: (1) currency appreciation, which favored imports and hampered exports; (2) costs associated to labor, due to the heating up of the labor market and to the increase in salaries; (3) low gains in productivity, due to low investment in innovation; (4) low growth of the investment in infrastructure, which generates elevated distribution and production costs.

Manufacturings participation loss in the economy is recurrently associated to the term "deindustrialization", though its definition and importance vary according to the theoretical stream used. The theoretical contributions about deindustrialization in developed countries, occurred between the 60s and the 70s, consider that this process was essentially a natural consequence of the economic dynamism exhibited by such economies (see for example, Fuchs, 1980; Rowthorn and Wells, 1987; Baumol et al., 1991; Rowthorn and Ramaswamy, 1999). In most of the advanced economies, labor productivity grew at a faster pace in the Industry sector than in the services sector, while growth in production was similar in both. In this context, services started to absorb a growing part of the workforce, raising its participation in total employment. The growth in productivity also led to a decrease in relative prices of industrialized products, reducing the participation of the sector in the value added. A second argument is based on the Engel's law, which states that, with the consistent rise of per capita income, there would be a natural tendency to a relative reduction of the demand for industrialized products in favor of services. As a result, the participation of industrial jobs would also retreat (Rowthorn and Ramaswamy, 1999). In total, in this process, there would be only one change in allocation of resources for the services sector, not compromising employment nor growth in the long run, representing then, a case of positive or natural deindustrialization.

In the case of developing countries however, the most common hypothesis raised is of the existence of an "early deindustrialization", associated to the "re-primarization of the exports guidelines" and "Dutch disease",[3] especially

[2] According to Baumol (1967), the low productivity in the services sector would lead to its increase relative to manufacturing, causing a change in relative prices. His theory is known in the literature as the "cost disease".

[3] Deindustrialization caused by appreciation of the real Exchange rate, which results from the valorization of the prices of the natural resources in the international market (Oreiro and Feijó, 2010, p. 231).

Table 2
Participation of manufacturing sectors in the production of the Brazilian economy, 2005–2011 (% of Gross Output).

Sector	% Industry share in Gross Output		
	2005 (A)	2011 (B)	B–A
Extractive industry	2.82	3.55	0.72
Oil and natural gas	1.88	2.14	0.26
Iron ore	0.62	1.04	0.41
Other mining and quarrying	0.32	0.37	0.05
Manufacturing industry	34.72	29.50	−5.21
Machinery and equipment, including maintenance and repairs	1.60	2.06	0.46
Automobile manufacturing, trucks and buses, except parts	1.92	2.21	0.29
Petroleum refining and coke	3.24	3.41	0.17
Manufacture of pesticides, disinfectants, paints and chemicals	0.53	0.68	0.15
Manufacture of non-metallic mineral products	0.85	0.97	0.12
Machinery, appliances and equipment	0.81	0.84	0.04
Alcohol	0.33	0.32	−0.01
Articles of apparel and accessories	0.74	0.73	−0.01
Smoke products	0.25	0.18	−0.08
Perfumery, hygiene and cleaning	0.46	0.37	−0.09
Furniture and products of various industries	0.87	0.75	−0.12
Non-ferrous metallurgy	0.67	0.54	−0.13
Other transport equipment	0.65	0.50	−0.15
Pharmaceutical products	0.72	0.58	−0.15
Leather goods and footwear	0.62	0.44	−0.18
Rubber and plastic	1.27	1.07	−0.20
Pulp and paper products	0.99	0.79	−0.20
Wood products – furniture exclusive	0.52	0.30	−0.22
Parts and accessories for motor vehicles	1.47	1.18	−0.29
Metal products – except machinery and equipment	1.40	1.09	−0.31
Textiles	0.89	0.58	−0.31
Newspapers, magazines, records	0.78	0.26	−0.52
Steelmaking and derivatives	1.94	1.29	−0.65
Food and drinks	6.79	6.03	−0.77
Manufacturing equip. computer, electronic and optical products	1.81	0.92	−0.89
Production of organic chemicals and inorganic resins and elastomers	2.59	1.42	−1.17
Total	37.54	33.05	−4.49

Source: Prepared by the authors from IBGE (2014).

in the Latin-American economies[4] Palma (2005) points that the deindustrialization processes have occurred in these countries in a premature way, before they reach the development level (per capita income, productivity, competitiveness) observed at the beginning of the deindustrialization in advanced countries. Such hypothesis is also shared by Rowthorn and Coutts (2004), Pieper (2003), Dasgupta et al. (2006) and Tregenna (2011).

According to Rodrik (2016), the reduction in manufacturing for low and medium income economies is considerate premature for two reasons: first, because these countries are enduring deindustrialization very early in a historical perspective, with lower levels of income, and secondly, they are also letting behind potential economic growth by losing manufacturing dynamics.

[4] In some western economies, particularly the Chinese economy, industry participation in the GDP continues increasing, surpassing the highest levels of Latin American economies.

For Brazil, several studies argue the existence of early deindustrialization that started in the mid-1990s. A combination of economic and financial liberalization, high interest rate, appreciated exchange rate, rising international commodity prices and low productivity of the manufacturing sector are the main causes identified by the literature (Palma, 2005; Bresser-Pereira, 2008; Bresser-Pereira and Marconi, 2010; Oreiro and Feijó, 2010; Marconi and Barbi, 2010; Marconi and Rocha, 2012; Cano et al., 2012; Arend, 2015).

Those explanations are consistent with more general descriptions concerning deindustrialization in developing countries. According to Rodrik (2016), when developing countries opened to trade, their manufacturing sectors were affected in two directions. First, those activities without comparative advantage turned out to be net importers of manufacturing. Secondly, they became exposed to the decline in relative price of manufacturing in the advanced countries creating a pressure on national prices.

This process would have deleterious effects on long-term potential growth. The manufacturing industry has an essential role as an engine of growth (Kaldor, 1967; Thirlwall, 2002; Tregenna, 2011), combining features such as dynamic economies of scale, strong intersectorial relations, learning-by-doing properties, innovation and technological progress and higher income elasticity of exports that would relieve restrictions on the balance of payments. In addition, the transfer of resources and labor from manufacturing to sectors of lower labor productivity would have adverse effects on economic productivity (Marquetti, 2002). In this context, an industrialization process would engender a reduction of long-term growth.[5]

On the other hand, part of literature argues that this process, if it actually exists, is part of a modernization of the Brazilian industrial park. This modernization was favored by the appreciated exchanged and by the neoliberal politics adopted from the 90s onwards and what, in a certain way, contributed for a more efficient industry (Nakahodo and Jank, 2006; Schwartsman, 2009; Almeida, 2012). Bonelli and Pessôa (2010) and Bonelli et al. (2013), for example, show that this trajectory of decrease in participation would be a result of the sectors adaptation to the international reality of the last decades,[6] following a global tendency. Thus, the change in the sectoral composition that occurred could be seen as a natural process.

More recently, the incapacity to respond to external competition, given the relative labor costs, has been pointed as one of the causes for deceleration of the manufacturing industry. Demand-led policies, heated labor market and inflation in services would have contributed to the increase of industry costs, markedly in workforce, unleashing a compressing effect to the sectors profit margins, and limiting its ability to invest (Pastore, 2012; Almeida, 2012).

Manufacturings loss of participation in the Brazilian economy, and in economies in general, is thus a subject surrounded by countless debates, both theoretical and applied. In this paper we aim to analyze in a consistent manner the manufacturings loss in participation in a recent period (2005–2011) for which we have a wide array of data and a specific simulation model. In this analysis we take into account both structural elements of the Brazilian economy (productive chains, demand compositions, factors usage), domestic conjecture elements (in the labor market, consumption and investment) and external elements (currency, external markets). Once identified and comprehended the factors responsible for the loss in participation in this period, the results may contribute to the elaboration of policies to counterbalance the determinants of the industry's loss in participation, if that is an objective of industrial policy for Brazil in the future. The purpose is not to judge whether or not this phenomenon occurred in Brazil, what we believe to be unequivocal, or either to discuss about its application on the long term growth of the economy. These themes have been explored by many researchers, as we point out in this section.

2. Methodology: BRIDGE model

In this context, in order to project the impact of the macroeconomic and sectoral constraints on the performance of the Brazilian manufacturing industry, and to understand the factors that influence gains and losses of participation of the manufacturing as a whole, and of its different segments, we used detailed data from national accounts together with a simulation model. The 2005–2011 period was chosen due to the availability of information for the methodological tool, for the data used in this paper and for the comparisons with the official data.

