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DEINDUSTRIALIZATION AND REGRESSIVE SPECIALIZATION IN THE BRAZILIAN ECONOMY BETWEEN 2000 AND 2014: A CRITICAL ASSESSMENT BASED ON THE INPUT-OUTPUT ANALYSIS

RIO DE JANEIRO
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Tese apresentada ao Programa de Pós-Graduação em Economia da UFRJ, como requisito parcial obrigatório para obtenção de título de Doutorado em Economia.

Orientador: Fabio Neves Peracio Freitas

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Tese apresentada à banca examinadora do Programa de Pós-Graduação em Economia do Instituto de Economia da Universidade Federal do Rio de Janeiro, como requisito necessário para obtenção de título de Doutora em Economia.

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BANCA EXAMINADORA

Prof. Dr. Fabio Neves Peracio Freitas (UFRJ), orientador

Prof. Dr. Carlos Aguiar de Medeiros (UFRJ)

Prof. Dra. Esther Dweck (UFRJ)

Prof. Dra. Ana Urraca Ruiz (UFF)

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Verdaderamente no sé qué sería del hombre si no tuviera
dentro de sí, escondido, superpuestos, sumergidos,
adyacentes, provisionales, otros muchos hombres que no
sólo no destruyen su personalidad, sino que la constituyen
al ampliarla, repetirla y hacerla posible de adaptación a las
más variadas circunstancias de la vida.
(…)
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ABSTRACT

Since the 2000s, many studies dedicated attention to analyzing the evolution of the productive structure of the Brazilian economy. One of the main topics of discussion in this literature is the existence of the processes of deindustrialization and regressive specialization. To collaborate with this debate, the principal question of the thesis is whether we can observe in the Brazilian economy these processes, and what is their intensity and time profile. Our principal aim is to provide an answer to the latter question that is corroborated by the empirical evidence available. The specific objectives are: developing a structural decomposition analysis of the rate of growth of gross output that isolates the effects of relative prices changes for the period 2000-2014 and subperiods (2000-2003, 2003-2008, 2010-2014), capturing the contributions of the pattern of trade, technological change, and final demand; and relating the sources of change in the structural decomposition analysis with the investigation of external (captured by the market share of Brazilian exports in foreign markets) and internal (through intersectoral relations of input-output and the market share of domestic goods) competitiveness, and technical change; and contributing to the debate on the processes of deindustrialization and regressive specialization in the Brazilian economy by focusing our analysis on the evolution the set of sectors that stand out as capable of generating and diffusing new technologies in the Brazilian economy. In other to achieve that objective we construct a series of annual input-output tables for 2000 to 2015 at constant prices and relative prices to allow an input-output analysis that isolates the effects of relative price changes.Moreover, we investigate the sectoral performance of the Brazilian economy according to a classification proposed by the GIC-UFRJ. In this context, we focus our analysis in the innovative industrial group, since this sector stands out for its capacity to stimulate the creation and diffusion of technological change in the economy. Although we found elements of deindustrialization and regressive specialization in the Brazilian economy between 2000 and 2014, it follows from our analysis that these processes are less intense and continuous than it is usually characterized in the literature. However, we sustain that, in general, these processes became more intense in the period after the world crisis of 2008, with the sole exception of the behavior of the domestic market competitiveness indicator. In particular, the latter characterization represents well the experience of the IM group in the period investigated, which we argued should be the focus of the analysis of structural change.

Keywords: Brazilian economy. Deindustrialization and Regressive specialization. Input-Output. Structural decomposition analysis.

RESUMO

Desde a década de 2000, muitos vem dedicando especial atenção à análise da evolução da estrutura produtiva da economia brasileira. Um dos principais tópicos de discussão nesta literatura é a existência dos processos de desindustrialização e especialização regressiva. Para colaborar com este debate, a questão principal da tese é se podemos observar na economia brasileira esses processos entre 2000 e 2014, e qual o seu perfil de intensidade e temporalidade. Nosso principal objetivo é fornecer uma resposta para esta última questão corroborada pela evidência empírica disponível. Para alcançar esse objetivo, construímos uma série de tabelas de insumo-produto anuais para o período entre 2000 e 2015 a preços constantes e preços relativos para permitir uma análise insumo-produto que isole os efeitos das mudanças de preços relativos. Além disso, desenvolvemos uma análise de decomposição estrutural da taxa de crescimento da produção bruta que isola os efeitos das variações dos preços relativos para o período de 2000-2014 e subperíodos (2000-2003, 2003-2008, 2010-2014), captando as contribuições do padrão do comércio, a mudança tecnológica e a demanda final. A análise envolve relacionar os fatores na análise de decomposição estrutural com a investigação da competitividade externa (capturada pela participação de mercado das exportações brasileiras nos mercados externos) e interna (por meio de relações intersetoriais de insumo-produto e participação de mercado de bens domésticos) e mudança técnica. Investigamos o desempenho setorial da economia brasileira segundo uma classificação proposta pelo GIC-UFRJ. Contribuímos para o debate sobre os processos de desindustrialização e especialização regressiva na economia brasileira, enfocando nossa análise sobre a evolução do conjunto de setores que se destacam como capazes de gerar e difundir novas tecnologias na economia brasileira. Neste contexto, concentramos nossa análise no grupo industrial inovador, uma vez que este setor se destaca pela capacidade de estimular a criação e difusão de mudanças tecnológicas na economia. Embora tenhamos encontrado elementos de desindustrialização e especialização recessiva na economia brasileira entre 2000 e 2014, conclui-se de nossa análise que estes processos são menos intensos e contínuos do que costumam ser caracterizados na literatura. No entanto, sustentamos que, em geral, esses processos se tornaram mais intensos no período após a crise mundial de 2008, com a única exceção do comportamento do indicador de competitividade do mercado doméstico. Em particular, a última caracterização representa bem a experiência do grupo IM no período investigado, que argumentamos que deveria ser o foco da análise da mudança estrutural.

Palavras-chave: Economia brasileira. Desindustrialização. Especialização regressiva.
Modelo insumo-produto. Decomposição estrutural.

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List of abbreviations and acronyms

AC	Processed agricultural commodities
AGR	Agricultural and related industries
BL	Backward linkages
CIF	Cost, Insurance and Freight
CNAE	National Classification of Economic Activities
COMTRADE	United Nations International Trade Statistics Database
EMI	Extractive and manufacturing industries groups
FL	Forward linkages
FOB	Free on Board
GDP	Gross domestic product
GEAD	Generalized Exactly Additive Decomposition
GFCF	Gross fixed capital formation
GIC-UFRJ	Research group of Manufacturing industries and Competitiveness– Federal University of Rio de Janeiro (in Portuguese, Grupo de Indústria e Competitividade)
GRAS	Generalized RAS
IBGE	Brazilian Institute of Geography and Statistics (in Portuguese, Instituto Brasileiro de Geografia e Estatística)
IM	Innovative manufacturing industry
IO	Input-ouput
IOT	Input-output tables
ISIC	International Standard Industrial Classification of All Economic Activities
MQC	Unprocessed and processed mining and quarrying commodities
NEREUS-USP	The University of Sao Paulo Regional and Urban Economics Lab
NPISH	non-profit institutions serving households
RAS	Biproportional method for balancing matrices
SDA	Structural decomposition analysis
SNA	System of national accounts
SUT	Supply and Use Table
TM	Traditional manufacturing industry
UN	United Nations
UNIDO	United Nations Industrial Development Organization
WIOD	World Input-Output Database

List of variables

According to the order of appearance in the text

Variable	***Dimension***	***Description***
$\mathbf{V}$	$(n \times m)$	make matrix
m	(1×1)	Number of products
n	(1×1)	Number of industries
$\mathbf{q}$	$(m \times 1)$	gross output by product;
$\mathbf{U_d}$	$(m \times n)$	intermediate domestic consumption matrix in the dimension product by industry
$\mathbf{U_m}$	$(m \times n)$	intermediate imported consumption matrix in the dimension product by industry
$\mathbf{F_d}$	$(m \times \varphi)$	matrix of the final demand for imported products
φ	(1×1)	number of final demand expenditures
$\mathbf{F_m}$	$(m \times \varphi)$	matrix of the final demand for imported products
$\mathbf{T_U}$	$(m \times n)$	matrix of values of taxes and subsidies associated with products
$\mathbf{T_F}$	$(m \times n)$	matrix of taxes and subsidies associated with products
$\mathbf{x}$	$(n \times 1)$	gross output by industry
$\mathbf{y}$	$(n \times 1)$	sectoral value added
$\mathbf{u_d^q}$	$(m \times 1)$	total intermediate demand by product
$\mathbf{f_d^q}$	$(m \times 1)$	total final demand by product
$\mathbf{i}$	(1×1)	unitary or summation vector
$\mathbf{D}$	$(n \times m)$	Market share matrix
$\mathbf{B_d}$	$(m \times n)$	domestic technical coefficients, in the dimension product by industry
$\mathbf{A_d}$	$(n \times n)$	domestic technical coefficients, in the dimension industry by industry
$\mathbf{f_d}$	$(m \times 1)$	total final demand by industry
$\mathbf{I}$	$(n \times n)$	identity matrix
$\mathbf{Z}$	$(m \times n)$	Leontief inverse matrix
p_{ij}^t	(1×1)	the price of each product i and industry j for a year t
q_{ij}^t	(1×1)	the price of each product i and industry j for a year t
t	(1×1)	Current year
λ_{ij}	(1×1)	cell-specific price index
Λ_{ij}	(1×1)	cell-specific chained price index
τ	(1×1)	being the last year of the desired chained index
$\mathrm{R_{ij}}$	(1×1)	generic matrix element from the IOT system

$\mathbf{R}$	♦	generic matrix from the IOT system (i.e., supply table and use table – domestic and imported)
Φ_{ij}	(1×1)	relative prices ratio
$p^{2010,\tau}$	(1×1)	chained total gross output deflator with 2010 as the base year
$\mathbf{UT_t^{pu}}$	♦	Use of products in purchaser's prices
$\mathbf{UT_n^{pr}}$	♦	Use table of domestic products in producer's prices
$\mathbf{UT_m^{pr}}$	♦	Use table of imported products in producer's prices
$\mathbf{UT_t^{pr}}$	♦	Use table of products in producer's prices
$\mathbf{x^p}$	$(n \times 1)$	sectoral relative price by product
$\mathbf{x^v}$	$(n \times 1)$	Gross output in volume
x_j^p	(1×1)	price index of the industry *j*
p	(1×1)	price index of total gross output deflator
$u_{d_{ij}}$	(1×1)	Elements of $\mathbf{U_d}$, intermediate consumption in the dimension product by industry
$u_{d_{ij}}^p$	(1×1)	relative price of product *i* used as an input by industry *j*
$u_{d_{ij}}^v$	(1×1)	volume measure of product *i* used as an input by industry *j*
$\mathbf{B_d^p}$	$(m \times n)$	matrix of relative price indices of domestic technical coefficients in the product by industry dimension
$b_{d_{ij}}^p$	(1×1)	2lements of $\mathbf{B_d^p}$
$\mathbf{B_d^v}$	$(m \times n)$	Matrix of domestic technical coefficients in volume units in the product by industry dimension
$b_{d_{ij}}^v$	(1×1)	matrix of domestic technical coefficients measured in volume terms
$\mathbf{f_{dq}^p}$	$(m \times 1)$	relative price of final demand vector by product
$\mathbf{f_{dq}^v}$	$(m \times 1)$	final demand vector by product in volume units
$f_{dq_i}^p$	(1×1)	final demand deflator by product
$\mathbf{D^v}$	$(n \times m)$	Market share in volume units
$\mathbf{V^v}$	$(m \times n)$	Make matrix in volume units
$\mathbf{q^v}$	$(m \times 1)$	gross output by product in volume units
$\mathbf{D^p}$	$(n \times m)$	Relative prices deflator of the market share matrix
$\widetilde{\mathbf{A}}_\mathbf{n}$	$(n \times n)$	matrix of domestic coefficients weighted by total relative prices
$\tilde{\mathbf{f}}_\mathbf{d}$	$(n \times 1)$	final demand vector weighted by total relative prices
$\tilde{\mathbf{Z}}$	$(n \times n)$	Leontief matrix weighted by total relative prices
χ_j	(1×1)	share the extractive and manufacturing industry groups in the total gross output in volume units

e_j	(1×1)	exports by industry in total units
e	(1×1)	total exports in total units
e_j^p	(1×1)	exports' price deflator by industry
e^p	(1×1)	total exports' price deflator
e_j^v	(1×1)	exports in volume units by industry
e^v	(1×1)	total exports in volume units
η_j	(1×1)	share of each group in total exports
η^v	(1×1)	export basket in volume units
$\mathbf{A_d^*}$	$(n \times n)$	Domestic technical coefficients weighted by sectoral relative prices deflator - $\mathrm{A_d}\hat{\mathrm{x}}^{\mathrm{p}}$
$\mathbf{s_d}$	$(n \times 1)$	domestic inventories vector
$\breve{\mathbf{A}}_{\mathbf{d}}$	$(n \times 1)$	sectoral changes of domestic technical coefficients in the volume gross output decomposition
$\breve{\mathbf{f}}_{\mathbf{d}}$	$(n \times 1)$	sectoral changes of domestic final demand in the volume gross output decomposition
$\breve{\mathbf{x}}^{\mathbf{p}}$	$(n \times 1)$	sectoral changes of total relative prices in the volume gross output decomposition
$\breve{\mathbf{s}}$	$(n \times 1)$	sectoral changes of inventories in the volume gross output decomposition
$\breve{\mathbf{A}}_{\mathbf{d}}^{\mathrm{v}}$	$(n \times 1)$	sectoral changes of domestic intermediate demand in volume units to the volume gross output decomposition
$\breve{\mathbf{f}}_{\mathbf{d}}^{\mathrm{v}}$	$(n \times 1)$	sectoral changes of domestic final demand in volume units to the volume gross output decomposition
$\breve{\mathbf{D}}^{\mathrm{v}}$	$(n \times 1)$	sectoral changes of the market share matrix in volume units to the volume gross output decomposition
$\breve{\mathbf{A}}_{\mathbf{d}}^{\mathbf{p}}$	$(n \times 1)$	sectoral changes of domestic intermediate demand in relative prices units to the volume gross output decomposition
$\breve{\mathbf{f}}_{\mathbf{d}}^{\mathbf{p}}$	$(n \times 1)$	sectoral changes of domestic final demand in relative prices units to the volume gross output decomposition
$\breve{\mathbf{D}}^{\mathbf{p}}$	$(n \times 1)$	sectoral changes of the market share matrix in relative prices units to the volume gross output decomposition
$\boldsymbol{\upsilon}$	$(n \times 1)$	Volume contribution to gross output in volume units
$\boldsymbol{\rho}$	$(n \times 1)$	Relative price contribution to gross output in volume units
$\mathbf{A}$	$(n \times n)$	total technical coefficients, in the dimension industry by industry
$\mathbf{A_m}$	$(n \times n)$	imported technical coefficients, in the dimension industry by industry
$\mathbf{B}$	$(m \times n)$	total technical coefficients, in the dimension product by industry

$\mathbf{B_m}$	$(m \times n)$	imported technical coefficients, in the dimension product by industry
$\mathbf{B^p}$	$(m \times n)$	matrix of relative price indices of total technical coefficients in the product by industry dimension
$\mathbf{B^v}$	$(m \times n)$	matrix of total technical coefficients in volume units in the product by industry dimension
$\mathbf{B^p_m}$	$(m \times n)$	matrix of relative price indices of imported technical coefficients in the product by industry dimension
$\mathbf{B^v_m}$	$(m \times n)$	matrix of imported technical coefficients in volume units in the product by industry dimension
$\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m}}$	$(m \times n)$	auxiliary matrix of imported technological coefficients supposing that it grows proportionally to the rate of growth of technical coefficients in volume
t^v_{ij}	(1×1)	the technological growth related to the input produced by product *i* and used by industry *j* between the final and initial period
b^v_{ij}	(1×1)	total technical coefficients in volume units in the product by industry dimension by product *i* and used by industry *j*
$\breve{b}^v_{m_{ij}}$	(1×1)	auxiliary imported technological coefficients supposing that it grows proportionally to the rate of growth of technical coefficients in volume by product *i* and used by industry *j*
$\breve{\mathbf{A}}^{\mathbf{v}}_{\mathbf{d}}$	$(n \times 1)$	sectoral changes attributed to volume changes of domestic technical coefficients in the volume gross output decomposition
$\breve{\mathbf{A}}^{\mathbf{v}}_{\mathbf{m}}$	$(n \times 1)$	sectoral changes attributed to volume changes of imported technical coefficients in the volume gross output decomposition
$\breve{\mathbf{A}}$	$(n \times 1)$	sectoral changes attributed to volume changes of total technical coefficients in the volume gross output decomposition
$\breve{\breve{A}}^{\mathbf{v}}_{\mathbf{m}}$	$(n \times 1)$	sectoral changes attributed to $\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m}}$ in the volume gross output decomposition
$\mathbf{UT^{tr}}$	♦	Transportation margin table
$\mathbf{UT^{ta}}$	♦	Trade margin table by product
$\mathbf{UT^{tx}}$	♦	Taxes margin table by product
$\mathbf{f}$	$(m \times 1)$	total final demand vector by product
$\mathbf{f_m}$	$(m \times 1)$	imported final demand vector by product
$\mathbf{f^p_q}$	$(m \times 1)$	relative price vector for total final demand by product
$\mathbf{f^v_q}$	$(m \times 1)$	total final demand vector by product in volume units
$\mathbf{f^p_{mq}}$	$(m \times 1)$	relative price vector for imported final demand by product

$\mathbf{f^v_{mq}}$	$(m \times 1)$	imported final demand vector by product in volume units
$\mathbf{\breve{c}^v_m}$	$(n \times 1)$	household consumption imported contribution to volume gross output changes in volume units
$\mathbf{\breve{k}^v_m}$	$(n \times 1)$	gross fixed capital formation imported contribution to volume gross output changes in volume units
$\mathbf{\breve{g}^v_m}$	$(n \times 1)$	government expenditures imported contribution to volume gross output changes in volume units
$\mathbf{\breve{e}^v_m}$	$(n \times 1)$	exports imported contribution to volume gross output changes in volume units
$\mathbf{\breve{c}^v}$	$(n \times 1)$	household consumption total contribution to volume gross output changes in volume units
$\mathbf{\breve{k}^v}$	$(n \times 1)$	gross fixed capital formation total contribution to volume gross output changes in volume units
$\mathbf{\breve{g}^v}$	$(n \times 1)$	government expenditures total contribution to volume gross output changes in volume units
$\mathbf{\breve{e}^v}$	$(n \times 1)$	exports total contribution to volume gross output changes in volume units

Symbols in Appendix C

Variable	***Dimension***	***Description***
$\mathbf{q^{pu}}$	$(m \times 1)$	gross output by product at purchasers' prices
$\mathbf{t^r}$	$(m \times 1)$	Transportation margin vector by product
$\mathbf{t^a}$	$(m \times 1)$	Trade margin vector by product
$\mathbf{t^x}$	$(m \times 1)$	taxes vector by product
$\mathbf{m}$	$(m \times 1)$	Imports vector by product
$\mathbf{u^{pu}}$	$(m \times 1)$	Intermediate demand by product at purchasers' prices
$\mathbf{f^{pu}}$	$(m \times 1)$	final demand by product at purchasers' prices
$\mathbf{U^{pu}}$	$(m \times n)$	Intermediate demand matrix by product-industry at purchasers' prices
$\mathbf{F^{pu}}$	$(m \times \varphi)$	Intermediate demand matrix by product-final demand component at purchasers' prices
$\mathbf{UT^{tr}}$	♦	use table of domestic transportation margins
$\mathbf{UT^{ta}}$	♦	use table of domestic trade margins
$\mathbf{UT^{tx}}$	♦	use table of domestic indirect taxes
$\mathbf{UT^{pr}_m}$	♦	use table of imported demand in producer's prices
ϑ^{pr}_{ij}	(1×1)	Mark-down for product *i* and industry *j* for domestic use table in producer's prices
ut^{pr}_{ij}	(1×1)	domestic use table element for product *i* and industry *j*

ut_{ij}^{pu}	(1×1)	total use table in purchaser's prices element for product *i* and industry *j*
ϑ_{ij}^{ta}	(1×1)	mark-down for product *i* and industry *j* for trade margin table
ut_{ij}^{ta}	(1×1)	trade margin element for product *i* and industry *j*
ϑ_{ij}^{tr}	(1×1)	mark-down for product *i* and industry *j* for transportation margin table
ut_{ij}^{tr}	(1×1)	transportation margin element for product *i* and industry *j*
ϑ_{ij}^{tx}	(1×1)	mark-down for product *i* and industry *j* for taxes margin table
ut_{ij}^{tx}	(1×1)	taxes margin element for product *i* and industry *j*
ϑ_{ij}^{m}	(1×1)	mark-down for product *i* and industry *j* for imported use table in producer's prices
ut_{ij}^{m}	(1×1)	imported use table element for product *i* and industry *j*
$\mathbf{\Theta}$	♦	generic mark-down matrix
$\widetilde{\mathbf{UT}}_t^{\mathbf{pr}}$	♦	estimates of the use table of domestic products in producer's prices
$\mathbf{\Theta}_{t^*}^{\mathbf{pr}}$	♦	mark-down matrix for domestic use table in producer's prices for the base year t^*
$\widetilde{\mathbf{UT}}_t^{\mathbf{ta}}$	♦	estimates of trade margin table
$\mathbf{\Theta}_{t^*}^{\mathbf{ta}}$	♦	mark-down matrix for trade margins for the base year t^*
$\widetilde{\mathbf{UT}}_t^{\mathbf{tr}}$	♦	estimates of transportation margin table
$\mathbf{\Theta}_{t^*}^{\mathbf{tr}}$	♦	mark-down matrix for transportation margins for the base year t^*
$\widetilde{\mathbf{UT}}_t^{\mathbf{tx}}$	♦	estimates of taxes margin table
$\mathbf{\Theta}_{t^*}^{\mathbf{tx}}$	♦	mark-down matrix for taxes for the base year t^*
$\widetilde{\mathbf{UT}}_t^{\mathbf{m}}$	♦	estimates of the use table of imported products in producer's prices
$\mathbf{\Theta}_{t^*}^{\mathbf{m}}$	♦	mark-down matrix for imported use table in producer's prices for the base year t^*

♦: $(m \times n\ |m \times 1|m \times \varphi|m \times 1|)$

Symbols in Appendix F

$\breve{\mathbf{h}}_{\mathbf{d}}^{\mathbf{v}}$	$(n \times 1)$	contribution of a generic demand expenditure h of changes in the domestic demand to volume gross output changes in volume units
$\breve{\mathbf{h}}^{\mathbf{v}}$	$(n \times n)$	contribution of a generic demand expenditure h of changes in the domestic demand to volume gross output changes in volume units
$\breve{\mathbf{h}}_{\mathbf{m}}^{\mathbf{v}}$	(1×1)	contribution of a generic demand expenditure h of changes in the domestic demand to volume gross output changes in volume units

$\breve{\mathbf{A}}^{\mathbf{p}}$	$(n \times 1)$	sectoral changes of the relative prices of total technical coefficients in the volume gross output decomposition
$\breve{\mathbf{A}}^{\mathbf{p}}_{\mathbf{m}}$	$(n \times 1)$	sectoral changes of the relative prices of imported technical coefficients in the volume gross output decomposition
$\breve{\mathbf{c}}^{\mathbf{p}}_{\mathbf{d}}$	$(n \times 1)$	contribution of the relative price of domestic household consumption to volume gross output changes in volume units
$\breve{\mathbf{k}}^{\mathbf{p}}_{\mathbf{d}}$	$(n \times 1)$	contribution of the relative price of domestic gross fixed capital formation to volume gross output changes in volume units
$\breve{\mathbf{g}}^{\mathbf{p}}_{\mathbf{d}}$	$(n \times 1)$	contribution of the relative price of domestic government expenditures to volume gross output changes in volume units
$\breve{\mathbf{e}}^{\mathbf{p}}_{\mathbf{d}}$	$(n \times 1)$	contribution of the relative price of domestic exports to volume gross output changes in volume units
$\breve{\mathbf{h}}^{\mathbf{p}}_{\mathbf{d}}$	$(n \times 1)$	contribution of the relative price of a domestic demand expenditure (h) to volume gross output changes in volume units

Symbols in Appendix G

$\mathbf{bl}$	$(n \times 1)$	vector of sectoral backward linkages
$\mathbf{\Psi}$	$(n \times n)$	generic impact matrix, that could represents the traditional Leontief inverse matrix or the extended Leontief inverse matrix (domestic and imported inputs)
$\mathrm{bl_j}$	(1×1)	backward linkage of sector j
$\mathbf{e_j}$	$(n \times 1)$	vector whose j-th component is equal to one and the other components have a null value
$\psi_{\mathbf{ij}}$	(1×1)	element the generic impact matrix for product i and industry *j*
$\mathbf{fl}$	$(n \times 1)$	vector of sectoral forward linkages
$\mathrm{fl}_{\mathbf{i}}$	(1×1)	forward linkage of sector j
$\overline{\mathrm{bl}}_{\mathbf{j}}$	(1×1)	average of sectoral backward linkages
$\overline{\mathrm{fl}}_{\mathbf{j}}$	(1×1)	average of sectoral forward linkages

Symbols in Appendix H

Γ_{j_t}	(1×1)	labor productivity of industry *j* for the year *t*
$Y^v_{j_t}$	(1×1)	sectoral real value added in volume units for industry *j*
L_{j_t}	(1×1)	sectoral labor input for industry *j*
Γ_t	(1×1)	aggregated productivity for the total economy
$Y^p_{j_t}$	(1×1)	sectoral price index for industry *j*

Y_t^p	(1×1)	price deflator for the total economy
L_t	(1×1)	economy wide labor input
y_j^p	(1×1)	value added relative price
$s_{L_{j_t}}$	(1×1)	share of labor used by industry *j* in period *t*
$s_{Y_{j_t}}$	(1×1)	value added share of industry j in total value added for a period
G_t^Γ	(1×1)	productivity growth rate
γ_j	(1×1)	sectoral labor productivity growth rates
ρ_j	(1×1)	sectoral real output price growth
σ_j	(1×1)	sectoral labor input share growth

Mathematical symbols and operations

$\otimes$	Hadamard product
$\boldsymbol{\Delta}$	Operator of finite difference
$\oslash$	Hadamard division
^	Diagonal operator
'	Transpose operator

CONTENTS

INTRODUCTION

1 Motivation

Since the 2000s, various studies dedicated attention to the analysis of the evolution of the productive structure of the Brazilian economy. One of the main topics of discussion in this literature is the existence, intensity and time profile of the processes of deindustrialization and regressive specialization. Two concepts are usually employed to explain and characterize the deindustrialization process. First, we have the classic indicators of deindustrialization based on Rowthorn & Wells (1987) among others, that define deindustrialization as the continuous fall in manufacturing employment share. They preferred this concept rather than the value added or gross output share because it sometimes was misleading due to changes in the relative prices. Recently, the literature reference Tregenna (2009; 2013) that bring back the concept that deindustrialization is defined as the decline in both the employment and value-added shares of the manufacturing industries. In the case of regressive specialization, the literature observes the change in the composition of exports, mainly the change of resource-based exports to manufacturing ones.

However, the literature also points out several criticisms towards the adequacy of these definitions alone in evaluating these structural change processes. For example, nowadays there are important changes in world production, like the verticalization of production and the Global Value Chains (hereafter GVC) that modifies the relation of between deindustrialization and structural change. In this context, some authors like Felipe, Metha, and Rhee (2018) and Haraguchi (2017) argues that the process of deindustrialization is a worldwide process affecting various countries, due, in large measure, to the increase in the manufacturing production of populous countries, like China. These also argue that it is even more difficult in this context to countries industrialize.

Also, a significant part of the structural dynamics of an economy is explained by the interaction between structural change and economic growth. More specifically, this interaction follows largely from the existence of a positive relationship between the output share of manufacturing industries and the investment-output ratio. So, when a country has a positive tendency of growth and an increase in the investment-output ratio, the share of manufacturing industries increase. Hence, taking this definition as the only indicator to analyze such complex phenomena is insufficient. Likewise, not all kinds of manufacturing industry are equally important in generating structural change in the economy. Only a restricted set of industries can generate and diffusing new technologies in the economic system and should be considered in analyzing the structural change dynamics.

In the analysis of structural change, the characteristics of a country are also essential to the investigation of the role of manufacturing industries and its output and exports shares. It will depend on several factors, such as the degree of openness of the economy, the size of a country (both concerning the size of its territory and population), the government policy framework and other institutional features. In the case of large countries, such as the Brazilian economy, the domestic market represents an important role in determining the characteristics of its productive structure. Hence, the external market has a limited capacity to stimulate the economy. Moreover, since Brazil has a huge natural resource endowment and a large territory, these characteristics corroborate to a structure of exports with relevant participation of extractive, mineral and agricultural commodities. So, we must be careful to use only this characteristic to identify a process of regressive specialization. Besides that, we should note that the process of regressive specialization, captured by the primarization of exports, may not be a specific feature of the Brazilian economy, but a more general process is affecting other countries.

Another difficulty of an analysis based on the behavior of the output (gross output or value-added) and exports shares of the manufacturing sector is that their changes can be associated with variations in both volume and relative prices. There is recent evidence on the reduction of the relative prices of manufacturing products, while is observed an increase in the relative prices of resource-based commodities between 2003 until 2011. Thus, this tends to underestimate the importance of manufacturing sectors in favor of extractive ones, and consequently, the analysis of structural change may be inaccurate. It is important to consider the contribution of changes in volume units and also in the relative prices to understand the structural change process.

Besides all that, the importance of the manufacturing industries may not be observed only by the behavior of the gross output, value-added and employment shares of the manufacturing sectors. Thus, following the tradition of structural change analysis in the development literature, the investigation can be fruitfully complemented by the analysis of the evolution of the interindustry relations of the economy

Next, based on the elements presented in this motivation subsection, we present, in the following section the research problem, the objectives and the main hypothesis of the thesis.

2 Research problem, objectives and hypothesis

In this thesis, we will address these criticisms to and qualifications of the traditional analysis of the processes of deindustrialization and regressive specialization in the Brazilian by amending it in various directions. In this direction, the principal question that the thesis addresses is whether we can observe in the Brazilian economy the processes of deindustrialization and regressive specialization, and what is their intensity and time profile. Our principal aim is to provide an answer to the latter question that is corroborated by the empirical evidence available.

Besides this general objective the thesis has the following specific objectives:

- Develop a structural decomposition analysis of the rate of growth of gross output that isolates the effects of relative prices changes for the period 2000-2014 and subperiods (2000-2003, 2003-2008, 2010-2014), capturing the contributions of the pattern of trade, technological change, and final demand;
- Relate the factors involved in the structural decomposition analysis with the investigation of external (captured by the market share of Brazilian exports in foreign markets) and internal (through intersectoral relations of input-output and the market share of domestic goods) competitiveness, and productivity;
- Contribute to the debate on the processes of deindustrialization and regressive specialization in the Brazilian economy by focusing our analysis on the evolution the set of sectors that stand out as capable of generating and diffusing new technologies in the Brazilian economy.

Two will be the central contributions of the thesis. The first is a methodological one, where we develop a version of the input-output model that excludes the influence of relative prices and estimates a series of indicators in volume units. For that, we will construct a series of annual input-output tables for the period between 2000 and 2015 at constant prices and relative prices to allow an input-output analysis and indicators that isolates the effects of relative price changes.

The second one is an interpretative contribution since we will analyze the processes of deindustrialization and regressive specialization from a broader perspective, to incorporate the criticisms to and qualifications associated with the traditional indicators. For the deindustrialization process, we consider the i) gross output share regarding only the volume, relating it to changes in the investment-output ratio, ii) the competitiveness of the domestic products in the total market, observing the influence of the imported goods inside the total supply; iii) the input-output linkages of domestic production; iv) the sectoral contribution to the productivity growth in volume; iv) the structural decomposition considering several sources of demand. For the regressive specialization, we will consider the composition of exports in volume units, which is only possible due to the estimated database due to the absence in most cases of exports' deflators. However, we also argue that it is essential to consider the insertion of exports' goods in the world market as a complement to the hypothesis of regressive specialization. We complement these two indicators with the contributions of the exports inside the structural decomposition analysis.

An essential aspect of the interpretative contribution is that we consider as conductor of the analysis the group of sectors, the innovative industry because they contribute directly in the process of generating and diffusing of new technologies, a central aspect to analysis the Brazilian economy.

The central hypothesis is that the dynamics of the economy is explained by the interaction between structural change (production technique, consumption pattern, foreign trade pattern) and the final demand of the economy (level and composition of expenditure). Regarding the structural change, we consider that there is a structural rigidity in the Brazilian economy (CARVALHO, KUPFER, 2011), and this might affect the diagnostic of deindustrialization and regressive specialization processes in the period under investigation.

3 The structure of the thesis

Besides this introduction, the present thesis contains four chapters and one section of final remarks. In Chapter 1, we will present a brief review of the literature that is directly related to the interpretation of the processes of deindustrialization and regressive specialization developed in this thesis. It is not the objective to do an exhaustive review of the literature, and we will only point out the central elements in the construction of the argument. In this sense, we will first present the concepts of deindustrialization and regressive specialization. Then, we discuss some criticisms of the usual indicators employed in the analysis of these processes. In section 3 we argue how an input-output methodology can be useful in the analysis of structural change processes, and we review some studies of the structural change process in the Brazilian economy based on this kind of methodology.

In Chapter 2, we present some essential features of the Brazilian economy in the period under discussion. There we point out that, since there is a stylized fact according to which there is a strong positive connection between the investment-output ratio and the trend rate of growth of output (see, e.g., DE LONG, SUMMERS, 1992), the economic performance of the Brazilian economy is fundamental to the understanding of the processes of structural change. We also complement the analysis by presenting the evolution of aggregate and sectoral fixed investment in the Brazilian economy. Furthermore, in this chapter, we will present the usual indicators employed in the literature to analyze the deindustrialization process (value added, gross output and employment shares) and regressive specialization (the composition of exports). Moreover, we present the performance of the sectors regarding its rate of growth of labor productivity.

In Chapter 3 we present the methodology used to develop the thesis. The core of the methodology is based on input-output techniques. Due to the inexistence of a long-term series of input-output tables (IOT) for the Brazilian economy that deals with the methodological changes in the System of National Accounts, we will discuss the methodological procedures utilized to obtain a consistent IOT series from 2000 to 2015. Moreover, we also present a methodology to construct IOT at constant and constant relative prices. We will discuss the necessity of a consistent deflated methodology concerning additivity and the impact of the different methodologies in the input-output model and technical coefficients. A version of the IO model explicitly accounting for relative prices will be developed, from which we propose a structural decomposition analysis of the gross output growth that explicitly disentangles volume changes from relative prices changes. In the presentation of the results of the application of the input-output methodology, we use a level of analysis containing 11 industries. We regroup the whole set of extractive and manufacturing industries into four industry groups according to the classification proposed by the Industry and Competitiveness research group of the Federal University of Rio de Janeiro, GIC-UFRJ (KUPFER, 1997; TORRACCA; KUPFER, 2014). The four industry groups are: Processed agricultural commodities (AC), Unprocessed and processed mining and quarrying commodities (MQC), Traditional manufacturing industry (TM), and Innovative manufacturing industry (IM). In this Thesis, we will consider the IM group as the most important one to the discussion of the processes of deindustrialization and regressive specialization because it is the one responsible for the most important technological/knowledge flows.

In Chapter 4, we will apply the methodology developed in Chapter 3 to analyze the existence, intensity and time profile of the processes of deindustrialization and regressive specialization. When possible, we will exclude the effects of relative prices changes and show how these changes affect the issues under investigation. Our analysis involves the use of indicators such as the gross output composition and exports composition by sector in volume units (excluding the relative price effect), indicators related to Brazilian external and domestic competitiveness, indicators capturing the interindustry relations based on input-output information, and changes in labor productivity. The use of these indicators is combined with and complemented by the analysis of the structural decomposition of the rate of growth of gross output presented in Chapter 3. Finally, we discuss some of the implications of the combination of these indicators to debate on the deindustrialization and regressive specialization processes.

We conclude the thesis with some final remarks that highlight its main contributions to the debate over the processes of deindustrialization and regressive specialization in the Brazilian economy in the 2000s.

1 STRUCTURAL CHANGE, DEINDUSTRIALIZATION, AND REGRESSIVE SPECIALIZATION

In the development literature, the concept of the economic structure has various dimensions. Syrquin (1988) mentions the increase in the rates of accumulation, as discussed in Rostow (1960) and Lewis (1954); Fisher (1939) and Clark (1940) relate the concept with the sectoral composition of the production system of the economy; Kuznets (1959) and Chenery and Taylor (1968) highlight the way the economic system use the factors of production; inter-industrial relations, as identified by the coefficients of input-product and productive linkages, are the focus of Rasmussen (1956), Chenery and Watanabe (1958), and Hirschman (1958) in their analysis of the structure of economic systems; and many other aspects, such as the spatial distribution of production activities (e.g., the urbanization process in the time of classical developmentism and the fragmentation of production in our more recent experience).

According to Syrquin (1988), structural change can be mainly identified by changes in the patterns of demand, trade, production (in terms of its sectoral composition and also in terms of the product mix involved) and employment (in terms of its sectoral, qualification and occupation compositions). In this context, the author considers the hypothesis that economic growth is related to structural changes, whether in the form of the interdependence between these processes or as a causal necessity.

In this Chapter, we will present a brief review of the literature that is directly related to the interpretation of the processes of deindustrialization and regressive specialization developed in this thesis. First, in the following two sections we present the concepts of deindustrialization and regressive specialization (section 1) and discuss some criticisms to the usual indicators employed in the analysis of these process (section 2). Next, in section 3, we present how the input-output methodology can be useful in the analysis of structural change processes, and we review some studies of the structural change process in the Brazilian economy based on this kind of methodology.

1.1 Deindustrialization and regressive specialization: a brief introduction

Since the 2000s, many studies dedicated particular attention to analyzing the evolution of the productive structure of the Brazilian economy. One of the main topics of discussion in this literature is the existence, intensity and time profile of the processes of deindustrialization and regressive specialization. Two concepts are usually employed to explain and characterize the deindustrialization process. First, we have the classic concept of deindustrialization based on Rowthorn and Wells (1987) among others, that define deindustrialization as the continuous fall in manufacturing employment share. Recently, the literature follows the suggestions of Tregenna (2009; 2015), and the deindustrialization is defined by the declining in both the manufacturing employment share in total employment and manufacturing value-added in total GDP.

Along the debate on deindustrialization, many authors consider different varieties of this process. The first one is positive deindustrialization, which appears as a natural consequence of the development process in developed economies. Clark (1940) considers that the evolution of the structure of employment along the process of economic development is explained by a sequence of changes in the composition of demand. By extrapolating Engel's Law and analyzing the elasticities of demand, he argues that, in the first stage, with the increase in *per capita* income, the proportion of expenditures on agricultural products declines in favor of manufacturing goods. Then, in a second stage, as *per capita* income growth stabilize the proportion spent on manufacturing goods decrease, and "according to Clark, deindustrialization in advanced economies would be a natural consequence of the shift in demand away from manufactures toward services" (ROWTHORN; RAMASWAMY, 1999, p.19).

There is also a negative variety of deindustrialization, which is a pathological phenomenon. It can affect economies at any stage of development as a result of economic failure and occurs when manufacturing industries face severe difficulties. In the negative deindustrialization case, the poor performance of manufacturing industries is not balanced by the good economic performance of the service sector. The occurrence of this variety of deindustrialization at a relatively low level of *per capita* income, indicates a premature specialization of the manufacturing system, originating from factors exogenous to the development process and should be analyzed with caution in the case of developing countries (CARVALHO, KUPFER, 2011).

The third variety of deindustrialization pointed out by Rowthorn and Wells (1987) is due to changes in the structure of foreign trade. This changes occur when the country's net export pattern changes from manufacturing to other types of goods and services. In this case, there is a redirection of employment and manufacturing resources to other activities, and as a result, there is a fall in the employment and value-added shares of manufacturing industries.

Many recent authors[1], following the tradition of Palma (2005) and Bresser-Pereira (2010), associate the causes of early or negative deindustrialization with the external market conditions. A common term is the process of Dutch disease, in which a country with abundant natural resources would specialize in the production of these goods given their comparative advantages to the manufacturing sector (PALMA, 2005). This process encourages the export of these goods and promotes surpluses in the trade balance, contributing to the overvaluation of the exchange rate. In the case of the Brazilian economy, Bresser-Pereira (2010) associate the Dutch disease also with a financialization aspect. Since the real interest rate is high in Brazil compared to other countries, there is an inflow of foreign exchange, appreciating the exchange rate. In its turn, the appreciation of the exchange rate stimulates the substitution of domestic production for imports, making foreign goods cheaper in domestic markets. By the reduction in the domestic demand, they argue that the investment in tradable manufacturing goods industries can be discouraging, disrupting some domestic sectors. Coutinho (1997) name this process as regressive specialization and argues that it initiated pos-liberalization in the Brazilian economy and by the policy of appreciated real exchange rates adopted to promote for the inflation stabilization after 1994 with the implementation of the Real plan.

1.2 A critical assessment of the usual indicators employed to evaluate the processes of deindustrialization and regressive specialization

In this section, we will present a critical evaluation of the indicators usually employed to assess the processes of deindustrialization and regressive specialization.

Relative prices

Using the value-added share of manufacturing industries as a measure of deindustrialization can be misleading because the observed changes of this indicator can be associated with variations in both relative volume and relative prices when it is measured as a ratio manufacturing value-added in current values to total value-added also in current values. This is the reason why Rowthorn and Wells (1987) prefer the employment share of the

[1] Such as Cunha et al. (2011), Cunha et al. (2012), Oreiro e D'Agostini (2016), Oreiro e Feijó (2010) and Torres and Silva (2015)

manufacturing industries as a more appropriate measure of industrialization or deindustrialization[2].

> The fall in the relative price of manufactures might make it difficult to pin down the real decline in manufacturing output, given the limitations of sectoral deflators, and this could be part of the reason for the focus in the literature on changes in manufacturing employment share rather than output share (TREGGENA, 2015, p. 99).

Rowthorn and Wells (1987), Rowthorn and Ramaswamy (1999) and, Rowthorn and Coutts (2004) mention that as the growth of labor productivity in manufacturing industries is higher than in other sectors, it is natural that we have a decline in the employment share of manufacturing industries. Hence, the changes in the employment composition reflected in the increase of the share of the service sector, which have low productivity growth, contributes to a reduction in the manufacturing relative prices, following the Baumol hypothesis of costs disease.

We can see this problem comparing the nominal and the real value-added share of manufacturing in world Gross Domestic Product (GDP), as presented in *Figure 1* with the data from United Nations Industrial Development Organization (UNIDO, 2017). There is a reduction of the share measured in nominal terms, but in real terms, we observe an increase in it. Thus, we do not observe a deindustrialization process regarding real production for the world economy. Since the 1990s we observe that the deflator for the total economy has grown at a higher pace than the manufacturing one (*Figure 2*). Therefore, the reduction in relative prices may give the misleading idea that manufacturing production is less important, not observed in volume units.

In this case, Balassa (1961 apud TEIXEIRA, 1983) and Rowthorn and Wells (1987) already criticized Chenery (1960) analysis of the manufacturing share, since the behavior of relative prices tends to underestimate the participation of manufacturing industries, while overestimating the participation of services sectors, especially in higher income countries.

As industrialization modifies the relative price structure, the product value of the service sector is generally overvalued by the mentioned price increase. In this context, the concept of increased participation of services as pointed out by Clark (1958) would not be verified in real terms since the share of the service sector should be lower (TEIXEIRA, 1983).