[5] About the sustainability of recent growth in developing countries see Rodrik et al. (2017).

[6] According to Bonelli et al. (2013), the country had over industrialized in the previous decades, showing a set of characteristics from the development stage, resources and demographics, facing the so-called "soviet disease".

Table 3
Indicators of sales and penetration of the manufacturing industry imports (Brazil, 2005).

	Sectors	Intermediate inputs		Primary factors		Other costs and taxes	Total	Capital/ labor ratio
		Domestic	Imported	Labor	Capital			
S1	Food and drinks	67.2%	2.7%	9.8%	8.6%	11.7%	100%	0.88
S2	Smoke products	73.2%	1.8%	9.1%	8.3%	7.6%	100%	0.92
S3	Textiles	46.4%	6.7%	15.6%	17.7%	13.6%	100%	1.13
S4	Articles of apparel and accessories	43.3%	4.3%	20.8%	2.4%	29.2%	100%	0.12
S5	Leather goods and footwear	55.0%	5.1%	22.4%	4.4%	13.1%	100%	0.19
S6	Wood products – furniture exclusive	52.8%	1.8%	17.9%	15.6%	11.9%	100%	0.87
S7	Pulp and paper products	56.6%	6.9%	14.4%	13.4%	8.7%	100%	0.93
S8	Newspapers, magazines, records	39.8%	6.7%	20.4%	23.3%	9.8%	100%	1.14
S9	Petroleum refining and coke	65.6%	17.3%	2.4%	7.1%	7.6%	100%	2.93
S10	Alcohol	51.6%	0.9%	10.0%	33.4%	4.1%	100%	3.35
S11	Chemicals	50.1%	22.0%	8.0%	9.7%	10.2%	100%	1.21
S12	Manufacturing resin and elastomers	63.8%	7.2%	6.8%	14.7%	7.5%	100%	2.15
S13	Pharmaceutical products	34.9%	12.4%	19.7%	26.5%	6.5%	100%	1.35
S14	Pesticides	56.5%	15.6%	9.1%	10.1%	8.7%	100%	1.12
S15	Beauty, hygiene and cleaning	53.1%	7.9%	12.0%	18.6%	8.4%	100%	1.55
S16	Paints, varnishes, enamels and lacquers	48.6%	17.1%	15.2%	10.7%	8.4%	100%	0.70
S17	Products and prepared several chemical	49.9%	17.1%	15.0%	9.5%	8.5%	100%	0.63
S18	Rubber and plastic	55.0%	9.7%	16.8%	9.9%	8.6%	100%	0.59
S19	Cement	53.2%	5.3%	10.0%	22.9%	8.6%	100%	2.29
S20	Other non-metallic mineral products	49.2%	4.6%	21.8%	13.7%	10.7%	100%	0.63
S21	Steelmaking and derivatives	53.8%	11.5%	8.2%	18.8%	7.7%	100%	2.29
S22	Non-ferrous metallurgy	45.5%	16.3%	10.9%	19.5%	7.8%	100%	1.79
S23	Metal products – except machinery and equipment	48.0%	3.8%	17.0%	21.3%	9.9%	100%	1.25
S24	Machinery and equipment, including maintenance and repairs	55.0%	8.9%	19.5%	7.4%	9.2%	100%	0.38
S25	Home appliances	61.6%	7.3%	14.2%	7.5%	9.4%	100%	0.53
S26	Office machinery and computer equipment	32.1%	38.1%	9.0%	3.9%	16.9%	100%	0.43
S27	Machinery, appliances and equipment	49.3%	10.3%	17.2%	14.8%	8.4%	100%	0.86
S28	Electronic material and communication equipment	47.8%	28.1%	10.5%	2.3%	11.3%	100%	0.22
S29	Appliances/medical and hospital instruments, measurement and optical	29.9%	14.8%	17.4%	28.3%	9.6%	100%	1.63
S30	Cars, trucks and utilities	63.2%	17.8%	1.3%	3.2%	14.5%	100%	2.52
S31	Trucks and buses	54.6%	21.4%	10.2%	0.7%	13.1%	100%	0.07
S32	Parts and accessories for motor vehicles	59.4%	5.4%	16.7%	7.9%	10.6%	100%	0.47
S33	Other transport equipment	52.4%	16.0%	16.1%	5.6%	9.9%	100%	0.35
S34	Furniture and products of various industries	42.9%	5.4%	16.8%	18.1%	16.8%	100%	1.08

Source: Model database from the input–output matrix of 2005.

BRIDGE (Brazilian Recursive Dynamic General Equilibrium Model) is a detailed dynamic general equilibrium model of Brazil. In common with MONASH-style general equilibrium models (Dixon and Rimmer, 2002) this model is designed to facilitate two types of analyses: historical simulations, that estimate the paths of unobservable variables over a historical period; and decomposition simulations, in which periods of economic history are explained in the context of the model and with reference to various driving factors estimated in the historical simulation. We have used these kinds of simulations exercises in this paper.

In methodological terms, we use a dynamic-recursive computable general equilibrium model (CGE). It was calibrated with Brazilian economic data from 2005. The theme of manufacturings loss of participation was not studied through this methodology, and we believe that it can clarify the mechanisms and the constraints of this phenomenon. The mathematical structure of a CGE model is comprised of blocks of equations that determine the relationships between

Table 4
Composition of production costs in the Manufacturing Industry (Brazil, 2005).

	Sector	Industry sales destination (% of total sales)						Imports in local market (% of supply)
		Input to other sectors	Inputs for investment	Household consumption	Exports	Government and stocks	Total	
S1	Food and drinks	35.4%	0.3%	45.9%	16.7%	1.6%	100%	2.2%
S2	Smoke products	5.2%	0.0%	52.9%	41.0%	0.9%	100%	26.2%
S3	Textiles	61.3%	0.3%	28.8%	11.0%	−1.4%	100%	8.1%
S4	Articles of apparel and accessories	11.5%	0.1%	85.6%	3.0%	−0.2%	100%	2.6%
S5	Leather goods and footwear	19.8%	0.4%	50.9%	25.9%	3.0%	100%	5.1%
S6	Wood products – furniture exclusive	65.6%	1.4%	2.3%	33.5%	−2.8%	100%	1.8%
S7	Pulp and paper products	70.1%	0.4%	16.5%	12.0%	1.0%	100%	10.4%
S8	Newspapers, magazines, records	71.1%	0.0%	27.6%	0.9%	0.4%	100%	1.3%
S9	Petroleum refining and coke	74.4%	0.0%	17.8%	6.0%	1.8%	100%	8.1%
S10	Alcohol	64.9%	0.7%	24.1%	13.0%	−2.7%	100%	0.0%
S11	Chemicals	89.6%	0.5%	0.9%	10.6%	−1.6%	100%	22.9%
S12	Manufacturing resin and elastomers	81.8%	0.4%	0.0%	17.0%	0.8%	100%	25.0%
S13	Pharmaceutical products	39.4%	0.1%	54.9%	5.0%	0.5%	100%	24.2%
S14	Pesticides	93.9%	1.7%	1.5%	7.5%	−4.6%	100%	18.7%
S15	Beauty, hygiene and cleaning	27.2%	0.2%	64.4%	5.9%	2.4%	100%	19.0%
S16	Paints, varnishes, enamels and lacquers	86.3%	0.1%	9.1%	5.5%	−1.0%	100%	7.6%
S17	Products and prepared several chemical	79.5%	0.4%	2.3%	15.0%	2.8%	100%	21.8%
S18	Rubber and plastic	92.6%	0.6%	3.2%	7.1%	−3.5%	100%	11.6%
S19	Cement	87.4%	0.0%	5.5%	3.3%	3.7%	100%	1.3%
S20	Other non-metallic mineral products	82.5%	0.4%	1.4%	16.3%	−0.6%	100%	7.2%
S21	Steelmaking and derivatives	74.9%	0.2%	0.1%	24.4%	0.4%	100%	7.8%
S22	Non-ferrous metallurgy	57.9%	5.5%	1.1%	33.7%	1.9%	100%	24.8%
S23	Metal products – except machinery and equipment	74.4%	18.6%	2.8%	4.2%	0.1%	100%	6.5%
S24	Machinery and equipment, including maintenance and repairs	27.2%	44.6%	3.0%	25.1%	0.1%	100%	30.2%
S25	Home appliances	12.8%	3.4%	71.3%	13.2%	−0.7%	100%	5.9%
S26	Office machinery and computer equipment	4.5%	71.0%	13.0%	10.0%	1.5%	100%	37.1%
S27	Machinery, appliances and equipment	71.9%	7.8%	3.6%	14.5%	2.1%	100%	22.0%
S28	Electronic material and communication equipment	13.1%	41.0%	24.7%	20.2%	0.9%	100%	39.7%
S29	Appliances/medical and hospital instruments, measurement and optical	34.3%	20.9%	30.1%	12.8%	1.9%	100%	47.9%
S30	Cars, trucks and utilities	4.6%	22.1%	43.5%	27.8%	2.0%	100%	10.5%
S31	Trucks and buses	11.8%	45.3%	5.0%	35.0%	2.9%	100%	7.5%
S32	Parts and accessories for motor vehicles	74.1%	1.6%	1.2%	20.2%	2.9%	100%	17.8%
S33	Other transport equipment	26.4%	12.4%	17.5%	46.3%	−2.7%	100%	31.2%
S34	Furniture and products of various industries	16.7%	18.8%	53.1%	10.9%	0.5%	100%	4.9%