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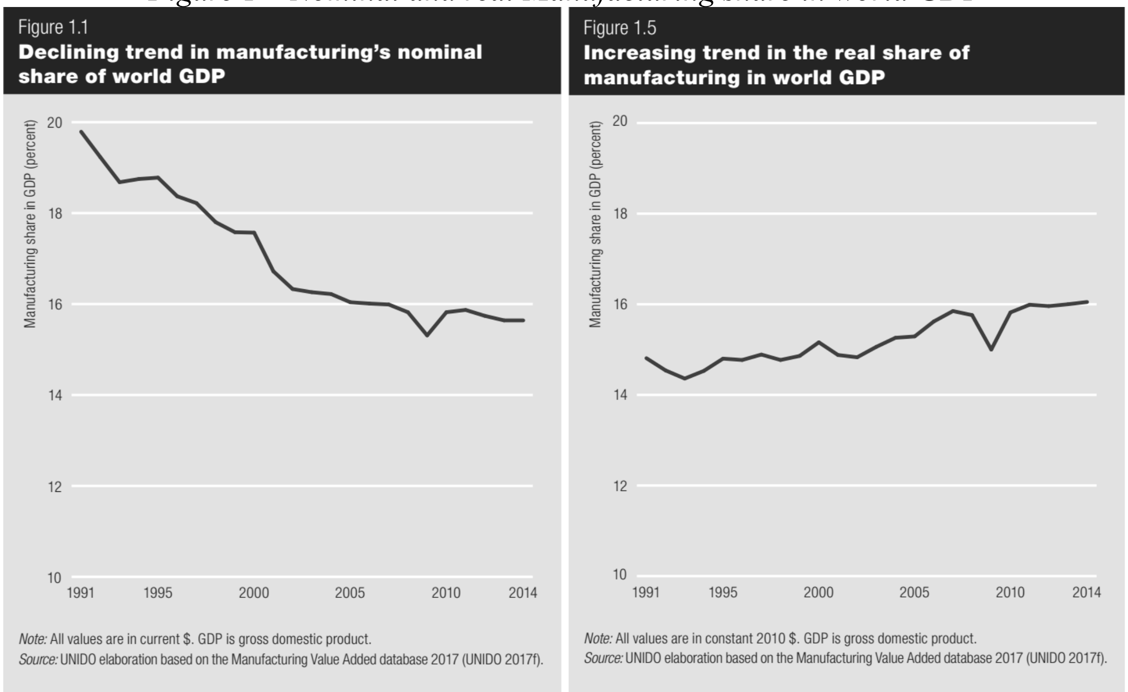
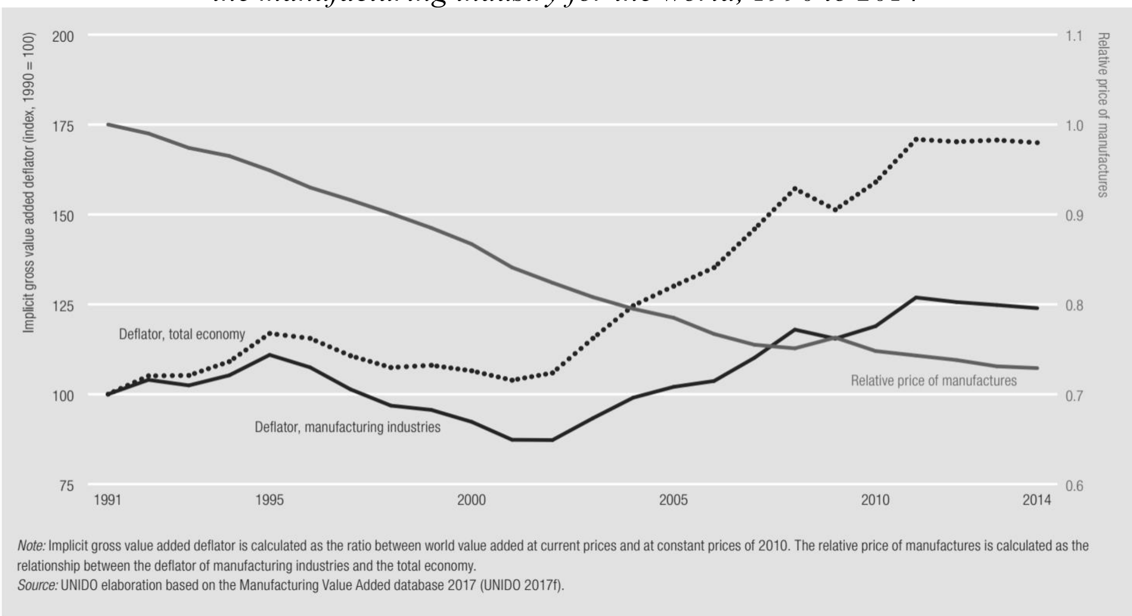
[2] Recent works, such as Felipe, Metha, and Rhee (2018) and Haraguchi (2017), analyze the employment and valued added structure for the manufacturing sector in several countries. They observe that achieving a certain share of manufacturing employment is more important than the manufacturing value added share to determinate the level economic development for the countries.

Figure 1 – Nominal and real Manufacturing share in world GDP



Source: UNIDO (2017).

Figure 2 – Total economy deflator, manufacturing industries deflator and the relative price of the manufacturing industry for the world, 1990 to 2014



Source: UNIDO (2017).

Rowthorn and Wells (1987), Rowthorn and Ramaswamy (1999) and, Rowthorn and Coutts (2004) observe that the low cost of imports from underdeveloped countries and the effect of increasing competition on enterprises in developed countries generate a pressure towards the reduction of the relative price of manufacturing products. Besides, there is a strong spillover effect of the fall in relative prices pointed by UNIDO (2017) that is the expansion of the numbers of consumers able to afford manufacturing goods, leading to an increase in their quality of life since it represents a low share of their income.

Therefore, the review of the literature shows that it is important to take care of relative prices changes when we analyze the deindustrialization and regressive specialization process based on output indicators.

Manufacturing share and economic growth

According to the classical literature on economic development, growth is a fundamental aspect to explain the structural changes in the economy, whether in the form of the interdependence or as a causal necessity (SYRQUIN, 1988). Recent studies, such as UNIDO (2017), have emphasized the role of demand variables to understand manufacturing development, but we find the same kind of approach in many authors before, such as, Marx (1991), Schumpeter (1997), Svennilson (1964), Cornwall (1977), Syrquin (1988), and Rowthorn and Ramaswamy (1999).

It is common among Keynesian development economists to consider that demand governs the process of economic growth in the long run. Thus, we the demand-led growth literature helps to explain the two well-known stylized facts: i) the investment-output ratio is a pro-cyclical variable; and ii) there is a positive relationship between the investment-output ratio and the trend rate of GDP growth (e.g., see DE LONG; SUMMERS, 1992).

Among the demand-led growth literature, we interpret these stylized facts based on the Supermultiplier models of economic growth[3]. According to these models, the expansion of autonomous demand determines the trend rate of growth of output and capacity output. The autonomous expenditures include the ones that are not financed by production decision (such as wage and salaries) and "nor capable of affecting the productive capacity of the capitalist sector of the economy" (SERRANO, 1995, p. 71). The non-capacity creating expenditures include private domestic expenditures such as residential investment and household consumption financed by credit, external demand, and public expenditures (including both government consumption and investment).

International organisms, such as UNIDO (2017), has been highlighting the importance of the changes in the consumption pattern as essential in creating a 'virtuous' cycle

[3] See Serrano (1995, 1996), Freitas and Dweck (2013), Allain (2015), Freitas and Serrano (2015), Lavoie (2016), Serrano and Freitas (2017), Girardi and Pariboni (2016), Fiebiger and Lavoie (2017) and Fiebiger (2018).

of manufacturing consumption. In this case, the increase in consumption demand promotes the expansion of the production of new manufactured goods. Hence, the "interactive process between demand and supply enables the diffusion of new, better and ever cheaper goods for consumers alongside the expansion and development of new industrial sectors and related providers" (UNIDO, 2017, p. 45).

According to Serrano (1995, 1996) and Freitas and Serrano (2015) the supermultiplier model captures two kinds of demand induction effects: the first one is attributed to the effect of changes in GDP on aggregate household consumption by the Kaleckian multiplier, and the second one is associated with changes in investment expenditures induced by changes in output according to the principle of capital stock adjustment (or flexible accelerator hypothesis). The latter suggests that, provided that at least a minimum rate of return is expected to be obtained, capitalist competition induce private enterprises to realize investment, in order to guarantee that they have sufficient capacity to supply demand at peak levels and the capacity utilization, remains, on average, in its normal or planned level. As a consequence, as the economy grows and fluctuates, investment decisions of private enterprises regulated by capitalist competition tend to maintain planned levels of spare productive capacity. This kind of investment behavior predicted by the flexible accelerator hypothesis implies the existence of a positive relationship between the investment-output ratio and the trend rate of growth of output in the economy, the stylized fact mentioned above.[4]

The investment has a dual nature, it is a source of demand in the current period, as it represents acquisitions of fixed capital assets by economic agents, but when these fixed capital assets become available in the process of production, we affect the productive capacity of the economy (SERRANO, 1995). Therefore, investment provides the main chain of the connection between demand and supply, having important consequences for the process of structural change in the economy. Cornwall (1977) explores the analysis of this kind of connection relating the processes of capital accumulation and structural change. The author combines the Kaldorian ideas with the views of Schumpeter (1997) and Svennilson (1964) on the

[4] Although most of the literature on the Supermultiplier growth model deals with aggregate versions of it, Dweck and Freitas (2011) developed a multisectoral version of model in order to analyze structural change scenarios for the Brazilian economy. The multisectoral supermultiplier model combines induced consumption expenditures according to the Kaleckian multiplier, induced fixed capital investment based on the flexible accelerator hypothesis and induced intermediate demand according to the Leontief output multiplier. Notice also that the construction of this kind of model requires information on the process of capital formation at a disaggregate level, which is provided by the capital flow matrices for the Brazilian compiled by Dweck and Freitas (2011) and, more recently, by Miguez (2016). Finally, for a more recent version of the multisectoral supermultiplier model see Cornelio, Freitas and Bustao (2018).

development process. According to Kaldor (1966) manufacturing industries are characterized by static and dynamic economies of scale, and hence are the main driving force of economic progress in the industrialized world. On the other hand, Schumpeter (1997) and Svennilson (1964) suggest that qualitative changes in the economic system are driven by the processes of innovation and diffusion of new technologies. Cornwall (1977) argues that the production fixed capital goods by the manufacturing industries induce technological diffusion, as a result of the research and development activities done by entrepreneurs or due to the effects of economies of scale and learning by doing.

Similarly, Rowthorn and Ramaswamy (1999) observe that the behavior of the investment-output ratio in the economy affects the analysis and measurement of the process of deindustrialization. The increase in the investment-output ratio leads to the expansion of the production of manufactured goods, such as machinery and equipment, at a faster pace than in the rest of the economy, thus contributing to the increase of the output share of manufacturing industries. Hence, given the connection of investment-output ratio and output growth through the flexible accelerator, the share of manufacturing industries tend to increase (decrease) if there is an increase (reduction) in the pace of economic growth. The government makes public investment reinforce this effect if it behaves in a pro-cyclical way. This kind of behavior has a direct effect on manufacturing production and also an indirect one since it may affect the behavior of the investment by private enterprises by the accelerator mechanism. The relevance of the effect of the investment in the output share of manufacturing industries depends on the market share of imported capital goods and other elements of the productive structure, such as the density of input-output relations captured by the interindustry linkages.

Moreover, another stylized fact in the literature is the positive relationship between the rate of growth of labor productivity and the rate of growth of output. The latter relationship is expressed in the Kaldor-Verdoorn's law (also known as the second law of Kaldor (1966)), which states that growth in manufacturing production is positively related to the growth of labor productivity. The causes behind this phenomenon are diverse, such as the existence of static and dynamic economies of scale, embodied technical change, and the increasing mechanization of economic activities. Besides, Kaldor (1966) also draws attention to the spillover effect over the labor productivity of other sectors in the economy. Thus, expansion in manufacturing production will lead to the growth of the output of this sector but will also have an overall (but not homogeneous) effect over labor productivity of various industries, leading to changes in the employment structure of the economy, trough the transfer of labor from low to high productivity sectors. Therefore, this kind of relationship must be taken into account when analyzing the evolution of the employment structure of the economy over time.

Manufacturing sector inside the global productive structure

Rowthorn and Ramaswamy (1999) argue that external factors can affect the process of deindustrialization of an economy. Hence, according to this perspective, we must analyze the changes in the economic structure of an economy taking into account how the economy is integrated into the global structure of production. Not doing so, would lead to a limited view of the processes of structural change and of the role of manufacturing industries in such processes.

Hiratuka e Sarti (2017) mention some factors that changed in the global production system, and they are relevant to understand the position of the different countries in the world, especially in the Brazilian case. The first one is the fragmentation of production with the expansion of the global value chains (GVC). Their origin occurs in a context where the strategy of transnational enterprises is towards cost reductions and the pursuit of economies scope and scale. Since the 1980s, not only has the volume of trade between countries increased but, particularly, in quality (MILBERG, 2004). In the case of GVC, there is a separation in the processes of production in two dimensions: fractionalization, the separation of the supply chains into more sophisticated stages of production; and dispersion, the geographical separation of the stages of production (BALDWIN, 2012). They were possible due to the development of information and communications technology, which facilitated the transmission of ideas, instructions, and information. “Plummeting costs of processing and transmitting information, organizational innovations and the development of international standards for products descriptions and business protocols have further facilitated the spread of GVCs” (BACKER; YAMANO, 2011, p. 1). Given the differences in labor costs between developed and underdeveloped countries, the separation involved the comparison regarding wage costs. So, the “ICT [Information and Communications Technology] made it possible; wage differences made it profitable” (BACKER; YAMANO, 2011, p. 1). So, the international enterprises moved many activities for those countries with low wages.

Hence, vertical specialization changed the relationship between manufacturing and economic development. Before the process of fragmentation of production, countries had to create the complete factory structure to produce goods for domestic and external demand, which would lead them to increase the output and employment shares of manufacturing industries.

However, Hiratuka and Sarti (2017) also highlight that as each country can participate in the stage of the global production process, the insertion in GVCs is not the guarantee of a prominent place for the manufacturing industry in the productive structure of the economy. The expansion of manufacturing activity can occur without the learning process, linkages and technological flows. Therefore, an increase in manufacturing capacity does not necessarily represent industrialization.

Another important change is the rise of China and other populous countries in the world market. They are, by one side, huge manufacturing suppliers with a big scale in production, but, by the other side, they demand inputs and final goods. Hence, Hiratuka and Sarti (2017) point to two main consequences of China's entry into the international scene. The first is the expansion of the demand for natural resources inputs, such as food, mineral, and energy commodities. The higher demand for these goods generated a boom from 2003 to 2008, contributing to a rise in their international prices.[5] The second consequence is the increase in the production of manufacturing goods to the international market at a low cost due to China's abundant and cheap labor force, contributing to a reduction in their global prices. Hence, the insertion and the rapid growth in the manufacturing capabilities of these populous countries make more difficult to have a higher share of manufacturing output and employment than before, as concludes Felipe, Metha, and Rhee (2018) and Haraguchi (2017). Therefore, becoming rich through industrialization is much more difficult after China's rise.

However, these authors have questioned whether manufacturing industries are still important nowadays after all these changes in the productive structure. They all conclude that having a higher share in manufacturing employment and output is still very important to economic development. Also, Su and Yao (2017) show evidence that a larger share of manufacturing industry in the economy positively influences the pace of technological accumulation in middle-income economies, and also can stimulate other sectors, including the services.

Deindustrialization and technological diffusion

Historically, the development literature gives much attention to the processes of industrialization and, modernly, deindustrialization. Some of this attention is because the sectoral composition of the economy has direct consequences to the analysis of the process of

[5] See Prates (2007) and Lima, Prado and Torracca (2016).

economic growth. According to the Kaldorian tradition, the literature sees the manufacturing industry as propelling economic growth and technical progress. Many authors, following the seminal work of Kaldor (1966) consider that the manufacturing sector is more important than the agriculture and service sectors due to the potential for static and dynamic scale economies in manufacturing production, the higher income elasticity of the demand for manufacturing goods, and the high potential for catching-up processes. Moreover, they consider that the manufacturing sector has special capabilities for generating growth because it enables faster productivity growth, which is transferred to the economy as a whole by spillover processes.

The manufacturing production includes sectors with low technological intensity and low-income elasticities, such as the traditional manufacturing industries and natural resource (agricultural, energy and mineral) processing industries. We argue that they must be excluded from the diagnosis of structural change since these sectors are not the main drivers of technological diffusion. Hence, we should consider only the part of the manufacturing industry that promotes the creation and diffusion of new technologies and catching-up opportunities as industries that fulfill the characterization of manufacturing activities attributed by the Kaldorian literature.

Based on the work of Kaldor (1966), Cornwall (1977) already highlighted the importance of a core "the technology sector,"[6] which were responsible for conducting the technological progress by the development of new and better products and processes. Kuznets (1971 apud SYRQUIN, 1988) also considered the science-based manufacturing activities as promoters of modern economic growth. However, it highlights the difficulty involved in sectoral classification when we want to distinguish industries according to their capacity to encourages the creation and diffusion of technological change.

The measurement of these effects is still more complicated in the context of the current manufacturing production organization, with the decentralization of the productive processes, such as the vertical specialization in the GVCs and modern technologies in manufacturing system (e.g., Industry 4.0). Moreover, Hiratuka and Sarti (2017) emphasize the role of huge transnational enterprises in the generation and exploitation of new technological knowledge. They usually have their origin in developed countries and have control over new technologies, stand out regarding research and development expenditures, own intellectual property rights over important patents, and have high valued and known brands, which allows

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[6] Conrwall (1977) considered chemical, electronic and machine tools industries as the core technology sector of the manufacturing industries.

them to capture most of the value-added generated along the GVCs. The "technology sector" is important because it develops linkages and creates technological diffusion through the activities of research and development investment and the development of product and process innovations. But if these activities are developed in other countries and just imported, the effect is very limited in the economies participating in the lower valued chains of the GVCs. Although there are some efforts to calculate the value added generated in each step in the GVC, they are insufficient to capture technological flows, since, for example, some part of the value-added generated in a developing country may return to developed countries as the payments of intellectual property royalties and other income transfers.

Deindustrialization and regressive specialization

The transmission of what happens in the external sector to the domestic productive structure depends on several factors, such as the degree of openness of the economy, the size of a country, (in terms of territory and population), and by the government policy framework and other institutional features, as pointed out by Kuznets (1958) and Amsden (2001). According to these authors, the external sector has higher importance and capacity to stimulate growth in small countries. However, in the case of large countries, such as the Brazilian economy, the internal markets have greater importance in determining the characteristics of its productive structure.

According to Syrquin (1988), the availability of resources endowments also exercises influence on growth strategies and experienced trajectories. Small countries with a restricted base of natural resources had to develop the manufacturing sector at an earlier stage to create a stimulus to growth. In its turn, it is more feasible for large countries to adopt inward developing strategies. For a country with large dimensions, exports usually represent only a small fraction of total demand, and therefore, changes in the export's structure contribute in a minor way to the deindustrialization process. It is common for these countries to have a disconnection between its productive structure and the product composition of its exports. For the Brazilian case, external demand has a smaller capacity to influence the domestic production pattern as is argued by Torracca (2017) in the 2000s.[7] Therefore, "the latter fact shows that the manufacturing share in total exports, a usual structural indicator, does not give us accurate

[7] Although she observed that production was converging towards a pattern established by exports in the period of 2000 and 2008.

information to evaluate the role of the manufacturing sector in an economy” (MEDEIROS; FREITAS; PASSONI, 2019, p. 9).

There is a common argument in the literature, as mention Black (2017), that in the case of countries that are rich in natural resources there is an existence of a natural-resource curse[8]. However, it is important to emphasize that countries with these characteristics, as the Latin American or African countries, did not adopt consistent development strategies and always showed a lack of coordination mechanisms to establish the state institutions required for the pursuit of development in modern times (MEDEIROS, 2014). Besides, the latter author emphasizes that the high concentration of income, especially in export activities, tends to block the positive effects associated with the increase in exports.

Besides, the processes of international production fragmentation and vertical specialization, mentioned above, changed the relationship between manufacturing exports and economic development. Before the diffusion of these processes, the exports of manufactured products implied the construction of a complete productive structure to supply external markets. However, nowadays each country may step in a specific stage of the global production process, implying that the flow of manufacturing exports may not induce the generation of a production chain inside the economy that is sufficient to provoke a significant impact on the process of development.

Besides that, one country can be benefited by improvements in trade conditions, increasing foreign exchange inflows by exporting more natural-resources based products. Nonetheless, as argued by Medeiros (2014), there is no evidence to prove that an export-led expansion founded in the exports of these goods can successfully lead to a development strategy based on manufacturing production. The author says that the development of manufacturing activities is more a result of the national strategies of development than to changes in the export’s composition.

Finally, we note that the process of regressive specialization as captured the primarization of exports may not be a feature of the Brazilian economy only, but a more general process affecting other countries. In this connection, Cunha et al. (2012) carried out a study analyzing data on the product composition of exports for several countries and concluded that there is a worldwide tendency towards the increase in the participation of the primary products and products intensive in natural resources, following the classification of Pavitt (1984). However, the authors emphasize that this process occurs more intensely in Brazil than in the

[8] For a deep discussion about the hypothesis of the resource curse hypothesis see Black (2017) and Vahabi (2017).

other countries analyzed. The latter result seems to be plausible since the Brazilian economy has important participation in the production and international trade of all the three most important kinds of commodities: foods, minerals, and energy (MEDEIROS, SERRANO, FREITAS, 2016).

1.3 Structural change and input-output analysis

Most of the studies presented in the previous section based on their analysis using data from national income and sectoral production (SYRQUIN, 1988). They serve as a basis to identify changes in the composition of demand (intermediate or final), in trade and also in the value-added coefficients. The growth accounting is another important instrument in the analysis of structural change since it allows us to have a quantitative evaluation of the contributions of domestic demand, external demand, substitution (or penetration) of imports[9].

Syrquin (1988) observe that during the development process the ratio of intermediate goods to total output features an increasing tendency, as the relative use of primary products declines and the use of manufacturing products and services increase. This change in intermediate goods mix does not affect the output in the aggregate level, but rather it affects the density of the interindustry relations. Hence, the input-output accounting framework has offered important indicators to the analysis of structural change. Indeed, Rasmussen (1956) assesses the structure of the economy based on the existing inter and intra-sectorial linkages derived from empirical input-output relations. This kind of information is not only useful to analyze the productive structure of a country but also in the comparative analysis of different countries over time. Chenery and Watanabe (1958) used linkages indicators derived from the direct coefficient input-output matrix, as well as from the Leontief inverse (or impact) matrix to compare sectors in different countries to characterize different patterns of economic development.

[9] Regarding the external contribution, the traditional form to evaluate this contribution is in terms of net exports. However, this way to capture the external sector contribution fails to consider that when other demand components besides exports changes, part of the demand impulse is directed towards imported products. Thus, not assigning this induced effect generates a bias in the contributions of domestic and external sectors, because it tends to overestimate the participation of the domestic components and to underestimate the participation of the external sector. With the disclosure of more regular and disaggregated national account data, several authors criticized the traditional form of growth accounting. They propose an alternative method to deal with the contribution of the external sector, the “attribution method”. According to this method, an induced imported demand is attributted to each demand component in order to calculate their growth contribution (KRANENDONK; VERBRUGGEN, 2005; HOEKSTRA; VAN DER HELM, 2010). For more information and applications for Brazil see Passoni (2014), Fevereiro (2016) and Fevereiro and Passoni (2018).

In its turn, Hirschman (1958) develops this approach and use it as the basis for identifying the effects of demand in creating linkages on the rest of the economy. There are two types of linkages, one related to the demand and another to the supply. The backward linkage refers to the demand created by the purchase of necessary inputs for the production. In a connected system, the expansion of production in a sector requests more inputs from other sectors, stimulating their production. There are also the forward linkages, where the sector can influence the supply possibilities in the productive chain. For example, if we observe the productivity growth in one sector, these gains will benefit other sectors in the productive structure, i.e., by reducing the price of inputs. Based on the combination of the value of these linkages indicators, Hirshman (1958) establishes the ranking of the activities in the productive structure, i.e., the key-sectors.

Hirshman (1958) argues that backward linkages have the most effective effect compared to forward linkages because when the demand increases, the economy must produce the intermediate inputs to respond to the supply's needs. In contrast, the forward linkages represent a "possibility" of creating demand that might not happen in their "pure form." The greater the domestic production capacity, the effect of linkages becomes greater, as a consequence of higher density in the interindustry or input-output relations. However, it is possible that imports satisfy part of the created demand for new inputs and this reduces the input-output linkages.

Following the traditions of structural decomposition analysis initiated by the classical development literature, another method used to discuss the process of structural change associated with input-output relations is the structural decomposition analysis (DIETZENBACHER, LOS, 1998; MILLER, BLAIR, 2009). This method is used to decompose the change in economic activity concerning the different factors that influence it. We can decompose the changes in gross output, value added, employment, trade (imports and exports), among others. From a general point of view, the structural decomposition method is defined as "[t]he analysis of economic change using a set of comparative static changes in key parameters in an input-output table" (ROSE, CHEN, 1991 apud ROSE, CASTLER, 1996 p.34). Therefore, this analysis contributes to the better understanding of the process of structural change, since it is possible to measure the contribution of technical coefficients and final demand variations to the changes of the selected variables between two years.

In the following section, we present an application of the input-output analysis to the investigation of the Brazilian economy.

1.3.1 The Brazilian economy

Most of the studies that use input-output analysis to identify changes in the productive structure use the Hirschman-Rasmussen backward and forward linkages. Morceiro (2012) compares Leontief inverse matrices for consecutive pairs of years (at the prices of the same year) for 2000 to 2008. He uses the matrices estimated by Guilhoto and Sesso Filho (2005; 2010). The author observes a reduction in the domestic coefficients, indicating that there are fewer productive connections in the system, as a result of the increased technological dependence on imports.

Nassif, Teixeira, and Rocha (2015) calculate the Rasmussen-Hirschman indices for the Brazilian economy in the years 1996, 2000, 2005 and 2009 and identify the ones with backward and forward linkages larger than the average economy (key-sectors). They used the IOT estimated by Nassif (2013) and Neves (2013). In 1996, metal-mechanics, chemical, and textile were considered key-sectors. But, in 2009 metal-mechanics, chemical, mineral extractive industry, and transportation, warehousing and mail have important forward and backward linkages. As a conclusion, they note that manufacturing industries continue to be very important in the Brazilian economy since it has the highest backward linkages. However, they observe that this sector has been losing the capacity to boost the economy over time. By the analysis of sub-periods, these chains experienced a more intense reduction between 1996 and 2000, with some recovering between 2000 and 2005. The authors conclude that there is little evidence to support the thesis that there was deindustrialization of the Brazilian economy in the period.

Marconi, Rocha, and Magacho (2016) calculated the key-sectors for the Brazilian economy to evaluate the capacity of the expansion of commodity exports to generate sustainable economic growth. They used the IOT estimated by Guilhoto and Sesso Filho (2005; 2010) and found that agricultural and mineral commodities have the lowest linkages effects compared to the manufacturing sector. Also, the higher linkages observed in the case of the manufacturing industry gives it the capacity to stimulate other sectors, such as sophisticated services.

Persona and Oliveira (2016) also analyze the forward and backward linkages for the Brazilian economy between 1995 to 2009, using the World Input-Output Database (hereafter, WIOD). They conclude that there were no significant changes in the forward linkages, but there was a loss of backward linkages. They disaggregate the manufacturing sector by technological groups based on OCDE (2005) and conclude that while resource-intensive manufacturing industries have increased their backward links, intensive demand, differentiated technology, and labor-intensive sectors have reduced.

For a more recent period, Passoni and Freitas (2017) using their an estimation of the IOTs for the period from 2010 to 2014, concluded that manufacturing activities are still very important to the productive structure. In the case of a more disaggregated manufacturing sector, the traditional industry has more connections from the input-output model. Also, based on the power and sensitivity of dispersion indicators (normalized forms for backward and forward linkages) and its composition, they show that there was no significant change in the Brazilian economy between 2010 and 2014.

Medeiros, Freitas and, Passoni (2019) analyze the linkages indicators between a larger period, 2000 and 2014, but focused on what is called the innovative industrial group. They show that there were small changes between 2000 and 2014, which provides no evidence of the deindustrialization process. However, analyzing the sub-periods, they found an increasing tendency between 2000 and 2008 and a declining trend in the period from 2010 to 2014. Based on that, they argue that there is evidence of deindustrialization only in the most recent sub-period.

The structural decomposition analysis (SDA) is also another input-output methodology used to identify the structural change in the Brazilian economy. Neves (2013), Messa (2013), Persona and Oliveira (2016) and Magacho, McCombie, and Guilhoto (2018) use this methodology with the objective of verifying the hypothesis of deindustrialization and regressive specialization. Because of the lack of availability of structural data, these studies analyze the performance of the Brazilian economy had the end year in 2009. An important aspect is that there is a lack of a consistent input-output database for a long period, due to changes in the Brazilian System of National Accounts (SNA). All these applications use the SNA 2000. Moreover, another important aspect when analyzing a long-term input-output series is the deflation method. Each of the mentioned work used different databases and methods to construct the deflated IOT series, affecting their results.

Persona and Oliveira (2016) using the WIOD database calculate the decomposition for value-added and employment between 1995 and 2009. They observe technological change (changes in national technical coefficients) had a negative influence on employment (more expressively), value added, gross product and growth. The authors associate this change with technological change, changes in products composition, changes in relative prices and trade pattern. As this study ended in 2009, they must also be affected by the negative performance in the Brazilian economy this year. According to the authors, the hypothesis of regressive specialization is correct, as changes of gross output and value added were related to industries based on natural resources and reduction of manufacturing sectors intensive in scale and technology importance.

Magacho, McCombie, and Guilhoto (2018) also use the WIOD database between 1995 and 2009 in their structural decomposition analysis of gross output changes. They obtained a deflated IOT series using accumulated Laspeyres quantum indices. Final demand is the most important effect inside the gross output decomposition, but the technological change had a positive effect on the period. Disaggregating the domestic technical coefficients in total and imported, they conclude that there was a substitution of national inputs that mitigate the domestic technological change. These results suggest that there is a penetration of imported inputs, and this is essential to the understanding of the Brazilian rate of output growth in the period analyzed. From a sectoral perspective, the authors observe that the substitution of national inputs is more pronounced in high- and medium-high-technology manufacturing sectors.

We must highlight that although Persona and Oliveira (2016) and Magacho, McCombie, and Guilhoto (2018) deflate the IOT to consider the effects of the exchange rates' volatility and relative price changes and analyze prices effect and quantity separately, we argue that both methods are insufficient to exclude the relative prices changes in the structural decomposition analysis. The double deflation method, used by Persona and Oliveira (2016), causes distortions in the deflated input-output table coefficients, changing the contribution of sectors with highest price variations[10]. Also, in both deflating methodologies additivity property is absent, while it is a desired property when dealing with price or quantum indices. The methods tend to overestimate the influence of natural resources industries due to the observed price increase in the period and underestimate the manufacturing industries due to downward movement in relative prices. In the case of the quantum Laspeyres indices used by Magacho, McCombie, and Guilhoto (2018), the volume accumulation over the years makes the IOT system loses its additivity.

In other to overcome these kinds of limitations, Messa (2013) and Neves (2013) proposes SDA for the Brazilian economy that includes the role of relative prices inside the SDA explicitly. Messa (2013) makes the gross output decomposition between 2000 and 2009 and

[10] We will present in the methodological part of the thesis.

disaggregate the changes in the contributions of the final demand and domestic technical coefficients. He uses the IOT 2000 published by IBGE and estimates the IOT 2009 using the SUT 2009 based on the method developed in Maciente (2013). The author deflated the IOT 2009 using the sectoral relative prices considering this year implicit GDP deflator. The final demand is the most important component to explain the gross output changes, and each final demand component influences some particular industry. Household consumption was important for the whole economy, GFCF concentrated the influence in the manufacturing and construction sector; exports contributed mostly to the mineral and agricultural sectors. He concluded that the input-output relations contributed to the reduction of the manufacturing and construction sector gross output. The author does not analyze the effect of this loss in for the importance of the manufacturing in the Brazilian economy but attributes the differences between the services and the manufacturing industry to the lower growth of domestic intermediate consumption of manufacturing inputs. We must highlight that 2009 is a year where the Brazilian economy had negative growth, and this may affect the decomposition result. Also, concerning the deflation method used, it only uses the sectoral deflator to deflate the gross output, but the others relative prices in the IOT table, such as intermediate and final demand, are not mentioned. This may influence the structural decomposition contributions.

Neves (2013) has developed the most complex deflation method among the presented studies. He estimates IOT for current and previous' years prices for 2000 to 2009 using the data from Brazilian SNA 2000 and constructed cell-specific deflators. By making the proper relative price adjustment, he arrives at consistent IOT that has the additivity property. The author makes the decomposition for employment and gross output, including the role of relative prices inside the SDA. Based on that, he argues that there is not strong evidence of a marked process of deindustrialization between 2000 and 2008, whether from the perspective of occupations or under the gross output. The author bases his argument on the idea that the manufacturing industry had the greatest contribution among all industries. However, as far as the trade pattern is concerned, there is import penetration in the manufacturing industry, especially more marked in the medium-low and medium-high technology sectors. Also, there is a negative contribution to technological change to gross output in volume in the period, which is mitigated by the change in relative prices. However, as we are going to see in Chapter 3, the way the author consider the relative prices and analyze it in the decomposition is not the most accurate one. There are missing relative prices changes inside the model, and also, he analyzes the role of the relative prices effect of each source of change individually effect separately, but it only has meaning when analyzed in a global way inside the decomposition.

2 BRAZILIAN ECONOMY OVERVIEW: 2000-2015

In this chapter, we present some essential aspects of the Brazilian economy to a better understanding of the growth trajectory in the period of study. We focus mainly on the level of activity, capital expenditures, and sectoral patterns. Furthermore, we aim to discuss pieces of evidence about the deindustrialization process and the trend towards a regressive specialization to shed light on the literature presented in the previous chapter. Sectoral information about value added, gross output, employment, and the Brazilian export basket are of particular importance. Lastly, we examine some data on sectoral productivity.

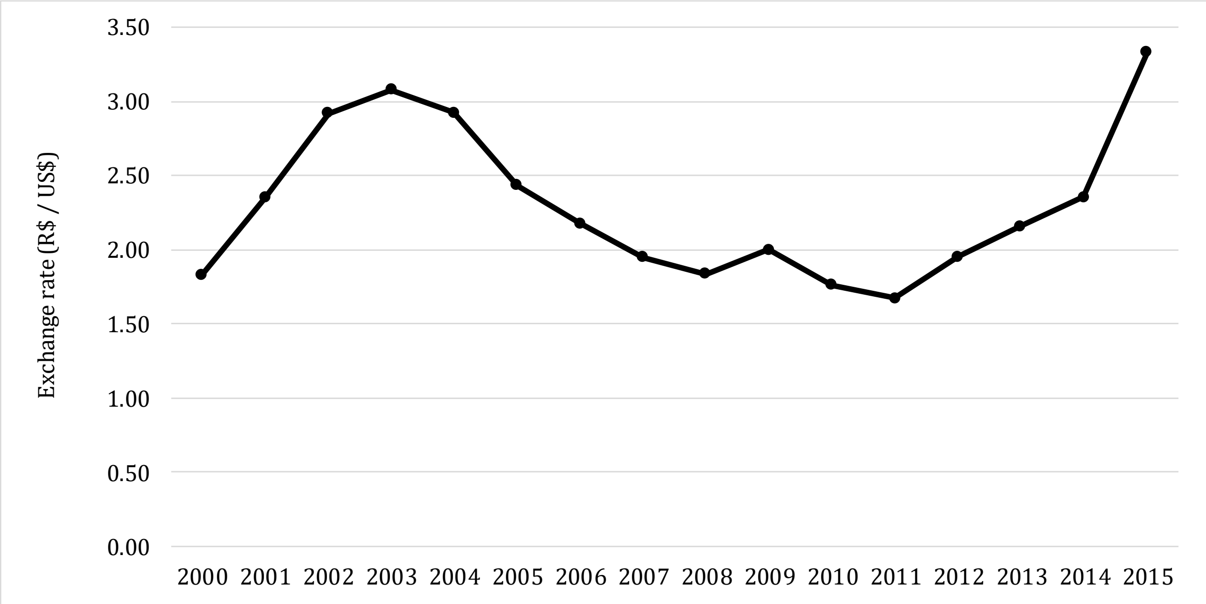
2.1 The performance of the Brazilian economy

During the 2000s the Brazilian economy faced significant changes related to both domestic and external factors. After a phase of liberal reforms in the 1990s, the macroeconomic policies have had the same aspects since 1999, as pointed by Serrano and Summa (2011). That includes the ideas from the “new macroeconomic consensus,” mainly based on the “macroeconomic tripod” – in which inflation targets, floating exchange regime, and fiscal targets are the three major features.

In the early 2000s, the Brazilian economy presented a poor performance as a consequence of the liberal policies previously undertaken. During the 2000-2003 period, the inflation rate persisted in being above the Central Bank target. One of the reasons for that was the significant devaluation process of the nominal exchange rate, inasmuch that it rose from around US$/R$ 1,80 in the January/2000 to around US$/R$ 3,80[11] in July/2002 (Figure 3 below). At the end of 2003, the exchange rate was still depreciated; in spite, it has reached the US$/R$ 2,90 level. Changes in the prices of the goods that compose the Brazilian exports were another important aspect in the first half of that decade. By that time, exports were highly concentrated on raw materials, and the dollar-prices of these goods had fallen up to 2003. After that, there was a considerable increase in the price of the commodities until 2008 (SERRANO; SUMMA, 2011).

[11] In 2002 the left-wing president Luís Inácio Lula da Siva was elected (and the part of the instability in the exchange rate and capital flows in that year is explained by that).

Figure 3 – Brazilian exchange rate - R$ / US$ - Annual average 2000-2015



Source: IPEADATA (2018), annual average.

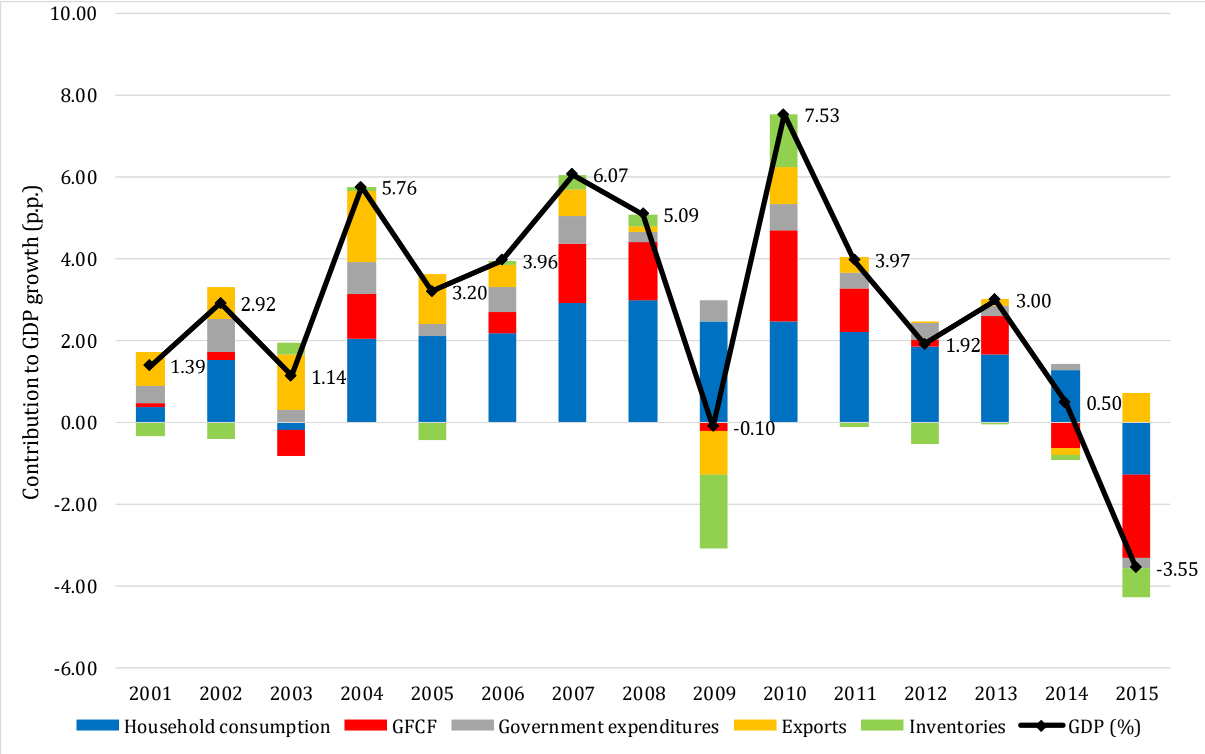
By analyzing the contribution of each component of the aggregate demand to the rate of growth, we can identify the main drivers of the macroeconomic performance in the period. To overcome some limitations in growth accounting, we decided to adopt the attribution method of demand-side growth accounting, which deduce the import share and its growth of each demand component[12]. The components are household consumption, capital expenditures (which include investments from private enterprises and public sector), government expenditures, and exports. Figure 4 shows the yearly decomposition and Table 1 details the sub-periods.

The external demand explains the economic growth up to 2003. The average growth rate in the 2000-2003 period was 1.81%, and exports contributed to more than half of the GDP expansion (0.98 percentage point, hereafter pp). Since the contribution of growth of each

[12] The common way to see the contribution to economic growth is using the "net-exports" method, in which the imports are fully deducted from the exports. The attribution method consists in deducting from all components of the final demand the correspond imports (for intermediate and final demand) each of them had demanded from abroad. By doing this we can measure the real demand-side contribution, deducting the demand that leaks for other countries. The IOT series estimated in this work provides the imported final demand attributed to each final demand component, according to IO model. In the case of intermediate imported demand, we estimated it, using the following equation: $\mathbf{M_{int}} = (\mathbf{I} - \mathbf{A_m})^{-1}\mathbf{F_d}$, where $\mathbf{I}$ is a Identity matrix, $\mathbf{A_m}$ is the matrix of imported technical coefficients (calculated according to the needs of imported inputs regarding the gross output), and $\mathbf{F_d}$ is the matrix with domestic final demand components. Hence, $(\mathbf{I} - \mathbf{A_m})^{-1}$ represents a version of the Leontief matrix, but indicates the direct and indirect imported inputs necessary in the production of $\mathbf{F_d}$. For further details and applications for the Brazilian economy see Freitas and Dweck (2013), Passoni (2013), Fevereiro (2013) and Fevereiro and Passoni (2018).

component is a weighted average between the rate of growth and their share in the GDP, analyzing the growth rate of each component give us an important sign of the growth dynamics[13]. Table 2 presents the annual average growth of final demand and their respective imports in each sub-period.

Figure 4 – Demand side growth accounting for the Brazilian economy, 2000-2015 (pp)



Source: Author's calculations based on information from the SNA/IBGE.

Table 1 – Demand side growth accounting for the Brazilian economy, 2000-2015 and selected periods (p.a.)

Year	Household consumption	GFCF	Government expenditures	Exports	Inventories	GDP (%)
2000-2014	1.85	0.55	0.46	0.53	-0.10	3.29%
2000-2003	0.58	-0.11	0.52	0.98	-0.15	1.82%
2003-2008	2.03	0.67	0.37	0.51	0.07	3.64%
2010-2014	1.20	0.11	0.20	0.01	-0.17	1.35%
2000-2015	1.63	0.37	0.41	0.54	-0.14	2.82%
2010-2015	0.85	-0.39	0.14	0.18	-0.34	0.44%

Source: Author's calculations based on information from the SNA/IBGE.

As one can verify, even with a low share in aggregate demand (an average of 10% in the period, Figure 6), exports were the component with the highest rate of growth (around 10%)

[13] The imported coefficient inside each expenditure category is another element that affects the growth rate since it represents whether the component is importing a higher or lower share of the final demand.

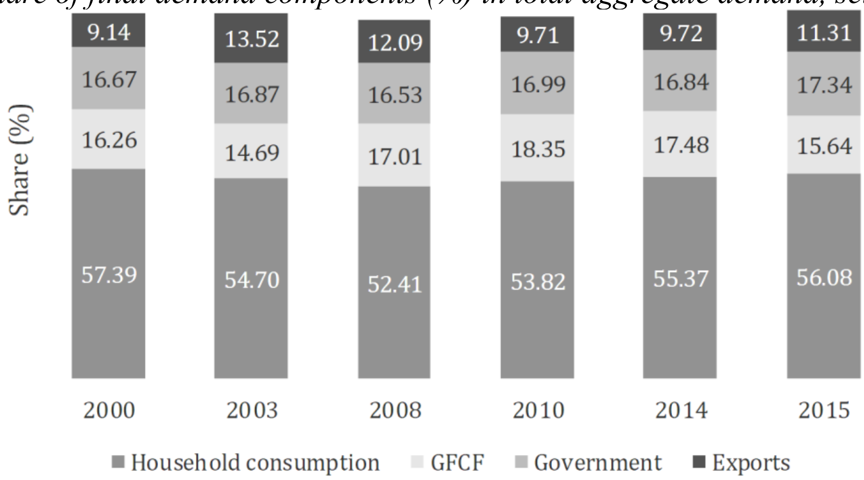
among 2001 and 2003 (check Table 1). Hence, in these years the dynamics of the Brazilian economy was concentrated in the external demand. The components of the domestic market had a poor performance, particularly household consumption and GFCF. As the imports are highly sensitive to income in the Brazilian economy, the growth contribution of these domestic components was not worse due to the negative growth in household consumption's and GFCF's imports (-2.34% and -2.36% respectively).

Table 2 – Annual average growth (%) of final demand and imports by demand's components, for the Brazilian economy, 2000-2015, selected periods

Period	Household consumption	GFCF	Government expenditures	Exports	Total
Final demand					
2000-2014	3.97	4.76	2.75	5.25	4.01
2000-2003	1.54	0.88	3.09	10.32	2.68
2003-2008	4.48	6.45	2.33	4.61	4.62
2010-2014	2.30	0.53	1.15	0.10	1.33
2000-2015	3.48	3.39	2.46	5.36	3.39
2010-2015	1.17	-2.55	0.62	1.41	0.07
Imports					
2000-2014	7.32	7.94	5.36	7.34	7.32
2000-2003	-2.34	-2.36	-2.86	7.70	-1.50
2003-2008	11.34	14.94	9.69	8.51	12.56
2010-2014	3.06	0.14	2.03	0.30	1.21
2000-2015	6.03	5.84	4.64	6.96	5.74
2010-2015	0.18	-4.14	0.57	0.60	-2.06

Source: Author's calculations based on information from the SNA/IBGE.