Source: Model database from the input–output matrix of 2005.

supply and demand, derived from hypothesis of optimization and market balance conditions. In general terms, the model uses traditional assumptions: firms that minimize costs, households that maximize utility and market clearing.

The BRIDGE model is set for 55 sectors and 110 products, reflecting the productive structure of the Brazilian economy in 2005. The information that feeds the model database comes from several sources, predominantly from the National Accounts and the Input–Output Matrix (IOM) generated by IBGE. This is a model of deterministic simulation, in which shocks to exogenous variables alter the balance in all markets, making it possible to observe their variances and adjustments toward the new equilibrium. To achieve the objective of this paper, the simulations are performed in a group of shocks and tendency elements in the Brazilian economy for the period being studied (2005–2011). When the shocks are applied to the model, it reaches a new equilibrium that characterizes the Brazilian economy in 2011, and its (observed) loss of industry participation. These simulations can be studied and analyzed in detail, taking advantage of the wide array of variables and results generated. For more details on the CGE model and the simulations of this paper see Appendix 1.

The results of the simulation (endogenous variables) project the changes in the sectoral structure of the economy. These simulations consist into two groups of information (shocks): (1) evolution of macroeconomic indicators (GDP; household consumption; government consumption, investment, general price index and population growth); and (2) variations of sectoral indicators (exports; import prices; numbers of workers; and average wage). Each one of these groups variables is seen as an exogenous factor in the yearly simulations, gradually moving the productive structure during the period analyzed. Below, we detail some relevant aspects of the database used, and the simulated economic scenario.

2.1. Indicators of the models database

BRIDGEs database is a portrait of the productive structure of the Brazilian economy in 2005. The results obtained in the simulations derive both from the shocks and from this structure. Accordingly, it is important to highlight some elements of the database that condition the simulation results and help understand them.

Table 3 shows sales indicators and the penetration of imports in the manufacturing industry in 2005. The table reports the participation of each destination of the sectoral sales: (i) input to other sectors, (ii) input to investment, (iii) household consumption, (iv) exports, and (v) government consumption and stock variance. We added the information regarding participation of the imports in the local market, an indicator of competition between imported and domestic production.

The so-called base industry sectors (Metallurgy, Chemistry and Cement) are mostly suppliers of intermediary inputs, important elements of different productive chains. The sectors of agricultural pesticides and rubber and plastic products have more than 90% of their sales destined to other sectors, followed by Chemical products (89.6%), Cement (87.4%) and Paints, varnish, enamel and lacquer (86.3%). On the other hand, sectors linked to machines and equipment show to be important for the composition of the gross fixed capital, having great part of their sales as input for investment. Office machines and computer equipment (71.0%), trucks and buses (45.3%), machines and equipment (44.6%) and Electronic material and communication equipment (41.0%) stand out in this sense.

In contrast, most of these sectors show relevant participation of imports in the total supply of products, an indicator that reflects the competition with the household production and, therefore, a high sensibility to the variations of the exchange rate (currency valorization processes tend to increase the participation of imports at the expense of domestic production). Among these sectors, stand out medical instruments and devices, where 47.9% of domestic supply is of imports, followed by Electronic materials (39.75%), Office machines (37.1%), Other transportation equipment (31.2%) and Machines and equipment (30.2%).

The light industrial sectors (Food and drinks, Products derived from tobacco, Clothing articles and accessories, Leathers artifacts and shoes) stand out in household consumption. The clothing articles sector is worthy of note, with 85.6% of the sales aimed at households. Appliances (71.3%), Beauty, Hygiene and cleansing (64.4%), Pharmaceuticals (54.9%), Furniture, and Several industrialized products (53.1%) are still added to these sectors with significant participations of their sales for household consumption. Overall, we can expect a positive effect of the economic constraints of the 2005–2011 period on the activities of those sectors, given the significant rise of household demand and the relatively small competition from imports.

Sales to the external market are also indicators of the sectors that are more susceptible to international markets and variations in exchange rate. In this case, we can highlight known exporter sectors, such as Other transportation

Table 5
Observed Macroeconomic Indicators, 2006–2011.

	2006	2007	2008	2009	2010	2011	Average
GDP (% change)[a]	3.96	6.09	5.17	−0.33	7.53	2.73	4.16
Employment (% change)[b]	9.98	9.29	7.89	8.08	6.74	5.98	7.99
Household consumption (% change)[a]	5.20	6.07	5.67	4.44	6.94	4.09	5.40
Government consumption (% change)[a]	2.58	5.13	3.17	3.11	4.23	1.93	3.35
Exports (% change)[a]	5.04	6.20	0.55	−9.12	11.52	4.49	2.91
Imports (% change)[a]	18.45	19.88	15.36	−7.60	35.84	9.75	14.52
Investimento (var. %)[a]	9.77	13.85	13.57	−6.72	21.33	4.72	9.05
Consumer price index (% change)[c]	3.14	4.46	5.90	4.31	5.91	6.50	5.24
Exchange rate BR$/US$[d]	2.18	1.95	1.83	2.00	1.76	1.67	1.90
World GDP (% change)[e]	5.54	5.68	3.06	−0.01	5.38	4.17	3.95
Minimal wage (real % change)[f]	13.47	3.25	2.56	7.62	3.02	0.74	5.02

Source: Prepared by the authors.
[a] IBGE/National Accounts.
[b] IBGE/PME.
[c] IBGE/IPCA.
[d] Central Bank of Brazil.
[e] International Monetary Fund (IMF).
[f] Ministry of Labor and Employment (MTE).

equipment (with 46.3% of sales directed to exportation), followed by Tobacco products (41.0%), Trucks and buses (35.0%), Metallurgy of non-ferrous metals (33.7%) and Wooden products (33.5%).

The composition of production costs in the manufacturing industry is also very heterogeneous by sector, as we can see in Table 4. This is a relevant element when determining the sectors dynamics, given the constraints imposed by the labor market in the 2005–2011 period. The sectoral production costs can be analyzed by its composition between intermediate input (domestic and imported) and primary factors (capital, labor and other costs and taxes). Technological differences along with the relative prices of the factors and inputs explain these differences. On average, over 50% of production costs are from local suppliers, i.e., domestic intermediate inputs. The following sectors are above this average Tobacco products (73.2%), Food and Beverages (67.2%), Petroleum and coke refining (65.6%), Manufacturing of resin and elastomers (63.8%) and Automotive, Pickup trucks and utilities (63.2%). By contrast, participation in input costs is relevant to the imported machinery sectors for Office and computer equipment (38.1%), Electronic material and communication equipment (28.1%), Chemical products (22.0%) and Trucks and buses (21.4%), and therefore tend to resonate more effects of foreign market and currency fluctuations.

Another differentiating element for the cost structure is the participation of primary factors. This is an important indicator to be evaluated since recently, matters regarding relative labor costs and labor productivity have been raised to explain manufacturings loss in participation. For example, labor accounts for 22.4% of production costs for Leather and footwear articles sector, and 20.8% for Articles of apparel and accessories, both very labor intensive sectors (see capital/labor ratio in the last column of Table 4). Other sectors, despite the higher participation of the factor labor in production costs (Other non-metallic mineral products, 22%, Newspapers, magazines, discs, 20.4%), show a more homogenous proportion between capital and labor. At the other end, the data shows that the Alcohol is more intensive in capital (capital/labor ratio of 3.35%).

2.2. *Simulations: macroeconomic evolution and sectoral indicators*

The first part of the shocks are the macroeconomic indicators observed from 2006 to 2011 (Table 5). This period is characterized by a delicate GDP oscillation, given the effects of the international financial crisis of 2009 and 2010. Despite that, GDP had a medium annual growth of 4.16%, following an expressive growth of household consumption (5.4% per year) and investment (9%). On the external side we can see the low dynamism of exports (2.9% per year) and the elevated growth of imports (14.5%), notably influenced by valorization of the currency in the same period (the exchange rate lowered from 2.18 to 1.67 R$/US$ from 2006 to 2011).

Table 6
Sectorial employment indicators and foreign trade in the Brazilian manufacturing industry (% average growth rate in the period 2006–2011).

		Wages[a] (nominal % change)	Employment[a] (% change in hours worked)	Exports[b] (% change quantum)	Imports prices[b] (nominal % change)
S1	Food and drinks	12.3	7.5	0.2	10.4
S2	Smoke products	14	−1.4	−2.4	5.4
S3	Textiles	14.4	1.6	−2.2	6.8
S4	Articles of apparel and accessories	7.4	4.5	−18	8.8
S5	Leather goods and footwear	7.3	1.3	−6.7	8.7
S6	Wood products – furniture exclusive	8.5	−2.1	−13.9	7.7
S7	Pulp and paper products	7	4	−7.6	0.6
S8	Newspapers, magazines, records	9.6	2.6	−10.2	−0.2
S9	Petroleum refining and coke	5	12.8	−3.9	12.2
S10	Alcohol	6.6	12.4	−3.8	12.1
S11	Chemicals	8.9	1.9	1.6	9.3
S12	Manufacturing resin and elastomers	8.9	0.6	1.7	9.3
S13	Pharmaceutical products	8.9	1.4	14.8	8.8
S14	Pesticides	8.9	6.3	1.7	9.3
S15	Beauty, hygiene and cleaning	−0.6	5.4	1.8	9.3
S16	Paints, varnishes, enamels and lacquers	8.9	5.1	1.7	9.3
S17	Products and prepared several chemical	8.9	0.7	1.7	9.3
S18	Rubber and plastic	3.2	4.9	1.3	5.8
S19	Cement	9.8	5.6	−5.5	2.2
S20	Other non-metallic mineral products	9.8	6.1	−5.5	2.2
S21	Steelmaking and derivatives	5.1	3.3	−0.7	8.7
S22	Non-ferrous metallurgy	5.1	2.5	−0.7	8.1
S23	Metal products – except machinery and equipment	7.4	6.2	0.4	2.2
S24	Machinery and equipment, including maintenance and repairs	6.9	10.2	−1.5	2.2
S25	Home appliances	5.2	6.1	−1.5	2.2
S26	Office machinery and computer equipment	0.4	6.6	−9.1	0.5
S27	Machinery, appliances and equipment	5.8	8	−3.5	3.9
S28	Electronic material and communication equipment	6.8	−1.2	−9.2	0.5
S29	Appliances/medical and hospital instruments, measurement and optical	10.1	18.2	−9.1	0.5
S30	Cars, trucks and utilities	7.2	5.4	−3.6	4.5
S31	Trucks and buses	7.2	4.4	−2.7	4.2
S32	Parts and accessories for motor vehicles	5.8	6.6	−0.4	4.4
S33	Other transport equipment	4.3	8.9	1.1	1.5
S34	Furniture and products of various industries	9.4	0.8	−9.5	5.9

Source: Prepared by the authors.
[a] RAIS-MTE.
[b] FUNCEX.

The labor market was characterized by relatively low unemployment rates and the rise of the real minimum wage that helps to explain the strong growth of household consumption. For the sectoral indicators we used the labor market and foreign trade indicators. For the first one, we obtained a percentage variation in employment and a percentage

Table 7
Percentage of industrial participation in the Gross Output for 2005 and 2011.

Sector	2005 (Input–output tables, IBGE)	2011 (Supply and use tables IBGE)	Own model forecast for 2011
Agriculture	5.14	4.46	4.85
Extractive industry	2.82	3.55	3.37
Transformation industry	34.72	29.50	29.92
Public Industrial Services	3.50	2.84	2.96
Construction	4.43	6.77	6.84
Services	49.39	52.88	52.05
Total	100.00	100.00	100.00

Source: Prepared by the authors from IBGE (2014) and model results.

variation in nominal wages from the Annual Social Information Relation – RAIS (MTE, 2015).[7] For the second one, the information provided by Foreign Trade Studies Centre Foundation (FUNCEX) regarding the variation in the quantum of sectoral exports and fluctuations in the imported products prices. These data were matched to the model breakdown and they were used for all the sectors/product of the model. Table 6 shows the average of those indicators for the manufacturing industry during the period 2006–2011.

As can be seen, average nominal wages increased for all sectors, except for Beauty, Hygiene and Cleaning products. Taking into account the average growth of the consumer prices index (CPI) of 5.2% in the period, sectors such as Office Machinery and Computer Equipment, Rubber and Plastic articles, among others, presented reductions in the average real wage. Those differences reflect, among other factors, the labor type composition of each sector. For example, due to increases in the minimum wage, sectors with high participation of low-qualification employees tend to present higher increases in wages, while sectors where wages are not indexed to the minimum tend to present smaller variations.

In turn, the amount of labor used is indication of the sectors activity level. Changes in the use of labor indicate variations in the sectoral production and thus, constitute one of the factors that lead the changes in the structural composition of the economy. It is worth noting that several studies characterize the loss of manufacturing industry participation in the economy based on employment participation. As shown in Table 6, thirteen sectors of the manufacturing industry had employment growth above the economy's average (5.8%), with emphasis on Medical instruments/machinery, Measurement and optical (18.2%), Petroleum and coke refining (12.8%), Alcohol (12.4%), Machinery and equipment, including maintenance and repairing (10.2%).

Despite the growth in employment in these sectors, export data suggest that its expansion was not related to foreign market. Contrary to these and many other sectors of the manufacturing industry there was a decrease in exports during the period, being the largest drop in the sectors of Clothes and accessories (−18.0%), Wood products not considering furniture (−13.9%). On the other hand, the Pharmaceutical products sector stood out with an increase of 14.8% in its exports.

Information about the price of imports make evident the increase/reduction of competitiveness of national sectors with foreign markets. According to the model assumptions, variations in the imported prices compared to domestic prices generate replacements for both the intermediary demand of companies and for the final demand of households and government. Thus, a higher increase (decrease) in import prices compared to domestic prices shows a reduction (increase) in competitiveness of the internal sector, which could affect production in the domestic sector positively (negatively). Therefore, sectors such as Petroleum and coke refining, Alcohol, Food and beverage, among others tend to benefit with those price variations (i.e., depending on how the internal prices varied when compared to the external ones).

We could try to draw the positive and negative effects on the growth of industrial sectors based on the indicators mentioned above, comparing the structural data (Tables 3 and 4) with the conjectural data (Tables 5 and 6) and,

[7] From Portuguese "Relação Anual de Informaccões Sociais". Its worth noting that RAIS takes into account only formal employment, and therefore underestimates the total number of employed workers. Nevertheless, just percentage variations were used in each sector. Therefore, unless there was a substantial variation in the ratio of formal and informal work in each sector, those variations can be used as a proxy for a sectoral employment variation.

Table 8
Projected sectoral dynamics (average percentage change between 2006–2011).

Sector	Production	Total cost (real % change)	Intermediate input cost (real % change)	Consumer price index (% change)
Agriculture	3.5	5.5	6.0	−0.4
Extractive industry	3.7	11.3	5.7	5.7
Transformation industry	2.5	5.7	4.4	0.6
Public Industrial Services	5.0	6.8	4.6	−0.6
Construction	8.2	12.5	6.1	5.4
Services	3.8	9.3	7.0	3.6

Source: Prepared by the authors from model results.

thus, study the loss of industry participation. However, that exercise requires causal relationships and ignores the interrelationship between sectors and the feedback effects between the balances of each market. Using the CGE model allows these factors to be considered explicitly and emerge from the simulation of a wide set of indicators to be analyzed.