Figure 5 – Share of final demand components (%) in total aggregate demand, selected periods



Source: Author's calculations based on information from the SNA/IBGE.

Between 2003 and 2004, several changes in the domestic and external economic environment occurred. From 2004 onwards, inflation rate kept around its target, not only because of the Central Bank intervention (setting the interest rate at a sufficiently high level to maintain the nominal exchange rate in an appreciated level) but also as a result of the external circumstances of low inflation. Furthermore, up to 2008, international liquidity was abundant, i.e., broad availability of credit prevailed, which favored the Brazilian economy by providing better financing opportunities.

After 2004 there was also a tendency of improvement in the labor market conditions, notably through a reduction in unemployment rates, a rise in formal employment, a decrease in the degree of informality, as well as wage gains in real terms (more evident from 2006 on). Consequently, regarding functional distribution, the wage earners had their position enhanced in comparison to the 2000-2003 when the wage share in the GDP declined (SERRANO; SUMMA, 2015). Another crucial aspect of the 2003-2008 period was the poverty reduction.

The rate of economic growth during the 2003-2008 years was higher than the first sub-period, with an annual average of 3.64%a.a. This performance is mainly explained by favorable external conditions and an active role of the internal macroeconomic policy, founded on the expansion of public expenditures (consumption and investment) and credit policies focused on financing household's consumption and new investments after 2009 (SERRANO; SUMMA; 2012).

The public sector had a central role in promoting economic growth between 2003 and 2008. Several conditions contributed to improving the fiscal balance, which widened the government's capacity to invest if one considers the set of constraints that the Brazilian legislation imposes to the fiscal policy. The combination of economic expansion and positive effects due to the commodities[14] boom increased the tax revenues, making it possible to maintain a systematic primary surplus at levels even above the legal target, especially after 2006[15]. A significant part of the investments was organized around the PAC program ("Programa de Aceleração do Crescimento"), released in 2007 with the purpose of stimulating

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[14] According to Carvalho (2018), the tendency of growing prices of commodities in international markets reinforces the government investment in two different ways. Firstly, by stimulating and increasing the capital available for investments in sectors related to the exported commodities, as the example of Petrobras, the Brazilian public-owned oil company. Secondly, by generating positive effects on related supply chains and raising tax revenues.

[15] The primary surplus was on average 3,4% of GDP between 2005-2008 (CARVALHO, 2018).

the economic growth. Infrastructure investments were one of its major priorities, focusing on areas such as housing, sanitation, transportation, energy, water resources, among others.

As observed in the growth decomposition, the government macroeconomic stimulus contributed to change the households consumption and GFCF growth rates. For the whole period, between 2003 and 2008 (except 2005), GFCF had a higher rate of growth than households consumption. The GFCF grew by an average rate of 6.5% *per annum* (hereafter p.a.). However, as it represents only 16% of the final demand, its contribution to GDP was no more than 18,5%. Private consumption grew by an annual average rate of 4.5%, but as this category has the largest share in aggregate demand (around 53%, Figure 6), it had a contribution of almost 56% for the total GDP growth.

Even though since 2003 household's consumption and GFCF rates of growth accelerated, in 2004 and 2005 exports were still the component with the highest growth rate in the period (15% and 10% accordingly)[16]. Only after 2006, the domestic components had a predominant role for the Brazilian GDP growth, especially GFCF. In this case, the (flexible) accelerator mechanism operated in the economy and the expansion of government investment had a direct effect on the creation of productive capacity to attend the higher demand (SERRANO; SUMMA, 2015). In 2007 and 2008 the GFCF grew around 12% per year (twice the rate observed for households consumption). Therefore, the GFCF increased its participation between all demand components (14,7% to 17%, Figure 6).

The demand for imports is another crucial aspect worth noting. As mentioned by Dos Santos et al. (2017), a large amount of Brazilian imports comprises intermediate goods, fuels and lubricants, transport services, royalty payments, and equipment rentals. Since the domestic production cannot offer a proper supply of these goods, the stronger demand expansion contributed to increasing the rates of growth of imports between 2003 and 2008. In addition, we also identify that the exchange rate appreciation in the period cheapened the imports, favoring their increase. Therefore, the total imports had an annual growth rate of approximately 12.6%, peaking in 2007, when the rate of growth reaches almost 20%. Analyzing the imports by demand components, we identify households' consumption and GFCF as the most important sources of expenditures, with an average growth of 11.3% and 14.9% in the mentioned period. In the case of GFCF, the import's performance is even more remarkable, since its rate of growth

[16] The importance of the external sector in the Brazilian economy after 2006 was much weaker in explaining the GDP growth path. For instance, the rate of growth of exports fell from 14.8% in 2004 to 1.7% in 2008, with an average rate of 8% p.a.

rose from 9.36% in 2004 to 25.72% in 2008, which represents an accumulated increase of 100%.

However, the 2008 financial crisis indeed affected the Brazilian economy, especially in 2009, when both the value added and gross output had a negative rate of growth (-0.10% and -1.21% respectively). The decrease in exports and the level of inventories partially explain this outcome. There was a 10% decrease in exports, mostly because of the world economic performance, which reduced the Brazilian external demand[17]. Moreover, the GFCF had a negative growth of roughly 2% in 2009. The rate of growth of the other components, i.e., household consumption and government expenditures (4.5% and 3%) were insufficient to stimulate the economy. As imports are highly sensitive to both the domestic income and level of output, the weak economic activity resulted in a (negative) growth rate of imports of -8.5% in 2009. There was a decrease in the imports needed by GFCF and exports (-5.8% and -13%), although the exports concentrated the fall in the intermediate imports and the GFCF in the final imports.

In 2010 the government decided to increase investments through the PAC program and Petrobras, as a way of stimulating the economy and mitigating the external scenario (CARVALHO, 2018). Among these policies, the “Minha Casa Minha Vida” program had the main objective of financing the construction of dwellings. Its strategy focused on subsidies, interest rates reduction for low-income families, tax breaks and support for residential investments in urban areas.

Because of the government intervention, the Brazilian economy could recover from the recession at a faster pace than the world economy did, presenting already in 2010 expressive rates of growth of value added (7.53%) and gross output (7.80%). The demand components that had the highest rate of expansion in the year were GFCF and exports, with 17,8% and 12%. Households consumption and government expenditures grew by 6.2% and 3.9% respectively. In 2010, the demand for imports registered an even higher rate of growth (33.7%) than the aggregate final demand (around 10%). If we analyze each demand component, GFCF’s, exports’ and household consumption’s imports grew 37%, 26%, 23% respectively. Considering their share in the total demand, household consumption and GFCF were the components that most contributed to the import’s rate of growth, with 33% (2.48pp) and 30% (2.26pp) to 7.5%.

After the outstanding growth performance in 2010, a declining growth trend took place in 2011, mainly due to changes in the Brazilian economic policy. The policies changed from a

[17] The world growth rate in 2009 was -1.73% (World Bank, 2018)

more active role of the government in stimulating the domestic market directly, through expansion of public sector expenditures and household credit, to one concerned on tax breaks to the private sector, primarily focused on exporting sectors and direct stimuli to private investments. The new strategy included encouraging exports by a policy of real exchange rate devaluations, while the incentive to private investment allegedly would come from policies such as the reduction of public utility tariffs, payroll exemptions, and lower interest rates.

However, these policies were not successful in achieving the expected result of maintaining a high level of economic activity. On the domestic side, despite all the governmental incentives, lower economic growth and decreasing rates of capacity utilization led to a reduction in the pace of capital accumulation by private enterprises from 2011 onwards. In this period, however, the GFCF was still the demand component with the highest rate of growth, 2013 being the only exception.

The external stimulus does not have the expected effect on the Brazilian economy. The real exchange devaluation was not able to encourage export's growth – confirming the evidence of the low real exchange rate elasticity of the Brazilian exports[18]. Meanwhile, we observe in the international scenario a slowdown in primary commodities demand, culminating in a slump of commodities prices after 2014. Additionally, the downturn in the world growth and international trade contributed to reducing the role of exports in stimulating the economy. In 2014 exports decreased by 2.2%, and its contribution to growth was -0.14%. The exports only grew at a higher rate than the other components in 2015 (6.8%), but its contribution to GDP growth was insufficient to offset what was happening to the domestic elements. In 2014, GDP growth was still positive (0.5%), but the economy began to give signs of a recession. After 2009, 2014 was the first year where GFCF had a negative growth rate (-4.2%)[19].

The domestic scenario deteriorated after president Rousseff re-election in 2014. In 2015 the government put in place a strong fiscal consolidation through the reduction of social transferences, overall budget cuts, reduction in government investments (PAC program), and tax increases to expand revenues. The results of these policies could be seen in the negative rates of growth of value added (-3.15%), gross output (-4.3%), employment (-3.3%) and GFCF (-12%) in 2015. Once there is a strong relation between imports and the level of domestic demand in the Brazilian economy, in 2014 the imports had a negative growth of -2.8%, and an even more remarkable contraction in 2015 (-14%). The demand components that mostly

[18] Dos Santos el al (2017).

[19] Part of this was an effect of the Operation "Lava Jato", an ongoing criminal investigation of money laundering and corruption in the Brazilian oil company Petrobras.

reduced their imports in 2014 were GFCF and exports (-6.2% and -6%), but in 2015 the domestic demand was in the center of this downturn process, with a slump of 11% and 21% of household consumption and GFCF.

2.2 GFCF and sectoral investment

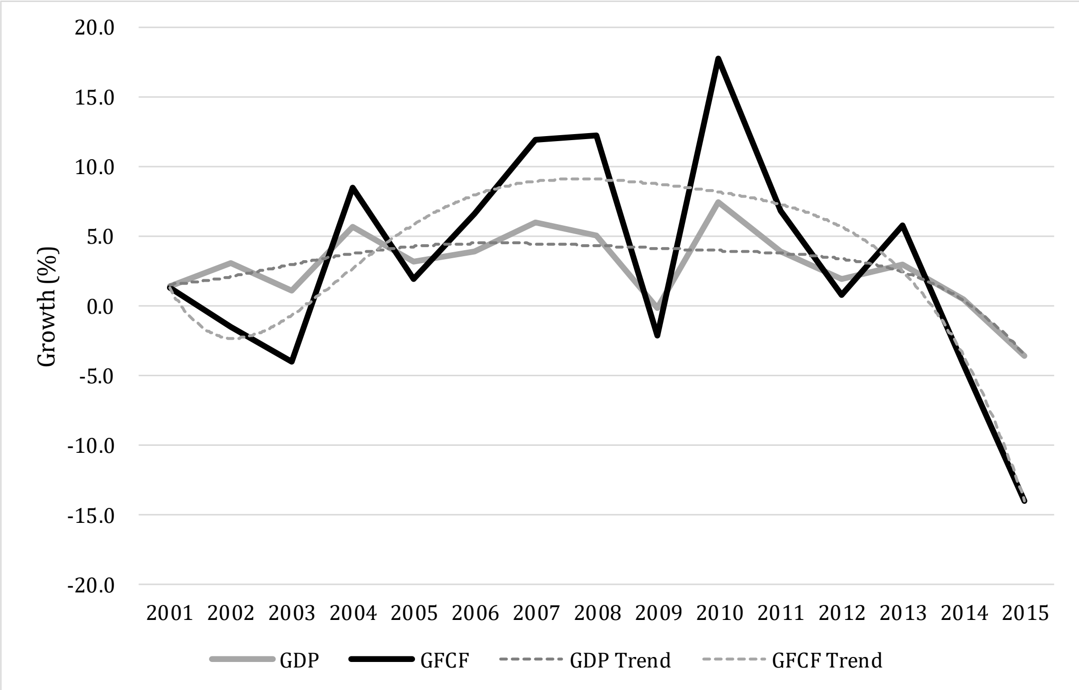
The investment, measured by the GFCF is an essential element to understand the pattern of structural change and growth in economic systems, due to its dual character, as mentioned in Chapter 1. First, it is a demand component. Once entrepreneurs and the government decide to invest and buy new equipment and machinery, it stimulates productive chains and activates the economic multipliers. The other aspect is that the GFCF contributes to the structural change by the expansion of the quantity and quality of the economy's stock of capital, therefore influencing both the cycle (short run) and the capacity to grow (long run).

It follows that there is a close relationship between the aggregate demand and the process of structural change through the investment-output ratio, which is the difference between the GFCF and GDP growth. New investment involves the production by the manufacturing industry of new machinery and equipment, and this contributes to technological diffusion effects through technological flows (depending on the domestic structure and the sectors involved).

Because of that, the GFCF, and the investment-output ratio trajectories are a fundamental feature to understand the Brazilian structural change. We begin our analysis with the path of GFCF and GDP growth, as shown in Figure 6. Here we notice that there is a strong empirical correlation between the GDP growth trend and the investment-output ratio, as already discussed by De Long & Summers (1992). We have identified different tendencies for the investment-output ratio. The first one goes from 2000 until 2008, a period in which we observe a substantial rise in the GDP rate of growth and the investment-output ratio; in this phase, GFCF grows at a higher rate than the GDP. Internal policies adopted by the government, founded on the direct investment and in the stimulus through credit had a central role between 2004 and 2008. Essentially, by provoking a demand expansion (both from consumption and investment), the policies can activate the flexible accelerator mechanism and enabling the creation of the productive capacity necessary to satisfy the growing demand.

From 2010 to 2015, it is possible to identify a distinct trend in the GFCF path characterized by a slowing GDP growth and, consequently, the investment-output ratio as well.

Figure 6 – GFCF and GDP growth for the Brazilian economy between 2000-2015



Source: Author's calculations based on information from the SNA/IBGE.

In 2010, there was a remarkable increase in the GFCF, mainly due to the rapid government response after the GDP result in 2009. As mentioned earlier in this Chapter, the government implemented some policies that affected the investment positively, as the Investment Support Program (in Portuguese, Programa de Sustentação do Investimento, PSI) and the maintenance of the investment plans of Petrobras (MIGUEZ, 2018). After 2011, however, the slowdown in the Brazilian economy, associated with the change in the policies through private investment stimulus, led to a continuous drop in GFCF growth and a reduction in the investment rate.

One can have a better understanding of the investment dynamics through a sectoral analysis, once it allows identifying the pattern of structural change. By analyzing the source of sectoral supply and demand regarding investment, one can have a picture of the actual sectoral dynamics. For this purpose, we use the data of sectoral investments present in the Capital Flow Matrices (CFM), estimated by MIGUEZ (2016)[20] for the 2000-2015 period, in constant prices. These matrices consist of disaggregated GFCF data, allowing an industrial analysis.

[20] Miguez (2016) prepared these matrices based on the information from the System of National Accounts, several annual surveys published by IBGE (the manufacturing survey, wholesale and retail survey, construction survey and services survey) and from some data available in the Brazilian National Development Bank (BNDES). The most recent estimation is done in Miguez and Freitas (2019). This version is at in constant prices, and the authors used the GFCF vector deflator by product (total, domestic and imported) to deflate the sectoral GFCF. These

We present information of 11 sectors using the extractive and manufacturing classification of the industry in four groups, as proposed by Torracca and Kupfer (2014): processed agricultural commodities (AC), unprocessed and processed mining and quarrying commodities (MQC), traditional manufacturing industry (TM) and innovative manufacturing industry (IM). We will discuss this classification in further details in Chapter 3, but the main objective of using it is to identify the sectors which are able to stimulate and promote technological diffusion, notably those that compose the IM industry.

During the whole period, we observe that the extractive and manufacturing sector had a modest performance, as they exhibit growth rates of sectoral GFCF below the economy's average (Table 3). Furthermore, their shares in total GFCF (Table 4) have reduced, while the services sectors had the opposite outcome, increasing their participation.

Table 3 – Sectoral GFCF growth for the Brazilian economy between 2000-2015 and subperiods

Sectors	2000-2003	2003-2008	2010-2014	2010-2015	2000-2014	2000-2015
Agriculture, fishing and related	8.29	3.70	-0.63	-1.80	5.32	4.50
MQC	-2.73	4.74	0.43	0.26	1.58	1.45
AC	-6.68	-4.58	-2.62	-4.60	-3.11	-3.74
TM	-6.68	4.94	-2.80	-3.18	0.44	0.09
IM	2.20	2.54	-6.95	-6.42	1.30	0.92
Public utility	-5.00	11.90	-0.79	-7.42	5.45	2.63
Construction	-23.02	10.08	-1.81	-7.49	-1.74	-3.68
Trade, accommodation and food	0.14	9.92	0.78	-4.69	7.82	5.36
Transport, storage and communication	-8.84	2.55	-3.53	-4.81	2.88	1.99
Financial intermediation, insurance and real estate services	17.33	-3.93	-0.02	4.86	5.54	6.84
Community, social and personal services	-4.85	6.30	3.11	-0.54	5.00	3.62
Total	-4.02	5.65	0.23	-2.39	3.49	2.36

Source: Own elaboration based in Miguez and Freitas (2019).

If we consider the IM group, it increased their performance in the first years of the series, 2000-2003 (2.2%p.a.) and from 2003 to 2008 (2.5%p.a.). This group follows the total GFCF trend between 2010 and 2014, with slower growth in the 2010-2013 period, but after that, the negative perspectives for the economy consolidated, and the slowdown contributed for a negative rate of growth in 2014 and an even worse outcome in 2015. The share of this industry group also declined along with the sub-periods, reaching the lowest level in 2010-2014. However, we must point out that in spite the data be in constant prices, the reduction mentioned above in the share and its rate of growth seem to have been affected by the decrease of manufacturing relative prices.

deflators were obtained using the GFCF valued at current prices and previous' year prices, available in the SUT published by IBGE.

In its turn, the commodities' boom positively affected the GFCF category of the MQC group, since the related enterprises had to invest in attending the increasing demand for exports in extractive industries. Moreover, the expansion of Petrobras investments in the oil and gas chains was beneficial, and in this group, GFCF grew in all sub-periods after 2003, having the highest growth rates between 2003 and 2008. Besides that, MQC lost share in total GFCF from 2000 until 2014. The worst performance among all manufacturing groups was GFCF of the AC group. Although it had a small share in total GFCF (an average of 1.9% from 2000 to 2014), it reduced its overall investments.

Table 4 – Sectoral GFCF composition for the Brazilian economy between 2000-2014 and sub-periods

Sectors	**2000-2003**	**2003-2008**	**2010-2014**	**2000-2014**
Agriculture, fishing and related	4.21	4.31	4.34	4.26
(Un)proc. mining and quarrying commodities	15.55	14.31	11.35	12.98
Processed agricultural commodities	2.98	2.16	1.26	1.88
Traditional manufacturing industry	8.95	8.10	7.01	7.72
Innovative manufacturing industry	11.41	10.59	10.05	10.45
Public utility	2.75	2.62	3.25	2.95
Construction	5.76	3.57	3.86	4.13
Trade, accommodation and food	7.63	12.90	12.61	11.94
Transport, storage and communication	3.48	4.31	3.98	3.98
Financial intermediation, insurance and real estate services	1.26	1.52	1.16	1.26
Community, social and personal services	36.02	35.61	41.12	38.45

Source: Own elaboration based in Miguez and Freitas (2019).

Regarding the services sectors, they had an impressive sectoral GFCF growth, especially Trade, accommodation, and food. The vital contribution of households consumption to GDP growth between 2010-2014 encouraged new investments until 2014. Consequently, the services sector increased its share in the total GFCF. Furthermore, we must highlight the performance of the construction sector between 2003 and 2008, registering an average growth of 10%p.a. The economic policies in the period, such as the PAC program and new credit lines for dwellings were of utmost importance in explaining this performance.

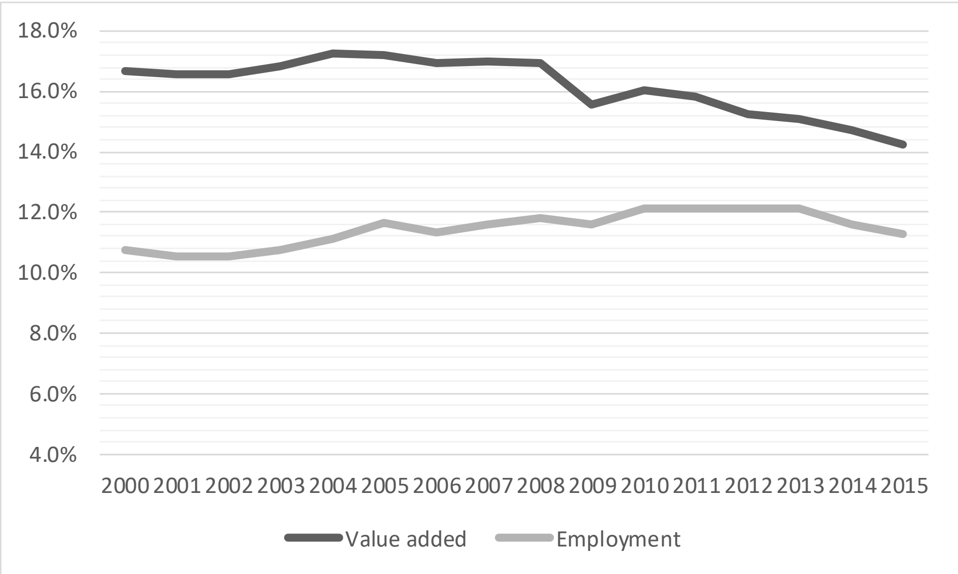
A central aspect of the sectoral GFCF accumulation is the downward tendency in almost all sectors in the 2010-2015 period, except for Financial and related services and MQC. The pessimistic projections for the Brazilian economy brought critical consequences for capital accumulation since entrepreneurs did not have the stimulus to invest, i.e., there were no expectations of increasing demand in sight.

2.3 Sectoral analysis: pieces of evidence for deindustrialization and regressive specialization

In the approach of the deindustrialization literature, it is worth analyzing the shares of value added[21] and employment for the manufacturing sector in the economy as a whole. It is fundamental to point out that the Brazilian economy has a substantial internal market, in which the services sector correspond to a large share of value added and employment, so there exists a reason for the low weight of the manufacturing sector in comparison to other economies. In this sense, one must not confuse the size of the services sector[22] with the low productive diversification and its consequences for the Brazilian economy.

During the period of our analysis, the share of value added in the manufacturing sector registered to movements (Figure 7): slight maintenance between 2000 and 2008 followed by a downward bias from 2009 to 2015. Regarding the manufacturing employment, the variation amplitude is quite small, but there is an increasing tendency from 2000 to 2013 and, afterward, it starts a declining path.

Figure 7 – Extractive and manufacturing shares in the Brazilian economy between 2000-2015



Source: Author's calculations based on information from the SNA/IBGE.
Note: We calculate the value added share using the value added deflator, obtained by the information in current and previous' years prices from SUT published by IBGE.

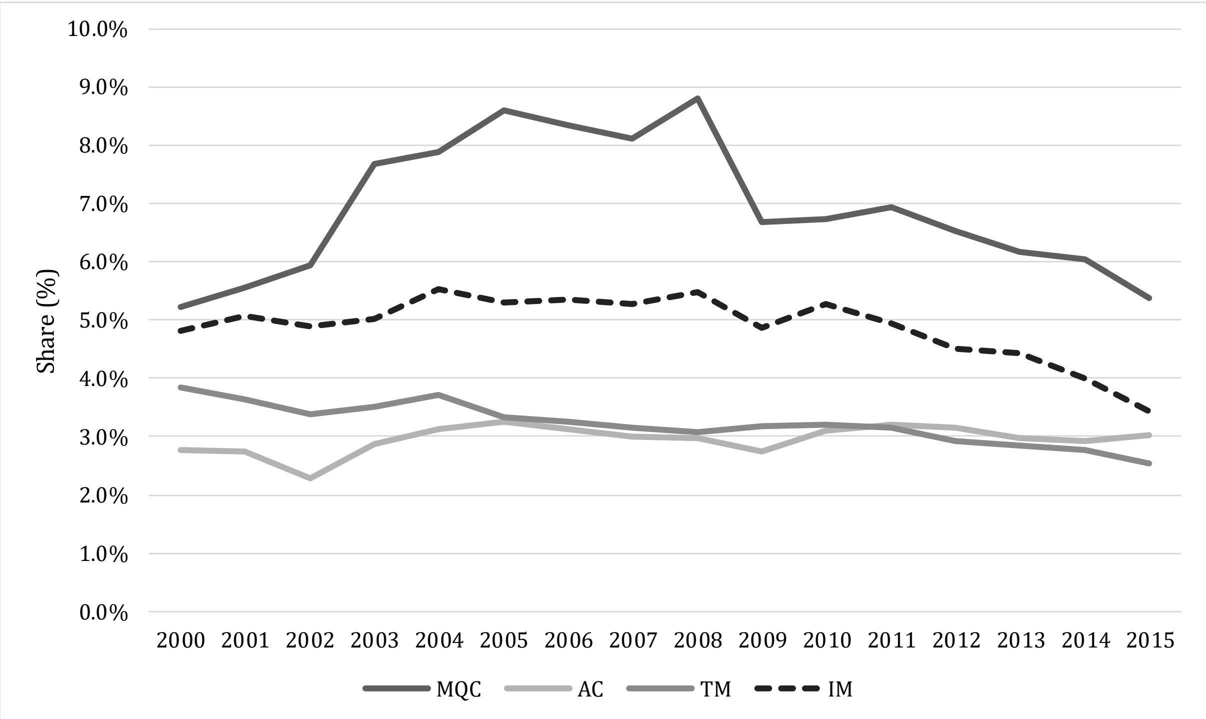
Nevertheless, not every kind of industry is relevant to the deindustrialization discussion. We focus our attention on the innovative manufacturing industry as the economy's dynamic center, because of its role in promoting technological change and capital diffusion. To analyze

[21] The manufacturing gross output share has almost the same trajectory, so by simplicity, we preferred to omit it.
[22] One may note that even the services sector may be a source of dynamism, notably through innovations and the development of sophisticated and high value added activities

these features, we present in Figure 8 below the sectoral value added share for the extractive and manufacturing industries groups, while in Table 5 the sectoral output, value added, and employment growth rates are shown. The innovative industry represents the second-highest share among the groups and, regarding its trajectory, this group increased the value added at an average rate of 0.4%p.a. (1.8% for gross output) between 2000 and 2015. Excluding 2015, the year in which the Brazilian economy had the worst performance in the series, the growth rate was approximately 1.8% (2.6%p.a. for gross output).

There is a correlation between the IM and the overall economic performance. In spite of this group have had a modest share increase in the 2003-2008 period, it has presented favorable rates of investment-output ratio. The corresponding employment indicator also expanded in the years mentioned above, with an average rate of growth of 4.7%p.a. Even though this sector represents a low share regarding the total employment, it happened to be the most dynamic one.

Figure 8 – Value added share (%) of extractive and manufacturing industry groups in total Brazilian employment (2000-2015)



Source: Author's calculations based on information from the SNA/IBGE.
Note: We calculate the value added share using the value added deflator for each group, obtained by the information in current and previous' years prices from SUT published by IBGE.

Table 5 – Gross output, value added and employment growth rates for manufacturing and extractive industries groups for the Brazilian economy, selected periods

Period	Sectora data	MQC	AC	TM	IM
2000-2014	Gross output	3.8	2.5	0.6	2.6
	Value added	4.3	3.6	0.8	1.8
	Employment	3.1	2.9	1.8	3.6
2000-2003	Gross output	8.4	4.5	-0.8	2.8
	Value added	13.3	0.7	-3.4	1.0
	Employment	0.9	2.8	1.5	3.2
2003-2008	Gross output	4.2	1.3	0.4	4.0
	Value added	6.1	2.8	0.0	3.6
	Employment	4.0	2.0	2.4	4.7
2010-2014	Gross output	0.5	1.0	-0.3	-2.1
	Value added	-1.9	-0.8	-1.6	-3.8
	Employment	0.9	0.7	0.2	-0.5
2000-2015	Gross output	2.8	2.2	0.1	1.4
	Value added	2.9	3.3	-0.1	0.4
	Employment	2.4	2.6	1.2	2.7
2010-2015	Gross output	-1.8	0.5	-1.8	-4.5
	Value added	-4.6	-0.7	-3.9	-6.7
	Employment	-0.7	0.2	-1.1	-2.2

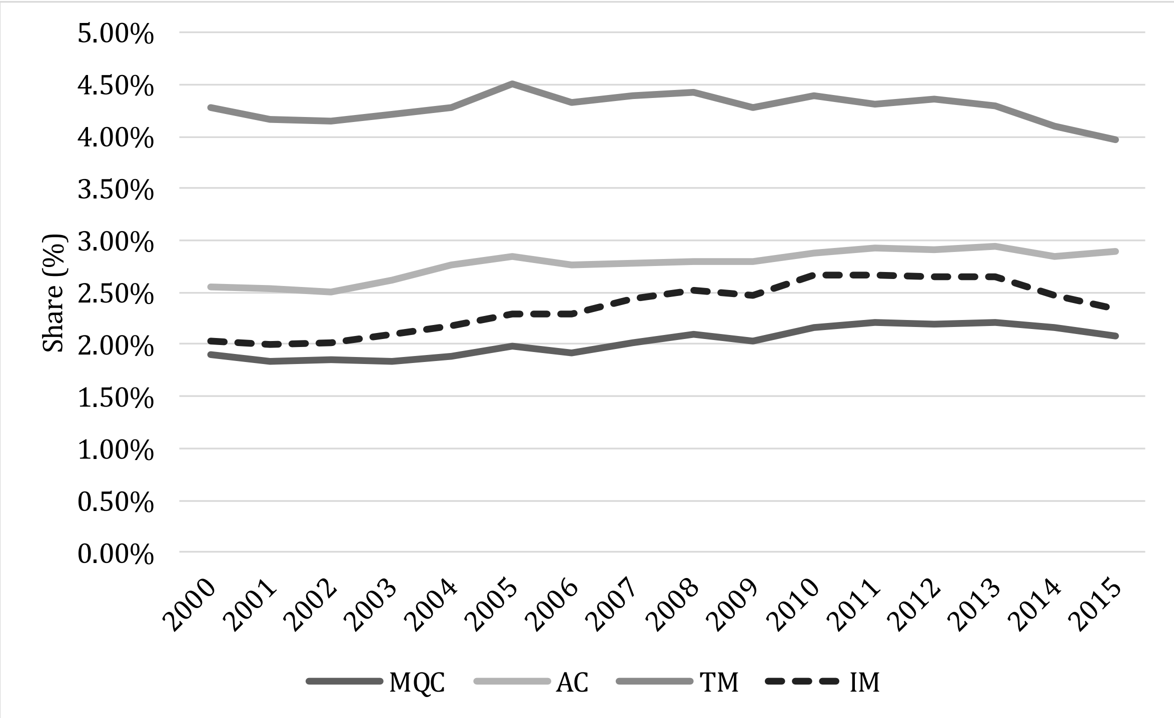
Source: Author's calculations based on information from the SNA/IBGE.
Note: The information of gross output and value added are the real ones, and the respective series was deflated using they own deflators, obtained by the information in current and previous' years prices from SUT published by IBGE.

Following the Brazilian slowdown due to political economy changes after 2011, there was a remarkable fall of the share of the IM group value added, and it had in 2015 the lowest participation in the period – decreasing by 6.7%p.a. between 2010 and 2014. Here we observe the main problem of considering only the value added/gross output share as the only measure of deindustrialization: the level of activity and the growth in the investment-output ratio do affect it. This effect is even more remarkable for the innovative industry since the capital accumulation in the expansion phase can increase its share in total value added/gross output.

However, the influence of relative prices is another limitation in the use of the value added/gross output approach. As mentioned in the previous chapter, since the 2000s the manufacturing prices have grown at a slower pace than the overall economic prices, reducing in this way the relative price of the group. Therefore, we can attribute part of the reduction in the IM share to a mere price effect. For example, comparing the value added information with the sectoral employment share (Figure 9), we identify a smoother movement of changes in the IM share.

Changes in relative prices can also explain the increasing share of unprocessed and processed mining and quarrying commodities (MQC) between 2003 and 2008, as we are going to see more clearly in Chapter 4. Since the level of prices of these commodities increased in the period (as discussed in Chapter 1), an overestimation of their share might have taken place because of the relative price effect. Regarding the employment share of this group, the indicator has the lowest share among all groups. The discrepancy between employment participation and value added is based on the group's specificities of production.

Figure 9 – Employment share (%) of extractive and manufacturing industry groups in total Brazilian employment (2000-2015)

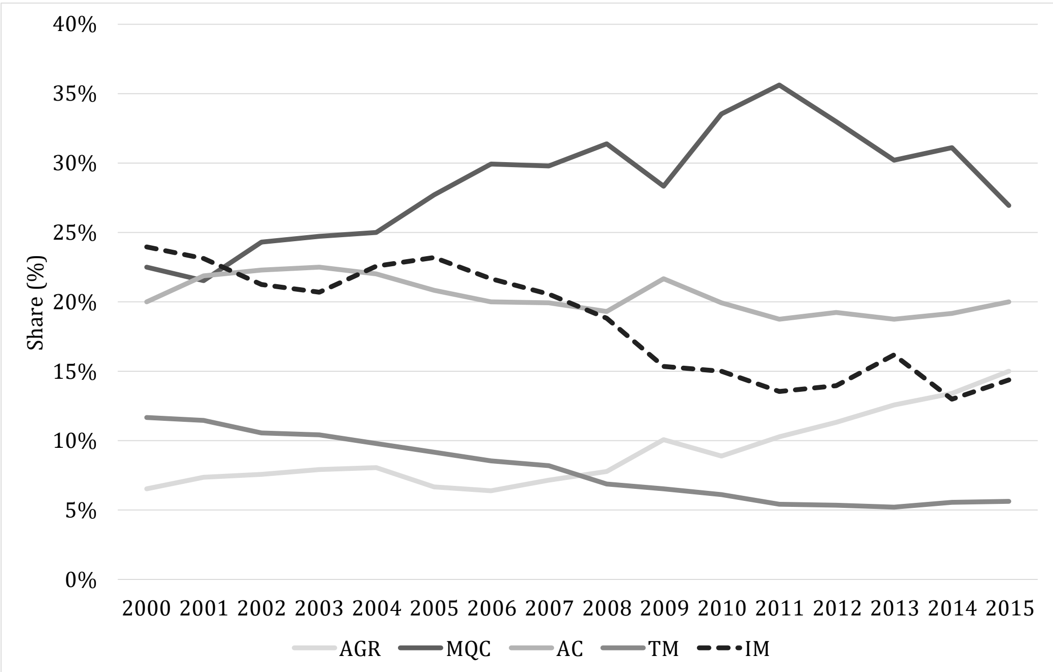


Source: Author's calculations based on information from the SNA/IBGE.

Among all extractive and manufacturing industries groups, the traditional group has the worst performance, considering either the value added or the employment share. Although the group is the one with the highest employment share (around 4%), because of its higher labor intensity nature (in relative terms), it had the lowest rate of growth between 2000 and 2015 (1.2%p.a.). By examining each sub-period, one can check that the employment grew only between 2000 and 2008. After that, and more specifically after 2013, its share declined. Regarding value added and gross output, the downward tendency is even stronger, considering their almost zero rates of growth and the persistence of a downward trend in the value added share after 2010. This group seems to be the most affected by the increasing external competition, notably after the crisis, as we pointed in Chapter 1.

Figure 10 below (Brazilian export basket) is useful to understand the issue of regressive specialization since it shows the share of the four extractive and manufacturing industries (EMI) groups in Brazil's total exports. Through that, we observe an increase in the share of extractive and manufacturing groups, which expresses the trend toward a regressive specialization from 2000 to 2015. Those groups are Agricultural and related (AGR) and MQC. In the case of MQC, the growth pattern is the most remarkable, particularly 2002 onwards. It accelerates between 2004 and 2011, except in 2009, due to the international crisis. Between 2003 and 2008, MQC grew at a higher rate (around 15%) than the world exports (14%). The increase of the AGR group in Brazilian export basket happens mainly after 2009 and has a steady trajectory of growth. The AC maintains its share in Brazilian exports in relative terms.

Figure 10 – Share (%) of the extractive and manufacturing industries groups in total Brazilian exports, 2000-2015



Source: Author's calculations based on information from the SNA/IBGE.

Note: The sectoral information exports are calculated using the sectoral deflators adjusted to the gross output deflator (to maintain additivity), obtained by the information in current and previous' years prices from SUT published by IBGE. However, it, in fact, represents the nominal share, since both numerator and denominator is the same. See chapter 3, section 3.7.2 for further information.

The innovative manufacturing industry presented the most significant loss of share in the Brazilian exports. Comparing to the other groups, it turned from the first position (around

25% in 2000) to the third one in 2015 (15%), but with three phases along the period. Its share remained unchanged between 2000 and 2005, later declining by almost 10pp, falling from around 25% to 15% (2005-2009). Since 2010, there is relative stability, at least until 2015.

Through the empirical evidence, a possible interpretation is that the process of regressive specialization has been happening in the Brazilian economy if we consider as a measure the greater share of goods with low technological content and lower shares of TM and IM. However, we must be careful with this interpretation because an essential aspect of analyzing the export basket is the effect that changes in relative prices have on it. We should highlight that since 2003 there has been an increase in the raw materials prices and a reduction in manufacturing prices. Consequently, this trend has contributed to enhance the relative importance of AGR, MQC and AC goods and decrease the share of traditional and innovative manufacturing industries.

2.4 Labor Productivity

Labor productivity is another central element in the analysis of structural change. Since its pattern potentially affects the employment dynamics, we must analyze this aspect through a broader overview of Brazilian structural change. In the literature on this topic, there are different ways in which we can calculate labor productivity, but here we decided to use the usual concept underlying the relationship between the real value added[23] and employment. Through this method, we can explain changes in labor productivity as a combination of what happens regarding value added and the overall economic activity.

Observing the whole period at a glance, we can identify a close relationship among the value added (GDP), and productivity growth, as shown in Figure 11. This result corroborates the Kaldorian/Structuralist view, expressed in the Verdoorn Law (discussed in Chapter 1), according to which the labor productivity growth follows the rate of capital accumulation.

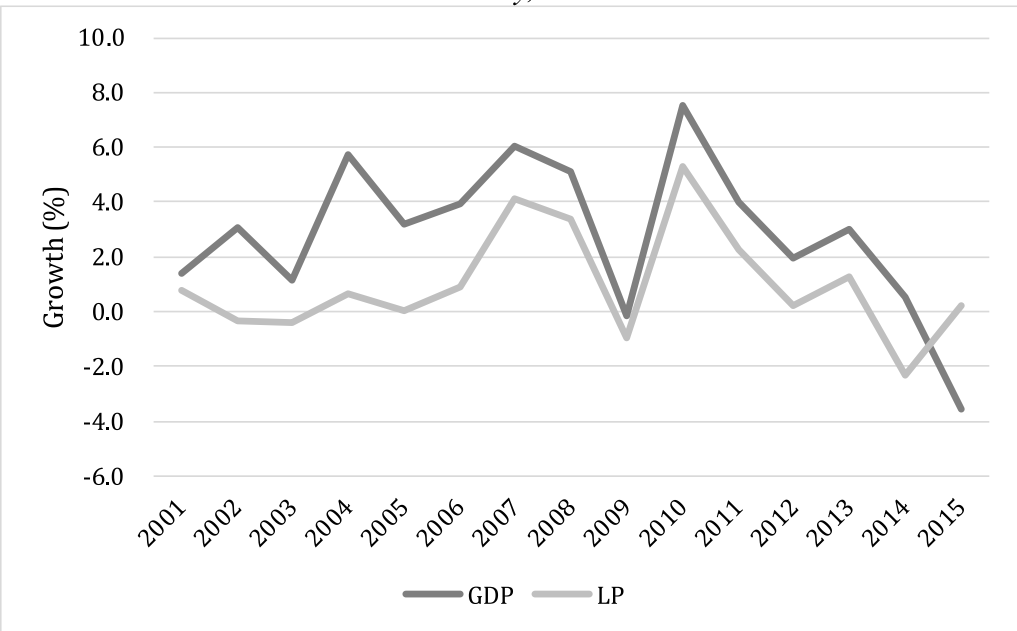
In the first part of the period, between 2001 and 2003, labor productivity growth shows a slight decline. However, from 2005 until 2010 (except 2009[24]) its rate of growth accelerates, as a result of the combined effect of value added booming and the employment is growing at a stable rate (around 2%). Afterward, between 2011 and 2014, a slowdown in labor productivity

[23] We calculate the value added share using the value added deflator, obtained by the information in current and previous' years prices from SUT published by IBGE.

[24] Note, however, that the rate of growth of employment maintained a positive value in 2009 (0.88%), implying a significant decline in labor productivity of approximately 1.0%.

growth takes place, following what was happening to the Brazilian economy (downturn in economic activity). The crisis paradoxically explains the slight growth in labor productivity in 2015 since the level of employment decreased more than value added did.

Figure 11 – Annual growth for GDP and labor productivity (LP) for the Brazilian economy, 2001 to 2015



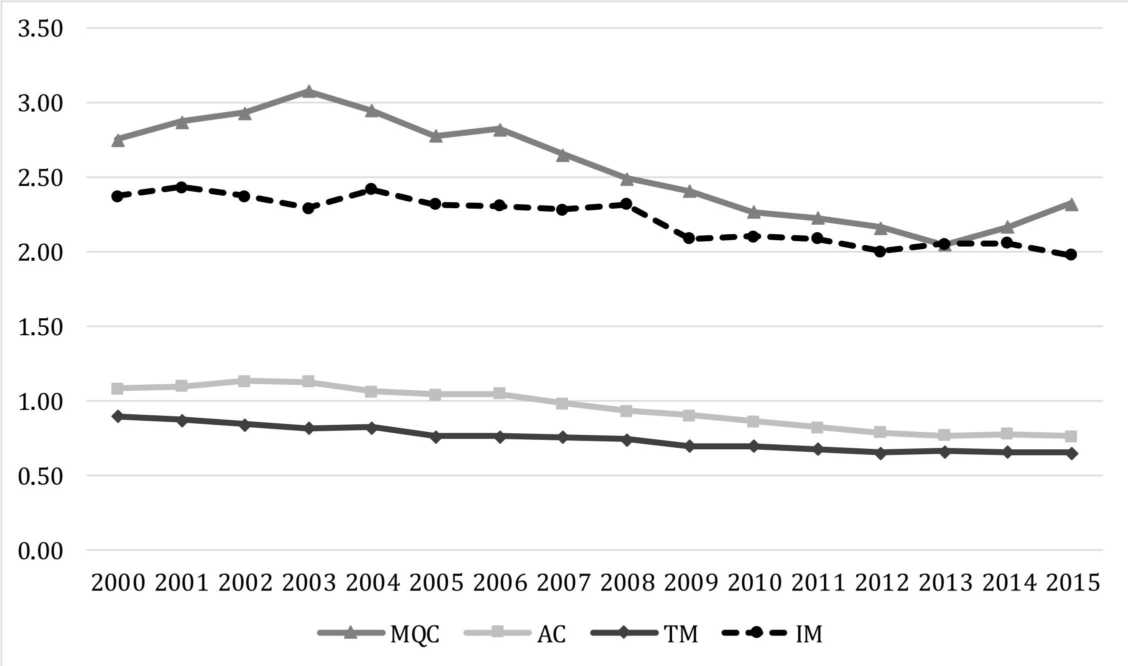
Source: Author's calculations based on information from the SNA/IBGE.
Note: We calculate the value added used in the measure of labor productivity using the value added deflator, obtained by the information in current and previous' years prices from SUT published by IBGE.

Another relevant aspect to consider is the relation of extractive and manufacturing industries productivity vis-a-vis the entire economy's productivity. Figure 12 clarifies whether each group has its productivity above (higher than one) or below (lower than one) than the overall economy's rate. An overview shows that, except for the TM group, all of them have higher labor productivity than the whole economy's average.

Figure 13 shows the annual average growth of labor productivity of the groups. The MQC and IM are the groups with the highest productivity, and the gap between them is shrinking. Moreover, MQC decline has been steeper than IM. In its turn, the IM group maintained its relation relatively stable until 2008, expanding at the same average rate (1.8%) of total productivity, but afterward, the gap between them has reduced[25].