3. Results

All the elements analyzed in the previous session (database indicators and simulation shocks) are determinants of the results. It is expected that they capture the loss of manufacturing industry participation in the Brazilian economy in that period, as shown in Tables 1 and 2. Preliminarily, the simulation indicators and shocks allow us to make assumptions about some of the effect we can expect on the activity of industrial sectors in the period: (a) export sectors affected by loss of external demand, (b) sectors that competes with imports, affected by a drop in external prices and exchange rate, and (c) labor-intensive sectors, affected by increases in real wages and rise in labor prices. On the other hand, some sectors may be affected positively and gain participation in the economy, such as those dependent on imported inputs that had a drop in prices or those important in composing investment, which benefit from the macroeconomic dynamic of that component and/or depend on household or government consumption.

A first way of verifying the robustness of the results is to compare the model projections with empirical data. This is not an easy task, because many of the indicators for that verification, such as real variation of industrial production for sector, for example, are not yet available. However, the observed modifications in the sectoral participation can be compared to the estimated modifications through the model (Table 7). The results show that the model, powered by a wide set of simulation shocks, correctly indicated the sense of a structural change, the loss in participation of the manufacturing industry and gain of services participation. The errors of projection are less than 0.8 percentage points, being the highest of them in services.

As discussed by some authors reviewed previously, one of the difficulties in assessing the real cause of manufacturing participation loss lies in the fact that the variations of prices and quantities are unknown. So the participation loss can be due to a combination of increase in real growth and decrease of relative price, or vice versa. An advantage of working with a detailed sectorial model is that it allows us to generate theoretically consistent estimates of different elements of the sectorial dynamics, like real sector growth, use of labor, variations in production costs and product prices. Table 8 shows the estimates of the sectorial dynamic between 2006 and 2011, in aggregated sectors.

The results indicate that the manufacturing participation loss is due both to the lower growth when compared to all other sectors, and to the relative loss of value. The price differential of extraction products increased 5.7%, services 3.6%, and only 0.6% for the manufacturing industry. Productivity earnings also indicate that the industry advanced in a less intense way, if compared with Mining and agriculture. It is interesting to note that in the most dynamic sectors (Construction and services) productivity gains increase even less than in the manufacturing.

Table 9 presents the dynamics of the 34 sectors of the manufacturing industry in the period 2006–2011 estimated by the model. The result indicates a very heterogeneous behavior of growth and the components of costs and prices between manufacturing sectors. The average growth of the manufacturing industry was 2.5% per year, though some sectors would be more dynamic such as Office machinery, Cement and beauty products, with an increase of 6–7% per year. Sectors relevant to the manufacturing industry, like Steel and metals, presents a slow growth dynamic, about

Table 9
Estimated sectorial indicators 2006–2011 (average % change).

	Sector	Production	Total cost (real % change)	Intermediate input cost (real % change)	Consumer price index (% change)
S1	Food and drinks	2.1	7.9	6.7	8.8
S2	Smoke products	0.1	1.7	0.0	2.1
S3	Textiles	0.1	4.4	2.9	5.8
S4	Articles of apparel and accessories	3.9	6.0	4.9	6.2
S5	Leather goods and footwear	0.5	6.2	5.5	6.6
S6	Wood products – furniture exclusive	−3.2	6.4	5.4	8.2
S7	Pulp and paper products	1.7	5.7	4.4	6.6
S8	Newspapers, magazines, records	3.7	7.0	4.3	7.5
S9	Petroleum refining and coke	2.6	7.3	7.5	7.8
S10	Alcohol	5.0	5.5	2.7	6.9
S11	Chemicals	2.0	3.6	3.3	4.0
S12	Manufacturing resin and elastomers	1.1	2.3	3.0	3.0
S13	Pharmaceutical products	5.4	5.4	4.2	4.9
S14	Pesticides	3.0	4.5	3.6	5.1
S15	Beauty, hygiene and cleaning	6.2	3.2	4.6	3.2
S16	Paints, varnishes, enamels and lacquers	4.9	5.1	3.5	5.3
S17	Products and prepared several chemical	2.4	3.9	2.9	4.1
S18	Rubber and plastic	1.7	3.7	3.3	4.8
S19	Cement	6.6	7.3	5.6	7.2
S20	Other non-metallic mineral products	3.9	7.5	5.8	8.4
S21	Steelmaking and derivatives	1.9	2.7	4.4	3.7
S22	Non-ferrous metallurgy	1.4	2.0	3.5	3.2
S23	Metal products – except machinery and equipment	3.1	5.2	4.4	6.5
S24	Machinery and equipment, including maintenance and repairs	4.8	5.5	3.6	6.7
S25	Home appliances	5.3	5.1	4.6	5.3
S26	Office machinery and computer equipment	7.2	−3.1	−4.0	−3.2
S27	Machinery, appliances and equipment	3.0	0.9	3.5	2.3
S28	Electronic material and communication equipment	4.7	0.5	−0.5	−0.1
S29	Appliances/medical and hospital instruments, measurement and optical	4.0	8.9	2.1	12.1
S30	Cars, trucks and utilities	2.6	3.2	3.2	3.4
S31	Trucks and buses	3.5	2.9	2.1	3.0
S32	Parts and accessories for motor vehicles	1.4	5.0	4.7	6.3
S33	Other transport equipment	2.6	2.6	1.7	3.8
S34	Furniture and products of various industries	4.0	6.4	4.8	6.3

Source: Prepared by the authors from model results.

1.5% per year, resulting in even inferior growth to that observed in the projection of Textile sectors (0.1%), Leather and footwear (0.5%) and Tobacco (0.1%). The simulation with the CGE model explains that heterogeneity of the industrial dynamic from the macroeconomic scenario shocks (Tables 3 and 4), the sectorial characteristics (Tables 5 and 6) and the model mechanisms, which will be done next.

The simulation allows us to observe, for each sector, the main components that influenced their activity level, taking into account both demand expansion elements and substitution effects for imports (relative prices). An accounting

Table 10
Decomposition of sectorial dynamics 2006–2011, according to sales destination (in percentage points of sectorial Gross Output).

	Sector	GDV in % change ($L+X+R$)	Effects by destination and relative price (% share of sectorial GDP)		
			Local market (L)	Exports (X)	Domestic share (S)
S1	Food and drinks	2.28	2.58	0.08	−0.38
S2	Smoke products	0.07	2.93	−1.01	−1.86
S3	Textiles	0.19	2.85	−0.27	−2.40
S4	Articles of apparel and accessories	3.87	4.92	−0.54	−0.51
S5	Leather goods and footwear	0.52	2.43	−1.81	−0.10
S6	Wood products – furniture exclusive	−3.07	1.95	−4.73	−0.28
S7	Pulp and paper products	1.74	2.80	−0.07	−0.99
S8	Newspapers, magazines, records	3.63	3.97	−0.08	−0.24
S9	Petroleum refining and coke	2.59	3.44	−0.37	−0.48
S10	Alcohol	3.83	4.25	−0.43	0.00
S11	Chemicals	2.06	2.63	0.17	−0.75
S12	Manufacturing resin and elastomers	1.17	1.76	0.29	−0.87
S13	Pharmaceutical products	5.33	5.22	0.73	−0.62
S14	Pesticides	2.91	3.56	0.11	−0.76
S15	Beauty, hygiene and cleaning	5.57	6.05	0.11	−0.60
S16	Paints, varnishes, enamels and lacquers	4.72	5.34	0.08	−0.70
S17	Products and prepared several chemical	2.38	2.82	0.25	−0.71
S18	Rubber and plastic	1.69	3.55	0.10	−1.96
S19	Cement	6.45	6.71	−0.11	−0.13
S20	Other non-metallic mineral products	3.87	5.43	−0.91	−0.65
S21	Steelmaking and derivatives	1.85	2.29	−0.19	−0.24
S22	Non-ferrous metallurgy	1.41	2.21	−0.30	−0.51
S23	Metal products – except machinery and equipment	3.14	4.69	0.02	−1.56
S24	Machinery and equipment, including maintenance and repairs	4.67	5.05	−0.38	0.00
S25	Home appliances	5.30	5.60	−0.19	−0.11
S26	Office machinery and computer equipment	6.95	7.63	−0.88	0.20
S27	Machinery, appliances and equipment	2.84	4.23	−0.52	−0.87
S28	Electronic material and communication equipment	4.59	5.86	−1.87	0.60
S29	Appliances/medical and hospital instruments, measurement and optical	4.19	6.80	−1.09	−1.53
S30	Cars, trucks and utilities	2.56	4.59	−1.02	−1.02
S31	Trucks and buses	3.40	4.96	−0.95	−0.61
S32	Parts and accessories for motor vehicles	1.64	2.40	−0.07	−0.69
S33	Other transport equipment	2.63	2.98	0.53	−0.88
S34	Furniture and products of various industries	3.92	5.48	−1.04	−0.51

Source: Prepared by the authors from model results.

decomposition of the sectorial dynamic variation, from the simulation results, is to calculate the effect of the local market, exports and competition with imports (domestic participation effect) over the sectorial production:

$$\text{Sectorial dynamic (Gross Output \% variation)} = \text{local market effect}\ \ (L) + \text{exports effect}\ \ (X) + \text{domestic participation effect}\ \ (S) \quad (1)$$

Table 10 depicts the decomposition of each sectors performance according to Eq. (1). Other decomposition of sectorial dynamic can be calculated using the sectorial sales components and the simulated variation rates, calculating

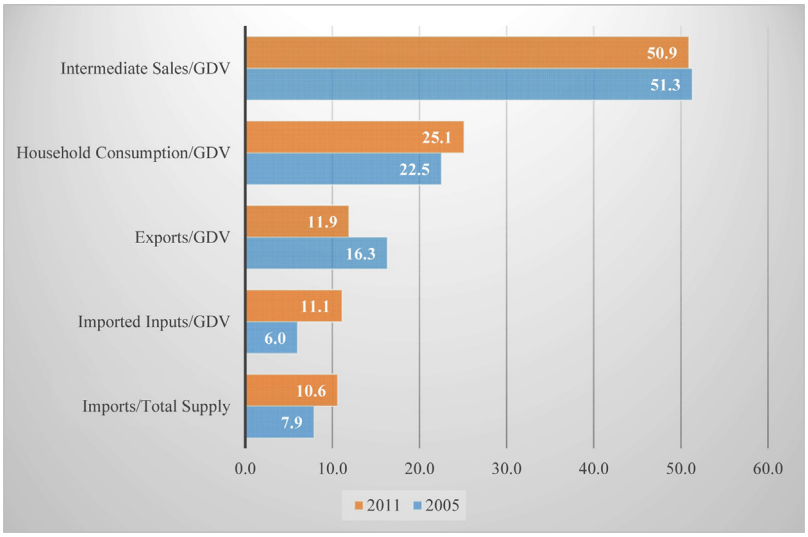

Fig. 1. Indicators of the Brazilian manufacturing industry – 2005 and 2011.
Source: Prepared by the authors from model results.

the contribution of each one to the result of the sector:

$$\text{Sectorial dynamic (Gross Output \% variation)} = \text{intermediate consumption} \quad (IC) + \text{investment} \quad (I) + \text{household consumption} \quad (C) + \text{exports and others} \quad (X) \tag{2}$$

Table 11 illustrates a decomposition of each sectors performance according to Eq. (2). All the components of Eq. (2) are obtained in terms of percentage change of the sectorial Gross Output, so that its addition represents exactly the percentage change of the sectors production.

The decomposition shows heterogeneous results among sectors, even though it can point out some patterns. In general terms, all manufacturing industry sectors have benefited from the domestic market conditions, even if it is in different proportions. In addition, most sectors have been affected by the weaker performance of exports. The effect of domestic participation is negative for most sectors, which indicates the combined effect of increase in production costs (particularly wages) and valuation of the interest rate. However, this effect is dominated by the contribution of exports and the local market. This shows that if it was not for the strong growth in sales to the domestic market, the result of manufacturing industry participation loss would have been even stronger.

However, different reasons explain the positive performance of the most dynamic sectors in the simulations. Office machinery for example, is one of the sectors least impacted by the domestic loss of participation due to the increase in real wages (costs) in the sector, as pointed out in section 3. Local market, particularly investment expansion (Table 11), explains the good performance of the sector, as well as of other sectors linked to investment (Cement, Machinery and equipment, Electronic material). The last one benefits from the changes in composition of domestic and imported goods, although affected by the reduction of exports.

Construction chain sectors (Cement, Non-metallic minerals) gain participation during the period, leveraged by the positive response of the intermediary demand (Table 11). On the other hand, the performance of other sectors such as Appliances, Beauty and Pharmaceutical products is directly related to the significant participation of their sales to household consumption, which, over the analysis period, is one of the most dynamic macroeconomic components, specially powered by growth in income and credit.

In the case of the Automobile sector, the positive effect of local market, a combination of demand from investment and households, overcomes the negative impact of exports and also the domestic loss of participation (expansion of imports encouraged by valuation of the exchange rate, the price of imports and increase of domestic costs). Other exogenous factors, not captured by the model or the shocks, can explain the sectors gain of participation seen in the period, such as policies directed to the sector.

Table 11
Decomposition of sectorial dynamics from 2006 to 2011 according to the production use (in percentage points of sectoral GDP).

	Sector	Total effect on production ($IC+I+C+X$)	Sectorial GDP components effects (% change)			
			Intermediate consumption (IC)	Investment (I)	Household consumption (C)	Exports (X)
S1	Food and drinks	2.27	0.85	0.00	1.34	0.08
S2	Smoke products	0.06	−0.04	0.00	1.11	−1.01
S3	Textiles	0.18	−0.31	0.00	0.75	−0.27
S4	Articles of apparel and accessories	3.88	0.41	0.00	4.01	−0.54
S5	Leather goods and footwear	0.52	0.15	0.00	2.18	−1.81
S6	Wood products – furniture exclusive	−3.17	1.40	0.08	0.08	−4.73
S7	Pulp and paper products	1.74	0.91	0.02	0.89	−0.07
S8	Newspapers, magazines, records	3.62	2.24	0.00	1.46	−0.08
S9	Petroleum refining and coke	2.55	1.85	0.00	1.07	−0.37
S10	Alcohol	3.93	2.30	0.01	2.06	−0.43
S11	Chemicals	2.09	1.80	0.02	0.10	0.17
S12	Manufacturing resin and elastomers	1.16	0.86	0.01	0.00	0.29
S13	Pharmaceutical products	5.30	1.20	0.00	3.36	0.73
S14	Pesticides	3.06	2.81	0.01	0.12	0.11
S15	Beauty, hygiene and cleaning	5.46	1.03	0.00	4.32	0.11
S16	Paints, varnishes, enamels and lacquers	4.80	3.82	0.00	0.90	0.08
S17	Products and prepared several chemical	2.31	1.91	0.01	0.15	0.25
S18	Rubber and plastic	1.75	1.38	0.03	0.25	0.10
S19	Cement	6.43	6.22	0.00	0.32	−0.11
S20	Other non-metallic mineral products	3.89	4.69	0.01	0.10	−0.91
S21	Steelmaking and derivatives	1.85	2.02	0.02	0.00	−0.19
S22	Non-ferrous metallurgy	1.39	1.49	0.16	0.03	−0.30
S23	Metal products – except machinery and equipment	3.15	1.46	1.45	0.23	0.02
S24	Machinery and equipment, including maintenance and repairs	4.67	0.87	4.01	0.17	−0.38
S25	Home appliances	5.35	0.44	0.14	4.95	−0.19
S26	Office machinery and computer equipment	6.84	0.13	6.20	1.40	−0.88
S27	Machinery, appliances and equipment	2.78	2.41	0.54	0.34	−0.52
S28	Electronic material and communication equipment	4.54	0.46	3.60	2.34	−1.87
S29	Appliances/medical and hospital instruments, measurement and optical	4.12	1.19	1.38	2.64	−1.09
S30	Cars, trucks and utilities	2.51	−0.05	1.72	1.85	−1.02
S31	Trucks and buses	3.28	0.31	3.79	0.13	−0.95
S32	Parts and accessories for motor vehicles	1.60	1.50	0.12	0.06	−0.07
S33	Other transport equipment	2.70	0.28	0.76	1.13	0.53
S34	Furniture and products of various industries	3.92	0.49	1.63	2.84	−1.04

Source: Prepared by the authors from model results.

The results for the least dynamic sectors, such as Textiles, Tobacco products, Leather articles and footwear, among others, show that the effect of domestic participation loss combined to the decrease of exports was the decisive element for the performance of those sectors, confirming the participation loss observed during the period.