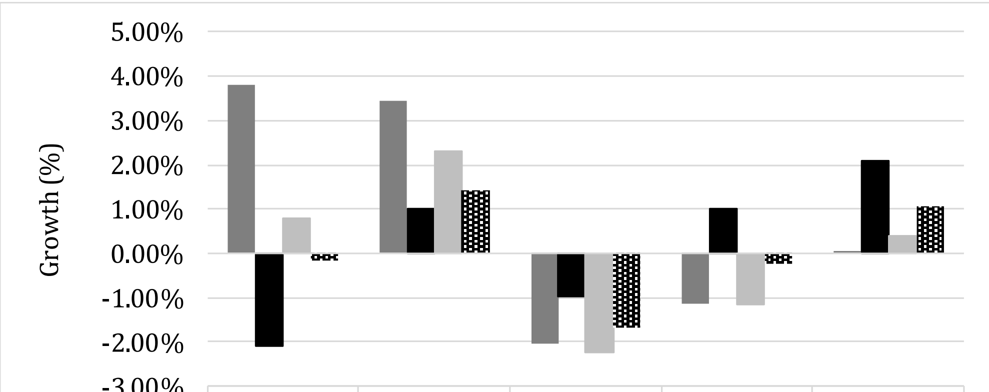
[25] As the productivity is calculated using the value added, the changes in the relative prices interfere in the analysis. To overcome this limitation, we will discuss in Chapter 4 the decomposition of productivity growth in order to have an accurate measure.

Figure 12 – Labor productivity of extractive and manufacturing industries groups in comparison to the average labor productivity of the economy



Source: Author's calculations based on information from the SNA/IBGE.
Note: We calculate the value added used in the measure of labor productivity using the value added deflator, obtained by the information in current and previous' years prices from SUT published by IBGE.

Figure 13 – Annual average growth of labor productivity (%) for the Brazilian economy and extractive and manufacturing industries groups, 2000 to 2014 and selected periods



	MQC	AC	TM	IM	Total economy
2000-2003	3.79%	3.46%	-2.05%	-1.15%	0.01%
2003-2008	-2.11%	1.00%	-0.97%	1.02%	2.10%
2010-2014	0.81%	2.32%	-2.23%	-1.14%	0.39%
2000-2014	-0.15%	1.41%	-1.66%	-0.25%	1.06%

Source: Author's calculations based on information from the SNA/IBGE.

Summing it up, we conclude that almost all groups declined their productivity in the sub-periods under analysis. However, between 2003 and 2008 the IM productivity grew faster the whole economy's average. We attribute this trend to the Kaldor-Verdoorn law and its intrinsic positive relationship between capital accumulation and productivity growth. Therefore, since the latter affects the employment structure, the growing tendency is the main explanation for the positive outcome of the IM group in that sub-period. Furthermore, as highlighted in many parts of this chapter, changes in relative prices do have a major effect on the value added. Thus such a phenomenon may contribute to a biased measure of IM productivity growth.

3 METHODOLOGY

The input-output framework has been used as a useful tool to do a multisectoral analysis and analyzing the structural change, as highlighted in Chapter 1. The data provided in the IO tables provides the researches disaggregated information about sectoral measures, such as the value added, gross output, imports, exports, final demand, and employment. Using them it is possible to construct indicators to characterize the economic structure, and in this turn, to analyze the structural change of a country.

Moreover, we will use another method to discuss the process of structural change that is the structural decomposition analysis. It was already used by the classical development literature to analyze the structural change considering the input-output relations (DIETZENBACHER, LOS, 1998; MILLER, BLAIR, 2009).

We must point out some limitations of the IO model in analyzing structural change. Two hypotheses are central in this model. The first one is the proportionality, directly connected with the Leontief's production function in the model. The technical coefficients measure fixed relationships between the sectoral output and its input. Both conditions make production in a Leontief system operating under constant returns to scale. Then, the economies of scale are absent when the production increases, i.e., due to a reduction in the transition cost and others factors.

The other important aspect is homogeneity, where each commodity or group of commodities is produced only by one industry. So, each industry produces a set of products that correspond to some industrial classification. In the Brazilian model, IBGE uses the technology of the sector, which means that the technology to produce commodities is the one attributed to the industries.

To understand the basic concepts involved, we present in section 2 a brief overview of the I-O model. To analyze the structural change process in the Brazilian economy, we constructed a long-term series of IOT tables for the Brazilian economy at current and previous' year prices, based on partial information from the Brazilian SNA and I-O matrix official statistics (IBGE, 2015; 2016). We present the methodological procedures used in the construction of this database in section 3.

Since our goal is to include relative price changes in the context of the I-O model and structural decomposition analysis in the Brazilian case, we also use I-O tables valued at **constant and constant relative prices,** as proposed in Casler (2006), Dietzenbacher and

Temurshoev (2012), Hillinger (2002) and Reich (2008). Thus, we present the deflation method in section 4.

In Section 5, we present the I-O model incorporating the distinction between relative price and volume changes for all variables in the model. In section 6 we present the sectoral level of analysis used in this work. In section seven, we present the structural decomposition for an I-O model that explicitly disentangle volume changes from relative prices changes.

3.1 The input-output model

The Brazilian Institute of Geography and Statistics (IBGE) compiles the Brazilian IOT according to product-by-industry accounting approach (Miller & Blair, 2009). We present the structure in Table 6 below (IBGE, 2016)[26].

Table 6 – Input-Output structure

	Domestic products	Industries	Final demand	Gross output
Domestic products		$\mathbf{U_d}$	$\mathbf{F_d}$	$\mathbf{q}$
Imported products		$\mathbf{U_m}$	$\mathbf{F_m}$	$\mathbf{M}$
Industries	$\mathbf{V}$			$\mathbf{x}$
Taxes		$\mathbf{T_U}$	$\mathbf{T_F}$	
Value added		$\mathbf{y}'$		
Gross output	$\mathbf{q}'$	$\mathbf{x}'$		

Source: IBGE (2016).

We present the description of each variable below:

$\mathbf{V}$ $(n \times m)$	the make matrix: shows for each industry (n) the production value of each of the products (m)
$\mathbf{q}$ $(m \times 1)$	gross output by product;
$\mathbf{U_d}$ $(m \times n)$	intermediate domestic consumption matrix: presents for each industry the value of the product of internal origin consumed;
$\mathbf{U_m}$ $(m \times n)$	intermediate imported consumption matrix: presents for each industry the value of the products of external origin consumed;
$\mathbf{F_d}$ $(m \times \varphi)$	the matrix of the final domestic demand in the dimension of products and of the value of domestic products consumed by final demand categories (φ). In this case, the final demand is composed by households consumption, non-profit institutions serving households, general government expenditures, gross fixed capital formation, exports and inventory changes);
$\mathbf{F_m}$ $(m \times \varphi)$	the matrix of the final demand for imported products: presents the value of the products of external origin consumed by the final demand components;

[26] Here, we follow the regular notation, denoting matrices with bold capital letters and vectors with bold lower-case letters; vectors are column vectors, and, thus, a row vector is represented by a transposed column vector.

$\mathbf{T_U}$ $(m \times n)$	the matrix of values of taxes and subsidies associated with products, incident on goods and services absorbed (inputs) by productive industries;
$\mathbf{T_F}$ $(m \times n)$	the matrix of taxes and subsidies associated with products, incident on goods and services absorbed by the final demand;
$\mathbf{x}$ $(n \times 1)$	gross output by industry;
$\mathbf{y}$ $(n \times 1)$	sectoral value added.

From an expenditure point of view, we can express the vector of gross output by product ($\mathbf{q}$, $m \times 1$, where m is the number of products) as the sum of total domestic intermediary and final demands vectors:

$$\mathbf{q} = \mathbf{u_d^q} + \mathbf{f_d^q} = \mathbf{U_d i} + \mathbf{F_d i} \qquad (1)$$

where $\mathbf{i}$ represents a unitary or summation vector[27], $\mathbf{u_d^q}$ $(m \times 1)$ represents the total intermediate demand by product, and $\mathbf{f_d^q}$ $(m \times 1)$ the total final demand by product. On the other hand, from the production viewpoint, we obtain the vector of total gross output by product from the make matrix ($\mathbf{V}$, n × m), as follows:

$$\mathbf{q} = \mathbf{V'i} \qquad (2).$$

Further, we can also obtain the gross output by industry ($\mathbf{x}, n \times 1$), as follows:

$$\mathbf{x} = \mathbf{V.i} \qquad (3).$$

Thus, as the summation of the components of the vectors $\mathbf{x}$ (gross output by sectors) and $\mathbf{q}$ (gross output by products) has the same value, we obtain the following relations below:

$$\mathbf{i'x} = \mathbf{i'Vi} = \mathbf{i'V'i} = \mathbf{i'q} \qquad (4).$$

IBGE basis the Brazilian IOT compilation on the industry technology assumption, which means that each industry uses the same technology to produce each of its products. Based on that, to transform all information that has the dimension product-by-industry, we distribute all product demand using a market share matrix. This expresses the share of each industry in the production of each product. The mathematical representation is:

$$\mathbf{D} = \mathbf{V\hat{q}^{-1}} \qquad (5)$$

where $\mathbf{D}$ $(n \times m)$ is the market share matrix, and $\mathbf{\hat{q}}$ is the gross output by product diagonal vector. Thus, by definition, if we pre-multiply the gross output by product matrix by the market share matrix, we will arrive at the gross output by industry matrix:

$$\mathbf{x} = \mathbf{Dq} \qquad (6).$$

This procedure is also valid to any other matrix or vector in the model that we want to transform a dimension product-by-industry to industry-by-industry.

[27] To simplify the exposition, we will omit the dimension of the summation vector. The latter can be easily inferred from the context in which these vectors are used.

One central aspect of the input-output model is the matrix of domestic technical coefficients of production. This relation represents the requirement of domestic intermediate inputs in the production of one unit of industrial output. In the dimension product-by-industry, the domestic technical coefficients ($\mathbf{B_d}, m \times n$) is calculated by the ratio of domestic intermediate inputs ($\mathbf{U_d}, m \times n$) to gross output:

$$\mathbf{B_d} = \mathbf{U_d}.\hat{\mathbf{x}}^{-1} \qquad (7).$$

Rearranging the previous equation, we can calculate the requirements of intermediate inputs $\mathbf{U_d}$ considering the technical relation, based on the actual output level. In this way,

$$\mathbf{U_d} = \mathbf{B_d}\hat{\mathbf{x}} \qquad (8).$$

Replacing (8) in (1), we have the gross output vector as a function of the domestic technical coefficients of production:

$$\mathbf{q} \ = \ \mathbf{B_d}\hat{\mathbf{x}}\mathbf{i} + \ \mathbf{f_d^q} \qquad (9).$$

Knowing that $\hat{\mathbf{x}}\mathbf{i} = \mathbf{x}$ and pre-multiplying the previous equation by the market share matrix, we have:

$$\mathbf{Dq} \ = \ \mathbf{DB_d x} + \ \mathbf{f_d^q}$$

$$\mathbf{x} = \ \mathbf{DB_d x} + \ \mathbf{Df_d^q} \qquad (10).$$

If we denote

$$\mathbf{A_d} = \mathbf{DB_d} \qquad (11)$$

as the domestic technical coefficients by industry ($n \times n$) and

$$\mathbf{f_d} = \mathbf{Df_d^q} \qquad (12)$$

as the final domestic demand by industry ($n \times 1$), we can express the gross output by industries as follows:

$$\mathbf{x} \ = \mathbf{A_d x} + \mathbf{f_d} \qquad (13).$$

Solving the model to the gross output, we obtain:

$$\mathbf{x} \ = (\mathbf{I} - \mathbf{A_d})^{-1}\mathbf{f_d} \qquad (14)$$

where $\mathbf{I}$ is an identity matrix ($n \times n$) and $\mathbf{Z} = (\mathbf{I} - \mathbf{A_d})^{-1}$ ($n \times n$) is the inverse Leontief (or impact) matrix that gives us the direct and indirect requirements of production to satisfy an additional unit of final demand.

3.2 Estimating a consistent series of input-output tables for Brazil from 2000 to 2015

One of the difficulties of conducting a long-term analysis of the productive structure of the Brazilian economy is the availability of input-output databases (i.e., the IOT). The main problem is the changes in the Brazilian Systems of National Accounts (SNA) methodology. It changed from SNA 2000 to SNA 2010, the latter incorporating the recommendations of SNA 2008 (UN, 2009). IBGE periodically releases Brazilian IOT, with an interval of five years, but the previous existing IOT (i.e., 2000 and 2005 in the SNA 2000) are not comparable with the most recent ones (i.e., 2010 and 2015 in the SNA 2010)[28].

The new SNA 2010 includes changes in conceptual and methodological recommendations, as well as the expansion of sources of information[29] used for the Brazilian economy and a new classification of products and activities integrated with National Classification of Economic Activities - CNAE 2.0[30] (IBGE, 2016). In the case of gross fixed capital formation (GFCF), there was the expansion of the concept of fixed capital assets, highlighting, for example, the importance of intellectual property assets (IBGE, 2016). These changes had an impact on the results obtained for large economic aggregates such as GDP (Gross domestic production) and GFCF, for example. Therefore, it is not possible to make a direct link between IOT 2000 and 2005 (published in the SNA 2000) and IOT 2010 and 2015 (SNA 2010) due to the significant methodological changes in the SNA.

To keep data compatible over time, IBGE (2015) published a retropolated series of Supply and Use Tables (SUT) for 2000 to 2009 in the SNA 2010. Nevertheless, IBGE did not republish the IOT 2000 and 2005 in the SNA 2010, and that represents a major difficulty associated with obtaining structural information from the IOT.

After some tests[31], we decided to estimate the entire series using the structural information from the SNA 2010. We are aware that this procedure leads us to the loss of the

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[28]Guilhoto and Sesso Filho (2005; 2010) provide inside NEREUS research group an estimative for the Brazilian IOT from 1995 and 2013, but they are not compatible over time and are published in different aggregation level. They have three different series: i) 1995 to 2009 with 42 industries and 80 products (SNA 2000); ii) 2000 to 2009, with 55 industries and 110 products (SNA 2000) and iii) 2010 to 2013, with 68 industries and 128 products (SNA 2010). There is also another database that could be used to analyze the Brazilian economy in the period, the World Input-Output Database (WIOD). Timmer et al (2015) presents the first estimative of this database for several countries from 1995 to 2009 in current and previous' year prices. Recently, Timmer et al (2016) proposes a review in the previous database, and expand the period of analysis, from 2000 to 2014. However, they are only available in current prices, so it is not possible to use this data to investigate the structural change considering the effect of the relative prices.

[29] Such as intermediate consumption, with the introduction of the Intermediate Consumption Survey (PCI, in portuguese), tax structure, trade and transportation margins, Federal Revenue data, new agricultural and demographic censuses, and changes in the Household Budget Survey (POF, in portuguese).

[30] This classification is in conform with the International Standard Industrial Classification of All Economic Activities (*ISIC*) from United Nations industry classification system.

[31] After proposing a product and industry correspondence tables, we used the method developed by Grijó and Berni (2006) to estimate a new version of IOT 2000 and 2005 using the data in the SUT 2000 and 2005 in the SNA 2010, but with the structure of IOT 2000 and 2005 in the SNA 2000. Then, we compared the originals IOT 2000 and with the estimated ones, using statistical measures such as mean, standard deviation and coefficient of variation. After that we found that there were significant changes in the structural information. The correspondence table was necessary because the product and industry aggregation levels in the two SNA

structural information available in IOT 2000 and IOT 2005, especially for the years far from 2010. However, this is the cost to obtain a long-term series, given the methodological changes that characterized the evolution of the Brazilian SNA in the period under analysis.

Another task was to reconcile the maximum disaggregation level of retropolated SUTs (2000-2009) and IOT 2010/2015. We constructed product and industries correspondence tables, based on the comparison of the SUT published for 2010 to 2015 in the retropolated level (51 industries and 107 products) and the maximum level of disaggregation (68 industries and 128 products). After that, we arrived at a maximum level of disaggregation of 42 industries and 91 products. The correspondence tables are available in Appendix B[32].

We used IOT updating techniques recommended by the specialized literature[33], and specifically the proposal of Grijó and Bêrni (2006) for the Brazilian economy. Such methods suggest the use of structural information (named mark downs) from official IOT to estimate annual IOT for the years not covered by official statistics. This methodology consists in calculating using a bench-mark IOT the ratios of domestic and imported use tables in producer's prices, transportation margin, trade margin and net taxes[34] as a proportion of the Use Table measured in purchaser's prices. We show more details in Appendix C.

We used different procedures to estimate the series between 2000-2009 and 2011-2014, as can be seen in Table 7 below. For the first period, we used the IOT 2010 aggregated to 42 industries and 91 products as the source of structural information to calculate the mark-downs. For IOT 2011-2014, we estimated them in the same disaggregation level of the IOT 2010, which is 67 industries and 123 products[35]. Finally, to complete the series we used the official IOT 2015 released by IBGE (2018). To have an entire IOT series at the same aggregation level, we aggregated the IOT 2011 to 2015 to the 42 industries and 91 products.

changed. In the SNA 2000, the most detailed level of information available was 55 activities and 110 products, using CNAE 1.0 as a reference. In the retropolated SUT in the SNA 2010, the most disaggregated level has 51 industries and 107 products and it used CNAE 2.0 as a reference. We constructed this correspondence using the official IBGE correspondence tables for CNAE 1.0 and SNA 2000 and CNAE 2.0 and SNA 2010. After that, we were able to arrive at a maximum level of disaggregation of 42 industries and 91 products.

[32] In total, there are six correspondence tables. There are three for products: 110 (SNA 2000), 107 (SNA 2010, retropolated) and 128 (SNA 2010, disclosure level) to 91 products; and three for industries: 55 (SNA 2000), 51 (SNA 2010, retropolated) and 68 (SNA 2010, disclosure level) to 91 products.

[33] Bulmer-Thomas (1982) e Miller and Blair (2009), Kurz, Dietzenbacher and Lager (1998) e Bacharach (1970).

[34] Although IBGE published in IOT 2010 the Trade and Transportation margins and Net taxes of subsidies by classification of origin (disaggregating between domestic and imported) we decided to use the total tables (domestic plus imported) as reference for the calculation of the mark-downs.

[35] Although the maximum level of IOT disaggregation is 127 products, we had to aggregate the transportation products to proper do the CIF-FOB adjustment and the estimation. For further information, see Appendix C.

Table 7 – IOT series from 2000-2015: source and aggregation level

Year	Source	Agregation level	Common level
2000-2009	Estimated based on IOT 2010 (SNA 2010) and retropoled SUT (SNA 2010)	42 industries and 91 products	42 industries and 91 products
2010	IBGE	67 industries and 127 products	42 industries and 91 products
2011-2014	Estimated based on IOT 2010 (SNA 2010) and SUT 2011-2014 (SNA 2010)	67 industries and 123 products	42 industries and 91 products
2015	IBGE	67 industries and 127 products	42 industries and 91 products

Source: Author's elaboration based on information from the SNA/IBGE.

In the next section we present the procedures to construct a deflated input-output table series based on this aggregation level.

3.3 Deflated input-output tables series between 2000 and 2015 for Brazil

In an input-output series, the deflation of IOT is essential to control the price variation as well as of relative prices changes over time. In the specialized literature, there are several methods used for deflating IOT. For the Brazilian case, as commented in Chapter 1, although Persona and Oliveira (2016) and Magacho, McCombie, and Guilhoto (2018) deflate the IOT to consider the effects of the exchange rates' volatility and relative price changes and analyze prices effect and quantity separately, we argue that both methods are insufficient to exclude the relative prices changes in the structural decomposition analysis.

Persona and Oliveira (2016) uses the double deflation method, the most traditional one as a deflating method. It consists of using gross output product deflators to obtain deflated intermediate and final demand. The value added is obtained as a residual, using the deflated sectoral gross output and intermediate demand. After that, we can calculate the price deflator for the value added as a result. However, this method causes distortions in the deflated input-output table coefficients, changing the contribution of sectors with highest price variations[36]. Magacho, McCombie, and Guilhoto (2018), by another side, use quantum Laspeyres indices to construct a series in volume. However, a desired property when dealing with price or quantum indices is absent in this method, because it does not conserve the additivity property.

Another method commonly used in the specialized literature is a heuristic approach using RAS method for the estimation of intermediate consumption from the deflated vectors

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[36] We will present in the methodological part of the thesis.

(DIETZENBACHER; HOEN, 1998; MILLER; BLAIR, 2009). In comparison to the double-deflation method, RAS method requires more exogenous information to perform the deflation in an appropriate way, such as the deflated vector of value added and imports per activity, or the final demand vector. Unfortunately, many statistical institutes do not offer such information, which makes it impossible to apply this method.

Although these methods are concerned with the measurement of the IOT at the same level of prices of a given year, little attention is given to the relative price changes that occur over time. Some studies focused on calculating sectoral productivity, based on the index number theory, developed methodologies to include this effect in the input-output models properly, such as the proposals of Casler (2006), Hillinger (2002) and Reich (2008). Based on them, we construct a Brazilian IOT series at constant relative prices for the period from 2000 to 2015. The update is conducted based on a preliminary version of this methodology developed by Neves (2013) for the Brazilian economy between 2000 to 2009.

The stages of this deflation methodology define the structure of the following subsections. First, we discuss the need to account for relative prices change to obtain a consistent deflated series over time and sectors/products. Then, we present the proposed deflation method, and finally, we show the necessary procedures for the empirical application for the Brazilian economy.

3.3.1 Additivity property and relative prices

Nowadays, official institutes of statistics publish the SNA data considering chained indices. The substitution of direct Laspeyres indices created the additivity problem in national accounts (BALK, REICH, 2008). While in the Laspeyres system the problem is inexistent, since there is a fixed-base in the reference period, in the chain indices the relative price vector changes yearly. For a large series, the chaining indices lead to a loose in the additivity[37], because each year has a different relative price relation. Additivity, in the context of national accounts, means that the order the researcher choose to conduct the deflation and aggregation operations should be interchangeable. In other words, to first deflate and then aggregate the values should yield the same result as when the same operations are conducted in the reverse order (BALK; REICH, 2008).

[37] In analyzing the history of choosing the most appropriate method, there was a conflict between the use of more accurate and updated information by adopting chained indices, on the one hand, and the additivity of national accounts, on the other. The non-additivity was "the lesser of two evils" to maintain the accuracy in the SNA, and nowadays is the most common in SNA (BALK, REICH, 2008).

Various authors, like Hillinger (2002), Balk and Reich (2008), Diewert (1998, 2015), Dumagan (2008) argue that the root of this non-additivity problem is due to changes in relative prices. So, by sorting away the variation of relative form the absolute price of a product, it is possible to construct additive results in the accounts.

> The absolute price (nominal price) is given by the amount of money paid in exchange for a unit of a commodity. Money itself, however, is not invariable in its purchasing power, but subject to more or less inflation. The variation is measured by the general price level, which is (more or less arbitrarily) defined as an average over the prices of all commodities. The relative price is then the price of a commodity relative to the chosen basket of all commodities, which we may then call the "real" price in analogy to the real wage or the real interest, known in macroeconomic analysis (BALK; REICH, p. 168).

Hence, the nominal price of a product is the result of the changing of two different aspects: one is the inflation over time, and the other is the relative prices.

A well-known example of the non-additivity problem in the national accounts is the demand side GDP decomposition[38]. If all the components of the GDP are deflated by their deflator (for example, household consumption, gross fixed capital formation, government expenditures, and exports) and then aggregated, it will not be equal to the GDP deflated by its deflator. The non-additivity happens because the relative price of each GDP's demand components about the GDP deflator is different and usually changes over time. The problem of additivity only would be absent if all the deflators were the same. In the context of IOT, this problem is even more complicated, since the discrepancy occurs for the totals as well as inside the IOT (by industry or product, and intermediate and final demand – or, by rows and columns). To overcome this problem, in the next sections we present the deflation methodology for the IOT that allows the maintenance of the additivity property.

3.3.2 The deflation method

In this section, we present the deflation method suggested by Balk and Reich (2008), Diewert (1995, 2015), Dumagan and Balk (2016). They first deflate all the database (price vectors) by the most aggregate deflator, which, in the I-O context, is the total gross output. This step eliminates the inflationary effect, putting all the variables in the price of a single chosen base period. After that, they adjust the volume index considering the changes in relative prices

[38] See Freitas and Dweck (2013) and Dugaman (2011).

(cell-specific price indices about the whole economy) to obtain the additivity property holding for multiple-base periods.

In our case, we prefer to present the method in the reverse order, first constructing cell-specific price indices, where the additivity property is not valid, and then making the proper adjustment for relative prices, to obtain the addictive series. From a user point of view, we argue that presenting the deflation method this way makes it easier to understand the problem of non-additivity and the changes in relative prices. It does not alter the results, and the steps are interchangeable.

3.3.2.1 Cell-specific price indices

The main characteristic of the deflation method we propose in this work is the cell-specific price indices as deflators. In this sense, we have a price index for each combination of producer/seller and purchaser/buyer existent in the IOT structure, as well as for the totals.

Let $(p^t q^t)_{ij}$ be the individual value of each cell of the tables in the system for a year *t*, where p and q represent, respectively, the price and quantity of each product i and industry j. We calculate the cell-specific price index (λ_{ij}) between two periods $(t, t-1)$ as being the ratio of each element in current and previous' year prices for each pair of years, as follows:

$$\lambda_{ij}^{t-1,t} = \frac{(p^t q^t)_{ij}}{(p^{t-1} q^t)_{ij}} \tag{15}$$

with $t = 2001, \ldots, 2015$.

As we are dealing with more than one period, the next step in the deflation process is to calculate the chained price indices for a fixed-base period. We calculate them by multiplying all the individual price indices from the first year up to the last year in the chain. The cell-specific chained price index, taking the year of 2000 as the base, up to the period τ $(\Lambda_{\mathrm{ij}}^{2000,\tau})$ is defined as:

$$\Lambda_{\mathrm{ij}}^{2000,\tau} = \prod_{t=2001}^{\tau} \lambda_{ij}^{t-1,t} \tag{16}$$

with τ being the last year of the desired chained index. As 2000 is the first year of the series, when $t = 2000$, we define $\Lambda_{\mathrm{ij}}^{2000,2000} = 1$. So, for example, to obtain the chained price index for $\tau = 2003$, we have:

$$\Lambda_{\mathrm{ij}}^{2000,2003} = \prod_{k=2001}^{2003} \lambda_{ij}^{t,t-1} = \lambda_{ij}^{2000,2001} \times \lambda_{ij}^{2001,2002} \times \lambda_{ij}^{2002,2003} \qquad (17).$$

As the period analyzed in this work goes from 2000 to 2015, we calculate the chained indices for each final year of the period t, having in total fifteen chained indices.

We adopt 2010 as the relative price base year since this year is the reference year of all estimated matrices. To modify the base year, we divided the chained price index of a specific year *t* by the chained price index for 2010, as:

$$\Lambda_{\mathrm{ij}}^{2010,\tau} = \frac{\Lambda_{\mathrm{ij}}^{2000,\tau}}{\Lambda_{\mathrm{ij}}^{2000,2010}} \qquad (18).$$

So, when τ=2010, $\Lambda_{\mathrm{ij}}^{2010,2010} = 1$. This way, all chained indices (and after, all variables in the output model) are expressed in prices 2010' prices.

3.3.2.2 Constant relative prices and constant prices

In the cell-specific deflation method, each cell is deflated by its chained cell-specific deflator for the period *t*. So, to have a series of IOT valued at 2010's prices, we have to divide each element of the IOT for the chained index up to year *t*. Thus, for a generic matrix element $\mathrm{R_{ij}}$, we have:

$$\mathrm{R}_{\mathrm{ij}}^{2010,\tau} = \frac{\mathrm{R}_{\mathrm{ij}}^{\tau}}{\Lambda_{\mathrm{R_{ij}}}^{2010,\tau}} \qquad (19)$$

where **R** is one of the IOT that we want to deflate (i.e., supply table and use table – domestic and imported, respecting its own structure) and $\Lambda_{\mathrm{R_{ij}}}^{2010,\tau}$ is the specific cell-deflator for this table. That is, we divide all the elements of each table in the period τ by its own accumulated cell-specific deflator up to τ. We name this series of tables that is obtained from this procedure **constant relative prices** because all entries are evaluated in of prices 2010, representing the *volume units*.

As we divide each cell by its cell-specific deflator, the series valued at 2010's constant prices lose its additivity property over products and industries. This way, the sum of the deflated products in industry *j* (by the cell-specific deflator) is different from the total deflated by the total deflator. This nonadditivity results from the changes in the "real" purchasing power of each industry (the relative prices divided by the total gross output deflator). The same happens if we look at the purchaser industries (the intermediate and final transactions of the use table). Thus, deflating all the elements and aggregating them later or deflate the aggregate directly is not interchangeable because the changes in the relative prices cause a breakdown of the additivity property.

To obtain the additivity, we must account for the change of the "real" purchaser power of each industry in relation to the economy´s general price changes. We do that by calculating the relative prices ratio (Φ_{ij}) as a division of each cell-specific chained price index by the chained total gross output deflator ($p^{2010,\tau}$):

$$\Phi_{ij}^{2010,\tau} = \frac{\Lambda_{R_{ij}}^{2010,\tau}}{p^{2010,\tau}} \quad (20).$$

By multiplying the constant relative price value by this relative price ratio, we obtain a **constant prices** IOT series, that also name *total units*, that preserves the property of additivity over time by-products and industries. Another way to interpret the procedure is that the total gross output is being calculated through a weighted average of the sectoral production.

$$R_{ij}^{2010,\tau,\Phi} = \Phi_{ij}^{2010,\tau} \times R_{ij}^{2010,\tau} \quad (21).$$

If we take a deeper look into the previous equation, doing the proper substitution of (19) and (20) in (21), we notice that we are deflating all the data by only one deflator, the total gross output deflator[39].

$$R_{ij}^{2010,\tau,\Phi} = \frac{\Lambda_{R_{ij}}^{2010,\tau}}{p^{2010,\tau}} \times \frac{R_{ij}^{\tau}}{\Lambda_{R_{ij}}^{2010,\tau}} = \frac{R_{ij}^{\tau}}{p^{2010,\tau}} \quad (22).$$

Using only the general deflator (in our case, the gross output deflator) is the easier way of deflating an IOT and maintain its additivity. However, having the information of cell-specific deflators and isolating the relative price ratio from the gross output is very useful to capture the effect of changes in the volume of each variable.

In Appendix D we present a hypothetical example of this deflation method procedure, this enables us to highlight some properties of the deflation method, its differences with the double-deflation method, and also the implications for the technical coefficients.

[39] In fact, this is the way that Reich and Balk (2008) and Reich (2008) presents the deflation method. First, they deflate the table considering the most aggregate deflator and then adjust for relative prices changes. At the end, the result is the same. However, we think that presenting that way is clear to understand the matter of non-additivity in a user point of view.

3.3.3 Empirical application

The main characteristic of the deflation method we propose in this work is the use of cell-specific price indices as deflators. The main tables in the IO model and the ones we are going to deflate are:

- Make matrix ($\mathbf{V}$);
- Use of products in purchaser's prices ($\mathbf{UT_t^{pu}}$);
- Use of domestic products in producer's prices ($\mathbf{UT_n^{pr}}$);
- Use of imported products in producer's prices ($\mathbf{UT_m^{pr}}$);
- Use of total products in producer's prices ($\mathbf{UT_t^{pr}}$).

To construct them we must have all IOT of the series, valued at current and previous' year prices. However, in the Brazilian SNA published by IBGE, IOT tables valued at previous' year prices are inexistent. To fill this gap, we estimate all IOT based on the SUT, using the recommendation of Dietzenbacher and Hoen (1998), which suggests that we can use the same IOT structure at current prices to estimate the IOT valued at previous's year prices.

The same estimation method used is the same as the one used to estimate IOT applied for current prices, based on Grijó and Bêrni (2006). Thus, we use the retropoled SUT series in previous year's prices of 2000 to 2009, and the structural information of IOT 2010, both data at the common level of 91 products and 42 industries. For 2010 to 2015 we use the series already available in the SCN 2010 valued at previous years prices. The IOT for 2010 to 2014 are estimated using the IOT 2010 structure at most disaggregate level (123 products and 67 industries). For 2015 in previous' year prices we use the IOT 2015 structure. The final step is applying the RAS method in the version proposed by Termushoev, Miller, and Bowmaster (2013) to balance the estimates according to the values published in the previous' years prices SUTs.

After this estimation process, we can calculate all cell-specific prices indices and apply the proposed methodology for 2000 and 2015[40].

[40] When calculated, some cell-specific price indices calculated for the Make matrix and Use Table in purchaser's prices (using the official SUT published by IBGE) were null or infinite. This is an inconsistency and we explain in details the proper adjustment in the SUT tables is Appendix C.

3.4 IO model in the context of relative prices

In this section, we present the IO model in the context of relative prices. The total sectoral output vector (in constant prices) is a combination of the sectoral relative price ($\mathbf{x^p}$) and the gross output in volume ($\mathbf{x^v}$):

$$\mathbf{x} = \hat{\mathbf{x}}^{\mathbf{p}}\mathbf{x}^{\mathbf{v}} \tag*{(23).}$$

The $\mathbf{x^v}$ is the gross output in constant relative prices (volume units), which is the sectoral gross output deflated by its cell-by-cell sectoral deflator. As mentioned in the previous sections, the relative price represents the relation of the price index of the industry j (x_j^p) and p the price index of total gross output deflator, expressed as follows:

$$\mathbf{x^p} = x_j^p/p \tag*{(24).}$$

As we aim to capture the influence of all kind of relative prices (over selling products and buying sectors) changes in the IO model components, we rewrite all variables presented in section 1 of this chapter, disaggregating them in the relative price and volume terms. The elements of the $\mathbf{U_d}$ matrix becomes:

$$u_{d_{ij}} = \frac{u_{d\,ij}^{\,p}}{p} \times u_{d\,ij}^{\,v} \tag*{(25)}$$

where $u_{d\,ij}^{\,p}$ is the relative price of product *i* used as an input by industry *j,* and $u_{d\,ij}^{\,v}$ is the volume measure of product *i* used as an input by industry *j*.

We obtain $\mathbf{B_d}$ using *(23).*, *(24).*, *(25)* in *(7)*, as:

$$b_{d_{ij}} = \frac{\frac{u_{d\,ij}^{\,p}}{p}}{\frac{x_j^p}{p}} \times \frac{u_{d\,ij}^{\,v}}{x_j^v} = \frac{u_{d\,ij}^{\,p}}{x_j^p} \times \frac{u_{d\,ij}^{\,v}}{x_j^v} \tag*{(26).}$$

Defining $\mathbf{B_d^p} = b_{d\,ij}^{\,p}$ as the matrix of relative price indices of technical coefficients in the product by industry dimension and $\mathbf{B_d^v} = b_{d\,ij}^{\,v}$ the matrix of domestic technical coefficients measured in volume units, as follows:

$$b_{d\,ij}^{\,p} = \frac{u_{d\,ij}^{\,p}}{x_j^p} \quad \text{and} \quad b_{d_{ij}}^{v} = \frac{u_{d\,ij}^{\,v}}{x_j^v} \tag*{(27)}$$

and using the symbol ⊗ to denote the Hadamard product, we rewrite $\mathbf{B_d}$ matrix as:

$$\mathbf{B_d} = \mathbf{B_d^p} \otimes \mathbf{B_d^v} \tag*{(28).}$$

By doing the same for the final demand, we obtain the vector regarding the relative price of the final demand vector by product ($\mathbf{f^p_{dq}}$) and volume final demand vector ($\mathbf{f^v_{dq}}$), obtaining the expression below:

$$\mathbf{f_{dq}} = \mathbf{\hat{f}^p_{dq} f^v_{dq}} \tag{29}$$

where $\mathbf{f^p_{dq}}$ is:

$$\mathbf{f^p_{dq}} = f^p_{dq_i}/p \tag{30}.$$

Finally, for the market-share matrix, the approach was somewhat different. First, we calculate the volume market share ($\mathbf{D^v}$) using *constant relative prices* data, which means in volume:

$$\mathbf{D^v} = \mathbf{V^v \hat{q}^{v-1}} \tag{31}.$$

where $\mathbf{V^v}$ is the make matrix in volume and $\mathbf{q^v}$ is the vector of gross output in volume units by product. Since there is not a direct relative prices deflator to D ($\mathbf{D^p}$) that guarantees consistent aggregation, we calculate it by the cell-by-cell Hadamard division ($\oslash$) of market share matrix in constant prices data ($\mathbf{D}$) and constant relative prices data ($\mathbf{D^v}$).

$$\mathbf{D^p} = \mathbf{D} \oslash \mathbf{D^v} \tag{32}.$$

Doing so, we represent $\mathbf{D}$ as:

$$\mathbf{D} = \mathbf{D^p} \otimes \mathbf{D^v} \tag{33}.$$

Back to equation (6), which defines de gross output concerning its intermediate and final demand, we have now:

$$\mathbf{\hat{x}^p x^v} = (\mathbf{D^p} \otimes \mathbf{D^v})(\mathbf{B^p_d} \otimes \mathbf{B^v_d})\mathbf{\hat{x}^p x^v} + (\mathbf{D^p} \otimes \mathbf{D^v}).\left(\mathbf{\hat{f}^p_{dq} f^v_{dq}}\right) \tag{34}.$$

Solving the last equation for the vector of gross output in volume terms we obtain:

$$\mathbf{x^v} = \left[\mathbf{I} - \left(\mathbf{\hat{x}^{p^{-1}}}(\mathbf{D^p} \otimes \mathbf{D^v})(\mathbf{B^p_d} \otimes \mathbf{B^v_d})\mathbf{\hat{x}^p}\right)\right]^{-1} \mathbf{\hat{x}^{p^{-1}}}(\mathbf{D^p} \otimes \mathbf{D^v}).\left(\mathbf{\hat{f}^p_{dq} f^v_{dq}}\right) \tag{35}.$$

To simplify the above equation, we denote $\mathbf{\widetilde{A}_n} = \mathbf{\hat{x}^{p^{-1}}}(\mathbf{D^p} \otimes \mathbf{D^v})(\mathbf{B^p_n} \otimes \mathbf{B^v_n})\mathbf{\hat{x}^p}$ and $\mathbf{\tilde{f}_d} = \mathbf{\hat{x}^{p^{-1}}}(\mathbf{D^p} \otimes \mathbf{D^v}).\left(\mathbf{\hat{f}^p_{dq} f^v_{dq}}\right)$ that are respectively the matrix of domestic coefficients and final demand vector weighted by total relative prices. In this way, we have:

$$\mathbf{x^v} = \left(\mathbf{I} - \mathbf{\widetilde{A}_n}\right)^{-1} \mathbf{\tilde{f}_d} \tag{36}.$$

Defining $\tilde{\mathbf{Z}} = \left(\mathbf{I} - \tilde{\mathbf{A}}_{\mathbf{n}}\right)^{-\mathbf{1}}$ as the Leontief inverse weighted by sectoral relative prices, we have:

$$\mathbf{x}^{\mathrm{v}} = \tilde{\mathbf{Z}}\tilde{\mathbf{f}}_{\mathbf{d}} \quad (37)$$

that represents the solution of the gross output in volume, isolated from the sectoral relative prices ($\mathbf{x}^{\mathbf{p}}$).

3.5 Analyzing the effect of relative prices in the IO model: a hypothetical example

To understand the problem of relative prices, we propose an example of a hypothetical economy with three products (C1, C2, C3), two industries (S1, S2) and two components of final demand (FD1, FD2). The example will be made considering three periods (00, 01 and, 02), priced at current prices (00p00, 01p01 and 02p02) and of the previous year (01p00 and 02p01). The objective of the exercise is to deflate the series and obtain the information of year 01 and 02 in prices of year 00.

The tables below show the Use Table at basic prices for year 01 at current prices and the prices of the previous year:

Figure 14 – Use Table at basic prices - current prices (01p01)

	Intermediate demand			Final demand			Total
	S1	**S2**	**S**	**FD1**	**FD2**	**FD**	
C1	10.00	5.00	*15.00*	7.00	20.00	*27.00*	**42.00**
C2	15.00	40.00	*55.00*	10.00	9.00	*19.00*	**74.00**
C3	20.00	30.00	*50.00*	16.00	12.00	*28.00*	**78.00**
Total	45.00	75.00	*120.00*	33.00	41.00	*74.00*	**194.00**

Source: Author's elaboration.

Figure 15 – *Use Table at basic prices – previous years' prices (01p00)*

	Intermediate demand			Final demand			Total
	S1	**S2**	**S**	**FD1**	**FD2**	**FD**	
C1	12.00	2.00	*14.00*	6.00	23.00	*29.00*	**43.00**
C2	11.00	45.00	*56.00*	11.00	7.00	*18.00*	**74.00**
C3	18.00	28.00	*46.00*	14.00	14.00	*28.00*	**74.00**
Total	41.00	75.00	*116.00*	31.00	44.00	*75.00*	**191.00**

Source: Author's elaboration.

Using this data, we can calculate the cell-specific prices indices ($\lambda_{ij}^{t,t-1}$), as is presented in Figure 16. Then, we obtain deflated values dividing the values presented in Figure 14 by the cell-specific deflators in Figure 16, obtaining the equivalent values in Figure 17.

Figure 16 – Cell-specific prices indices (01p00)

	Intermediate demand			Final demand			Total
	S1	**S2**	**S**	**FD1**	**FD2**	**FD**	
C1	0.83	2.50	*1.07*	1.17	0.87	*0.93*	**0.98**
C2	1.36	0.89	*0.98*	0.91	1.29	*1.06*	**1.00**
C3	1.11	1.07	*1.09*	1.14	0.86	*1.00*	**1.05**
Total	1.10	1.00	*1.03*	1.06	0.93	*0.99*	**1.02**

Source: Author's elaboration.

Figure 17 – Deflated Use Table, constant relative prices (01p00)

	Intermediate demand			Final demand			Total	*Testing S sum*	*Testing FD sum*	*Testing Total sum*
	S1	**S2**	**S**	**FD1**	**FD2**	**FD**				
C1	12.00	2.00	*14.00*	6.00	23.00	*29.00*	**43.00**	0.00	0.00	0.00
C2	11.00	45.00	*56.00*	11.00	7.00	*18.00*	**74.00**	0.00	0.00	0.00
C3	18.00	28.00	*46.00*	14.00	14.00	*28.00*	**74.00**	0.00	0.00	0.00
Total	41.00	75.00	*116.00*	31.00	44.00	*75.00*	**191.00**	0.00	0.00	0.00
Testing C sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**

Source: Author's elaboration.

Note: Testing C sum=(C1+C2+C3)-Total (by column); Testing S sum=(S1+S2)-S;
Testing FD sum=(FD1+FD2)-FD; Testing Total sum=(S1+S2+FD1+FD2)-Total (by row)

Note that the value obtained in Figure 17 is the same as in Figure 15, by definition. In this case, the additivity property between the sum of deflated products by its deflators (C1+C2+C3) and the total of products deflator is the same (we can see that in the row Testing C sum). The same happens if we see the additivity between the intermediate and final demand. In the column "Testing S sum" we verify if S1+S2 is equal to S, even when they deflated by its deflators. In the column "Testing FD sum" we verify if FD1+FD2 are equal to FD, even when they deflated by its deflators. Moreover, in "Testing Total sum" we test if S1+S2+FD1+FD2 are equal to total demand when deflated by the cell-specific deflators.

The additivity property remains here, but this only happens because we are dealing with only two consecutive periods, with just one price index (01p00). As we are going to see later in this example, by the introduction of accumulated price indices, this property is no longer valid for this case.

Even though the additivity is a valid property for this year, it is necessary to make the relative price adjustment. As we saw earlier, money is not invariable in its purchasing power. In this sense, as the price of every cell-specific element changes in a different way in time, these variations affect the "purchasing power" of each product/industry. To capture the change in relative prices, we divide the value of each price index cell by cell by the general deflator of production (1.02, Figure 16)[41]. By doing so, we obtain:

Figure 18 – Relative prices relation (01p00)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	0.82	2.46	*1.05*	1.15	0.86	*0.92*	**0.96**
C2	1.34	0.88	*0.97*	0.90	1.27	*1.04*	**0.98**
C3	1.09	1.05	*1.07*	1.13	0.84	*0.98*	**1.04**
Total	1.08	0.98	*1.02*	1.05	0.92	*0.97*	**1.00**

Source: Author's elaboration.

In the previous Figure, we have the relation of each cell-specific price index about the total gross output. For example, the products C1 and C2 prices indices grew below gross output deflator, as their relations are less than one. The opposite happens with the C3, that had a higher in prices above gross output.

To obtain the proper relation across the time and the elements of the Use table, we have to multiply the Deflated Use Table presented in Figure 17 by the relative prices relations presented in Figure 18 By doing so, we obtained the Deflated Use Table but valued at constant prices (total units).

Figure 19 – Deflatated Use Table, constant prices (01p00)

	Intermediate demand			Final demand			Total	*Testing S sum*	*Testing FD sum*	*Testing Total sum*
	S1	S2	S	FD1	FD2	FD				
C1	9.85	4.92	*14.77*	6.89	19.69	*26.58*	**41.35**	0.00	0.00	0.00
C2	14.77	39.38	*54.15*	9.85	8.86	*18.71*	**72.86**	0.00	0.00	0.00
C3	19.69	29.54	*49.23*	15.75	11.81	*27.57*	**76.79**	0.00	0.00	0.00
Total	44.30	73.84	*118.14*	32.49	40.37	*72.86*	**191.00**	0.00	0.00	0.00
Testing C sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**	**0.00**	**0.00**

Source: Author's elaboration.

We note that this step also preserves the additivity and the total sum is the same. However, there are some changes in the distributions across the elements inside the Use Table in total units. For example, the proportion of S2 intermediate consumption form C2 in the total in Figure 17 is 23.6%, and in Figure, 19 is 20.6%. The proportion is smaller because the price index of this combination grew below the gross output deflator.

Now we are going to do the same steps for the year 02. In the two next figures, we present the Use Table in current prices and previous' year prices.

[41] Note that we can use the total deflator of Use Table as the gross output deflator because these totals are equal, assured by the balance between supply and demand in the input-output model.

Figure 20 – Use Table at basic prices – current prices (02p02)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	13.00	8.00	*21.00*	12.00	26.00	*38.00*	**59.00**
C2	17.00	59.00	*76.00*	18.00	16.00	*34.00*	**110.00**
C3	27.00	38.00	*65.00*	22.00	19.00	*41.00*	**106.00**
Total	57.00	105.00	*162.00*	52.00	61.00	*113.00*	**275.00**

Source: Author's elaboration.

Figure 21 – Use Table at basic prices – previous years' prices (02p01)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	12.00	5.00	*17.00*	8.00	25.00	*33.00*	**50.00**
C2	14.00	50.00	*64.00*	20.00	17.00	*37.00*	**101.00**
C3	16.00	30.00	*46.00*	21.00	20.00	*41.00*	**87.00**
Total	42.00	85.00	*127.00*	49.00	62.00	*111.00*	**238.00**

Source: Author's elaboration.

Calculating the cell-specific deflators for the year 02 concerning year 01, we have:

Figure 22 – Cell-specific prices indices (02p01)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	1.08	1.60	*1.24*	1.50	1.04	*1.15*	**1.18**
C2	1.21	1.18	*1.19*	0.90	0.94	*0.92*	**1.09**
C3	1.69	1.27	*1.41*	1.05	0.95	*1.00*	**1.22**
Total	1.36	1.24	*1.28*	1.06	0.98	*1.02*	**1.16**

Source: Author's elaboration.

As the exercise's purpose is to express the year 02 in prices of year 00, we have to accumulate the prices indices, by multiplying the prices indices of 01p00 by 02p01 (Figure 16 and Figure 22). In this case, we will have:

Figure 23 – Accumulated cell-specific prices indices (02p00)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	0.90	4.00	*1.32*	1.75	0.90	*1.07*	**1.15**
C2	1.66	1.05	*1.17*	0.82	1.21	*0.97*	**1.09**
C3	1.88	1.36	*1.54*	1.20	0.81	*1.00*	**1.28**
Total	1.49	1.24	*1.32*	1.13	0.92	*1.00*	**1.17**

Source: Author's elaboration.

To obtain the Use Table deflated for 02, but in 00's prices, we have to divide the Use table p02q02 in current prices (Figure 20) about the accumulated cell-specific deflators (Figure 23). Then, we have the deflated Use Table in constant prices for the second period presented in Figure 24. The obtained deflated Use Table in constant relative prices is compatible over time; however, as discussed earlier, also changes the industries' structure because of the changes in the relative prices. This is reflected in the non-additivity since the real purchase power of each sector now is different. As a consequence, the sum of the rows deflated by its deflators is not the same as the total deflated by its deflator. The same happens to the columns, where we have the intermediate and final demand information.

Figure 24 – Deflated Use Table - constant relative prices(02p00)

	Intermediate demand			Final demand			Total		Testing S sum	Testing FD sum	Testing Total sum
	S1	S2	S	FD1	FD2	FD					
C1	14.40	2.00	*15.87*	6.86	28.75	*35.44*	**51.19**		0.53	0.16	0.82
C2	10.27	56.25	*65.16*	22.00	13.22	*35.05*	**101.00**		1.35	0.17	0.74
C3	14.40	28.00	*42.32*	18.38	23.33	*41.00*	**82.54**		0.08	0.71	1.57
Total	38.27	85.00	*122.77*	46.03	66.54	*112.50*	**234.32**		0.50	0.07	1.51
Testing C sum	0.80	1.25	0.58	1.20	-1.23	-1.00	0.41		**2.47**	**1.11**	**4.64**

Source: Author's elaboration.

To obtain the additivity, we have to adjust for relative prices to obtain a consistent IOT over time and products and industries, we do the same as in Figure 18, and we calculate the relation between the relative prices. So, we have:

Figure 25 – Relative prices relation (02p00)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	0.77	3.41	*1.13*	1.49	0.77	*0.91*	**0.98**
C2	1.41	0.89	*0.99*	0.70	1.03	*0.83*	**0.93**
C3	1.60	1.16	*1.31*	1.02	0.69	*0.85*	**1.09**
Total	1.27	1.05	*1.12*	0.96	0.78	*0.86*	**1.00**

Source: Author's elaboration.

As we saw, the total relative price relation of C1 in 01p00 (Figure 18) was less than one because its deflator grew below the gross output deflator. However, for 02p01 there was a high increase in its price index in 02p01 (1.77). This way, when combined these two prices indices, we can see that for 02p00, the relative price relation is above one, so for the total period, there was an increase of C1's price about gross output.

By multiplying the relative price relation (Figure 25) to deflated Use Table in constant relative prices (Figure 25), we have the Deflated Use Table in constant prices for the period 02.

Figure 26 – Deflated Use Table – constant prices(02p00)

	Intermediate demand			Final demand			Total		Testing S sum	Testing FD sum	Testing Total sum
	S1	S2	S	FD1	FD2	FD					
C1	11.08	6.82	*17.89*	10.22	22.15	*32.38*	**50.27**		0.00	0.00	0.00
C2	14.49	50.27	*64.76*	15.34	13.63	*28.97*	**93.73**		0.00	0.00	0.00
C3	23.01	32.38	*55.38*	18.75	16.19	*34.93*	**90.32**		0.00	0.00	0.00
Total	48.57	89.47	*138.04*	44.31	51.98	*96.28*	**234.32**		0.00	0.00	0.00
Testing C sum	0.00	0.00	0.00	0.00	0.00	0.00	0.00		**0.00**	**0.00**	**0.00**

Source: Author's elaboration.

We can see that by making this adjustment, we have the necessary additivity among all elements in the IOT.

3.5.1 Comparing to the double-deflation method

An important limitation in the application of this method is that we need all the IOT in current and previous' year prices and this is not available all the time. A popular alternative applied is the double-deflation method. This method consists in using the information of the sectoral gross output deflators to deflate all the input-output table. Usually, the literature uses this methodology because the information needed (sectoral gross output deflators) is generally available in Make matrix.

The double deflation method consists of a double procedure to obtain deflated value added. First of all all the elements of the Use Table (intermediate, final demand and, total output) by the sectoral gross output deflators. After that, to ensure the elements of total inputs are equal to total outputs, the method suggests that we calculate the deflated value added by resting the intermediate consumption by the total output.

We are going to do the double-deflation of the example above to see the consequences for the additivity property and relative prices. For the year 01, The first step is dividing all the elements in Figure 14 by the Total (column) deflator of Figure 15. Then, we have:

Figure 27 – Double deflation method: Deflated Use Table (01p00)

	Intermediate demand			**Final demand**			**Total**	*Test*	*Test*	*Test*
	S1	**S2**	**S**	**FD1**	**FD2**	**FD**		*S sum*	*FD*	*DT*
C1	10.24	5.12	*15.36*	7.17	20.48	*27.64*	**43.00**	0.00	0.00	0.00
C2	15.00	40.00	*55.00*	10.00	9.00	*19.00*	**74.00**	0.00	0.00	0.00
C3	18.97	28.46	*47.44*	15.18	11.38	*26.56*	**74.00**	0.00	0.00	0.00
Total	44.21	73.58	*117.79*	32.35	40.86	*73.21*	**191.00**	0.00	0.00	0.00

Source: Author's elaboration.

The first thing to note is that exists the additivity by product (columns). That happens because we used the same sectoral deflator to the columns. For the industries, we calculate a new total, by the sum of the elements. However, if we compare the new total in the double-deflation method (Figure 27) to the values obtained in the Deflated Use Table at constant prices (Figure 17), we observe a difference in the intermediate and final demand totals and also for each cell. We can see this difference in Figure 28. We note that for the first year, there is no difference between the two methods. Also, the difference in the intermediate and final demand is very small. However, the difference for the inside of the IOT is very remarkable and maybe result of the different price deflators and also because of relative prices changes. For the total by product, we see an important difference, with a sub estimation of product C3 and a super estimation of C1 and C2.

Figure 28 – Difference of Double deflation method and constant prices deflated Use Table (01p00)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	0.39	0.20	*0.59*	0.27	0.79	*1.06*	**1.65**
C2	0.23	0.62	*0.85*	0.15	0.14	*0.29*	**1.14**
C3	-0.72	-1.07	*-1.79*	-0.57	-0.43	*-1.00*	**-2.79**
Total	-0.09	-0.26	*-0.35*	-0.14	0.49	*0.35*	**0.00**

Source: Author's elaboration.

If we do the same for year 2, we will see that the differences are still more noticeable. Figure 29 shows the double-deflation method for 02p00, using the accumulated total column deflator from Figure 23, we have:

Figure 29 – Double deflation method: Deflated Use Table (02p00)

	Intermediate demand			Final demand			Total	*Testing S sum*	*Testing FD sum*	*Testing Total sum*
	S1	S2	S	FD1	FD2	FD				
C1	7.34	4.52	*11.86*	6.78	14.69	*21.47*	**33.33**	0.00	0.00	0.00
C2	17.34	60.19	*77.54*	18.36	16.32	*34.69*	**112.22**	0.00	0.00	0.00
C3	21.15	29.77	*50.92*	17.24	14.89	*32.12*	**83.05**	0.00	0.00	0.00
Total	45.84	94.48	*140.32*	42.38	45.90	*88.28*	**228.60**	0.00	0.00	0.00

Source: Author's elaboration.

The additivity along the columns exists, although when we compare the data of the double deflated method with the constant prices, we see much difference.

Figure 30 – Double deflation method: Deflated Use Table (02p00)

	Intermediate demand			Final demand			Total
	S1	S2	S	FD1	FD2	FD	
C1	-3.26	-2.00	*-5.26*	-3.01	-6.51	*-9.52*	**-14.78**
C2	3.48	12.08	*15.56*	3.68	3.27	*6.96*	**22.51**
C3	-0.87	-1.22	*-2.08*	-0.71	-0.61	*-1.32*	**-3.40**
Total	-0.64	8.85	*8.21*	-0.03	-3.85	*-3.88*	**4.33**

Source: Author's elaboration.

In this period, we see that the total gross output is not the same (as we saw in the period 01p00 – Figure 29). Also, the difference in the columns increased, and the same happens in the IOT's inside.

3.5.2 Implications to technical coefficients

An important implication for the deflation method are the differences in the technical coefficients. To do so, we must have the information of the make matrix to construct the proper technical coefficients. So, we do the same deflation process for the make matrix, where we have all the production flows. In the following figures, we have the make matrices for period 01 in current prices and previous' year prices:

Figure 31 – Make matrices– current prices (p01q01) and previous' year prices (p00q01)

p01q01				p00q01			
	S1	S2	S		S1	S2	S
C1	23.00	19.00	*42.00*	**C1**	21.00	22.00	*43.00*
C2	24.00	50.00	*74.00*	**C2**	23.00	51.00	*74.00*
C3	32.00	46.00	*78.00*	**C3**	31.00	43.00	*74.00*
Total	79.00	115.00	*194.00*	**Total**	75.00	116.00	*191.00*

Source: Author's elaboration.

For the period 02, the make matrices for the two periods are:

Figure 32 – Make matrix– current prices (p02q02) and previous' year prices (p01q02)

p02q02				p01q02			
	S1	S2	S		S1	S2	S
C1	37.00	22.00	*59.00*	**C1**	32.00	18.00	*50.00*
C2	40.00	70.00	*110.00*	**C2**	36.00	65.00	*101.00*
C3	43.00	63.00	*106.00*	**C3**	34.00	53.00	*87.00*
Total	120.00	155.00	*275.00*	**Total**	102.00	136.00	*238.00*

Source: Author's elaboration.

The cell-specific price indices are:

Figure 33 – Make matrix cell-specific price index, yearly

p00q01				p01q02			
	S1	S2	S		S1	S2	S
C1	1.10	0.86	*0.98*	**C1**	1.16	1.22	*1.18*
C2	1.04	0.98	*1.00*	**C2**	1.11	1.08	*1.09*
C3	1.03	1.07	*1.05*	**C3**	1.26	1.19	*1.22*
Total	1.05	0.99	*1.02*	**Total**	1.18	1.14	*1.16*

Source: Author's elaboration.

The accumulated cell-specific prices indices are:

Figure 34 – Make matrices' accumulated cell-specific price indices for period 01 and 02 in prices of 00

p00q01				p00q02			
	S1	S2	S		S1	S2	S
C1	1.10	0.86	*0.98*	**C1**	1.27	1.06	*1.15*
C2	1.04	0.98	*1.00*	**C2**	1.16	1.06	*1.09*
C3	1.03	1.07	*1.05*	**C3**	1.31	1.27	*1.28*
Total	1.05	0.99	*1.02*	**Total**	1.24	1.13	*1.17*

Source: Author's elaboration.

Deflating the current data by the cell-specific deflators, we have the make matrices for the period one (Figure 35) and period two (Figure 36) in constant relative prices.

Figure 35 – Make matrix, constant relative prices, (p00q01)

	S1	S2	S	Testing S sum
C1	21.00	22.00	*43.00*	0.00
C2	23.00	51.00	*74.00*	0.00
C3	31.00	43.00	*74.00*	0.00
Total	75.00	116.00	*191.00*	0.00
Testing C sum	0.00	0.00	0.00	**0.00**

Source: Author's elaboration.

Figure 36 – Make matrix, constant relative prices, (p00q02)

	S1	S2	S	Testing S sum
C1	29.22	20.84	*51.19*	-1.13
C2	34.50	66.30	*101.00*	-0.20
C3	32.94	49.54	*82.54*	-0.06
Total	96.84	137.18	*234.32*	-0.30
Testing C sum	-0.18	-0.50	0.41	**-1.69**

Source: Author's elaboration.

We present the relative price relations in the next figures:

Figure 37 – Make matrix - relative price relation, (p00q01)

	S1	S2	S
C1	1.08	0.85	*0.96*
C2	1.03	0.97	*0.98*
C3	1.02	1.05	*1.04*
Total	1.04	0.98	*1.00*

Source: Author's elaboration.

Figure 38 – Make matrix - relative price relation, (p00q02)

	S1	S2	S
C1	1.08	0.90	*0.98*
C2	0.99	0.90	*0.93*
C3	1.11	1.08	*1.09*
Total	1.06	0.96	*1.00*

Source: Author's elaboration.

Making the proper relative price adjustment, the deflated make matrices are:

Figure 39 – Make matrix - constant prices (p00q01)

	S1	S2	S	Testing S sum
C1	22.64	18.71	*41.35*	0.00
C2	23.63	49.23	*72.86*	0.00
C3	31.51	45.29	*76.79*	0.00
Total	77.78	113.22	*191.00*	0.00
Testing C sum	0.00	0.00	0.00	0.00

Source: Author's elaboration.

Figure 40 – Make matrix– constant prices (p00q02)

	S1	S2	S		*Testing S sum*
C1	31.53	18.75	*50.27*		0.00
C2	34.08	59.64	*93.73*		0.00
C3	36.64	53.68	*90.32*		0.00
Total	102.25	132.07	*234.32*		0.00
Testing C sum	0.00	0.00	0.00		0.00

Source: Author's elaboration.

Using the information of the make matrices for both years, we can calculate the technical coefficients. We express them in the product-by-industry dimension (b_{ij}, for product i and industry j) as seen in (7), diving the intermediate consumption (u_{ij}) by the total production by industry (x_j)[42]. We present the technical coefficients at current prices, constant prices (cell-specific deflators), and using the double deflation method in the following figures, respectively:

Figure 41 – Technical coefficients for period 00, 01 and 02 – current prices

p00q00			p00q01			p00q02		
	S1	S2		S1	S2		S1	S2
C1	0.1455	0.0230	**C1**	0.1266	0.0435	**C1**	0.1083	0.0516
C2	0.1818	0.2299	**C2**	0.1899	0.3478	**C2**	0.1417	0.3806
C3	0.2364	0.2069	**C3**	0.2532	0.2609	**C3**	0.2250	0.2452

Source: Author's elaboration.

Figure 42 – Technical coefficients for period 00, 01 and 02 – constant prices

p00q00			p00q01			p00q02		
	S1	S2		S1	S2		S1	S2
C1	0.1455	0.0230	**C1**	0.1266	0.0435	**C1**	0.1083	0.0516
C2	0.1818	0.2299	**C2**	0.1899	0.3478	**C2**	0.1417	0.3806
C3	0.2364	0.2069	**C3**	0.2532	0.2609	**C3**	0.2250	0.2452

Source: Author's elaboration.

Figure 43 – Technical coefficients for period 00, 01 and 02 – double deflation method

p00q00			p00q01			p00q02		
	S1	S2		S1	S2		S1	S2
C1	0.1455	0.0230	**C1**	0.1266	0.0435	**C1**	0.1102	0.0524
C2	0.1818	0.2299	**C2**	0.1899	0.3478	**C2**	0.1526	0.4091
C3	0.2364	0.2069	**C3**	0.2532	0.2609	**C3**	0.2055	0.2235

Source: Author's elaboration.

[42] In this type of model, it is possible to obtain the technical coefficients in the usual dimension of the IO model, industry by industry, by pre-multiplying the coefficients in product by industry by a market shares matrix (**D**). We present in the appendix this data, although this do not affect the results.

As for the period 00, we have the same information and there is no difference. For the period 01, we also do not observe any difference, because it is expressed in the prices of 00 periods, so the purchasing power is the same. For the second period, the technical coefficients are the same in both current prices and for the cell-specific method. This happens because in the cell-specific method both the numerator and the denominator are deflated for the same price index, the gross output deflator. However, if we compare them with the double-deflation method, there are differences in the technical coefficients. We attribute this to the changes in relative prices of each selling and buying sector that are not considered in the double-deflation method. In the next figure, we show these differences between the current prices/constant prices and the double-deflation method in absolute and as a proportion of the total of the previous in the next figure.

Figure 44 – Technical coefficients in current price compared with double deflation method, period 02

	Absolute difference			**Proportional difference**		
	S1	**S2**	**Sum**	**S1**	**S2**	**Sum**
C1	-0.0019	-0.0008	-0.0027	-1.76%	-1.56%	-1.70%
C2	-0.0109	-0.0285	-0.0394	-7.69%	-7.48%	-7.54%
C3	0.0195	0.0217	0.0412	8.67%	8.85%	8.77%
Sum	0.0067	-0.0076	-0.0009	1.41%	-1.12%	-0.07%

Source: Author's elaboration.

In this case, we see that the industries that had the most intense price variation, in this example C3, had its technical coefficients overestimated. The opposite happens with C1 and C2. Note that the positive and negative differences do not cancel itself, having an overall underestimating of 0.07% of total direct multipliers. One may consider this difference as minimal, but in this case, we are dealing with just only three periods in a very small economy. The difference will increase if we consider more years in the series since the price chain increases the relative price discrepancy. Also, the influence of external factors, such as products boom or exchange rates changes, can increase the relative prices effect over time.

It is reasonable to think that each deflation method gives different results. Although, an important property is that the whole table conserves its property of additivity, not only though industries but also in the product. Also, a method that considers the changes in the relative prices is preferred because as the IO model is a multisectoral model, measuring the share or the participation in growth may be influenced by these changes. The importance is still more remarkable when using models that include variables measured in value, such as structural decomposition analysis or productivity growth. Another important conclusion is that if a researcher wants to analyses the economy by only looking at the technical coefficients or any share indicator, it can be done by using the IOT data in current prices, without having to deflate it for an initial analysis.

However, in a constant prices IOT series (total units), there are also relative prices changes inside it. So, we briefly analyze this effect on the technical coefficients.

As mentioned in section 3.4 in (26), the technical coefficient (b_{ij}) in total units is a ratio of the intermediate demand including the relative price and the volume units presented in (25) and the output by industry in (24). In b_{ij}, the gross output deflator (that represents the inflation in the economy), "disappear" because it is present both in the numerator and the denominator. In terms of prices, only remains the relative price relation, that we need to calculate the technical coefficient properly. So, although there is no difference in the calculated technical coefficients in total units and in current prices, there is the relative prices relation (u_{ij}^p/x_j^p) in the deflated one.

In our example, the relative prices relation inside the technical coefficient (u_{ij}^p/x_j^p, for u_{ij}^p see Figures 17 and 23 and for x_j^p see Figure 34) are:

Figure 45 – Relative price relation present in the technical coefficients, periods 01 and 02

p00q01			p02q02		
	S1	**S2**		**S1**	**S2**
C1	0.7911	2.5217	**C1**	0.7285	3.5402
C2	1.2946	0.8966	**C2**	1.3362	0.9283
C3	1.0549	1.0807	**C3**	1.5131	1.2011

Source: Author's elaboration.

In addition, the technical coefficients in volume units (u_{ij}^v/x_j^v for u_{ij}^p see Figures 17 and 24 and for x_j^p see Figure 35 and 36) are:

Figure 46 – Technical coefficients in volume units, periods 01 and 02

p00q01			p02q02		
	S1	**S2**		**S1**	**S2**
C1	0.1600	0.0172	**C1**	0.1487	0.0146
C2	0.1467	0.3879	**C2**	0.1060	0.4100
C3	0.2400	0.2414	**C3**	0.1487	0.2041

Source: Author's elaboration.

By multiplying Figures 45 and 46, we will have the technical coefficients at total units (or current prices). Making the difference between the technical coefficient in constant prices (total) and constant relative prices (volume), we observe in Figure 47 its effects.

Figure 47 – Difference form technical coefficients in total units and volume units, absolute and proportional, p00q01 and p00q02

p00q01	Absolute		Proportional	
	S1	S2	S1	S2
C1	-0.0334	0.0262	-26.40%	60.34%
C2	0.0432	-0.0401	22.76%	-11.53%
C3	0.0132	0.0195	5.20%	7.47%
p00q02	Absolute		Proportional	
	S1	S2	S1	S2
C1	-0.0404	0.0370	-37.27%	71.75%
C2	0.0356	-0.0294	25.16%	-7.72%
C3	0.0763	0.0411	33.91%	16.75%

Source: Author's elaboration.

Comparing the technical coefficients in total units with volume units, we observe, for example, that the multiplier of the purchasers S1 from C1 in period 01 and 02 is underestimated in volume units because there was a decrease in the relative prices relation. The same happens for purchasers S2 from C2. For the other combination of sectors and commodities, there is an overestimation of technical coefficients in total units compared with in volume units, due to an increase in the relative price relation. Hence, we showed how important it is to include the relative price inside the IO model for a more accurate measure of structural change.

3.6 Multisectoral analysis

For organization and disclosure of results, we propose an aggregated level of analysis containing 11 industries. We regroup the whole set of extractive and manufacturing industries into four industry groups according to the classification proposed by the Research group of Manufacturing industries and Competitiveness – GIC-UFRJ (KUPFER, 1997; TORRACCA; KUPFER, 2014). The description of the industries that contain this classification is in Appendix E.

As discussed in Chapter 1, inside this classification, we will consider in our analysis the sectors able to promote and induce technological change as the most important to understand the structural change and deindustrialization. Thus, we need a sectoral classification to fulfill this necessity.

We adopt the one proposed by GIC-UFRJ since it captures supply factors, such as the global pattern of competition and technological flow and also aspects related to demand, as the technological intensity of demanding manufacturing and extractive goods.

Table 8 – Description of 11 industries disaggregation level

	11 industries level	Description
Agriculture and related	*Agriculture, fishing and related* (AGR)	all industries related to agriculture, hunting, forestry, and fishing
Extractive and manufacturing industries	*Processed agricultural commodities (AC)*	industries intensive in natural and energy resources is generally associated with agribusiness and homogeneous products of high tonnage;
	Unprocessed and processed mining and quarrying commodities (MQC)	natural resource intensive activities related to mineral extractive industry, metallurgy, and basic chemistry;
	Traditional manufacturing industry (TM)	industries that produce goods with less technological content, with few requirements regarding productive scale; production of wage goods, inputs, industrial parts and complements, and manufactured consumer goods;
	Innovative manufacturing industry (IM)	more sophisticated activities in terms of technology and organization of the production process that are the principal contributors to the technology diffusion process in the economy, including high-tech and durable consumer goods (automobiles, electronics) industries.
Other groups	*Public utility*	providers of electricity, gas, water, or sewerage;
	Construction	residential, industrial, commercial and service buildings and other services related;
	Trade, accommodation, and food	trade and vehicles repairs, information about accommodation and food services;
	Transport, storage, and communication	transportation of cargo and passengers by land, water, air; mail and other delivery services; communication services such as books, newspapers and magazines, film, music, radio and television services, other information services systems;
	Financial intermediation, insurance, and real estate services	financial intermediation, insurance, and supplementary pension, effective and imputed rent and real estate services,
	Community, social and personal services	social and welfare services, associations, public services, and social security;

Source: Author's elaboration based on SNA/IBGE and Torracca and Kupfer (2014)

We consider this classification better than the ones based only on the technological intensity of products (such as OECD intensity classification) because the latter does not differentiate the industries responsible for the diffusion of technical progress through technical innovations, as suggest Urraca-Ruiz, Britto, and Souza (2014). In this way, we consider the IM group[43] as the most important to the discussion about the deindustrialization because it is responsible for technological/knowledge flows in the economic system and the most important to assess if the industry still has a higher income elasticity of demand and potential for a productivity catch-up.

3.7 The share of sectoral gross output and the exports composition in volume units

In this section, we present the usual indicators of the deindustrialization (sectoral gross output) and regressive specialization (export's composition) considering the changes in relative prices.

3.7.1 Sectoral gross output in volume units

We consider that analyzing the sectoral share regarding the volume of each extractive and manufacturing group is important to determinate the dynamics of the productive industry and their path in the time. The share (χ_j) gross output by industry (x_j^v) in the total gross output (x) in volume unity is:

$$\chi_j = \frac{x_j^v}{x} \qquad (38).$$

Note that for the total gross output, the sum of x must be equal to total x^v, it is the total deflated by the volume deflator.

As mentioned earlier, one of the main problems in decomposing variables in volume and price effects inside the IO model is that they separately do not have the additivity property[44].

[43] The classification utilized in this work although have this objective, may not consider all aspects related to the technological diffusion and technical progress and may have some limitations for the analysis scope of this work. One possible suggestion to improve this classification is using external information to identify the sectors that in fact are related to the technological diffusion and technical progress, such as the technological flows matrices between the sectors of the economy. Queiroz (2018) develops an application for the Brazilian economy and "incorporate R&D and other innovative activities data as estimates of innovative efforts incorporated in the acquisition of intermediate consumer goods and capital goods from the economic sectors" (p.8). Campos e Urraca-Ruiz (2009) and Urraca-Ruiz, Britto and Souza (2014) uses a classification to estimate the regressive specialization in the Brazilian economy based on the capacity to innovate, the growth in the international demand of exports and in the productive linkages based on Chenery and Watanabe (1958). Another useful information for a more precise classification is using the information in the capital flow matrices (MIGUEZ, 2016), in which is possible to see the investments realized by each sector. Another crucial limitation of this classification is that it does not consider the sectoral insertion in the GVCs. In this context the production is still more decentralized, and the countries are specializing in some tasks. So, for example, the innovative sector can increase its share, but the most important aspect of innovation (i.e., tasks of research and development) can be done in another country and the Brazilian economy do no appropriate the technological diffusion.

[44] "We have pointed out already that volumes are not quantities and do not describe a state, but a change of state of a market or of an industry. Volume is a variable of movement between two years ('speed' as opposed to

In this sense, it is not possible to aggregate directly the changes in volume unit in groups or even for the total of the economy. Hence, to obtain the share in volume units (χ_j), we rearranged the data in a different way. First, we aggregated the industries of the IOT series 2000-2015 in current and previous' year prices, passing from a most disaggregated level with 91 products and 42 industries to 91 products and 11 industries. After that, we constructed deflators indices with this new aggregation level, using the procedure presented in Section 3. This step includes obtaining the cell-specific price deflators and then, chaining them using 2010 as a base year. Then, we calculated the IOT in volume units (constant relative prices), and doing the proper adjustment for relative prices, we obtain the IOT series in total units (constant prices). These procedures were necessary because we must have the information of sectoral gross output in volume units for the extractive and manufacturing groups, compatible to the analytical level of 11 industries.

3.7.2 The composition of exports in volume units

We calculate the export basket as the division of each group exports (e_G) in total exports (e). However, inside of this share, we have two relative prices relations, as shows the following equation:

$$\eta_j = \frac{e_j}{e} = \frac{\frac{e_j^p}{p}}{\frac{e^p}{p}} \times \frac{e_j^v}{e^v} = \frac{e_j^p}{e^p} \times \frac{e_j^v}{e^v} \tag{39}$$

The first one (in the numerator) is the relation of each group's exports deflator over the gross output deflator (e_j^p/p); the second one (in the denominator) represents the total export's deflator in the total gross output deflator (e^p/p). Since both of this have in the denominator the gross output deflator, the expression is simplified, representing only the price relation of each group exports deflator to the total export's deflator (e_j^p/e^p).

As the exports' prices of one group can increase in a higher/lower proportion than the total exports' prices, it may affect the exports' composition. So, an interesting way is viewing the export basket in volume units (η^v):

'location') in the direction of product growth, in contrast to the movement of prices, which expresses the terms of exchange of those products" (REICH, 2008, p. 423).

$$\eta^{v} = \frac{e_{j}^{v}}{e^{v}} \qquad (40).$$

Due to the additivity problem, the data for the group's exports (11 groups) in volume units is not obtained by the direct aggregation of the exports (42 industries) in volume units. Hence, we use the information of e_j^v and e^v we obtained from the IOT series in the level of 91 products and 11 industries, as mentioned in section 3.7.1.

3.8 Structural decomposition

The structural decomposition analysis (SDA) approach is a technique that disaggregates the change of some economic aspect into various components contributions - disaggregating an identity into several components (MILLER; BLAIR, 2009). Any economic variable can be decomposed into its elements, enabling a better understanding of the variation between two periods.

The variable of interest, in this paper, is the change in Brazilian gross output (**x**) between 2000 and 2014, and three subperiods: 2000-2003, 2003-2008 and 2010-2014. Although the database goes up to 2015, we decided to use 2014 as the final year of the decomposition to avoid some conjunctural effect of negative GDP growth in 2015 in the structural analysis. We chose the subperiods based on the macroeconomic characteristics of the Brazilian economy.

We propose a two-level decomposition. The first one disaggregates the change of gross output presented in equation (23). in changes in total volume ($\mathbf{x^v}$) and total relative prices ($\mathbf{x^p}$). The decomposition follows Dietzenbacher and Los (1998) and Miller and Blair (2009), using the average of the two extreme decomposition situations. Denote '0' and '1' as superscripts for the initial and final, respectively.

3.8.1 The first level of the decomposition

The **first level decomposition** for gross output change ($\boldsymbol{\Delta}\mathbf{x}$) becomes:

$$\boldsymbol{\Delta}\mathbf{x} = \hat{\mathbf{x}}_{\mathbf{1}}^{\mathbf{p}}\hat{\mathbf{x}}_{\mathbf{1}}^{\mathbf{v}} - \hat{\mathbf{x}}_{\mathbf{0}}^{\mathbf{p}}\hat{\mathbf{x}}_{\mathbf{0}}^{\mathbf{v}} \qquad (41)$$

$$\underbrace{\boldsymbol{\Delta}\mathbf{x}}_{\substack{total\ gross\ output \\ changes}} = \underbrace{\frac{\mathbf{1}}{\mathbf{2}}\left(\hat{\mathbf{x}}_{\mathbf{1}}^{\mathbf{p}} + \hat{\mathbf{x}}_{\mathbf{0}}^{\mathbf{p}}\right)\boldsymbol{\Delta}\mathbf{x}^{\mathbf{v}}}_{volume\ changes} + \underbrace{\frac{\mathbf{1}}{\mathbf{2}}\boldsymbol{\Delta}\hat{\mathbf{x}}^{\mathbf{p}}\left(\hat{\mathbf{x}}_{\mathbf{1}}^{\mathbf{v}} + \hat{\mathbf{x}}_{\mathbf{0}}^{\mathbf{v}}\right)}_{\substack{relative\ prices \\ changes}} \qquad (42).$$

We express all the decomposition's results regarding its contribution to total gross output growth. To obtain it, we must divide each variable in the previous equation concerning the initial gross output x_0.

3.8.2 The second level of the decomposition

However, the first level decomposition is not enough to isolate all relative price effect because inside the changes of total gross output in volume ($\mathbf{x^v}$) there are other relative prices (i.e., intermediate and final demand relative prices). In this way, we propose a **second level decomposition** that separate volume contribution from all elements from their relative prices' contribution to $\mathbf{x^v}$ growth. To this decomposition, we apply the difference between all the variables at the final and at the initial point in *(37)* to find $\mathbf{\Delta x^v}$ and its *volume* and *price effect contribution*. So, we have:

$$\mathbf{\Delta x^v} = \mathbf{\Delta}\left(\mathbf{\tilde{Z}\tilde{f}_d}\right) \quad (43)$$

and the decomposition is:

$$\mathbf{\Delta x^v} = \frac{\mathbf{1}}{\mathbf{2}}\mathbf{\Delta\tilde{Z}}\left(\mathbf{\tilde{f}_{d_1}} + \mathbf{\tilde{f}_{d_0}}\right) + \frac{\mathbf{1}}{\mathbf{2}}\left(\mathbf{\tilde{Z}_1} + \mathbf{\tilde{Z}_0}\right)\mathbf{\Delta\tilde{f}_d} \quad (44)$$

As we want to disaggregate the changes of the Leontief inverse matrix, we also have to the decomposition for $\mathbf{\Delta\tilde{Z}}$. As suggested by Miller & Blair (2009), it becomes:

$$\mathbf{\Delta\tilde{Z}} = \mathbf{\tilde{Z}_1\Delta\tilde{A}_d\tilde{Z}_0} \quad (45).$$

To analyze the determinants of $\mathbf{\Delta\tilde{A}_d}$, its decomposition is (remembering that $\mathbf{\tilde{A}_d} = \mathbf{\hat{x}^{p^{-1}}A_d^*}$):

$$\mathbf{\Delta\tilde{A}_d} = \frac{\mathbf{1}}{\mathbf{2}}\mathbf{\Delta}\left(\mathbf{\hat{x}^{p^{-1}}}\right)\left(\mathbf{A^*_{d_1}} + \mathbf{A^*_{d_0}}\right) + \frac{\mathbf{1}}{\mathbf{2}}\left(\mathbf{\hat{x}_1^{p^{-1}}} + \mathbf{\hat{x}_0^{p^{-1}}}\right)\mathbf{\Delta A_d^*} \quad (46).$$

As we defined $\mathbf{A_d^*} = \mathbf{A_d\hat{x}^p}$, $\mathbf{\Delta A_d^*}$ is:

$$\mathbf{\Delta A_d^*} = \frac{\mathbf{1}}{\mathbf{2}}\mathbf{\Delta A_d}(\mathbf{\hat{x}^p}_\mathbf{1} + \mathbf{\hat{x}^p}_\mathbf{0}) + \frac{\mathbf{1}}{\mathbf{2}}\left(\mathbf{A_{d_1}} + \mathbf{A_{d_0}}\right)\mathbf{\Delta\hat{x}^p} \quad (47).$$

If we substitute $\mathbf{\Delta A_d^*}$ and $\mathbf{\Delta\tilde{A}_d}$ inside $\mathbf{\Delta\tilde{Z}}$, we will have

$$\mathbf{\Delta\tilde{Z}} = \mathbf{\tilde{Z}_1}\left[\frac{\mathbf{1}}{\mathbf{2}}\mathbf{\Delta}\left(\mathbf{\hat{x}^{p^{-1}}}\right)\left(\mathbf{A^*_{d_1}} + \mathbf{A^*_{d_0}}\right) + \frac{\mathbf{1}}{\mathbf{2}}\left(\mathbf{\hat{x}_1^{p^{-1}}} + \mathbf{\hat{x}_0^{p^{-1}}}\right)\left[\frac{\mathbf{1}}{\mathbf{2}}\mathbf{\Delta A_d}(\mathbf{\hat{x}^p}_\mathbf{1} + \mathbf{\hat{x}^p}_\mathbf{0}) + \frac{\mathbf{1}}{\mathbf{2}}\left(\mathbf{A_{d_1}} + \mathbf{A_{d_0}}\right)\mathbf{\Delta\hat{x}^p}\right]\right]\mathbf{\tilde{Z}_0} \quad (48).$$

In this way, the change in $\tilde{\mathbf{Z}}$ is a result of the changes in the sectoral relative prices and domestic technical coefficients.

In the decomposition process, from now on we define the final demand $\mathbf{f_d}$ and $\tilde{\mathbf{f}}_\mathbf{d}$ as the sum of household consumption, GFCF, government expenditures and, exports, excluded the part of inventories (s). This is an empirical adaptation, since they not have any economic meaning and are calculated as a residual part in the national accounts system. We calculate the inventories contribution to gross output change separately, to maintain the additivity of the final demand contribution. Doing the proper decomposition of $\tilde{\mathbf{f}}_\mathbf{d} = \hat{\mathbf{x}}^{\mathbf{p}^{-1}}\mathbf{f_d}$, we have:

$$\Delta\tilde{\mathbf{f}}_\mathbf{d} = \frac{1}{2}\Delta\left(\hat{\mathbf{x}}^{\mathbf{p}^{-1}}\right)\left(\mathbf{f}_{\mathbf{d}_1} + \mathbf{f}_{\mathbf{d}_0}\right) + \frac{1}{2}\left(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\right)\Delta\mathbf{f_d} \quad (49)$$

and for inventories:

$$\Delta\tilde{\mathbf{s}}_\mathbf{d} = \frac{1}{2}\Delta\left(\hat{\mathbf{x}}^{\mathbf{p}^{-1}}\right)\left(\mathbf{s}_{\mathbf{d}_1} + \mathbf{s}_{\mathbf{d}_0}\right) + \frac{1}{2}\left(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\right)\Delta\mathbf{s_d} \quad (50).$$

Replacing $\Delta\tilde{\mathbf{Z}}$, $\Delta\tilde{\mathbf{f}}_\mathbf{d}$ and $\Delta\tilde{\mathbf{s}}_\mathbf{d}$ inside $\Delta\mathbf{x}^\mathbf{v}$, we find:

$$\Delta\mathbf{x}^\mathbf{v} = \frac{1}{2}\Delta\tilde{\mathbf{Z}}\left(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\right) + \frac{1}{2}\left(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0\right)\left[\Delta\tilde{\mathbf{f}}_\mathbf{d} + \Delta\tilde{\mathbf{s}}_\mathbf{d}\right] \quad (51).$$

Reorganizing the previous equation, we can express the gross output in volume according to the sectoral changes of domestic technical coefficients ($\breve{\mathbf{A}}_\mathbf{d}$), domestic final demand ($\breve{\mathbf{f}}_\mathbf{d}$), total relative prices ($\breve{\mathbf{x}}^\mathbf{p}$) and inventories ($\breve{\mathbf{s}}$):

$$\Delta\mathbf{x}^\mathbf{v} = \breve{\mathbf{A}}_\mathbf{d} + \breve{\mathbf{f}}_\mathbf{d} + \breve{\mathbf{x}}^\mathbf{p} + \breve{\mathbf{s}} \quad (52)$$

where $\overbrace{[\ldots]}$ represents the sectoral changes between the final and initial period inside the $\Delta\mathbf{x}^\mathbf{v}$ for each variable assigned. In other to simplify the exposition of the methodology, the mathematical equations of the previous variables are presented in Appendix F.

The final step to obtain the isolation of all relative prices changes is disaggregating the decomposition of the domestic technical coefficient by industry ($\breve{\mathbf{A}}_\mathbf{d}$) in the changes of the variables that are inside it: the relative price relation and volume of the market share matrix ($\mathbf{D}^\mathbf{p}$ and $\mathbf{D}^\mathbf{v}$) and the technical coefficient relative price ($\mathbf{B}_\mathbf{n}^\mathbf{v}$) and in volume units ($\mathbf{B}_\mathbf{n}^\mathbf{p}$), in the dimension product by industry. In a analogous way, we disaggregate the decomposition of the domestic final demand by industry ($\breve{\mathbf{f}}_\mathbf{d}$) in the changes of the elements related to the market share matrix ($\mathbf{D}^\mathbf{p}, \mathbf{D}^\mathbf{v}$) and in the final demand relative price ($\mathbf{f}_\mathbf{dq}^\mathbf{p}$) and in volume units ($\mathbf{f}_\mathbf{dq}^\mathbf{v}$), both in the product dimension.

After the methodological procedures, we rearrange the gross output changes in volume units to capture the *volume* ($\boldsymbol{\upsilon}$) and *relative price contribution* ($\boldsymbol{\rho}$).

$$\Delta\mathbf{x}^{\mathbf{v}} = \left[\underbrace{\left(\breve{\mathbf{A}}^{\mathbf{v}}_{\mathbf{d}} + \breve{\mathbf{f}}^{\mathbf{v}}_{\mathbf{d}} + \breve{\mathbf{D}}^{\mathbf{v}}\right)}_{\text{volume contribution } (\upsilon)} + \underbrace{\left(\breve{\mathbf{x}}^{\mathbf{p}} + \breve{\mathbf{A}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{f}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{D}}^{\mathbf{p}}\right)}_{\text{relative prices contribution } (\rho)} + \breve{\mathbf{s}} \right] \tag{53}$$

We present the equations definitions in Appendix F. The volume contribution is the sum of the volume changes in the domestic intermediate demand $\breve{\mathbf{A}}^{\mathbf{v}}_{\mathbf{d}}$, the final demand $\breve{\mathbf{f}}^{\mathbf{v}}_{\mathbf{d}}$ and the market share contribution $\breve{\mathbf{D}}^{\mathbf{v}}$. The price contribution considers the effect of sectoral relative prices, the change in the relative prices inside domestic intermediate inputs coefficients, final demand and market share matrix. We must notice that $\breve{\mathbf{A}}^{\mathbf{v}}_{\mathbf{d}}/\breve{\mathbf{A}}^{\mathbf{p}}_{\mathbf{d}}$ and $\breve{\mathbf{f}}^{\mathbf{v}}_{\mathbf{d}}/\breve{\mathbf{f}}^{\mathbf{p}}_{\mathbf{d}}$ contributions, in fact, represents the change in $\mathbf{B}^{\mathbf{v}}_{\mathbf{d}}/\mathbf{B}^{\mathbf{p}}_{\mathbf{d}}$ and $\mathbf{f}^{\mathbf{v}}_{\mathbf{dq}}/\mathbf{f}^{\mathbf{p}}_{\mathbf{dq}}$ since they are weighted by the market share matrix. Inside $\breve{\mathbf{D}}^{\mathbf{v}}/\breve{\mathbf{D}}^{\mathbf{p}}$ we include the changes of the volume market share matrix, weighted by $\mathbf{A}_{\mathbf{d}}$ and $\mathbf{f}_{\mathbf{d}}$.

Finally, to obtain the total change of gross output growth decomposition (and maintain the additivity property in the system), we must substitute the result of second level decomposition *(53)* in the first level decomposition *(42)*. Doing that we have the following contributions:

$$\frac{\Delta\mathbf{x}}{x_0} = \underbrace{\frac{1}{x_0}\left\{\frac{1}{2}\left(\hat{\mathbf{x}}^{\mathbf{p}}_{\mathbf{1}} + \hat{\mathbf{x}}^{\mathbf{p}}_{\mathbf{0}}\right)\left[\overbrace{\left(\breve{\mathbf{A}}^{\mathbf{v}}_{\mathbf{d}} + \breve{\mathbf{f}}^{\mathbf{v}}_{\mathbf{d}} + \breve{\mathbf{D}}^{\mathbf{v}}\right)}^{\text{volume contribution } (\upsilon)} + \overbrace{\left(\breve{\mathbf{x}}^{\mathbf{p}} + \breve{\mathbf{A}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{f}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{D}}^{\mathbf{p}}\right)}^{\text{relative prices contribution } (\rho)} + \breve{\mathbf{s}}\right]\right\}}_{\textit{volume units changes}} + \underbrace{\frac{1}{x_0}\left\{\frac{1}{2}\Delta\hat{\mathbf{x}}^{\mathbf{p}}\left(\hat{\mathbf{x}}^{\mathbf{v}}_{\mathbf{1}} + \hat{\mathbf{x}}^{\mathbf{v}}_{\mathbf{0}}\right)\right\}}_{\textit{relative prices changes}} \tag{54}$$

Weighting the volume changes by the sectoral relative price $\left(\hat{\mathbf{x}}^{\mathbf{p}}_{\mathbf{1}} + \hat{\mathbf{x}}^{\mathbf{p}}_{\mathbf{0}}\right)$ is necessary not only to arrive at the total gross output change but also to make them addible[45].