Fig. 1 synthetizes some indicators of the manufacturing industry in 2005 (base year for the model) and 2011 (projection). The results indicate that the manufacturing industry can have gone through important modifications in that period, such as a decrease in importance of exports, the increase of imported inputs, penetration, decrease of domestic inputs and increase of the participation of imports in the local market. Household consumption becomes more important for the sales of the manufacturing industry, which was expected given the economic environment and the changes in relative prices. Therefore, it seems clear that more important than the manufacturings loss in participation in the economy is the loss in density in the industry productive chains, loss in participation of exports and substitutions for imported production in the local market.

4. Conclusions

The loss of manufacturing industry participation in the Brazilian economy, phenomenon recurrently known as "deindustrialization", has been observed for some time, and it seems to have intensified since the mid-2000s. We seek to consistently analyze the loss of participation in a recent period (2005–2011), for which we have a broad set of data. The methodology consisted in simulations with a dynamic recursive computable general equilibrium model. This methodology accommodates both structural elements of the Brazilian economy (productive chains, composition of demand and factors usage), and a combination of domestic (in the labor market, consumption and investment) and external elements (exchange rate valuation and external markets).

The period from 2005 to 2011 is characterized by a sensitive oscillation of the GDP, given the effect of the International Financial Crises of 2009 and 2010, but with a relatively high average growth rate (4.16% per year). The period is distinguished by strong growth of household consumption (5.4% per year) and investment (9% per year). On the external side, we can observe the low dynamism of exports (2.9% per year) and the high imports growth (14.5% per year), particularly influenced by the valuation of the exchange rate in the period (the rate declined from 2.18 to 1.67 R$/US$ from 2006 to 2011). The average nominal wage increased for all sectors, and in many of them real growth of wage and employment was observed with a dynamic recursive computable general equilibrium model. This methodology accommodates both structural elements of the Brazilian economy (productive chains, composition of demand and factors usage), and a combination of domestic (in the labor market, consumption and investment) and external elements (exchange rate valuation and external markets).

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This scenario applies to a very heterogeneous industrial structure regarding production costs, sales to the domestic market, external sales and competition with imports. The model database captures all those indicators to consistently present the impact of these conditions in the economy. The results showed that the model, powered by the wide set of simulation shocks, correctly indicates the sense of structural change, the manufacturings loss of participation and services gain of participation. The manufacturing industry sector dynamic can be seen and explicit the factors that contributed to each sectorial result.

The projected average growth of the manufacturing industry was 2.5% per year, however some sectors would be much more dynamic, like Office Machinery, Cement and Beauty, with increases between 6 and 7% per year. Relevant sectors such as Metallurgy present slow growth dynamic, around 1.5% per year; an even lower result than this one can be seen in the projection for sectors such as Textile (0.1%), Leather and Footwear (0.5%) and Tobacco (0.1%).

The results show that the manufacturing industry sectors benefited from the domestic Market conditions (Especially household consumption and investment), even if it was in different proportions. The domestic participation effect is negative for most sectors, indicating the combined effect of increase in production costs (particularly salaries) and the valuation of the exchange rate. However, this effect is dominated by the contribution of exports and of the local

market, which indicates that if it was not for a strong sales expansion of the local market, the participation loss result would have been even stronger. In this way, most of the results found are in accordance with the literature, especially the premature deindustrialization hypothesis for developing countries, and the specific role of the overvaluation of Brazilian exchange rate (see Palma, 2005; Marconi and Rocha, 2012; Nassif et al., 2014; Rodrik, 2016).

Nevertheless, it is worth noting that aspects of the structural dynamics of the Brazilian economy are not directly contemplated in these simulations due to the short length of the time frame and its peculiar characteristics. Additionally,

1. Results of optimizing decisions
1.1. Production:
$$x1s_{c,i} - [a1tot_i + a1s_{c,i}] = x1tot_i$$
$$x1prim_i - [a1tot_i + a1prim_i] = x1tot_i$$
$$x1oct_i - [a1tot_i + a1oct_i] = x1tot_i$$
$$x1_{csi} - a1_{csi} = x1s_{ci} - \sigma 1_c[p1_{csi} + a1_{csi} - p1s_{ci}]$$
$$x1lab_i - a1lab_i = x1prim_i - \sigma 1prim_i[p1lab_i + a1lab_i - p1prim_i]$$
$$x1cap_i - a1cap_i = x1prim_i - \sigma 1prim_i[p1cap_i + a1cap_i - p1prim_i]$$
1.2. Investment:
$$x2s_{ci} - [a2tot_i + a2s_i] = x2tot_i$$
$$x2_{csi} - a2_{csi} = x2s_{ci} - \sigma 2_c[p2_{csi} + a2_{csi} - p2s_{ci}]$$
1.3. Household demands:
$$d_c + p3s_c = d$$
$$x3_c = B3LUX_c(d - p2s_c) + (1 - B3LUX_x)q$$
$$x3tot = \sum_c S3S_c * x3_c$$
$$p3tot = \sum_c S3S_c * p3_c$$
$$x3_{cs} - a3_{cs} = a3s_c - \sigma 3_c[p3_{cs} + a3_{cs-p3s_c}]$$
2. Exports
$$x4_c - f4q_c - f4qtot = -\varepsilon exp_c[p4_c - phi - f4p_c]$$
3. Other demands
$$x5_{cs} = f5_{cs} + x3tot + f5tot2$$
$$x0mar_{csim} = x0_{csi} * a0mar_{csim}$$
4. Supply equals demand for commodities
4.1. Domestic demand:
$$X0DOM_c = \sum_i X1_{c,dom,i} + \sum_i X2_{c,dom,i} + X3_{c,dom} + X4_c + X5_{c,dom} + X6_{c,dom} + \sum_i MAR0_{dom,i}$$
4.2. Demand for imports:
$$X0IMP_c = \sum_i X1_{c,imp,i} + \sum_i X2_{c,imp,i} + X3_{c,imp} + X5_{c,imp} + X6_{c,imp}$$
5. Imports, price effect
$$p0_{c,imp} = pf0cif_c + phi + t0imp_c$$

Chart 1. Stylized version of BRIDGEs main equations.

Source: Adapted from Dixon and Rimmer (2002) and Horridge (2011).

6. GDP

6.1. GDP from income side

$$x0gdpinc = [1/V0GDPINC][V1LAB_{io} * employ_i + V1CAP_i * x1cap_i + tax]$$

6.2. GDP from expenditure side

$$x0gdpexp = [1/V0GDPEXP][V2TOT_i * x2tot_i + V3TOT * x3tot + V5TOT * x5tot + V4tot * x4tot + V6TOT * x6tot - V0CIF_c * x0cif_c]$$

7. Recursive Dynamics

7.1. Capital Accumulation

$$K_i^t = (1 - D_i)K_i^{t-1} + V2TOT_i$$

$$IKRATIO_i = V2TOT_i/K_i$$

$$EROR_i = \psi_K[K_i^t/K_i - 1] + f_{k(i)}$$

$$EROR_i = \psi_Q[Q_i, PI_i] + f_{EROR(i)}$$

7.2. Labor Market

$$[\tfrac{WR_t}{WR_{t-1}} - 1] = [\tfrac{LTOT_{t-1}}{LTOT_{trend,t-1}} - 1] + \alpha[\tfrac{LTOT_t}{LTOT_{trend,t}} - 1] + f_{WR}$$

Chart 1. (*Continued*)

the models data and parameters were calibrated considering the economy as it was between 2005 and 2011, and therefore, further modifications in preferences and other behavioral parameters may change in the future, bringing other interpretation for sectoral performance. But, most importantly, our results show the Brazilian economy can suffer from deindustrialization if the economy experiences the type of shocks observed in the period.