3.8.2.1 Volume contribution and sources of change

In the previous procedure, we isolate the changes in the Brazilian gross output related to volume because it is our variable of interest. We analyze here in details the factors that

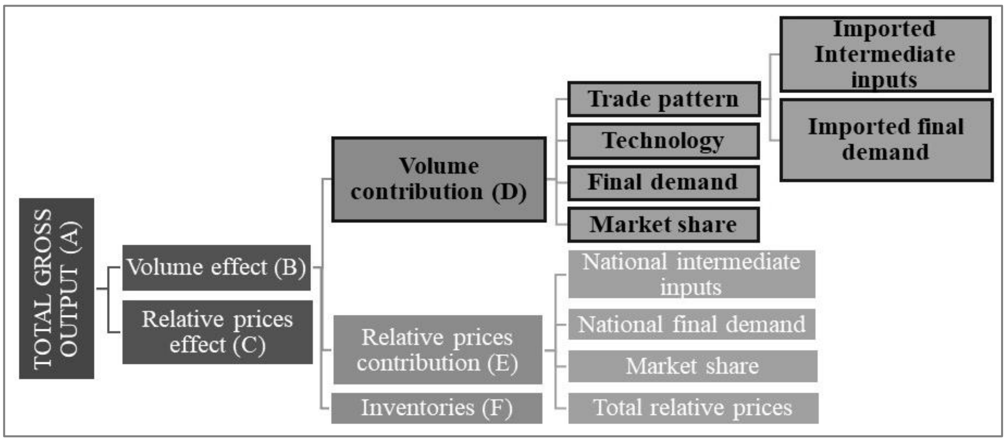
[45] "Summing the volume variation of the sub-aggregates weighted by their prices yields the volume variation (in euros) of the aggregate, while summing the price changes of the sub-aggregates weighted by their volumes yields the change in value of the aggregate, which is caused by price changes of its elements, again in euros. The decomposition acknowledges the fact that neither prices nor volumes are additive by themselves, but only their combination is: values (REICH, 2008, P. 421).

contribute to volume changes in output, proposing the following sources of change: **trade pattern**, **technological change**, and **final demand**.

The changes in the trade pattern reflect the effect of penetration/substitution of inputs or final goods and services. The technological change's contribution shows the consequence of a change in the 'production recipe.' The last factor is the final demand's contribution that displays the effect of the variations of final demand in the gross output.

After all disaggregation, we present the final version of the two-level decomposition in *Figure 48*.

Figure 48 – Structural decomposition diagram



Source: Author's elaboration.

To capture the source of changes, we express all domestic variables in total demand and imported demand. The changes in matrix $\mathbf{A_d}$ are due to variations in the technology itself ($\mathbf{A}$) or also on the trade pattern of imported inputs, we calculate domestic technological coefficients as a difference between total technical coefficients ($\mathbf{A}$) and imported technical coefficients ($\mathbf{A_m}$), as:

$$\mathbf{A_d} = \mathbf{A} - \mathbf{A_m} \quad (55).$$

We must also disaggregate $\mathbf{A}$ and $\mathbf{A_m}$ considering the technological coefficients in the level product-by-industry and the market shares matrices, so:

$$\mathbf{A} = (\mathbf{D^p} \otimes \mathbf{D^v}).(\mathbf{B^p} \otimes \mathbf{B^v}) \quad (56)$$

$$\mathbf{A_m} = (\mathbf{D^p} \otimes \mathbf{D^v}).\left(\mathbf{B^p_m} \otimes \mathbf{B^v_m}\right) \quad (57).$$

In this sense, variations in $\mathbf{A}$ will express the contribution to technological change, and the contribution of $\mathbf{A_m}$ shows the changes in the trade pattern of inputs in the Brazilian economy. Note that as Brazilian SNA express the inputs information in a product-by-industry level, changes in $\mathbf{B}$ and $\mathbf{B_m}$ changes are observable.

The changes in technology are related to column-specific changes, as a simplification (MILLER; BLAIR; 2009). As each column of $\mathbf{A}$ shows the way of production of each industry (the 'industry's production recipe'), the change column by column extracts the effect of input changes in each industry of the economy. So, the changes in technological coefficients will show the changes in input needs for the production in each industry.

However, the change in the technology itself may demand more imported inputs than was previously necessary. An increase/decrease in total imports this way may not be related to a change in trade pattern, such as penetration or substation of imports, but only reflects the technological needs for production. To isolate this effect, as Schuschny (2005) and Kupfer, Freitas, & Young (2003) propose, we estimate an auxiliary matrix of imported technological coefficients.

The basic idea of this hypothesis is disaggregating the changes in $\mathbf{B^v_m}$ that are influenced by the changes in the technology and the one which is due exclusively to the trade pattern. As technological requirements are better analyzed considering only the volume, we calculate this auxiliary matrix of imported technological coefficients ($\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m}}$) supposing that it grows proportionally to the rate of growth of technical coefficients in volume, denoted as

$$t^v_{ij} = \frac{b^v_{ij_1}}{b^v_{ij_0}} - 1 \tag{58}$$

where t^v_{ij} is the technological growth related to the input produced by product i and used by industry j between the final and initial period.

We calculate the auxiliary matrix of imported technical coefficients ($\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m0}}$) by multiplying each element of the imported technological coefficient at the initial period ($b^v_{m_{ij_0}}$) by $1 + t^v_{ij}$:

$$\breve{b}^v_{m_{ij_0}} = \frac{b^v_{ij_1}}{b^v_{ij_0}} \times b^v_{m_{ij_0}} \tag{59}$$

where $\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m0}} = \left[\breve{b}^v_{m_{ij_0}}\right]$ and $\mathbf{B}^{\mathbf{v}}_{\mathbf{m_0}} = \left[b^v_{m_{ij_0}}\right]$.

The difference between $\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m0}}$ and $\mathbf{B}^{\mathbf{v}}_{\mathbf{m_0}}$ shows only the change on imported inputs that changed only because of the technic of production. The other part, $\mathbf{B}^{\mathbf{v}}_{\mathbf{m_1}}$ deducted $\breve{\mathbf{B}}^{\mathbf{v}}_{\mathbf{m0}}$, shows in fact if there was a substitution or penetration of imports, reflecting a change in competitive imports. Inserting this information into the structural decomposition, we express the changes in

B (product-by-industry) matrices in the **A** matrices (industry-by-industry). In this way, we rearrange the volume contribution of domestic technical coefficients $\breve{\mathbf{A}}_{\mathbf{d}}^{\mathbf{v}}$ as:

$$\breve{\mathbf{A}}_{\mathbf{d}}^{\mathbf{v}} = \underbrace{-\left(\breve{\mathbf{A}}_{\mathbf{m_1}}^{\mathbf{v}} - \breve{\breve{\mathbf{A}}}_{\mathbf{m_0}}^{\mathbf{v}}\right)}_{\substack{\textbf{Intemediate} \\ \textbf{trade pattern}}} + \underbrace{\left[\breve{\mathbf{A}} - \left(\breve{\breve{\mathbf{A}}}_{\mathbf{m_0}}^{\mathbf{v}} - \breve{\mathbf{A}}_{\mathbf{m_1}}^{\mathbf{v}}\right)\right]}_{\substack{\textbf{National} \\ \textbf{Technological change}}} \tag{60}$$

where the first part of the previous equation represents the changes in the intermediate trade pattern and the second one represents the contribution of domestic technological change.

We do the disaggregation of final domestic demand in total ($\mathbf{f}$) and imported ($\mathbf{f_m}$), excluded inventories, as expressed at:

$$\mathbf{f_d} = \mathbf{f} - \mathbf{f_m} \tag{61}$$

where, as observed on (14):

$$\mathbf{f} = \mathbf{D}.\left(\hat{\mathbf{f}}_{\mathbf{q}}^{\mathbf{p}} \mathbf{f}_{\mathbf{q}}^{\mathbf{p}}\right) \tag{62}$$

$$\mathbf{f_m} = \mathbf{D}.\left(\hat{\mathbf{f}}_{\mathbf{mq}}^{\mathbf{p}} \mathbf{f}_{\mathbf{mq}}^{\mathbf{p}}\right) \tag{63}.$$

where $\hat{\mathbf{f}}_{\mathbf{q}}^{\mathbf{p}}$ and $\hat{\mathbf{f}}_{\mathbf{mq}}^{\mathbf{p}}$ represents the diagonal vector of relative price relation for total and imported final demand by product ($m \times 1$); $\mathbf{f}_{\mathbf{q}}^{\mathbf{v}}$ and $\mathbf{f}_{\mathbf{mq}}^{\mathbf{v}}$ are the total and imported demand in volume units. The changes in $\mathbf{f_m}$ represent the trade pattern effect on final demand, which means the penetration or substitution of imports associated with final goods and services on the economy. We disaggregate final demand in households consumption (*c*), government expenditures (*g*), gross fixed capital formation (*k*), and external demand (*e*), which represents exports.

Putting together all the previous elements, the *volume contribution* to gross output in volume, when analyzed by the sources of change, is expressed as:

$$\boldsymbol{\upsilon} = \underbrace{\left[\overbrace{-\left(\breve{\mathbf{A}}_{\mathbf{m_1}}^{\mathbf{v}} - \breve{\breve{\mathbf{A}}}_{\mathbf{m_0}}^{\mathbf{v}}\right)}^{intermediate} \overbrace{-\breve{\mathbf{c}}_{\mathbf{m}}^{\mathbf{v}} - \breve{\mathbf{k}}_{\mathbf{m}}^{\mathbf{v}} - \breve{\mathbf{g}}_{\mathbf{m}}^{\mathbf{v}} - \breve{\mathbf{e}}_{\mathbf{m}}^{\mathbf{v}}}^{final\ demand}\right]}_{trade\ pattern} + \underbrace{\left(\breve{\mathbf{A}} - \left(\breve{\breve{A}}_{\mathbf{m_0}}^{\mathbf{v}} - \breve{\mathbf{A}}_{\mathbf{m_1}}^{\mathbf{v}}\right)\right)}_{domestic\ technology} \tag{64}$$

$$+ \underbrace{\breve{\mathbf{c}}^{\mathbf{v}} - \breve{\mathbf{k}}^{\mathbf{v}} - \breve{\mathbf{g}}^{\mathbf{v}} - \breve{\mathbf{e}}^{\mathbf{v}}}_{\substack{final \\ demand}} + \underbrace{\Delta\mathbf{D}^{\mathbf{v}}}_{\substack{market \\ share}}$$

To obtain the contribution to gross output, we must divide each change to the initial gross output x_0.

4 MULTISECTORAL AND STRUCTURAL DECOMPOSITION ANALYSIS

In this Chapter, we present some indicators to help us identify if there is a process of deindustrialization and regressive specialization in the period of the investigation. When possible, we exclude the effects of relative prices in the analysis and show how this affects the issues under investigation. As mentioned in the previous chapters, we consider the innovative manufacturing group (IM) as the most relevant one to evaluate if there is a process of deindustrialization, as we pointed in Chapter 1 and 3. For the hypothesis of regressive specialization, we analyze the change in the composition of the agricultural and mining and quarrying unprocessed and processed, and commodities present in the agricultural and related group (AGR), AC (processed agricultural commodities), and MQC (unprocessed and processed mining and quarrying commodities) and the IM group.

Here we present some usual indicators used to evaluate if the Brazilian economy is in the presence the processes of deindustrialization and regressive specialization, such as the share of the groups in volume units and total units for the gross output (section 1) and exports (section 2). Also, we discuss some indicators related to Brazilian external and domestic competitiveness (section 3), intersectoral relations based on the input-output information (section 4) and, changes in labor productivity (section 5). Then, we complement the analysis presenting the structural decomposition analysis developed in the methodological chapter and discuss its implications for Brazilian structural change (section 6). Finally, we discuss the implications of the several indicators investigated here to the deindustrialization and regressive specialization in the Brazilian economy.

4.1 Gross output share in total and volume units

One of the most used indicators to question if there is a deindustrialization process is the share of the industries groups in gross output, as we saw in Chapter 1. According to this literature, if there is a decrease (increase) in the percentage of the manufacturing industry in the production, it indicates that there it lost (gain) importance in the economy.

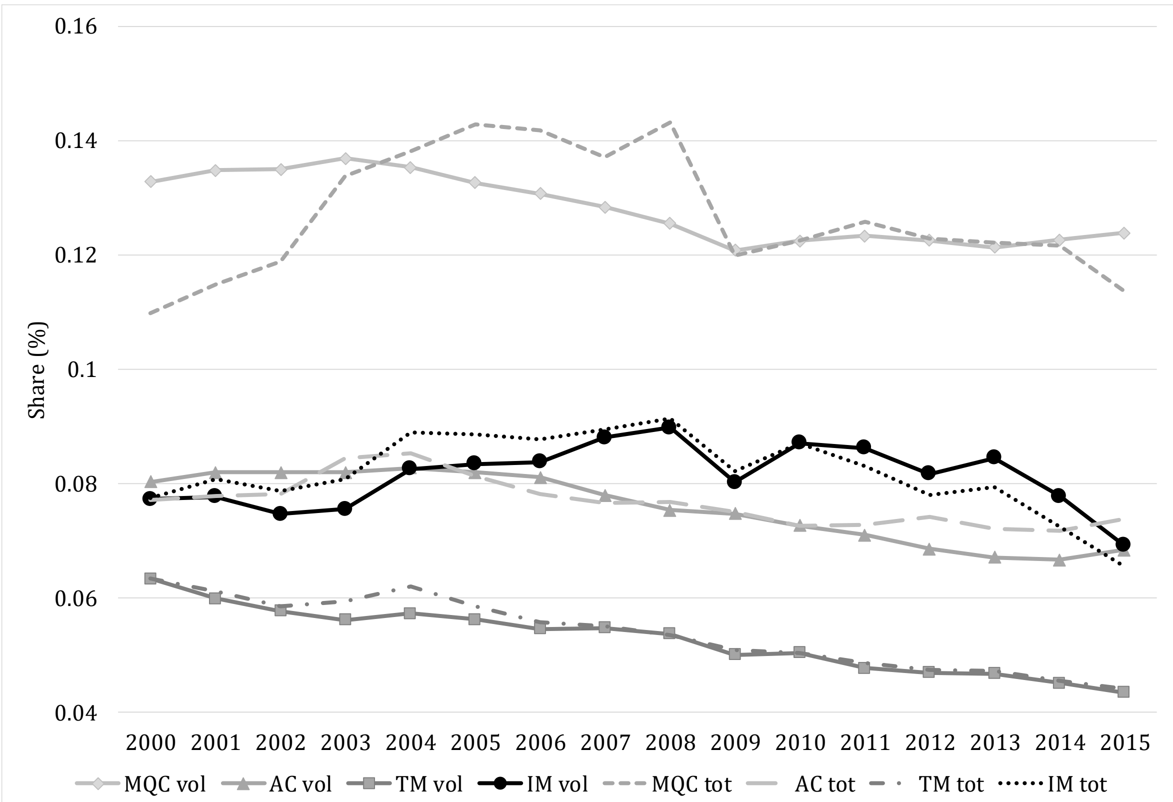
However, as discussed previously, the changes in this percentage can be associated with the changes in volume production, but also to the relative prices of the sector about total gross output deflator. To understand how the relative prices affect this, we present in Figure 49 the gross output shares of each extractive and manufacturing groups (EMI), both in volume units

(VOL, full line and associated with $\mathbf{x^v}$) and in total units (TOT, dotted line, related to $\mathbf{x}$). The difference between them represents the relative price level ($\mathbf{x^p}$).

Focusing on the IM group, we observe small changes over the period. However, if we compare the growth of the share between 2000 and 2014 we notice that in total units this group loses share, growing at an inferior rate than the total gross output (-0.48% p.a., *Figure 50*) while in volume they maintained almost the same pace, with a slight growth (0.05% p.a.). The difference indicates that there is a relative price reduction associated with this group, which is in line with the international trend we presented in Chapter 1.

MQC represent the highest gross output share, with an average of 12% and also is the one whose share varies the most among all EMI, either in volume or in total units. It is the industry group most affected by relative prices changes since it produces the commodities which displayed the highest prices changes in the period. Thus, if we consider the series in total units, the relative price influence increases their participation in total gross output when there is a trajectory of price increase (for example, between 2003-2008). In the whole period, its gross output share increased in total units (0.74% p.a.) but decreased in volume units (-0.56% p.a.).

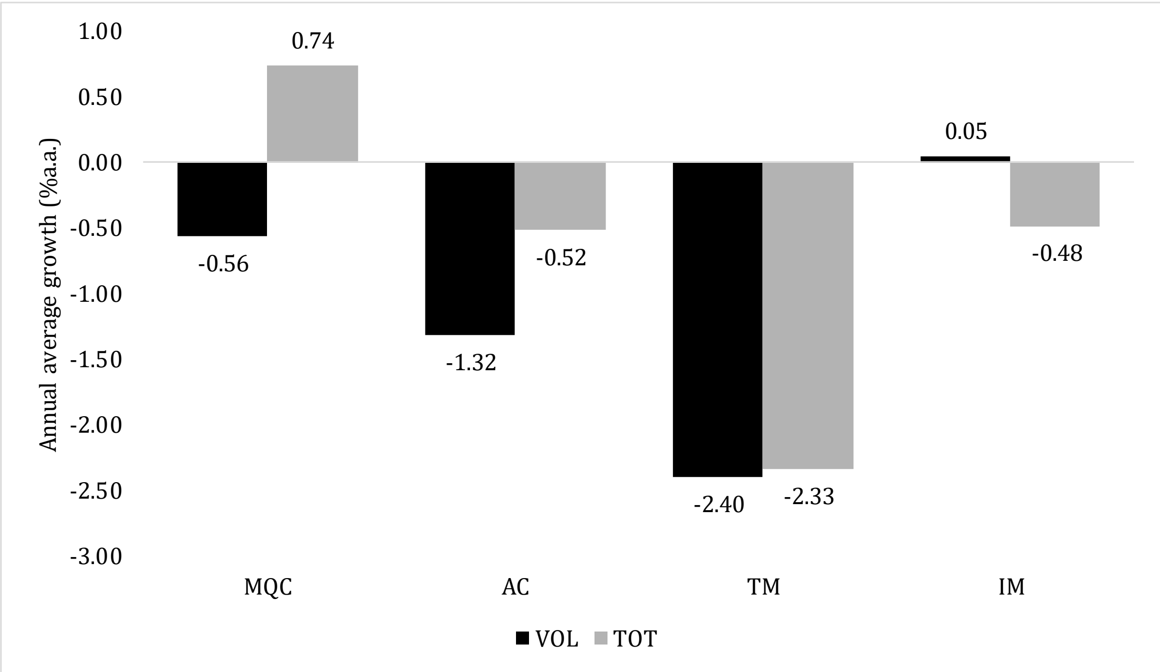
Figure 49 – Gross output share of extractive and manufacturing industry groups in total and volume units, 2000 to 2015.



Source: Author's calculations from the estimated IOT series, based on information from the SNA/IBGE.

Concerning the other industry groups, we see a marked reduction in the gross output share of TM and AC groups. The TM group reduced its share from 6.3% to 4.5%, and the share of the AC group went from 8.7% to 6.7%, both concerning volume units. For both groups they grew at an inferior rate than the gross output between 2000 and 2014, reducing their share in the total gross output. However, the loss is higher considering volume rather than total units, indicating a reduction of their sectoral relative prices.

Figure 50 – Annual average growth (% p.a.) in volume and total units of the gross output share for AC, MQC, TM, and IM for Brazil, 2000-2014



Source: Author's calculations from the estimated IOT series, based on information from the SNA/IBGE.

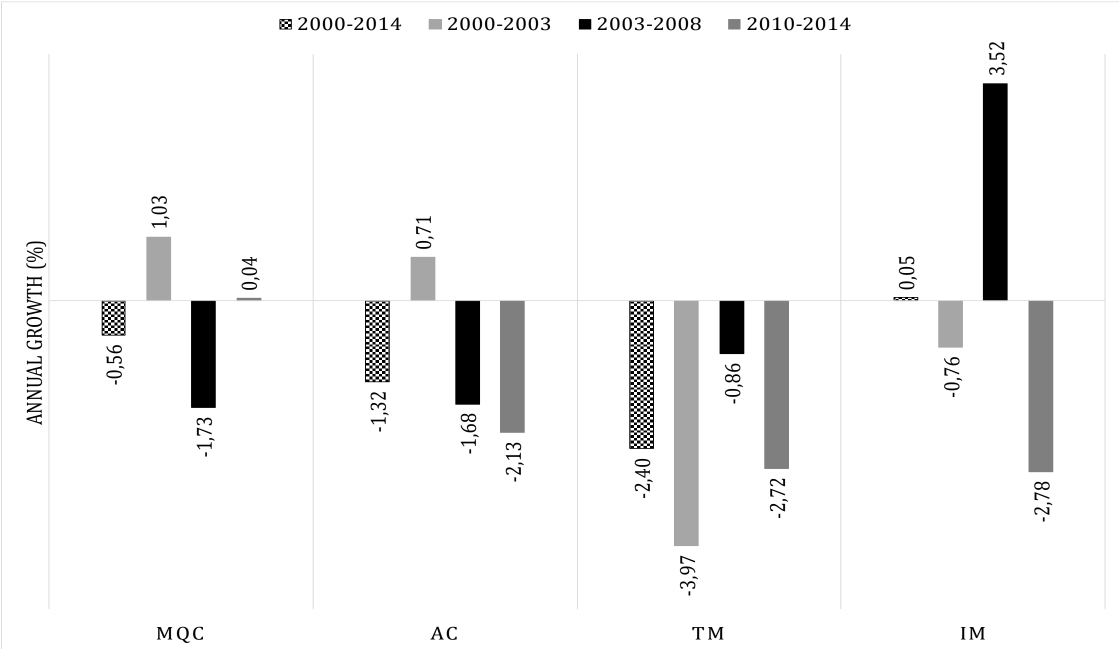
Moreover, besides the effects of relative prices changes, we can also verify that there is a significant tendency towards a reduction of the gross output share of the industry groups in volume units[46].

To advance in our interpretation, we present in Figure 51 the growth rate of the gross output shares of these groups in volume units for subperiods. Analyzing the growth rate of IM group's share, we see that it has grown during 2000-2014 (0.05%) and 2003-2008 (3.52%), being the only group with an increasing gross output share in volume units. In connection with the literature review presented in Chapter 1, we argue that this increase is explained, in great part, by a strong relationship between the IM group and the investment-output ratio. Since the IM group produces durable goods (including machinery and equipment, automobiles and

[46] Except for the MQC group, that featured an approximately zero rate of growth in the period.

electronics), the intensity of the process of capital accumulation (captured by the investment-output ratio) explains the increase of the gross output share of this group, as presented in Figure 52.

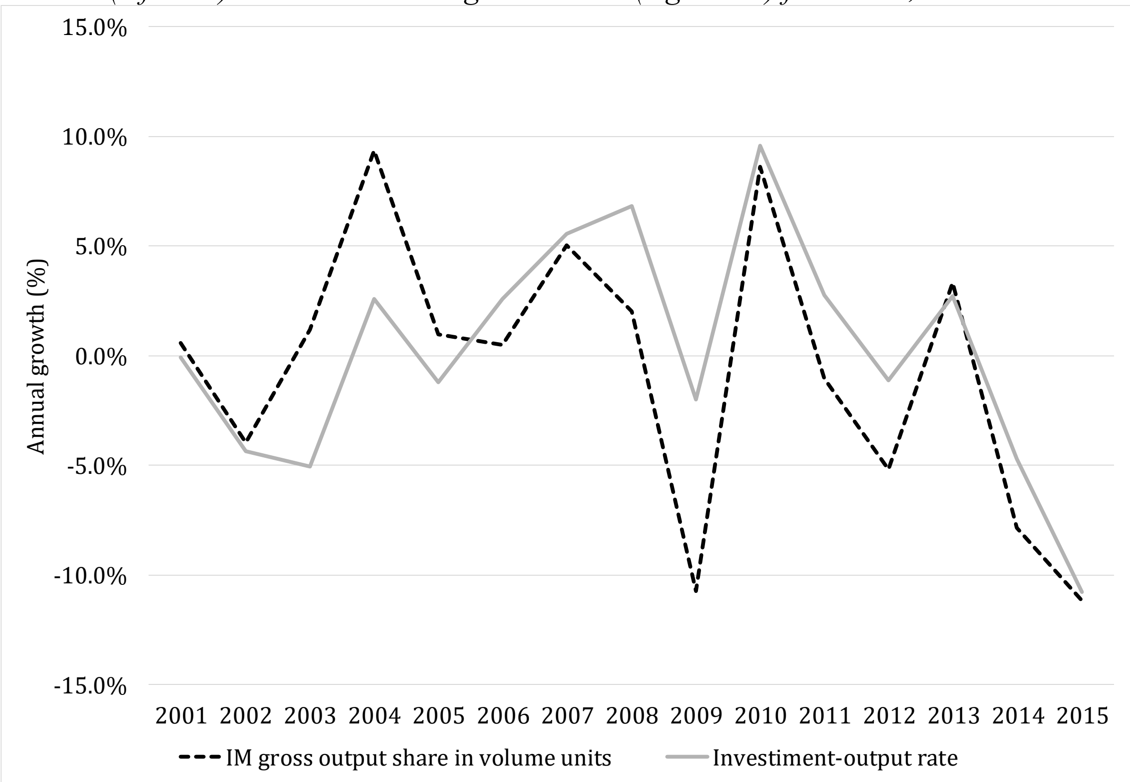
Figure 51 – Annual average rate of growth (% p.a.) of the gross output shares of extractive and manufacturing industry groups in volume units for Brazil, 2000 to 2014 (selected periods)



Source: Author's calculations from the estimated IOT series, based on information from the SNA/IBGE.

For the other periods, 2000-2003 and 2010-2014, in which the GDP and GFCF have a poor performance, the IM group reduces its share in the total gross output. Hence, the period between 2010 and 2014 is the worst for the innovative manufacturing industry group due to the reduction in the path of capital accumulation. Thus, the closest relation between economic growth and the IM group share in gross output expresses the limitation of considering only this indicator as a measure of deindustrialization. As pointed out in Chapter 1, the accelerating rate of investment-input ratio affects the evolution of the manufacturing industry share, and even more in the case of the innovative sector. Therefore, a decrease in the trend rate of growth of the economy can lead to the misleading conclusion that a deindustrialization process is going on, when in fact represents a change in the path of accumulation.

Figure 52 – Annual rates of growth (%) in volume units of GFCF and IM's gross output share (left axis) and annual GDP growth rates (right axis) for Brazil, 2000 to 2014



Source: Author's calculations from the estimated IOT series, based on information from the SNA/IBGE.

Considering all the limitations of the use of the manufacturing share as the unique indicator for deindustrialization presented in Chapter 1, we find that the process of deindustrialization in Brazil is less intense and continuous as literature characterize. First, there is no reduction in the share of the innovative industry in the gross value of production between 2000 and 2014 in volume units. The effect of the decrease in the relative price of these goods gives us the impression of the total that this group lost importance, which we do not observe in the real production of these goods.

Second, because the IM share along the period is not continuous and depends on the investment-output ratio, in the most recent subperiod (2010-2014), there is a decline in IM's share of production. However, only this argument is inaccurate to conclude that this movement is related to deindustrialization because, given the close relationship between investment output-ratio and the IM share, the percentage reduction may be temporary and not structural. We will complement this information with other indicators in this chapter.

Third, although we find a drop considering the other manufacturing groups, they have a second role in the diagnosis of deindustrialization because they have low capacity in the technological diffusion and provides limited possibilities for the catch-up. Moreover, the traditional manufacturing industry is the one with the highest losses in the share and also the most affected by the process of de-verticalization of production in the CGV. Hence, this type of goods is more susceptible to the expansion of the competition of the large populous countries, like China, in this new production context.

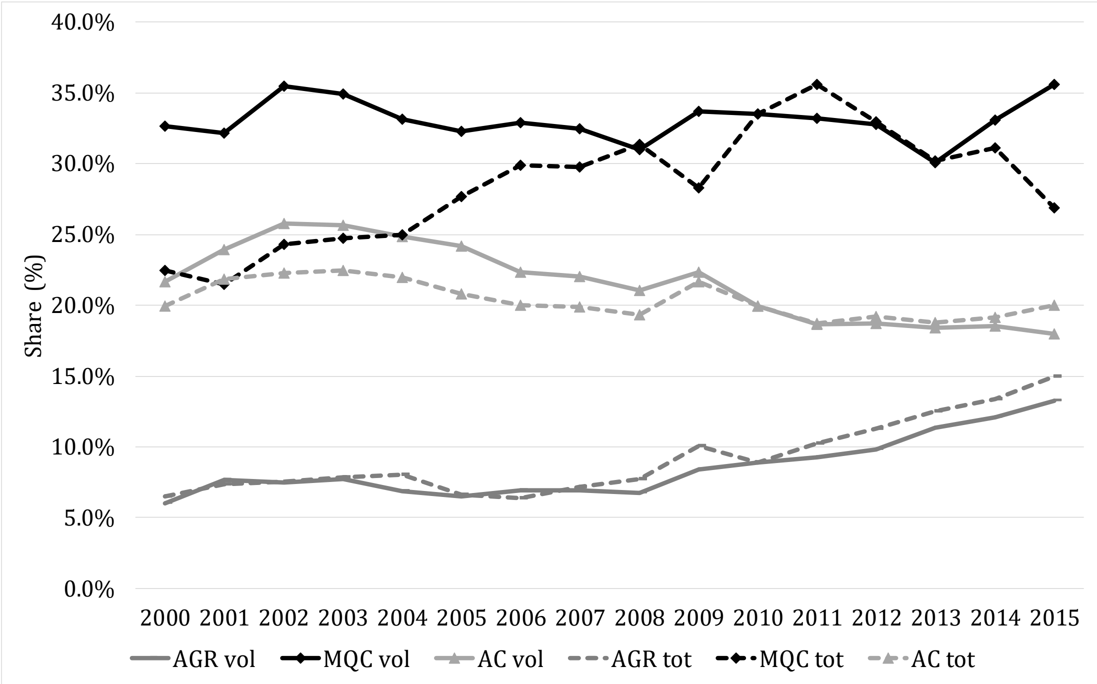
4.2 Exports and regressive specialization

If we do a similar exercise, but considering exports, we will see that relative prices also have an important role in explaining changes in the composition of exports and thus have also a significant impact on the evaluation of the validity of the regressive specialization hypothesis. In Figure 53 and Figure 54 we present the sectoral composition of Brazilian exports in volume units (full line) and total units (dotted line). Notice that, the difference is a result of relative prices changes all over the series. Figure 53 presents the series for the exports of Agriculture and other primary activities (denoted AGR), MQC and AC industry groups, the three groups concerned with the argument of regressive specialization. On the other hand, Figure 54 presents the series for the other two EMI groups, the TM and IM industry groups.

First, we observe the MQC group has the highest share in the total exports, and its trajectory over time is very different when we contrast the series in volume and total units. In total units (which includes the changes in volume and relative prices), this group had an expressive increasing along the years, especially between 2000 and 2008 (jumping from 22.5% to 31.4%), corresponding to the period when the MQC group exports' deflator begins to grow at a higher pace than the total export’s deflator. It still increased its share in total units until 2011, but after there was declining, and in 2015 its share in total exports was around 26%.

However, if we consider the exports share in volume units, we observe stable participation of the MQC group in total exports along the period (32.6% in 2000 and 33.1% in 2014). Hence, the intensity of the demand pressure for this type of commodities, resulting in a grand measure of China’s fast expansion in the period, had the effect of increasing relative prices without contributing to increasing the exports share this group in volume units.

Figure 53 – Composition of Brazilian exports in volume and total units, for AGR, MQC, and AC, 2000 to 2015



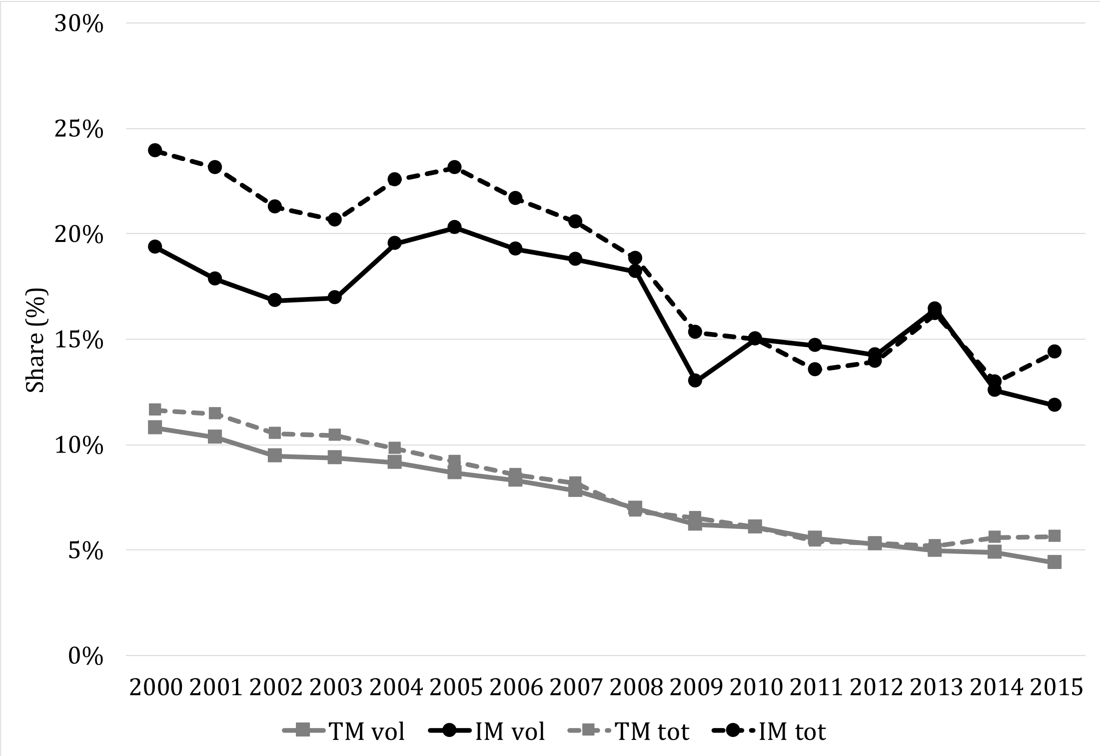
Source: Author's calculations based on information from the SNA/IBGE.

The AC group has the second-highest exports share. For this group, the relative prices also affect its share, but in a less significant measure when compared to the MQC group. We see a declining trend in the group's exports share in volume units, especially after the peak that occurred in 2002-2003, from a value slightly above 25% to a value of 18.6% in 2014. From a general point of view, the share in volume units is higher than the one for total units. It indicates that the relative price effect contributes to underestimate the movement of AC during 2000-2009. Hence, the share of this group maintained almost the same value (it changed from 20% in 2000 to 19.1% in 2014) in total units,

Finally, the other group generally associated with the hypothesis of regressive specialization is the AGR group. Compared to the other two groups analyzed before, it has the lowest share in Brazilian exports and shows little influence of relative prices. However, recently this group has increased its share in total exports, either in volume units or in total units. In the first part of the period under analysis, between 2000 and 2008, it almost maintained the participation in volume units, increasing only from 6% to 6.8%. Nonetheless, after 2009 this group increased its share in Brazilian exports in volume units, reaching 13.3% in 2015.

The exports share of the other two groups, IM and TM, featured a declining trend, both in total and in volume units (Figure 54). In the case of IM group, we observe that in the first part of the period, between 2000 and 2008, the share in total (24% and 21%) is higher than in volume (19.4% to 18.8%). Since the distance between the two lines of the share in volume units and total units is diminishing, it represents a reduction in the IM exports relative price. In the overall period, there is a decline in the share in volume units, although the fall in the share is more pronounced from 2010, where the parcel is 15%, reaching 11.8% in 2015.

Figure 54 – Composition of Brazilian exports in volume and total units, for the TM and IM groups, 2000 to 2015



Source: Author's calculations based on information from the SNA/IBGE.

The TM group also declined its share in the Brazilian exports, and it has the lowest share of total exports among the groups analyzed. The declining tendency is constant in the period and might be related to the process of fragmentation of production. We already pointed out this effect for gross output, but it also influences the Brazilian exports. As we presented in Chapter 1, the low costs of production (low unit labor costs) in many populous countries create strong competition for the Brazilian products, and especially these more homogenous goods.

By analyzing the trajectory of AGR, AC, and MQC, we can conclude that the diagnostic of the process of regressive specialization in the Brazilian economy is affected by the influence of relative prices, and especially in the case of MQC. If we consider the share in volume units, we observe a slight decline in the exports share of the AC group and a relatively stable value of the exports share the MQC group along the period. However, the only group that contributed in a way to increase our regressive specialization is the AGR group, which produces unprocessed agricultural and related goods. By the other side, there was a reducing in the exports of processed agricultural commodities and might indicate that we are switching the exports of more processed goods to unprocessed ones. The reduction of exports of the IM group (and the TM group) is one evidence of the existence of regressive specialization in the Brazilian economy. This tendency is even more evident between 2010 and 2014.

However, this indicator only analyzes the situation of the Brazilian export agenda without considering world demand. It is possible that Brazilian exports of these goods have declined as a result of a lack of world dynamism in the market for these goods. Thus, having a reduction in the export of TM and IM on Brazilian exports would reflect a world tendency. Hence, we must compare the Brazilian export basket to the insertion of these goods in the world market, to have a proper diagnosis of regressive specialization.

Moreover, the conclusion of the regressive specialization effect on the productive structure is incomplete, especially for the case of the Brazilian economy. Exports represent a small share of demand (as presented in Chapter 2) since Brazil is a country of vast proportions. Also, it is expected that the Brazilian export basket is a result of its natural resource endowment (agricultural, mineral and extractive).

In this sense, the inflow of foreign exchange by the expansion of the natural resources commodities places the exchange rate at a higher level than would be "optimal" for the development of the manufacturing industry. However, as discussed by Medeiros (2013), there is no evidence to prove that the expansion of natural resource-based exports will replace manufacturing output. The author says that manufacturing development is more related to the national strategies of development than to changes in the export's composition. Besides, he highlights that the foreign exchange inflows increase can strengthen manufacturing expansion through the relaxation of external constraints.

4.3 Brazilian Competitiveness in External and Internal markets

Although analyzing the composition of exports in the Brazilian economy is essential to understand the structural dynamics of the Brazilian economy, we argue that an investigation of the Brazilian competitiveness in external and internal markets allows us to have a better evaluation of the hypothesis of deindustrialization and regressive specialization.[47] Regarding external competitiveness, we analyze the market share of Brazilian exports in the world exports for the four industrial groups, using the COMTRADE database and the correspondence table provided by Torracca (2017). In the case of the competitiveness in domestic markets, we focus on the market share of the total imports in total supply (imports plus production) in the Brazilian market, using the IOTs database estimated for this work.

4.3.1 Competitiveness in external markets

Before analyzing the Brazilian market share of world exports, we present a quick view of the rates of growth of exports. For total exports, which includes all agricultural, extractive and manufacturing and services industries, Brazilian exports had an impressive growth (10.4%) compared to world's exports (7.8%)[48], between 2000 and 2014[49]. However, the behavior is different according to the distinct industrial groups.

Amaral, Freitas, and Castilho (2018) analyzed the evolution of Brazilian exports growth between 1995 and 2014. Using a shift-share decomposition analysis, they found that the world income and the world trade income elasticity were the factors that most contributed to this growth. The Brazilian economy has benefited from that, mainly because of the higher world prices and real demand for the production of industries groups that the country was already specialized, AC, AGR, and MQC (as we will see in Figure 55).

Moreover, the authors refer to two other factors that contributed in a positive but minor way to total export's growth during 2000-2014: the Brazilian market shares (as a measure of competitiveness) and the dynamics of the world market for the exported products[50]. In a disaggregated analysis by period, Amaral, Freitas, and Castilho (2018) showed that for 2011-2014 the last two effects increased their relevance, explaining almost 90% of the Brazilian exports growth in this period, overcoming the importance of world income growth and world trade elasticity.

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[47] Moreover, in the long run, the competitiveness analysis also contributes to projecting the likelihood of the Brazilian economy facing an external constraint on its growth path.

[48] It is important to note that there is a relative price effect of Brazilian exports deflator in relation to world's exports deflator, that may affect both rates of growth. Since we use the COMTRADE database, we were not able to isolate the volume and relative price effect.

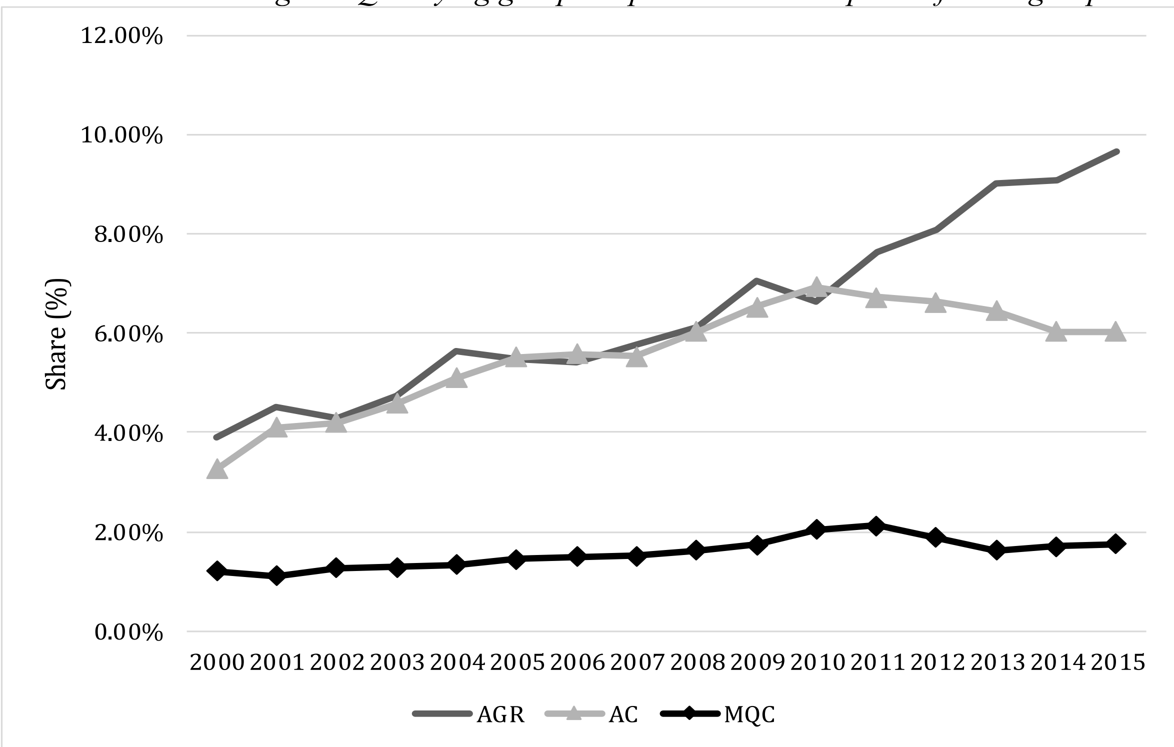
[49] The growth between 2000 and 2015 was 6.8% and 9.2% for the world and Brazilian economies respectively.

[50] They consider dynamic a product (or industry) when the exports of this product grow at faster pace than global exports, leading to an increase in their participation in international trade.

As the Brazilian market share of the industrial groups represents an important measure of their external competitiveness, we present the external market share (%) of AGR, MQC, and AC in Figure 55 and for TM and IM in Figure 57. In Figure 55 we see that the AC, AGR, and MQC groups increased their shares in their external markets between 2000 and 2015. The AC and AGR groups are the ones with the highest and growing share in their respective global markets. To complement this information,

Figure *56* is a proxy for world export basket and shows the exports composition by groups in the world exports of goods (agricultural, mining and quarrying and manufacturing). Hence, these groups increased the market share in groups that represent a constant and low share in the world's export.