Therefore, the methodology used clearly do not to capture all the factors responsible for the changes in participation of each sector in the manufacturing industry, but it signalize the constraints derived of the main scenario and structural elements. Some policies, such as sectorial exoneration, for instance, can be important to explain participation loss or gain in some sectors, even though they are not captured directly by the model through the implemented shocks. The set of results obtained in this work allowed some considerations about the current situation of the industry. The short and medium term scenarios point to negative growth rates for Brazilian economy in the next years (2015–2017), particularly influenced by the retraction of the domestic market. The increase in unemployment and high inflation led to a decrease in real household consumption, and the maintenance of high level interest rates is holding down investments. The retraction of government consumption also leads in the same direction. Currency devaluation in 2015 already shows an impact in exportation, but the effect tends to be small given the low expansion of global economy. Imports, and therefore the competition with domestic products, tend to drop, expanding the local industrial production space. Nevertheless, the model results showed that the external effects are less impacting than the domestic constraints for most of the sectors. That allows us to foresee that manufacturing industry growth in the next years tends to be small, or retracting in important segments, indicating that the process of participation loss should be emphasized.

Appendix 1. Model

The BRIDGE model was developed from the theoretical structure of the ORANI model (Dixon et al., 1982) and ORANIG (Horridge and Orani, 2006), incorporating elements of recursive dynamic. Those elements are especially essential for the simulation related to the capital stock (which accumulates over time), or the labor market (that presents certain inertia in the adjustment of wages and employment).

The BRIDGE model was set for the year 2005, according to the sectorial and product classification with the IBGE input–output matrix: 55 sectors and 110 products, five components of the final demand (household consumption, government consumption, investment, exports and stocks), two elements of primary factors (capital and labor), two

margin sectors (commerce and transportation), imports per product for each one of the 55 sectors and five components of the final demand, an aggregate of indirect taxes and an aggregate of taxes over production.

The theoretical specification of the model follows the pattern in CGE national models. The productive sectors minimize production costs subject to a technology of constant returns of scale, where the mix of intermediary input and a primary factor (aggregate) were determined by fixed coefficients (Leontief). In the input composition there was substitution, through prices, of domestic and imported products, and through constant elasticity of substitution functions (CES). In the composition of the primary factor there is also substitution via price between capital and labor by CES functions. Even though all the sectors show the same theoretical specification, the effect of substitution via prices are differentiated according to the domestic/imported composition of the input used.

The first letter(s) indicates the type of variable:	
a	Technical change
del	Ordinary change
f	Shift parameter
p	Prices in local currency
pf	Prices in foreign currency
S	Share
σ	Substitution elasticity
t	Tax
V	Value in level
x	Real Variable
The number indicates the aggregate to which the variable refers:	
1	Production
2	Investment
3	Consumption
4	Exports
5	Government
6	Stocks
0	All above
Additional final letters contain additional information:	
bas	Basic prices
cap	Capital
cif	Imports at frontier prices
imp	Imports after taxes
lab	Labor
lux	Supernumerary
mar	Margins
oct	Other cost
$prim$	Primary factors
pur	Purchase prices

Chart 2. Variables notation. Upper and lowercase: capital letters represent level and lowercase variables represent percent variations.
Source: Adapted from Dixon and Rimmer (2002) and Horridge (2011).

Additional final letters contain additional information:	
s	All sources (domestic and imported)
sub	Subsistence goods
tar	Tariff
tax	Indirect tax
tot	Total or average for a given user
$gdpexp$	GDP from expenditure side
$gpdinc$	GDP from income side
Subscripts:	
i	Industries (55 types)
c	Commodities (110 types)
s	Source (Domestic, Imported)
t	Current year
$trend$	Tendency
Other variables for dynamics	
K	Capital Stock
D	Depreciation
$IKRATIO$	Investment/Capital Stock ratio
Q	Rental rate of capital
PI	Asset price of capital
WR	Real wage
α	Labor market dynamic adjustment
ψ	Functions
Upper and lowercase:	
Capital letters represent level and lowercase variables represent percent variations	

Chart 2. (*Continued*)

The household demand is specified from the Stone-Geary non-homothetic utility functions (Peter et al., 1996), dividing the goods and services consumption into luxury and subsistence portions, in such a way that a fixed portion of expenses is reserved for subsistence and the residual portion for luxury expenses, which allows for income changes to cause differentiated modification in product consumption, and hence its non-homothetic character. At the same time, the composition between domestic and imported is established through CES functions.

Sectorial exports answer to demand curves negatively associated to domestic costs of production and positively to those affected by the exogenous expansion of international income, adopting the small country hypothesis in international commerce. Government consumption is typically exogenous, being able to be associated or not to household consumption or tax collection. Stock accumulates according to production variation. Charts 1 and 2 summarize the stylized version of the main equations of the BRIDGE model and the notation of variables, respectively.

The parameters were extracted from literature. Their references and values are summarized in Chart 3 (Tourinho et al., 2007; Domingues et al., 2009; Hoffmann, 2010; Almeida, 2011; Domingues, 2002; Haddad and Hewings, 1997; Oreiro et al., 2005; Gonzaga and Corseuil, 2001). Those parameters are chosen to represent long-run and structural responses for the model. Sensitivity analysis showed the results are robust to their values.

All those relationships between agents and economic sectors form a system of m equations and n variables whose initial solution (X_0) can be obtained through data referent to 2005. In turn, in the simulations the variations in m variables of the model (endogenous) are calculated, caused by changes in the other $(n - m)$ variables (exogenous) in comparison to the base year (Dixon and Rimmer, 2002). Therefore, for any simulation, the first step is to define the so-called model closure, that means, the variable set that remain constant in the simulation shocks (exogenous) and the variables solved internally by the equation system (endogenous).

Parameters	Dimension	Description	Values	References
Armington elasticities ($\sigma 1, \sigma 2$)	c	Elasticities of substitution - domestic and imported	0.15 a 5.28	Tourinho et.al. (2007)
Primary Factor elasticities ($\sigma 1 prim$)	i	Elasticities of substitution - primary factors	0.01 a 1.58	Domingues et.al. (2009)
Elasticity of expenditure (σ_3)	c	Household expenditure elasticities	0.73 a 1.27	Hoffman (2010)
FRISCH parameter (frisch)	1	Sensitivity of the marginal utility	-1.94	Almeida (2011)
Export Demand elasticities (εexp)	c	Price elasticity of export demand	0.04 a 4.00	Domingues (2002)
Investment elasticity (ψ)	i	Investment elasticity	3.00	Haddad and Hewings (1997)
Depreciation (D)	i	Depreciation rate	0.0342	Oreiro et.al. (2005)
Employment wage elasticity (α)	i	Elasticity of wages relative to employment	0.66	Gonzaga and Corseuil (2001)

Chart 3. Parameters in BRIDGE model.

Exogenous in the historic closure and endogenous in the decomposition closure		Exogenous in the decomposition closure and endogenous in the historic closure	
Variable	Description	Variable	Description
x0gdpinc	GDP from income side	*aprimtot*	Primary factors productivity
x5tot	Government consumption	*f5tot2*	Government consumption shift
x3tot	Household consumption	*f3tot_h*	Households preferences changes
x2tot_i	Investment	*invslack*	Investment shift
x4	Exports	*f4q*	Exports shift
p3tot	Consumer Price Index	*phi*	Exchange rate
x1lab	Labor usage	*a1lab*	Technological change in labor usage

Chart 4. Swap variables in the historic and decomposition closures.

Source: Prepared by the authors.

In the historical simulation, for the observed variables to be imposed on the model, it is necessary to make it flexible using variables of technological change, preferences or swap parameters. In turn, the results for those variables are used as shocks in the decomposition simulation, allowing the identification in the historical period (2006–2011), of the importance of each one of the observed variables. Following the Australian tradition of CGE models, the change between endogenous and exogenous variables in historical simulations and decomposition is called swap, indicating the exchange between these variables, as detailed in Chart 4

The variables observed between 2006–2011 and that received shocks in the historical simulation were: the GDP on the income side, government consumption, household consumption, total investment (all sectors), exports (per product), import prices (per product), consumer price index, utilization of labor per sector and average wage per sector. Each one of those variables (except for wage) has its own endogenous counterpart, respectively: total productivity of primary factors (all sectors), shift in government consumption, changes in preference of household consumption (all households), shift in investments, shift in exports, exchange rate (currency) and technological changes in the sectorial use of the factor labor.

In its turn, in the decomposition simulation, the exogenous variables receive the calculated shocks endogenously in the historical simulation, or shocks identical to the ones in the historical simulation for exogenous variables in both simulations (in this case, wages and population growth). Thus, the results of the historical simulations and the decomposition are the same in aggregates because all the exogenous variables in the decomposition receive, as shocks, the same values calculated exogenously in the historical simulation. However, only in the decomposition simulation is it possible to verify in an isolated manner the effect of each one of the elements of the scenario.

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