Figure 55 – Market share (%) of Processed Agriculture Commodities and Unprocessed and Processed Mining and Quarrying groups' exports in world exports of these groups

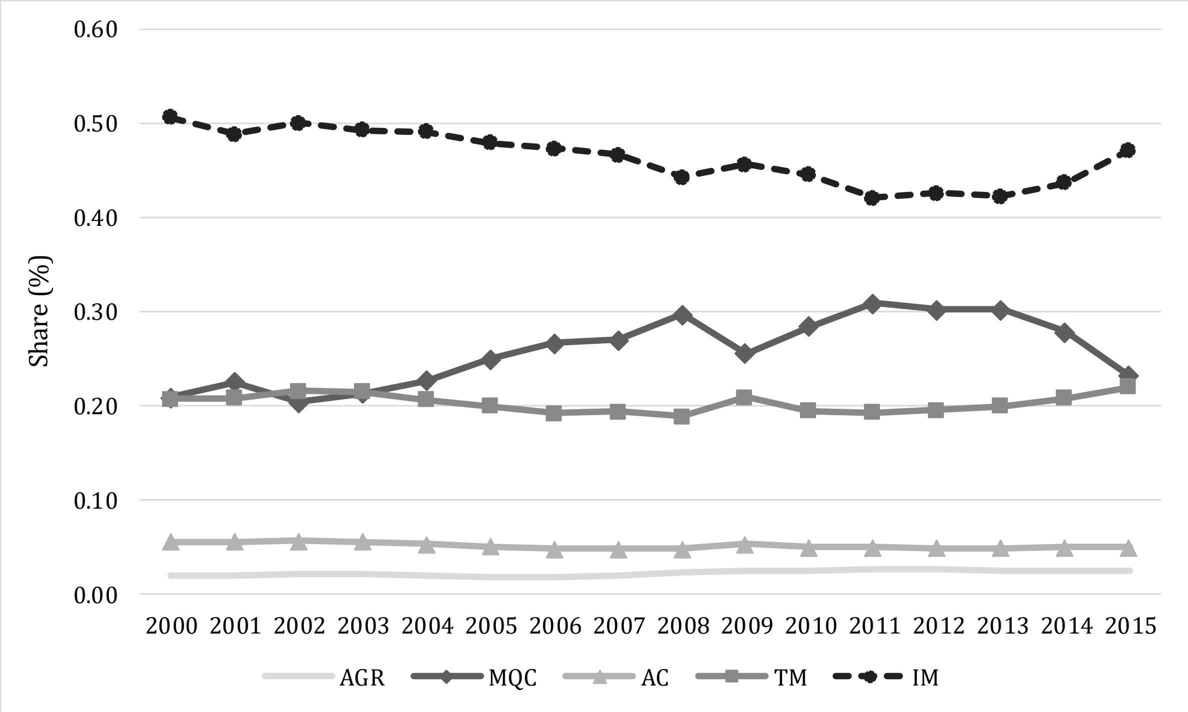


Source: Elaboration by GIC-IE/UFRJ based on COMTRADE (2017) database.

After the 2008's crisis, there was a reduction in the world income and trade growth, and as a reflection, total Brazilian exports growth slowed down, and 2010-2014 is the only period in which it had a negative rate of growth of 3.2%, a relatively poor performance when compared to the performance of world exports, which expanded at a rate of 0.8%. After 2009, there is a change in the industrial group's market shares. While the AGR group increases its share between 2010 and 2014 (6.6% to 9.8%), the AC group had a reduction (from 6.9% to 6.0%).

The latter result reinforces the argument (see section 2 above) that we are losing competitiveness in the external markets for processed agricultural commodities and gaining competitiveness in unprocessed agricultural products. However, the dynamic of these groups in the world market is very modest.

Figure 56 – Composition by groups of the world exports of goods, 2000 to 2015

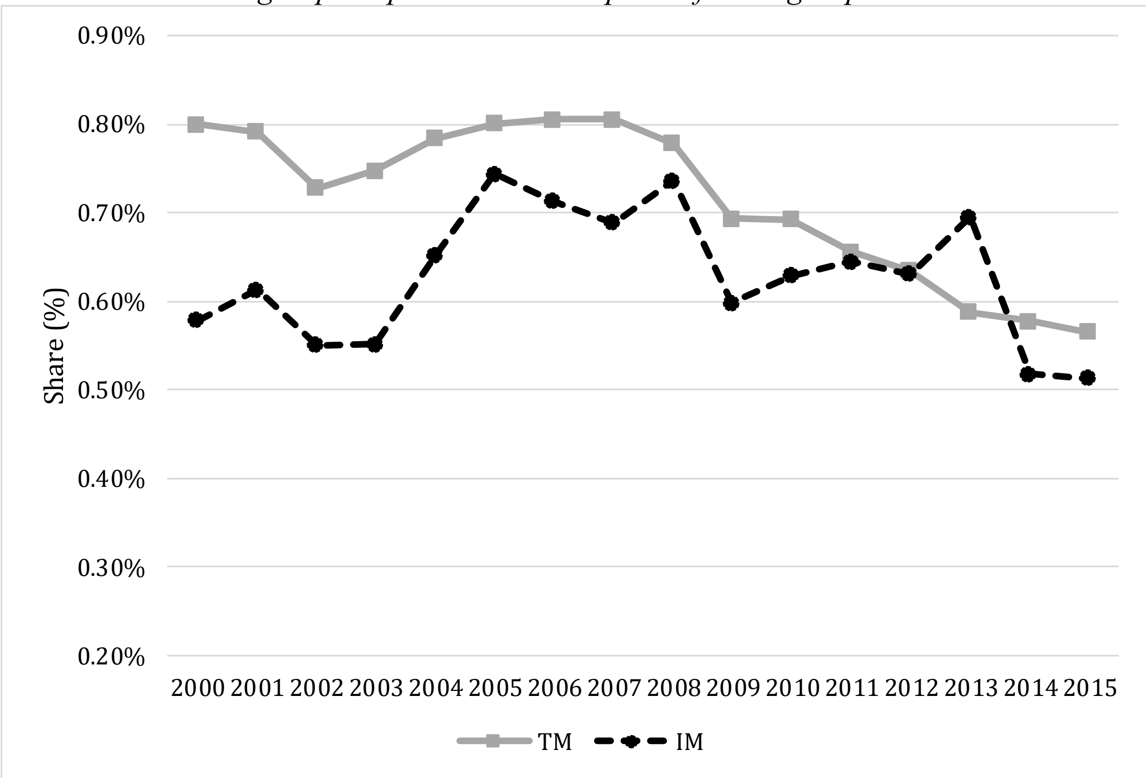


Source: Elaboration by GIC-IE/UFRJ based on COMTRADE (2017) database.

Although presenting a lower share than the AC group, the market share of MQC group is almost the same, with an increase between 2000-2011 achieving a peak of 2.1% and a declining tendency from then on until 2015 (with a share of approximately 1.6%). However, we must remember that besides the MQC represents a small share in world's market, they are very important for the Brazilian economy, as it has the highest share in gross output and exports in the Brazilian economy (as we saw in sections 1 and 2 of this chapter).

The TM and IM groups (Figure 57) lost share in world exports between 2000 and 2014. However, the IM group has a good performance in the world market, increasing at a higher rate than the world's exports. The decrease in the IM group market share concentrates after 2009, decreasing from 0.63% to 0.51% between 2010 and 2014. This might be explained as a result of the strategy adopted by some countries to boost their growth in increasing exports.

Figure 57 – Market share (%) of the Traditional manufacturing and Innovative manufacturing groups' exports in world exports of these groups.



Source: Elaboration by GIC-IE/UFRJ based on COMTRADE (2017) database.

An example of this strategy is the consequence of China's entry into the Latin American market. The largest share of the Brazilian IM group exports is designated for this market (TORRACCA, 2017) and with the intensification of Chinese competition, Brazil lost part of its market share in these products. Despite the Brazilian loss of competitiveness in the IM group, worldwide this group has been losing share in world exports of goods. However, the fall in the percentage of the IM group in the Brazilian economy is more pronounced when compared to the world economy.

In the case of the TM group, the Brazilian economy maintained is market share until 2008, with the percentage around 0.8%. As the IM group, the group starts losing share after the international crisis and reduced from 0.7% in 2010 to 0.58% in 2014. In contrast, the TM group raised the share of total world exports of goods in this period. The "structural" China effect (MEDEIROS; CINTRA, 2015) in the Brazilian economy contributed to the reduction of the market share of many manufacturing sectors, but mostly in the labor-intensive traditional sectors. As mentioned in Chapter 1, Hiratuka and Sarti (2017) the increasing the production of manufacturing goods to the international market at low cost creates to Brazilian exports increase the competition in this group the world market[51].

All these facts combined do not reveal a good record for the structural dynamics of Brazilian exports since 2010. The (regressive) specialization is growing in the sectors with the lowest ability to generate value added (i.e., AGR against AC) and more subject to variation in international prices. Moreover, the progressive reduction of the IM group share, which has the highest technological content, brings serious implications for Brazilian external constraint on growth in the long-run view.

To complete the analysis and verify the effect of the changes of the sectoral market shares and their implications for the growth trajectory of the Brazilian economy, we will see in the following section the market share imported goods in the sectoral supply, providing a measure of the competitiveness of domestic production.

4.3.2 Competitiveness in domestic markets

Another critical dimension of the competitiveness of the Brazilian extractive and manufacturing industries is the domestic one. We have already seen some aspects of its importance in Chapter 2 at a macroeconomic level and its impacts on Brazilian growth. Indeed, studies such as Morceiro (2012), Neves (2013), Passoni (2016), Marcato and Ultremare (2015; 2018), Magacho, McCombie and Guilhoto (2018), Persona and Oliveira (2016), among others, have already drawled attention to the role of growth of imports in attending demand expansion in some years of the period under investigation. Also, as we saw in Chapter 1, the increment in imports market share may have consequences in reducing the input-output linkages and the effect of the expansion of the final demand.

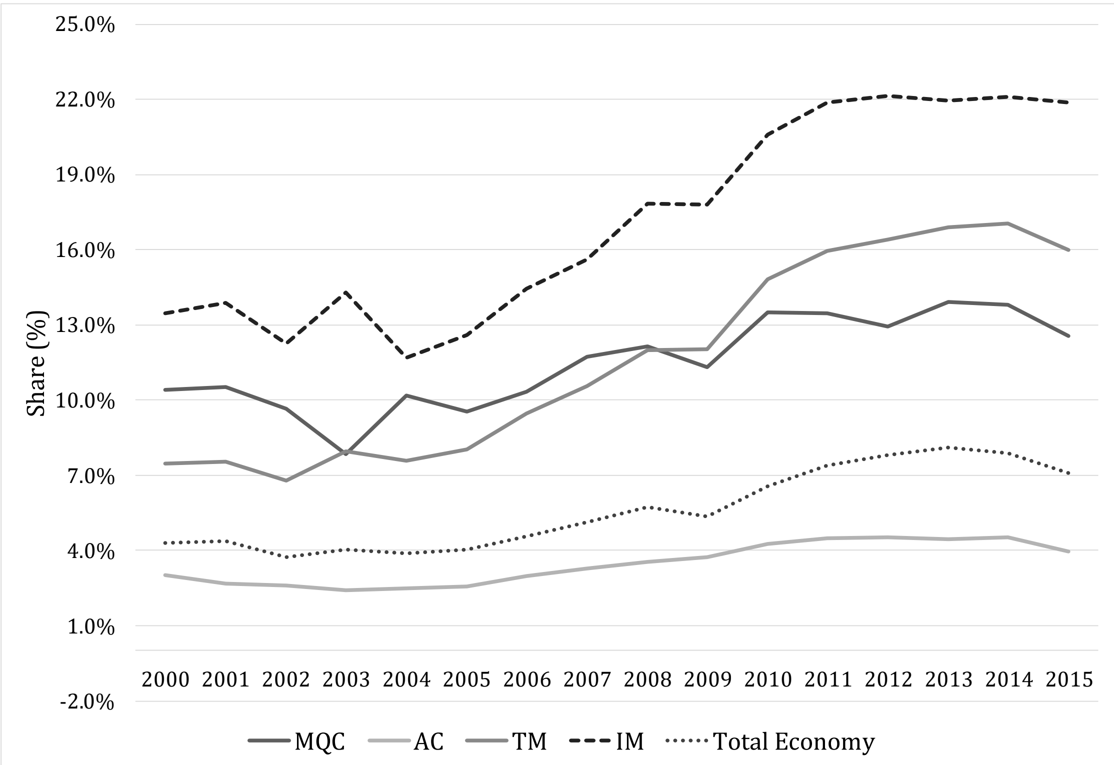
In Figure 58, we see the market share of imports in total demand, calculated as a ratio of the imports by origin industrial group to total demand for the groups' supply (imports plus domestic production). It shows the imported supply necessary in the production process of each extractive and manufacturing industries. This market share is an indirect measure of competitiveness since it is the complement of the share of domestic supply in total demand.

[51] Franke et al. (2018) analyses the impact of the increase in China's exports on exports of industrialized products from Brazil and Mexico to world trade from 2001 to 2016 using an econometric study. The authors conclude that the Chinese exports displace Brazil and Mexico exports in the world market. Besides, they observe that Brazilian and Mexico exports are losing market share in the world market because the analyzed Latin American exports have a smaller elasticity compared to China.

Although other studies like Passoni (2016), Castilho, Torracca and Freitas (2019) and Medeiros, Freitas, and Passoni (2019) had already done something similar, here we show this information excluding relative price effects (i.e., in volume units). As the total supply and imports are affected by the real exchange rate, it is interesting to know whether import penetration or substitution in the supply market follows from real changes.

All extractive and manufacturing industrial groups, except the AC group, have in general a higher share of imported content the average import content coefficient of the economy, which is expected given the productive structure of the Brazilian economy[52]. Along the period under analysis, we observe that the imported market share for the economy grew from 4.3% in 2000 to 7.9% in 2014 (Figure 58). By use category, the increase in the market share is higher for the final demand (went from 1.6% in 2000 to 3.4% in 2014 (Figure 60), compared to the intermediate one, that increased from 7.5% in 2000 to 14.8% in 2014 (Figure 59). However, we must highlight that this increase in the intermediate use put the imported market share in a more remarkable level compared to the final one.

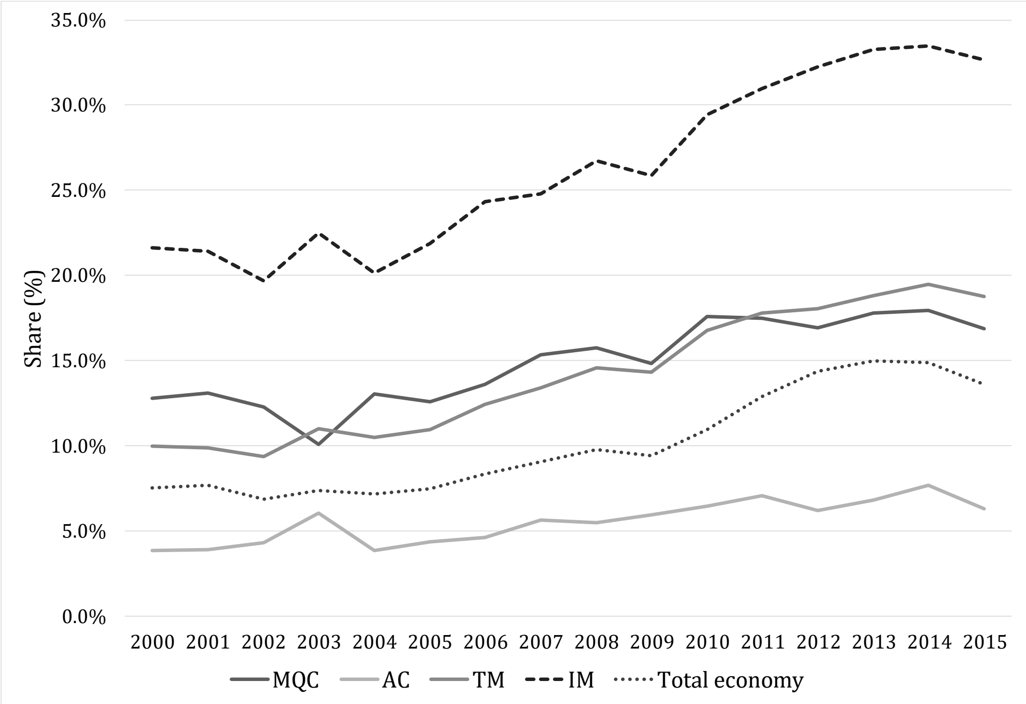
Figure 58 – Market share (%) of imports in total demand in the Brazilian economy (2000-2015)



Source: Author’s calculations based on information from the SNA/IBGE.

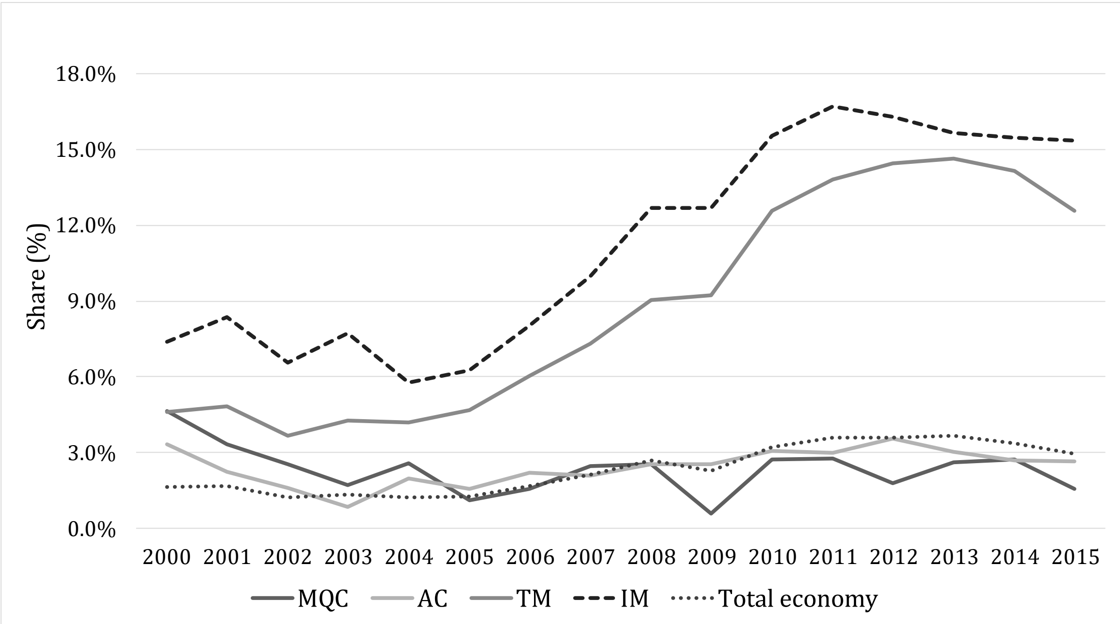
[52] Brazil has a big internal market and is rich endowments of natural resources, the service and agricultural sector has a higher share in total demand. Besides, these sectors by their nature have a low import content in total demand (the market share of imports of agricultural products and services are around 3%).

Figure 59 – Market share (%) of imports in intermediate demand in the Brazilian economy (2000-2015)



Source: Author's calculations based on information from the SNA/IBGE.

Figure 60 – Market share (%) of imports in final demand in the Brazilian economy (2000-2015)



Source: Author's calculations based on information from the SNA/IBGE.

By subperiods, we observe that the increase in the market share of imports for most groups occurs from 2003 until 2011 and it is more remarkable for the final demand. This reflected an increase in the imported market share for the total economy from 4% to 6.6% in the total demand and from 1.3% to 3.3% for the final demand. This pattern is clearer for the IM group, and we notice an increase in the final imported market share between 2003-2008 (7.7% to 12.7%). Here we observe some leakages in demand since the imported supply is increasing the importance in the economy. This process might be a result of a reduction in price and non-price competitiveness. Concerning the price competitiveness, is period there is a real appreciation process in the exchange rate[53] that might have influenced the increase in the imports as the proportion to the total supply since it reduces the cost of imported inputs. One crucial element of non-price competitiveness is productivity growth. As we are going to see in section 5 below, the IM group productivity grew in the period between 2003 and 2008. However, compared to other countries, it had a lower dynamism. [54] The IM group imports the highest share of total supply among the groups, and we also observe an increase in the period (22.5% to 27.6%).

After 2010 there is a change in this increasing movement of the market share, especially after 2011. Regarding the total economy, there as modest growth in the imported market share between 2010 and 2013, when it reached the peak in the series (8.1%), with a slowdown in 2014 and 2015 (7.1%). In the case of the IM group, the total imported market share remains almost unchanged between 2010-2014. There is a slight increase in the intermediate imported market share (29.4% to 33.5%) and maintenance of the final one (around 15.5%).

Therefore, the increase in the imported share in the total supply observed in the period (for example see Medeiros, Freitas, and Passoni (2019) for the graph in total units[55]) may be explained by the devaluation of the exchange rate, which converts on the increase the price of imports in domestic currency. As seen in Chapter 2, the government with the objective of making Brazilian exports more competitive devalued the exchange rate. However, this measure did not affect reducing the real share of the imported market in the same proportion and returning to the level observed in the subperiod 2003-2008. Note, then, that the argument of the

[53] Although some theories assume a positive relation between the appreciation of exchange rate and the increase of imports, Dos Santos et al (2015), after analyzing the Brazilian imports by use show that they are very insensitive in relation to exchange rates changes. However, it seems that the indirect effect of exchange rate in raising the real wage contribute do increase the purchase power, and by this income linkage, the exchange rate affects the amount of imports.

[54] See Miguez and Moraes (2014) and Kupfer and Miguez (2017).

[55] If we compare the imported market share without taking apart the relative price effect, we notice the trajectory occurs with the opposite direction. For example, in the case of IM there is a reduction of the market share between 2003-2008 and an increase in 2010-2015. This follows the real exchange rate evaluation and devaluation in both periods.

importance of the exchange rate for the explanation of the real variation of the imported coefficient is insufficient to explain the maintenance of the level of the imported portion of imports in the total supply. Thus, other reasons seem to favor the high maintenance of this level, such as the increase in non-price competition, the productivity performance of domestic suppliers (in comparison to the competitors) and the increase in international competitiveness. Also, the changes in the political economy strategy to depreciate the exchange rate to stimulate the exports may have a more direct consequence in the amount imported for this good.

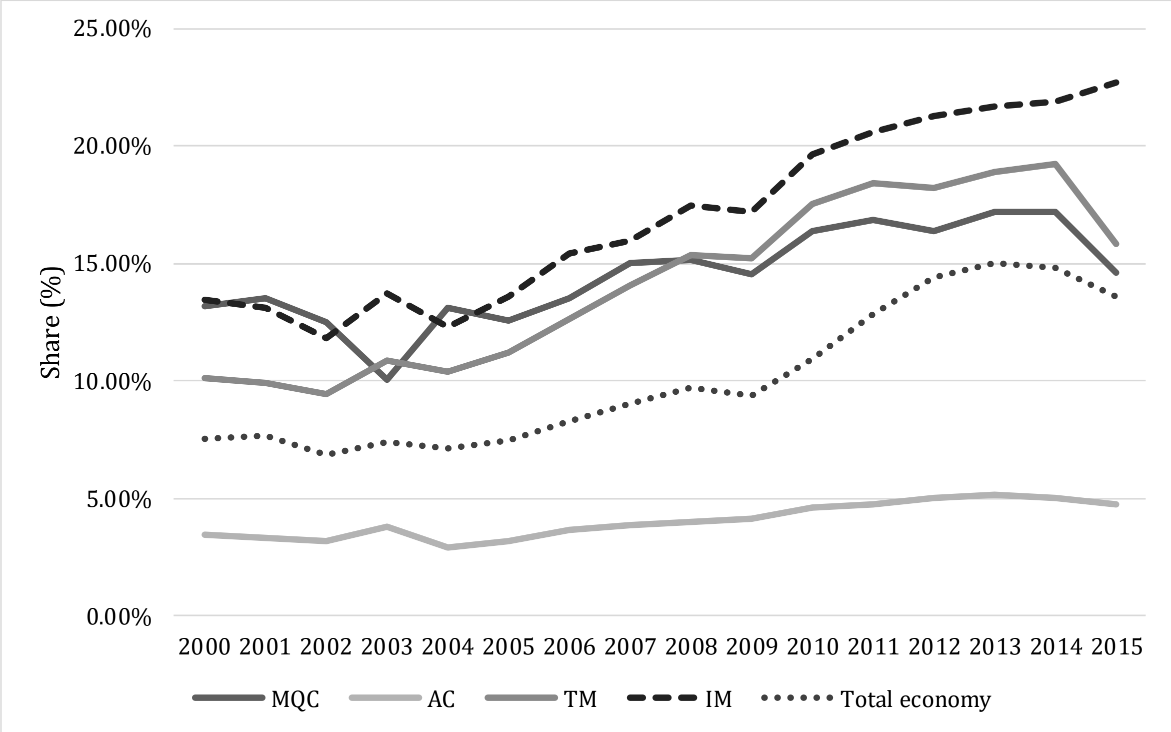
Although larger part the IM group market is supplied by, either for intermediate or final demand, the imports penetration was more important in the case of the market for TM group products. From 2000 and 2014, both intermediate and final demand shares for imports in the markets for the products of the TM products increased (from 11% to 14.6% and 4.3% to 9.1%, respectively), and almost in the same proportion (around 5%).

After the international crisis, all countries were looking for external markets to sustain or stimulate their demand. Moreover, the verticalization of production and the GVC stimulate a decentralized production, and this way, the imports. In this context, the trend initialized in the previous subperiod continued, and there was an increase in the share of imports in the markets for TM products, either for intermediate or final use[56]. However, differently, from 2003-2008 where the loss of competitiveness was more concentrated in final demand, between 2010-2015, it concentrates in intermediate demand (average growth of 3.8% and 3.0% p.a., respectively).

The previous analysis deals with the share of imports in the markets (intermediate and final demand) for the products originating in the four industrial groups. Nonetheless, to better understand the impact of imports in the productive structure of the Brazilian economy we complement the latter analysis with an investigation of the role of the same industrial groups in affecting the intermediate demand for imported products (i.e., an analysis of the imports destined to four industrial groups). In this case, we observe in Figure 61 the share of imported inputs in total intermediate consumption (imported plus domestic inputs), indicating if there was a penetration (or substitution) of imports in the intermediate consumption of each industrial group.

[56] Also, another important fact that happened after the international crisis was the change in the Brazilian System of National Accounts (SNA), adopting the version SNA 2010. Although the data were compatibilized both by the National Institute of Geography and Statistics, the changes between 2000-2009 and 2010-2015 must be related to these methodological changes. For more details see the methodological discussion in Chapter 3.

Figure 61 – Proportion of intermediate imported inputs in a total of inputs for the Brazilian economy, by extractive and manufacturing industries groups 2000-2015



Source: Own elaboration, IOT in 2010's constant relative prices constructed in this work based on SNA/IBGE.

Among the four industrial groups under investigation, the IM group stands out as the one with the higher share of imported inputs in total intermediate consumption. All over the period, we found that there was a constant process of penetration of imports (in volume), in which the substantial increase happens between 2003 and 2008 (13.7% to 17.5%). There is also an increase after the crisis but at a slower pace. The penetration of imports increased from 19.6% to 22.73%.

We can also see that the other groups are buying a large proportion of imported demand in Figure 61. For example, between 2000 and 2014 the share of imported inputs by the TM and MQC groups went from 10.1% to 19.2% and 13% to 17%, respectively. The increase is concentrated in the period 2003-2008 but is still there in the period between 2010-2014. For the groups, 2015[57] represents a reduction of the penetration of imports and must be related to the negative GDP growth of the Brazilian economy.

As we saw, since 2010 the Brazilian economy reduced the competitiveness in the market share of imports in intermediate demand and reduced the intermediate demand for domestic products. This fact stands for the total economy, but particularly in the case of IM and TM groups. Both processes may have a direct consequence in the Brazilian productive structure,

[57] If we calculate the same indicator in total units we do not see this fall in 2015.

since the effect of imported inputs may reduce the density of domestic input-output relation. To go deeper into this discussion, we discuss in the next section the interindustry density relations.

4.4 The density of interindustry relations

In this section, we analyze the characteristics and the evolution of the interindustry relations over the period and subperiods under discussion to complement the analysis of the Brazilian productive structure. We use the total and the domestic backward and forward linkage indicators proposed by Rasmussen (1957) and Hirschman (1958) and their evolution over time. We assume that if there was a loss in the density of these relations, this might be an indicator of deindustrialization.

As we presented in Chapter 1, the domestic backward linkage (hereafter BL) indicator captures the direct and indirect effects of a change of unit in the final demand for the domestic production of one industry over the gross output of overall supplier industries (including the one which expanded its final demand). On the other hand, the domestic forward (hereafter FL) indicator, as measured here, captures the direct and indirect impact over the gross output of an industry caused by an overall change in the total final demand for the production each industry in one unit. These both indicators are calculated using the Leontief inverse matrix[58].

Also, we calculate the total BL and FL using an expanded Leontief inverse matrix, where the technical coefficients represent both the domestic and imported input-output relation. The total BL and FL indicators would represent the potential effect if the domestic demand were able to fulfill the all intermediate demand since the imports in the input-output model are considered competitive[59]. See Appendix G for mathematical formalization. The comparison of domestic (Table 9) and total (Table 10) BL and FL give us a measure of variations in the potential (total) and effective (domestic) linkages. As we saw in Chapter 3, the technical coefficients are sensible to sectoral relative prices relation, so we must be careful in the interpretation[60]. We focus our attention on the characteristics of the linkage indicators related

[58] Although we calculate both using the Leontief inverse matrix, we are aware that some studies prefer to use the Ghosh matrix for calculating the FL indicator. The Ghosh is a supply driven model, that stablishes the relation through value added and production, indicating how much value added is needed in each sector to generate an additional unity of gross product. For more details see Miller and Blair (2009).

[59] In the input-output model, the imports are considered competitive (Rose and Castler, 1996). According to this hypothesis, it is possible at one extreme to import all goods consumed domestically and in the other, to produce all imported goods. However, the validity of this hypothesis depends on the level of substitutability between goods. Santos et al. (2015) observe that not all imported goods have perfect domestic substitutes in the Brazilian economy, due to the structural characteristics of the productive system.

[60] As the BL and FL are calculated based on the Leontief inverse matrix, which derives from the technical coefficients, it is the same to calculate them based on current or constant prices. This happens because as the technical coefficients is a ratio, both numerator and the denominator are divided by the same gross output

to the IM group since this sector that have a higher capacity to promotes technology diffusion in the economy.

By the information in Table 9, we see that all EMI groups have a domestic BL indicator above the average of the economy indicating that they have a higher capacity to induce gross output changes. However, we should note that among the four industrial groups the IM group has the only third position in the rank. On the supply side, we see that only the MQC and TM groups present a higher FL indicator compared to the whole economy average. The smaller FL values for the AC group and, mainly, the IM group rely on the fact that by the nature of their production they have a relatively more intense supplier connection with the final demand than with its direct and indirect intermediate demand. Since the FL only captures intermediate flows of products that are utilized within the same production period (circulating capital) and not the flows related to fixed capital (machinery and equipment), they appear to have a weak supplier connection. However, if we could take into consideration the flows of fixed capital products as a derived demand (similarly to the case of intermediate inputs), the role of the IM group as a supplier for the production would be much more relevant.

As regarding the time path of the BL and FL indicators, we observe a difference in the behavior of these indicators for the IM group when compared to the others, industrial groups. The domestic BL indicator for the IM group presents a definite accumulated increase (2.6%) between 2000 and 2014, showing that the sector was able to absorb the creation of potential linkages since the total BL increased in the period (4.1%). In the case of the other groups the same indicator shows a declining trend, and when compared to the total BL, we observe the same pattern, which means that there was a reduction in the potential input-output linkages (i.e., for the MQC and AC groups) or almost stagnant value (for the TM group).

The domestic BL indicator for the IM group increased between 2000 and 2008 (0.6%p.a.), and compared to the creation of potential linkages by the total BL (0.4%), the domestic Brazilian economy had a better performance[61].

deflator. However, inside of each element of technical coefficients also there is the relative price effect of sectoral intermediate demand about the sectoral production and affects the linkages indicators. For viewing the impact of this indicators, see the hypothetical example in the deflation method methodological appendix.

[61] Differently from the other sections, here we prefer to present only two subperiods: 2000-2008 and 2010-2014, to capture a wider long-term structural change through the BL and FL indicators.

Table 9 – Domestic backward and forward linkages (2000, 2008, 2010, and 2014) and their evolution for selected periods

Industries	**Backward Linkages**								**Forward Linkages**							
	Average BL				**Annual average growth rate (% p.a.)**			**Accum. %**	**Average FL**				**Annual average growth rate (% p.a.)**			**Accum. %**
	2000	**2008**	**2010**	**2014**	**2000-2008**	**2010-2014**	**2000-2014**	**2000-2014**	**2000**	**2008**	**2010**	**2014**	**2000-2008**	**2010-2014**	**2000-2014**	**2000-2014**
Agriculture, fishing and related	0.147	0.160	0.152	0.153	1.0%	0.1%	0.3%	4.1%	0.285	0.307	0.286	0.287	0.9%	0.1%	0.0%	0.7%
Industrial Commodities	1.948	1.829	1.844	1.843	-0.8%	0.0%	-0.4%	-5.4%	1.719	1.886	1.738	1.755	1.2%	0.2%	0.1%	2.1%
Agricultural Commodities	0.802	0.824	0.790	0.778	0.3%	-0.4%	-0.2%	-3.0%	0.592	0.577	0.576	0.557	-0.3%	-0.8%	-0.4%	-5.9%
Traditional Industry	1.376	1.384	1.321	1.299	0.1%	-0.4%	-0.4%	-5.6%	1.001	0.958	0.945	0.930	-0.5%	-0.4%	-0.5%	-7.0%
Innovative Industry	**1.019**	**1.072**	**1.051**	**1.046**	**0.6%**	**-0.1%**	**0.2%**	**2.6%**	**0.747**	**0.754**	**0.748**	**0.725**	**0.1%**	**-0.8%**	**-0.2%**	**-3.0%**
Utilities	0.157	0.168	0.163	0.190	0.9%	3.9%	1.4%	21.4%	0.279	0.262	0.273	0.264	-0.8%	-0.8%	-0.4%	-5.4%
Construction	0.164	0.183	0.167	0.165	1.4%	-0.2%	0.1%	0.8%	0.134	0.134	0.135	0.132	0.0%	-0.6%	-0.1%	-2.0%
Trade, accommodation and food	0.316	0.317	0.302	0.302	0.0%	-0.1%	-0.3%	-4.4%	0.466	0.534	0.542	0.556	1.7%	0.7%	1.3%	19.4%
Transportation, storage and communication	0.332	0.333	0.323	0.320	0.0%	-0.3%	-0.3%	-3.8%	0.600	0.584	0.580	0.579	-0.3%	-0.1%	-0.3%	-3.6%
Financial, insurance and real estate activities	0.236	0.242	0.238	0.236	0.3%	-0.1%	0.0%	0.1%	0.477	0.395	0.396	0.382	-2.3%	-0.8%	-1.6%	-19.9%
Community, scial and personal services	0.808	0.812	0.805	0.785	0.1%	-0.7%	-0.2%	-2.9%	1.005	0.932	0.939	0.951	-0.9%	0.3%	-0.4%	-5.4%
Total Economy Avarage	0.664	0.666	0.651	0.647	0.0%	-0.1%	-0.2%	-2.6%	0.664	0.666	0.651	0.647	0.0%	-0.1%	-0.2%	-2.6%

Source: Author's calculations based on information from the SNA/IBGE.

Table 10 – Total backward and forward linkages (2000, 2008, 2010, and 2014) and their evolution for selected periods

Industries	**Total Backward Linkages**								**Total Forward Linkages**							
	Average BL				**Annual average growth rate (% p.a.)**			**Accum. %**	**Average FL**				**Annual average growth rate (% p.a.)**			**Accum. %**
	2000	**2008**	**2010**	**2014**	**2000-2008**	**2010-2014**	**2000-2014**	**2000-2014**	**2000**	**2008**	**2010**	**2014**	**2000-2008**	**2010-2014**	**2000-2014**	**2000-2014**
Agriculture, fishing and related	0.165	0.186	0.172	0.182	1.5%	1.5%	0.7%	10.9%	0.310	0.331	0.306	0.310	0.8%	0.3%	0.0%	0.1%
Industrial Commodities	2.390	2.238	2.222	2.323	-0.8%	1.1%	-0.2%	-2.8%	2.203	2.538	2.259	2.450	1.8%	2.0%	0.8%	11.2%
Agricultural Commodities	0.909	0.937	0.882	0.900	0.4%	0.5%	-0.1%	-1.0%	0.647	0.614	0.617	0.604	-0.6%	-0.5%	-0.5%	-6.7%
Traditional Industry	1.697	1.742	1.633	1.693	0.3%	0.9%	0.0%	-0.2%	1.133	1.076	1.058	1.067	-0.6%	0.2%	-0.4%	-5.8%
Innovative Industry	**1.312**	**1.358**	**1.312**	**1.367**	**0.4%**	**1.0%**	**0.3%**	**4.1%**	**0.964**	**0.918**	**0.903**	**0.900**	**-0.6%**	**-0.1%**	**-0.5%**	**-6.7%**
Utilities	0.177	0.194	0.182	0.219	1.1%	4.7%	1.5%	23.8%	0.321	0.297	0.307	0.299	-1.0%	-0.7%	-0.5%	-6.9%
Construction	0.184	0.208	0.186	0.188	1.5%	0.3%	0.2%	2.5%	0.141	0.141	0.141	0.139	0.0%	-0.4%	-0.1%	-1.8%
Trade, accommodation and food	0.347	0.349	0.328	0.333	0.1%	0.4%	-0.3%	-3.9%	0.542	0.614	0.620	0.653	1.6%	1.3%	1.3%	20.6%
Transportation, storage and communication	0.372	0.374	0.359	0.365	0.0%	0.4%	-0.1%	-1.9%	0.704	0.686	0.670	0.695	-0.3%	0.9%	-0.1%	-1.3%
Financial, insurance and real estate activities	0.245	0.251	0.246	0.246	0.3%	0.0%	0.0%	0.2%	0.569	0.444	0.442	0.436	-3.0%	-0.4%	-1.9%	-23.4%
Community, scial and personal services	0.870	0.873	0.859	0.843	0.0%	-0.5%	-0.2%	-3.1%	1.134	1.050	1.060	1.107	-1.0%	1.1%	-0.2%	-2.4%
Total Economy Avarage	0.788	0.792	0.762	0.787	0.1%	0.8%	0.0%	-0.1%	0.788	0.792	0.762	0.787	0.1%	0.8%	0.0%	-0.1%

Source: Author's calculations based on information from the SNA/IBGE.

However, although there was a penetration of imports in the period[62], the domestic linkages were positively affected by other factors, for example, the increase in the investment-output relation and the increase in the IM group share in volume in the period. Nevertheless, for the period after the crisis, 2010 to 2014, the was a creation of potential linkages (1.0%p.a.), but there was a decline in the domestic one. Hence, the IM sector was able to absorb more the effect of an increase in the potential linkages in the first period compared to the second one.

Analyzing the FL indicator, we observe that the MQC group presents a significant accumulated change of 2.6% for the whole period from 2000 to 2014, while the other three groups show a declining trend for the same period: IM (-3%) and AC (-5.9%) and TM (6%)[63]. The creation of potential FL maintains the same pattern regarding the groups, but in a higher proportion.

Analyzing the subperiods, we observed a modest increase in domestic FL for the IM group between 2000-2008 (0.1% p.a.). However, there is a reduction in total FL (-0.6p.a.), representing that the IM group was able to absorb linkages even in a context of reduction of potential linkages (-0.6% p.a.). Between 2010-2014, there is a reverse trend, and despite the reduction of domestic FL (-0.8% pa) and total (-0.1%p.a.) indicators, the IM group effectively reduces its sensitivity to variations in the demand from other sectors in a higher proportion than would occur considering the potential FL.

Overall, we see that the IM group and the total economy BL and FL indicators changes are minimal in the analyzed period. However, we showed that the IM group BL and the FL (in a minor way) presented a better performance between 2000 and 2008, being able to create and absorb the effects of an increase in the potential linkages. There is a change in the pattern in the period 2010-2014, where we observe a declining in the domestic BL and FL, but also in the capacity of the TM group appropriate the potential creation of linkages. Hence, both facts give evidence of deindustrialization in the Brazilian economy only in the recent period.

[62] Notice that in total units, there is a decrease in the imported share in the intermediate supply between 2003-2008, so we must be careful in the direct comparation with these indicators as they are sensible to relative price changes.

[63] We must consider that for the MQC group there in the period an increase in the relative prices, that must contribute to an increase in the input-output relations, where for the IM and TM groups there is reduction trend in their sectoral relative prices.

4.5 Labor Productivity

Another central element in the analysis of structural change is labor productivity. As there is a close relationship among the value added, capital accumulation and productivity growth, these changes affect the structure of value added and employment directly, as we discussed in Chapter 1. To understand the factors that contributed to the changes in productivity growth we use a decomposition of labor productivity growth based on the shift-share analysis[64]. More specifically, we use a Generalized Exactly Additive Decomposition (GEAD) proposed by Diewert (2015)[65]. This method decomposes the productivity growth in four effects: direct, labor composition, price and interactive effect[66].

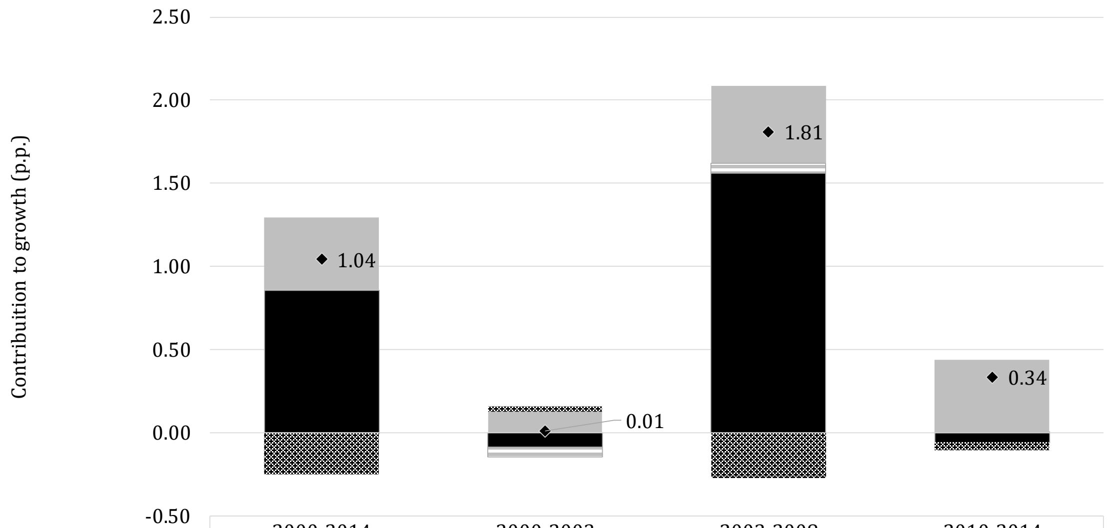
In Figure 62, we present the decomposition for the aggregate, showing the average annual rates of growth in the period and the contributions of the separate effects. The direct impact, which represents the increase of the sectoral productive with no interference from the change of relative prices and labor composition, is the most critical effect in the periods with higher growth, such as 2003-2008, representing more than 80% of the labor productivity growth of the economy. On the other hand, in the period of weak GDP growth, as in 2000-2003 and 2010-2014, there is evidence that shows a loss in the competitiveness. It corroborates the well-known evidence in the literature of the Kaldor-Verdoorn law. The change in the sectoral composition of labor also contributed in a positive way to the productivity growth for all periods, indicating that the reorganization in the labor structure was beneficial for the performance of the economy regarding labor productivity growth. As expected, in the aggregate the relative price effect is meager, because positive and negative changes may compensate each other.

[64] We used the Supply and Use Table published in the Brazilian SNA (IBGE, 2016), in 2010's reference.

[65] We present this methodology in Appendix H. For a general review of productivity decomposition methods, see Fevereiro and Freitas (2015) and Kupfer and Miguez (2017).

[66] The *direct effect* represents the growth in the labor productivity of industry *n*, considering that relative prices and labor composition remains unchanged. The *labor composition effect* consists in the changes in the impact of changes in the labor use structure. The *price effect* corresponds to the changes in the rate of growth in the real output price of industry n, when the labor composition and real sectoral labor productivity remains constant. And finally, the *interactive effect* is the effect of interaction terms, to guarantee the total decomposition consistency. We do not attribute any economic meaning to this term. It is important to notice that the price and the labor composition effects do not have a meaning in the analysis of isolated industry, because they are a result of changing proportions and relative prices among all industries. Hence, a positive effect for one industry corresponds to negative effect in one or more industries.

Figure 62 – Annual average rates of growth of labor productivity (%) and its decomposition (contributions to growth in percentage points, pp) for the Brazilian economy, 2000 to 2014 and selected periods



	2000-2014	2000-2003	2003-2008	2010-2014
Inter	-0.24	0.03	-0.27	-0.05
Labor Composition	0.44	0.13	0.46	0.44
Price	-0.01	-0.06	0.06	0.00
Direct	0.86	-0.09	1.56	-0.06
Growth (%)	1.04	0.01	1.81	0.34

Source: Author's calculations based on information from the SNA/IBGE.

Regarding what happened to the groups, Table 11 presents the disaggregated decomposition according to subperiods. The sectoral contribution to total productivity growth of the IM group in 2000-2014 is almost null. It is a combined result from periods with a higher contribution, like 2003-2008, with an average of 0.43pp, and from others, like 2010-2014 where there is a negative contribution of -1.23pp. Regarding the direct effect, only in 2003-2008, there is a positive contribution (0.10p.p.). When comparing to other extractive manufacturing industrial groups, we observe that the IM group is the only group with a positive direct effect in productivity.

The productivity of this group depends on several factors but is positively correlated with the aggregate output of the economy. In this period there was an increase in the investment-output ratio and, as we saw in Chapter 2, the IM group has the highest added value growth (3.6% p.a.) which tends to be procyclical. Besides, that the contribution attributed to the direct effect of the IM group is only positive when the same happens for the total productive (i.e., the direct contribution in the case of the total economy is 0.89p.p. between 2003-2008).

The TM group had positive direct contribution between 2000-2014 (0.07p.p.) comparing to the other groups (i.e., MQC and AC had a negative direct contribution). We must highlight the good performance of the agricultural industry since it had the highest direct contribution between 2000 and 2014. We observe the same pattern for all subperiods, but with the most important growth in 2000-2003 (1.27p.p.) and 2010-2014 (1.19). As we saw in section 3.1, the increase in the AGR group productivity may have contributed to the increase in agricultural exports in the world market.

Table 11 – AGR, MQC, AC, TM and IM productivity decomposition for the Brazilian economy, selected periods

Sectors	Direct	Price	Labor composition	Inter	Contribution to productive growth
2000-2014					
AGR	0.37	-0.06	-0.14	-0.15	0.02
MQC	-0.03	0.10	0.05	0.00	0.12
AC	-0.12	-0.03	0.02	0.01	-0.13
TM	0.07	0.06	-0.01	0.01	0.13
IM	0.00	-0.07	0.07	-0.02	-0.01
2000-2003					
AGR	1.27	0.70	-0.33	0.03	1.67
MQC	0.61	1.88	-0.17	0.13	2.45
AC	-1.63	0.07	0.06	-0.08	-1.58
TM	1.44	-0.01	-0.07	-0.03	1.34
IM	-0.16	0.22	0.15	-0.01	0.20
2003-2008					
AGR	0.29	-0.28	-0.21	-0.05	-0.25
MQC	-0.17	0.35	0.22	-0.02	0.37
AC	-0.02	-0.06	0.02	0.00	-0.06
TM	-0.04	0.10	0.05	0.00	0.11
IM	0.10	-0.10	0.19	-0.01	0.19
2010-2014					
AGR	1.19	-0.04	-0.72	-0.18	0.25
MQC	-0.21	-0.40	0.01	0.01	-0.59
AC	-0.04	-0.05	-0.01	0.00	-0.10
TM	-0.24	0.17	-0.36	0.00	-0.43
IM	-0.04	-0.89	-0.38	0.07	-1.23

Source: Author's calculations based on information from the SNA/IBGE.

In 2010-2014 there was a poor performance in the sectoral productivity growth. All groups, except for AGR, had a negative contribution associated with the direct effect. Moreover, in the aggregate, the direct effect also had a negative contribution[67] to the total productivity growth in the period.

[67] Analyzing the disaggregated decomposition for the 11 sectors, only 3 have a positive direct contribution: agricultural and related, public utility and transport, storage and communication. However, these positive effects were insufficient to balance out the negative contribution of the other sectors.

The period of 2010-2014 shows a deteriorating situation comparing to the previous subperiod. All four industrial groups had a negative direct effect corresponding to their productivity growth, so there was not any positive stimulus to contribute the productivity growth, neither domestic (by the GDP and GFCF and its influence to the IM and TM groups), nor external (that would affect the MQC and AC groups productivity).

Although the productivity growth itself does not represent itself as an indicator of sectoral competitiveness, as we must consider it about the productivity growth of the competitors, it shows important aspects of the productive structure. Since the IM sector in the period 2010-2014 had a poor performance, it corroborates the warning signs of section 4 above a reduction of the dynamism of the sector recently, contributing to the deindustrialization hypothesis.

However, based on i) the stylized fact of the positive relation between the growth in the manufacturing production and the sectoral labor productivity growth in the Kaldor-Verdoorn's law[68], ii) and the positive relation of the investment-output ratio growth and manufacturing output growth (as we saw in chapter 1), there is a strong connection of the productivity performance of the IM sector and the economic performance.

4.6 Structural decomposition analysis

In the previous sections, we saw the importance of relative prices effects for the analysis of the process of structural change, and some of the relations between structural change and the process of economic growth. In this section, we complement the latter analysis by the use of the structural decomposition methodology presented in chapter 3. Thus, in the first part of this section, we analyze the effect of relative prices at the first level of our decomposition exercise. Next, we present the results of the second decomposition level that captures the effects of changes in final demand, trade pattern and technological change, and highlight some implications for the process of structural change of the Brazilian economy.

4.6.1 The first level of the decomposition

As mentioned in chapter 3, the decomposition methodology is applied in two stages or levels. The first decomposition level (as seen in Eq. 42, Chapter 3), captures the influence of relative prices and volume changes on the gross output vector in total units. Figure 51 presents

[68] For recent works and applications for the Brazilian economy see Borgoglio and Odisio (2015), Magacho and McCombie (2017), Morrone (2016), Silva (2018).

the changes in gross output in total units (Column A) and the volume contribution to such changes (Column B) for the period between 2000-2014.[69] As mentioned in the previous chapter, the analysis based on the volume contribution allows us to evaluate better the direction of the process of changes in the productive structure of the economy than an analysis based on gross output changes in total units. Also, the first level of the decomposition is another way of seeing the changes in the share of sectoral gross output in volume units that we presented in section 1 above.

Let us first note that, for the economy as a whole, the relative price effect is not relevant (has a minor negative contribution of -0.01 pp), the contribution of volume changes (3.06 pp) explains almost the total annual average rate of growth of gross output in the period (3.05%). Thus, in an analysis at the aggregate level, the whole exercise of volume/relative price decomposition here proposed would seem not to be justified.

However, looking at the industry level[70], there are considerable changes in relative prices (column C) in the first level that balance out in the aggregate level, implying that an evaluation of each industry contribution in terms of total units (column A) underestimates or overestimates their real contribution as captured by the contribution measured in volume units (column B). Thus, relative prices affect sectoral growth performance, and we should recognize its influence if we want a more accurate decomposition analysis.

Turning to the analysis of specific sectors, the IM is the only group among the four industrial groups under analysis that has its contribution underestimated when expressed in total units during the period between 2000 and 2014. In fact, the contribution of the IM group in volume units (0.23pp) is 22% higher than its contribution in total units (0.19pp).

In contrast, in the case of the MQC group we have the most important example of overestimation of the contribution to gross output growth when this contribution is measured in total units. Indeed, the contribution of this group in volume units (0.30pp) represents 68% of the contribution in total units (0.44pp). The same kind of overestimation occurs in the cases of the AC and TM groups but on a smaller scale. Remember that in section 1 both groups reduced their share in volume and total units, but the relative price effect overestimates the fall.

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[69] The contributions in the decompositions represents the contribution yearly, so it is possible to compare the different subperiods.

[70] Note that we present the results at a disaggregation level of 11 industries groups. Since they are aggregation of the 42 industries, among each group may have positive and negative effects of relative prices that compensate each other.

Table 12 – Sectoral contributions to the annual average rate growth of gross output (in percentage points, pp), 2000-2014

Industries groups	Total units changes (A)	Volume units changes (B)	Relative prices changes (C)
Agriculture, fishing and related	0.14	-0.03	0.15
MQC	0.44	0.14	0.30
AC	0.19	0.06	0.12
TM	0.04	0.01	0.03
IM	0.19	-0.04	0.21
Public utility	0.07	-0.03	0.11
Construction	0.19	-0.01	0.20
Trade, accommodation and food	0.62	0.20	0.42
Transport, storage and communication	0.25	-0.09	0.33
Financial intermediation, insurance and real estate services	0.22	-0.27	0.50
Community, social and personal services	0.71	0.06	0.66
Total	**3.05**	**-0.01**	**3.04**

Source: Author's calculations based on information from the SNA/IBGE.

As we already noted, the relative price effect has implication for the hypothesis of deindustrialization, as it changes the importance of the group regarding the group contribution[71] attributed to exports. This evidence complements the analysis we showed section 1, where the IM group share of gross output in total units is lower than in volume units. For the MQC group, we observed a lost share in volume units but increased regarding the total units.

However, we must complement this analysis by excluding the intermediate and final demand relative prices and identify the determinants of the changes in gross output in volume units, as we do in the second level decomposition.

4.6.2 The second level of the decomposition

As we saw in chapter 3, when we presented the decomposition methodology, in the second level of the decomposition, we aim to identify the main factors determining the changes of gross output in volume units (Eq. 54, Chapter 3). Here again, it is necessary to distinguish between volume and relative prices effects. Hence, for example, we have to deal with changes in the relative price between the different products absorbed by intermediate and final demands. Isolating the effects of volume variations from changes in relative prices the decomposition

[71] In the analysis of the process of deindustrialization in the Brazilian economy, some authors using the value added find similar result. See for instance see Oreiro and Feijó (2010) and Bonelli and Pessoa (2010) for an aggregate view and Squeff (2012) for a sectoral one.

exercise provides a more accurate way to assess the contribution to the growth of various factors.

In Table 13 we present the summary of the yearly contribution results for the first levels decomposition of aggregate gross output changes between 2000 and 2014 and subperiods. As presented in *Table 12*, we also present in Table 13 the information regarding the first level of the decomposition of the total gross output in change (A) in volume effect (B) and relative price effect (C). However, here we present the second level of the decomposition in which we disaggregate the volume effect in the volume contribution (D) and relative prices contribution (E) and Inventories (F), as we already presented in Eq. (53, Chapter 3). Column D represents the contribution to gross output in total units as a result of the changes in gross output in volume originated in the final demand in volume units, excluded the inventories.
Column E represents the relative price contribution to gross output in total units and compute the effect of the changes in gross output in volume attributed to the intermediate and final demand relative prices, also excluded the changes in inventories. This information is useful in the exposition of the decomposition analysis presented in this section.

Table 13 – Contributions to the rate of growth of aggregate gross output, 2000-2014 and selected periods (in pp)

Periods	Total Gross output change (A)	Volume effect (B)				Relative prices effect (C)
		Volume contribution (D)	Relative Prices contribution (E)	Inventories (F)	Total (B=D+E+F)	
2000-2014	3.05%	3.04	0.01	0.01	3.06	-0.01
2000-2003	1.44%	1.07	0.47	-0.12	1.42	0.02
2003-2008	4.57%	4.55	-0.37	0.37	4.54	0.02
2010-2014	2.33%	3.06	-0.58	-0.17	2.31	0.02

Source: Author's calculations based on information from the SNA/IBGE.

Although the effect of relative prices changes is more noticeable at a more disaggregated level,[72] in Table 13 we already able to identify the relevance of the relative prices in the volume effect (i.e., column E). Indeed, for the whole period 2000-2014, it affects in a very limited way the gross output growth (0.01), but for the subperiods, it tends to underestimate the volume contribution in the periods between subperiods 2003-2008 (-0.37) and 2010-2014 (-0.58) and overestimate the growth in volume in 2000-2003 (0.47).

Since our objective is to analyze the Brazilian economy concerning volume units, we discuss in the next subsections the disaggregated decomposition of volume contribution

[72] There is also a balance between the relative prices attributed to the sources of change (for example, intermediate and final demand). The idea is the same for the first decomposition level, where the relative prices effect for the total economy is small.

(column D, Table 13) by the source of changes: trade pattern (intermediate and final), technological change and final demand in Table 14. The other results of the decomposition are available in Appendix I.

4.6.2.1 Final demand

The most important source of change to volume contribution in all subperiods is the final demand (see Table 15). For the aggregate, the domestic demand represents the higher share on final's demand contribution in almost all subperiods analyzed, except for 2000-2003. In a more disaggregated level for the whole period, 2000-2014, we observe that "Other sectors" (that includes services sectors) presents the most important contribution to a higher share to total gross output [73]. Since Brazil is a large economy when the internal market has a consistent demand trajectory, the sectors related to the production of goods (such as IM and TM) and services have higher importance, contributing this way with a higher proportion of gross output.

In a sectoral perspective, the IM group was the most dynamic sector, since it had the higher final demand growth (4.0%) in volume among the four industry groups in focus. However, since the MCQ group has a higher share in total gross output[74], the growth of 2.8% in the period represents regarding the contribution 0.44 pp, higher than the one of the IM group (0.40 pp).[75]

The domestic demand is the most important source for the TM and MQC group, but how important is different among them. The domestic final demand contribution of the MQC group represents approximately 66% of sector's total final demand contribution, while for the IM group this share is higher than 90%, in the whole period 2000-2014.

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[73] The decomposition exercise is sensible to the aggregation level. Hence, is probable that large groups have more importance than small ones. Note that we calculated the contribution of the 42 sectors and only after we aggregate them in the groups.

[74] As we saw in the methodological part, the contribution is also affected by the weights (an average of the two years) of the sectoral relative price, final demand relative price, technical coefficients and the market share matrix.

[75] The relative price effect also affects the comparative performance of these groups. Concerning the total contribution that includes relative prices and volume changes, we observe that the MQC group contribution is much higher (0.38pp) than the IM group one (0.26pp). In this case, the relative price effect affects this in a double manner: on one hand, there is the increase in the commodities' relative prices and on the other, the reduction in the relative price of manufacturing goods.

Table 14 – Volume contribution to the gross output rate of growth, 2000-2014 and selected periods

Industries groups	Trade pattern				Tech Change	Final demand				Market share	Total
	Inter	Final		Subtotal		Cons	GFCF	Ext	Subtotal		
		Cons	GFCF								
2000-2014											
AG	0.00	-0.01	0.00	-0.01	0.00	0.07	0.01	0.08	0.16	0.00	0.15
MQC	-0.12	-0.02	-0.01	-0.15	0.00	0.19	0.10	0.15	0.44	0.01	0.30
AC	-0.03	-0.02	0.00	-0.05	-0.02	0.11	0.01	0.07	0.20	-0.01	0.12
TM	-0.05	-0.04	-0.01	-0.10	-0.01	0.09	0.04	0.01	0.15	0.00	0.03
IM	-0.06	-0.06	-0.06	-0.17	0.00	0.20	0.16	0.04	0.40	-0.01	0.21
Other sectors	-0.17	-0.09	-0.03	-0.29	0.08	1.73	0.46	0.22	2.41	0.02	2.23
Total	**-0.42**	**-0.24**	**-0.12**	**-0.78**	**0.05**	**2.41**	**0.78**	**0.57**	**3.75**	**0.02**	**3.04**
2000-2003											
AG	0.00	0.10	0.00	0.11	-0.01	-0.01	0.01	0.17	0.17	0.00	0.26
MQC	0.13	0.02	0.00	0.15	0.02	-0.06	-0.04	0.34	0.23	0.09	0.49
AC	-0.19	0.00	0.00	-0.19	-0.01	-0.07	-0.01	0.27	0.19	0.00	-0.01
TM	-0.05	0.00	0.00	-0.05	-0.04	-0.11	-0.02	0.07	-0.06	0.00	-0.15
IM	-0.05	-0.02	0.01	-0.06	-0.01	-0.02	-0.06	0.10	0.01	-0.01	-0.07
Other sectors	-0.18	-0.01	-0.02	-0.21	-0.15	0.72	-0.14	0.29	0.87	0.04	0.54
Total	**-0.33**	**0.08**	**0.00**	**-0.25**	**-0.20**	**0.45**	**-0.27**	**1.23**	**1.41**	**0.11**	**1.07**
2003-2008											
AG	0.00	-0.01	0.00	-0.01	0.01	0.11	0.01	0.06	0.19	0.00	0.19
MQC	-0.34	-0.04	-0.03	-0.41	-0.03	0.27	0.20	0.27	0.74	-0.01	0.28
AC	0.00	-0.02	0.00	-0.02	-0.04	0.20	0.02	0.09	0.31	0.01	0.25
TM	-0.05	-0.04	-0.02	-0.12	-0.01	0.17	0.10	0.04	0.30	0.01	0.19
IM	-0.07	-0.07	-0.12	-0.26	-0.02	0.33	0.41	0.20	0.94	0.00	0.67
Other sectors	-0.20	-0.08	-0.05	-0.33	0.06	2.02	0.68	0.54	3.23	0.01	2.97
Total	**-0.67**	**-0.25**	**-0.24**	**-1.16**	**-0.03**	**3.10**	**1.43**	**1.20**	**5.72**	**0.01**	**4.55**
2010-2014											
AG	0.00	0.00	0.00	-0.01	0.01	0.08	0.00	0.06	0.14	0.00	0.14
MQC	-0.02	-0.01	0.00	-0.03	0.10	0.28	0.06	0.03	0.37	-0.01	0.43
AC	-0.01	-0.01	0.00	-0.02	0.00	0.10	0.01	0.01	0.11	-0.03	0.07
TM	-0.01	-0.02	0.00	-0.03	0.02	0.10	0.03	-0.02	0.12	-0.01	0.09
IM	-0.01	-0.01	0.00	-0.02	0.03	0.16	0.04	-0.03	0.17	-0.01	0.17
Other sectors	-0.04	-0.06	0.00	-0.09	0.36	1.47	0.36	0.06	1.89	0.02	2.17
Total	**-0.09**	**-0.11**	**0.00**	**-0.20**	**0.52**	**2.19**	**0.50**	**0.11**	**2.79**	**-0.05**	**3.06**

Source: Author's calculations based on information from the SNA/IBGE.

Note: In final demand trade pattern we opted to exclude the contributions of exports and government consumption because their final demand import (and its contribution) is not significant. To see their contribution, see Appendix I.

In this sense, there is a difference between the external and domestic source of demand and its effect on sectoral production. In fact, as highlighted by Torracca (2017), Brazilian exports and the domestic productive structure have different characteristics and promotes the stimulus in different sectors. Therefore, depending on the source of the final demand (external or domestic) the sectoral contributions to gross output changes are distinct. For example, the

AGR, AC, and MQC sectors are more affected by changes in external final demand compared to TM and IM, which response more to changes in domestic final demand.

Table 15 – Share of the contributions in volume to gross output contribution in volume units, 2000-2014 and selected periods

Industries groups	Trade pattern				Tech Change	Final demand				Market share	Total
	Inter	Final		Subtotal		Cons	GFCF	Ext	Subtotal		
		Cons	GFCF								
2000-2014											
AG	-0.12	-0.24	-0.02	-0.38	-0.01	2.38	0.24	2.74	5.36	-0.01	4.97
MQC	-3.82	-0.81	-0.44	-5.08	0.16	6.40	3.17	4.88	14.44	0.43	9.96
AC	-0.97	-0.63	-0.08	-1.68	-0.57	3.77	0.40	2.26	6.43	-0.21	3.96
TM	-1.55	-1.24	-0.40	-3.19	-0.48	3.11	1.47	0.21	4.79	-0.01	1.11
IM	-1.86	-1.92	-1.87	-5.65	-0.09	6.68	5.18	1.17	13.02	-0.43	6.84
Other sectors	-5.61	-2.88	-1.04	-9.53	2.62	56.89	15.10	7.31	79.29	0.78	73.16
Total	**-13.93**	**-7.73**	**-3.85**	**-25.51**	**1.63**	**79.22**	**25.55**	**18.57**	**123.33**	**0.55**	**100.00**
2000-2003											
AG	0.33	9.53	0.05	9.90	-1.21	-0.80	0.59	15.80	15.60	0.10	24.39
MQC	11.94	1.56	0.19	13.69	2.10	-5.71	-3.87	31.55	21.96	8.28	46.03
AC	-17.56	-0.15	0.02	-17.69	-1.21	-6.78	-0.50	24.84	17.56	0.11	-1.23
TM	-4.74	0.18	0.12	-4.45	-3.70	-10.06	-2.24	6.98	-5.32	-0.10	-13.57
IM	-4.59	-1.89	0.99	-5.48	-0.93	-2.16	-5.82	9.36	1.38	-1.33	-6.37
Other sectors	-16.48	-1.36	-1.61	-19.44	-14.09	67.48	-13.22	26.68	80.94	3.33	50.74
Total	**-31.11**	**7.87**	**-0.24**	**-23.48**	**-19.03**	**41.97**	**-25.05**	**115.21**	**132.12**	**10.39**	**100.00**
2003-2008											
AG	-0.04	-0.25	-0.03	-0.33	0.25	2.53	0.29	1.42	4.24	0.01	4.17
MQC	-7.56	-0.78	-0.73	-9.06	-0.76	5.89	4.46	5.93	16.28	-0.30	6.16
AC	-0.01	-0.42	-0.10	-0.54	-0.82	4.32	0.54	1.90	6.77	0.19	5.60
TM	-1.16	-0.95	-0.54	-2.65	-0.15	3.71	2.10	0.87	6.68	0.23	4.11
IM	-1.45	-1.53	-2.64	-5.62	-0.41	7.30	9.10	4.34	20.74	-0.01	14.69
Other sectors	-4.41	-1.66	-1.13	-7.21	1.29	44.39	14.86	11.82	71.08	0.11	65.27
Total	**-14.64**	**-5.60**	**-5.18**	**-25.42**	**-0.60**	**68.14**	**31.37**	**26.28**	**125.79**	**0.23**	**100.00**
2010-2014											
AG	-0.05	-0.13	0.00	-0.18	0.23	2.49	0.07	2.12	4.67	-0.14	4.59
MQC	-0.56	-0.37	-0.03	-0.96	3.40	9.11	1.95	0.92	11.98	-0.46	13.96
AC	-0.42	-0.28	0.01	-0.69	-0.04	3.33	0.26	0.17	3.76	-0.86	2.17
TM	-0.46	-0.67	0.06	-1.07	0.61	3.37	0.91	-0.52	3.76	-0.36	2.94
IM	-0.22	-0.43	0.12	-0.53	0.94	5.09	1.43	-1.06	5.46	-0.42	5.45
Other sectors	-1.22	-1.85	-0.01	-3.08	11.84	48.05	11.61	1.96	61.62	0.52	70.89
Total	**-2.93**	**-3.74**	**0.15**	**-6.52**	**16.99**	**71.43**	**16.23**	**3.59**	**91.26**	**-1.72**	**100.00**

Source: Author's calculations based on information from the SNA/IBGE.

From 2000 to 2003, the final external demand represents the most important source of demand (the contribution represents 125% of total volume contribution). In this period, economic activity was very week in the Brazilian economy, and, as we saw in Chapter 2, exports were the most dynamic final demand component in the period. External demand was responsible for almost 90% of all final demand contribution and is concentrated in sectors in which Brazilian exports are more competitive such as the AGR sector (0.17pp), the MQC group (0.23pp) and the AC group (0.19pp).

In contrast, contributions of changes in final domestic demand were generally negative, in particular when we consider the for industrial groups for which all contributions are negative for both final consumption and gross fixed capital formation. In the case of the contribution of final consumption (household and government), we have a negative effect, except for the final consumption of the products of the "Other Sectors" group. [76] Notice, however, the latter contribution (0.72 pp) was strong enough to overcome all negative contributions, leading to a positive contribution of overall final consumption (0.45pp). This positive contribution was greater than the negative contribution of the GFCF (-0.27pp), which implied a positive contribution of overall domestic final demand (0.18pp). Finally, in the specific case of the IM group, there is a clear association between the poor performance of the GFCF final demand component (with a negative annual average rate of growth of -1.4% between 2000-2003) on the one hand, and the negative contribution of GFCF related to this group (-0.06 pp), on the other.

The period 2003-2008 features the highest average rate of growth of gross output. We can explain this performance by favorable external conditions and an active internal macroeconomic policy, founded on the growth of public expenditures (consumption and investment) and credit expansion for household's consumption and investment, as mentioned in Chapter 2. Both domestic and external final demands had an important role in explaining the expansion of the gross output in volume units, but the domestic demand is the most important source of demand.

The improvement in the labor market, in income distribution and poverty indicators, the gains in real wages and the inflation under control contributed directly to significant growth in final consumption and reflected in its contribution to gross output (3.10pp). However, GFCF is the final demand component with the highest growth in volume units for most sectors, but it is especially important in the case of the IM group due to the close relationship between this group's production and the final demand for GFCF. Thus, between 2003-2008, the IM group had a relatively important role in explaining gross output growth. Furthermore, this industrial group was also the one with the highest growth related to other demand components, such as household consumption and exports.[77] Another important sector in explaining the final demand

[76] In fact, the positive contribution associated with Services is only visible in terms of volume. If we compare with the total contribution, it also is negative, due reduce in the relative price of this sector. See Table I.11 in Appendix I.

[77] If we compare the contributions in volume units to the one in total units, the declining tendency of relative prices leads to an underestimation of the rate the growth in volume units (0.20pp against 0.04pp in total units).

stimulus to gross output is the MQC group, which featured the third most important sectoral final demand contribution (0.74 pp)[78].

The reversion in the tendency of economic growth of the Brazilian economy in 2010-2014 also reflects the relevance of final demand as a source of gross output changes in volume units. The contribution of final domestic demand is the highest one in this period, mostly related to the contribution of final consumption and, in particular, to the expansion of the final consumption of the "Other Sectors" products. Regarding the IM group, we can verify that this industrial group loses importance in explaining gross output growth when compared to the previous subperiod, notably due to the decline of the investment-output ratio in the period.

Notice that, under the impact of the world crisis, the contribution of external demand for the products of the IM group becomes negative (-0.03pp). Moreover, despite the efforts in the conduction of economic policy to maintain the pace of economic growth, the contribution of final domestic demand for the products of the IM group also featured a reduction in the period under analysis, although the contribution is still positive. Hence, the positive contribution of final domestic demand (0.16pp for final consumption and 0.04 pp for GFCF) was great enough to lead to a positive contribution of overall final demand (0.17pp)

Analyzing the decomposition contribution to have some insight about the regressive specialization, we calculated the share of AGR, MQC, and AC in total export's contribution. For the whole period, these sectors contributed to 53%[79] for 2000-2014. For 2000-2003, since these sectors increased their share in Brazilian's exports and the external market, they contribute with a higher share (63%) to total's exports contribution.

The contribution of the mentioned groups decreased in 2003-2008 corresponding only to 35% of the total exports. By the other side, we observe an increase in the IM contribution compared to the other subperiods. Not only the sector contribution was higher, but we also note that the IM was the one with the highest growth associated with their exports contribution among all selected groups.

From 2010 and 2014 we see that the exports' contribution in volume to gross output is meager compared to the other subperiods, representing only 3% of the 3.06% average growth. Besides that, AGR, MQC, and AC represent almost 90% of all exports' contribution. We

[78] If we compare the contribution of the final demand of the products of this group in terms of volume units and in total units (0.84pp), an increase of relative prices overestimates its contribution in volume units as compared to the one in total units.

[79] If we consider this contribution for the total decomposition, without excluding the relative prices effect, this amount is higher (67%)

highlight that AGR is the only sector that increases its share in Brazilian export basket and has a higher contribution among these sectors.

4.6.2.2 Trade pattern

Analyzing the trade pattern we can observe if there is substitution (penetration)[80] of imports in the Brazilian economy and its effect on gross output. It means that we are importing relatively less (more) to satisfy the domestic intermediate and/or final demands in the final period as compared to the initial one.

From the results of the structural decomposition exercise, we observe a generalized process of *penetration of imported inputs* in the total (domestic and imported) intermediate demand for all subperiods.[81] If we combine this information with the increase in the share of imported intermediate demand (*Figure 58*), we can argue that there is a loss of competitiveness of domestic producers against the external suppliers (see section 3.2 above). The same happens in the case final demand, for almost all sub-periods, except for 2000-2003 where there is import substitution. We attribute this different pattern in the final demand to exchange rate depreciation and the weak performance of the economy that characterized the period just mentioned.

From 2003 to 2008, the changes in the trade pattern feature more relevant contributions to gross output growth (-25.42%) compared to the other subperiods. The penetration of intermediate demand (-0.67 pp) represents almost 15% of the total volume contribution. Besides, we observe the higher contribution of the components of the final demand (0.49pp, almost 11%) compared to other subperiod. We already saw that the increase in the imported market share was concentrated in this period, probably explained partially by the appreciation of exchange rate, but also effect of the increase in the income in the period (mainly in the final demand).

From 2010 to 2014 the change in trade pattern is the less critical effect in explaining the overall rate of growth of total gross output, for almost all sectors. As we saw (section 3.2 above), the market share of imported products changed very little compared to other subperiods. The depreciation exchange rate and the slowdown in the path of the economic growth did not

[80] In fact, as we calculate the domestic final demand as a difference, the amount may vary because there is a higher share of total inputs or final demand attended by imports and because there is an overall increase due to economic expansion.

[81] An interesting fact to point out is that the same contribution for the total, without excluding the relative price effect indicates a substitution of imports for the intermediate demand and for some sectoral's final demand. In this case, one of the main relative prices changes is due to the exchange rate, and this interferes in a proper interpretation of the external trade pattern.

stimulate the imports. However, we observe that in this period the Other sector group was the only with a significant process of penetration of imports (mainly related to transports and trade sectors).

From a sectoral perspective, we observe the same tendency in the subperiods, but especially for the IM group, for which we find a strong effect of import penetration. In a different way from the other groups, the imported final demand is essential to explain the changes in the trade pattern. Not only this group has a higher share of imported final demand, but also it grew at a higher pace than intermediate demand for most of the periods (except for the period 2010-2014). Hence, given the specialization of the Brazilian economy, the trade effect is more concentrated in the GFCF, and the pace of capital accumulation affects the process of import penetration. From 2003-2008 we observe a higher penetration of imports compared to 2010-2014, where there is a slowdown of GFCF/GDP growth. As a consequence, the final demand penetration of imports in the IM group concentrates in the household consumption (0.01pp) and not in GFCF (which had a null contribution). The deceleration in the tendency of the investment-output ratio and the slight reduction in the final demand market share of this group are possible reasons for that pattern.

Another sector where the penetration of imports is significant to understand the Brazilian economy is the TM group. Regarding contribution, there was penetration of imports associated to the intermediate (0.06pp) and final demand (0.06pp) between 2000-2014 (-0.05pp). However, if we compare the volume growth of each one, we observe that final demand increased in a higher proportion than the intermediate one, and mainly in the case of household consumption. Therefore, we had already seen in section 3.2 above the loss of competitiveness in the production of this type of products as a result of the increasing imported market share, as a consequence of several factors. For example, if we compare the two subperiods 2003-2008 and 2010-2014, the penetration of imports of the TM group is more remarkable in the period with the valorization of the exchange rate. However, it is essential to highlight that international increase in the competition after 2010 in the production of these goods (by large populous countries) may have contributed directly to affects the internal market share of the TM group.

The other two EMI groups, MQC and AC, have their penetration of imports higher in intermediate demand between 2000-2014. In the case of intermediate goods, we observe a penetration of imports, that may be associated with the increase of imported supply.

4.6.2.3 Technological change

The technological change is the effect with smaller contributions compared to the other sources of change [82] between 2000 and 2014. For the whole period the impact the contribution is positive[83], indicating that the economy demanded more inputs to produce a unit of gross output in volume units, as we already saw in the BL and FL indicators (section 4 above). However, this effect is positive or negative depending on the subperiod we focus on.

The variation of national technical coefficients had a positive impact on gross output growth in 2010-2014 and a negative one in 2000-2003 and 2003-2008. In 2000-2003, the technological change had a negative contribution of -0.20pp. Also, we can see this adverse effect is similar in the sectoral perspective, but the larger part is due to Other sectors group changes.

In 2003-2008 we also saw a negative contribution of technological change, but its sectoral composition is different. It is more concentrated in the extractive and manufacturing groups, indicating that the 'recipe of production' contributes in a negative way for the gross output. As a consequence, the production of these sectors is more efficient, since there is an economy in the use of inputs[84]. Notice that we also observed in the period an increase in the labor productivity for the IM group.

Particularly in the case of the IM group, there is a lack of significant changes in the density of interindustry relations, and for example, this effect has a null contribution to gross output change between 2000-2014. For the others subperiods the effect is also very small, but with a reverse sign. Between 2000-2003 and 2003-2008 the sector follows the results of the aggregate economy and has a negative contribution, which might indicate the sector is more efficient using the inputs. In 2010-2014 the IM group had a positive (0.03pp) contribution to technological changes and represented a more significant part to the sectoral gross output changes (0.17pp) compared to other subperiods. This represents that the sector is using more inputs to produce. However, for the total economy, most of its contribution is due to the Other

[82] Nagashima (2018) indicates that there is a sign reversal problem in structural decomposition analysis. Using Monte Carlo simulations for Japan in an intensity energy SDA model he founds that there is an instability in the decomposition results, particularly the ones related to technical coefficients and the economic structure term. In this way we might be careful analyzing this effect.

[83] However, if we compare the technological change source of change in volume and for the total (Table G.10 in Appendix I), we observe that the effect is negative.

[84] Although it contributes negatively to the growth of final demand, it may be beneficial for the economy when we consider other mechanism not directly captured by our empirical methodology.

sectors[85] group, and specifically with Public utility, Transportation and Financial, insurance and real estate activities.

As mentioned in the methodology, we calculated some part of the technological change that induces imports to satisfy its demand. Although for the other subperiods the effect of non-competitive imports is minimal, for 2010-2014 we notice that for most sectors the changes in the total coefficients induced to the utilization of more imported inputs. As we already notice in the BL and FL linkages, there was the creation of potential linkages, but the domestic production was not capable of absorbing it. In the case of the IM group, the non-competitive imports (see Table I.4 in the Appendix I) reduced in a half (-0.03pp) the total technological change (0.06pp).

4.7 The implications for deindustrialization and regressive specialization

The objective of this chapter was to present a series of indicators that allow the diagnosis on the existence, intensity, and time-profile of the processes of deindustrialization and regressive specialization in the Brazilian economy between 2000 and 2014. In addition to the usual indicators discussed in the literature (the share of gross output and the sectoral composition of exports), other structural elements were discussed to complement our analysis, such as the external competitiveness in the domestic and foreign markets, interindustry indicators, the performance of labor productivity growth, and a structural decomposition analysis of the gross output growth[86]. To have an accurate measure of these processes, we eliminate the effect of relative price changes on these indicators when it was possible. Also, we considered that the innovative industry as the most important sector in promoting structural change due to its central role in the generation and diffusion of technological flows, which turns it is an essential sector for the discussion of the deindustrialization and regressive specialization processes.

[85] As we already mentioned earlier, as the decomposition and its results are sensible to the aggregation level.

[86] UNIDO (2017) uses similar indicators to measure the competitive industrial performance, related to the ability of each country to export and produce manufactured goods in a competitive way. For the value added they combine information of: the manufacturing value added per capita; the share of manufacturing value added in GDP; the share of medium and high-tech activities in total manufacturing value added; industrialization intensity; the share of world manufacturing value added. In the case of the manufacturing exports, they consider the manufacturing exports per capita; the share of manufacturing exports in total exports; the share of medium and high-tech activities in total manufacturing export; index industrial export quality index and the share in world manufacturing export. The index result of the combination of this group of information shows that the Brazilian economy (and Russia and South Africa among the BRICS) lost competitiveness between 2010-2015.

In the period between 2000 and 2014, we observed that there was a small increase in the share of the innovative industry in the gross output in volume units, indicating that there was no deindustrialization according to this criterion. Further, there was an increase in the density of the interindustry relations of the IM group BL and FL domestic linkages. However, we should note that the potential linkages (which include domestic and imported inputs) increased by more than the domestic ones, indicating that the domestic sectors were not able to fully take advantage of the increase in potential linkages. Another important aspect of the evolution of the Brazilian productive structure was the increase of the import penetration in the IM group's intermediate consumption and domestic markets for its products. We saw that there was an increase in the market share of imported products in the whole period, both in intermediate and final demands, indirectly suggesting that there was a loss of competitiveness of the IM group. The latter effect was also captured in the structural decomposition exercise by the negative trade pattern contribution to the rate of growth of gross output.

Another indicator is the changes in labor productivity. The IM group featured a null contribution to the overall rate of growth of labor productivity between 2000 and 2014. Concerning the efficiency in the use of intermediate inputs in production processes, we showed that there was a general tendency towards an increase in the efficiency of the use of the inputs, as captured by the contribution of technological change in the structural decomposition exercise. Therefore, based on the set indicators discussed, it is not possible to affirm that there was deindustrialization in this period as a whole, despite the presence of a significant process of import penetration into the IM group's intermediate consumption and main domestic markets.

However, it is fruitful to investigate the deindustrialization process by analyzing the indicators according to the subperiods, because the performance of the IM group was different depending on the subperiod chosen. As mentioned in the other subsections of this Chapter, there is a relationship between the output share of the IM group and the pace of economic growth and capital accumulation in the Brazilian economy. In this sense, the contribution of the IM group (considering the different indicators) varies according to the trend rate of growth output, and we must consider this in order to have an appropriate assessment of the deindustrialization process.

Hence, the output share of the IM group was affected by the pace of economic growth. Indeed, it increased in the period where there was an increase in the trend rate of growth of output and the investment-output ratio (2003-2008), while the opposite movement occurred in the period in which there was a reduction in the trend rate of growth of output and the investment-output ratio (2010-2014). The intensity of the process of economic growth also positively affected the pace of labor productivity growth of the IM group, featuring a better performance between 2003 and 2008 than in the period 2010-2014. Finally, the increase in the effective and potential BL and FL linkages for the IM group between 2000 and 2008 also corroborates the idea that the process of deindustrialization was less intense or even inexistent in this period As a counterpoint to the latter idea, we have the tendency towards an increase of the import penetration in the domestic markets of the IM group, as captured by the observed increase of the import content of the intermediate demand and, in particular, of the final demand in the period between 2003 and 2008. As we argued, such result seems to be the consequence of the loss of competitiveness of the IM group in domestic markets due to the influence of price (e.g., the real exchange rate appreciation and a relatively, to the competitors, low rate of productivity growth) and non-price determinants (e.g., innovative performance).

The situation was different between 2010 and 2014, in which the downward trajectory of capital accumulation has important implications for the deindustrialization process. Indeed, we observed a reduction in the gross output share of the IM group in volume units and a reduction in the contribution of this group to the growth of gross output in volume units according to our structural decomposition analysis. We also observed a decrease in the rate of growth of labor productivity in relation to the previous subperiod, a decrease sufficient to turn a positive rate of growth into a negative one. Moreover, we saw that the domestic BL and FL linkages indicators of the IM group featured a decrease in the subperiod, while the total or potential linkages presented an increase. The latter result shows that the IM group not only was unable to absorb the increase of the potential linkages but, in fact, it featured a reduction in the density of its interindustry relations.

With regard to the behavior of imports between 2010 and 2014, we observed that, even with the tendency towards a real exchange rate depreciation after the world crisis, the imports share of the IM group's overall domestic markets (i.e., for intermediate and final use) maintained an approximately stable value. Thus, the observed real exchange rate depreciation was not able to bring the indicator of import penetration back to its lower value at the beginning of the 2000s. The non-price determinants of the domestic competitiveness of the IM group seem to have counterbalanced the effects of the real exchange rate depreciation.

By analyzing Brazilian exports, we saw that there was a tendency towards a pattern of regressive specialization between 2000 and 2014, since there was a reduction of the share of exports associated with the IM group. However, this effect is less intense in volume units than in total units. It is necessary to qualify this result in light of the arguments presented in Chapter 1. The structure of exports depends on the natural resources' endowment of a country, and in the case of Brazil, it has a great territorial extension and an important reserve of extractive and mineral resources. Hence, it is expected that these resource-based exports have a higher share of Brazilian exports. Moreover, as is well known, Brazil is a relatively closed economy, In fact, hence exports are a small percentage of the Brazilian final demand, and since it is has a large internal market, domestic demand is more relevant to explain the Brazilian productive structure.

The validity of the regressive specialization hypothesis is different when analyzed under the subperiods. Between 2003-2008 there is slight maintenance of the share of the IM group in Brazilian export basket and a good performance in terms of growth in the TM group exports in volume units. However, the regressive specialization process is most noticeable after the crisis, in the period between 2010-2014. There is a reduction, although not linear, of the share of IM group in Brazilian exports' structure and its importance to the variation of the gross value of production in units of volume. The loss of importance of the IM group (and the TM group) may be related to the increase in competitiveness in the post-crisis, especially China's entry into the Latin American market.

However, the process of regressive specialization is most noticeable after the crisis, in the period between 2010-2014. There is a reduction, although not linear, of the share of IM group in Brazilian exports' structure[87]. Moreover, the IM group in this period contributed little to the variation of the gross output in units of volume, indicating the loss of participation and dynamism of the exports of this sector. The loss of competitiveness, the performance of the IM group may be related to the increase in competitiveness in the post-crisis, especially China's entry into the Latin American market. This market absorbs a larger share of Brazilian manufacturing exports compared to other partners. We also saw that the competition had the strongest effect in the TM group, more susceptible to price-competition.

On the other hand, we noticed that the unprocessed agricultural exports (represented by the AGR group) increased its share in Brazilian exports between 2010 and 2014. In contrast, the processed agricultural commodities reduced its share, and this fact might indicate that we are switching from exports of more processed goods to the unprocessed ones. Although the

[87] The reduction in the real exchange rate seems to have had little effect on the structure of Brazilian exports in the period.

MQC group had the highest share in Brazilian exports, it remained relatively constant in the period.

However, we must beware of the implications of the expansion of natural resource-based exports in replacement of the manufacturing output. For the Brazilian economy, Torracca (2017) shows that exports and the productive domestic structure have different characteristics, and are driven by distinct factors. As discussed by Medeiros (2013), manufacturing development in the Brazilian economy is more related to national strategies of development than to changes in exports' composition.

In a broad view, we showed that the relative price affects the analyses of deindustrialization, but mainly for the regressive specialization, because it tends to reduce the importance of the innovative group and increase the relevance of the mining and quarrying commodities, due to their distinct patterns of relative price changes in the period. So, taking apart relative prices effects guarantee accuracy on results. Also, we considered several indicators to identify these phenomena, and according to this perspective, the deindustrialization and regressive specialization are less intense and continuous between 2000-2014 than most of the literature (OREIRO; FEIJÓ, 2010; CANO, 2014; BRESSER-PEREIRA, 2016) characterized it. However, the scenario for the IM group is not good between 2010 and 2014 either for gross output and exports. So, if the Brazilian economy maintains the trajectory of low growth for more years and without the implementation of any effective economic policy to stimulate the IM group, it may lead to a major loss in the importance of this group for the output and exports.

FINAL REMARKS

Since the 2000s, many studies dedicated attention to analyzing the evolution of the productive structure of the Brazilian economy. One of the main topics of discussion in these studies is the existence, intensity and time profile of the processes of deindustrialization and regressive specialization between 2000 and 2014. The dominant interpretation in the literature is that the Brazilian economy has been, indeed, subject to the processes of deindustrialization and regressive specialization in the 2000s and that these processes can be characterized as highly intense and relatively continuous over time. In contrast, our hypothesis is that these processes were, in fact, less intense and continuous than argued by the dominant literature.

To substantiate our hypothesis we critically analyzed the arguments advanced by the dominant interpretation, as well as their empirical base. In this connection, we pointed out some criticisms to the usual indicators employed in the characterization of the processes of deindustrialization (such as the sectoral gross output, value-added and employment shares) and regressive specialization (e.g., the sectoral or product composition of exports). Indeed, the critical review of the literature in Chapter 1 has shown that a proper analysis of processes of structural change, as the deindustrialization and regressive specialization ones, should take into account: the effects of relative price changes; the connection between the output share of manufacturing industries, on the one hand, and the pace of economic growth and capital accumulation (explained by the supermultiplier model and the Kaldorian perspective), on the other; the pattern of integration of the manufacturing activities in the global productive structure; the need of focus in the analysis of the set of manufacturing sectors characterized by relatively high technological dynamism; and, finally, the implications of the regressive specialization to the deindustrialization process. Moreover, we argued that an assessment of structural change processes benefits from the use of structural indicators based on the input-output framework of analysis.

As discussed in Chapter 3, one of the difficulties of conducting a long-term analysis of the productive structure of the Brazilian economy is the availability of consistent input-output database (i.e., the IOTs). Due to the methodological changes in the Brazilian System of National Accounts following the recommendations of the SNA 2008 (UN, 2009), the previous existing IOTs (i.e., 2000 and 2005 in the SNA 2000) are not comparable with the most recent ones (i.e., 2010 and 2015 in the SNA 2010). Thus, one of the contributions of this thesis was to estimate a consistent and comparable series of annual IOT for the period of 2000 to 2015 in current and previous' years prices. The IOT series is based on the Brazilian SNA information and was estimated by the use of input-output updating methodology suggested by specialized literature and, especially, the one suggested by Grijó e Berni (2006), which is directly applicable to the Brazilian data. This task involved considerable work in constructing correspondence tables between the SNA 2000 and SNA 2010 at the most disaggregated level of disclosure of the system and its retropolated series.

As discussed in Chapter 1, relative prices changes affect the indicators used in the discussion of the processes of deindustrialization and regressive specialization. In fact, in the period under analysis, we saw that the world economy was characterized by significant changes in the relative prices of commodities (overall upward tendency) and manufacturing products (overall downward tendency). Since relative prices changes may lead to an inaccurate analysis of both processes, we constructed a series of deflated IOT, which allowed us to deal with relative prices changes properly. We constructed a series of IOT valued at constant *(total units)* and constant relative prices *(volume units)* for the Brazilian economy between 2000 and 2014. The deflated IOTs were constructed using cell-specific deflators and making the proper adjustment (in relation to gross output deflator) to obtain an IOT series that preserves the additivity property, which is a particularly desirable property in the multisector analysis.[88]

For the organization and presentation of the results, we worked with an aggregation level of analysis containing 11 industries. We regrouped the whole set of extractive and manufacturing industries into four industrial groups according to the classification proposed by the GIC-UFRJ (KUPFER, 1997; TORRACCA; KUPFER, 2014): processed agricultural commodities, processed and unprocessed mineral and quarrying commodities, traditional manufacturing industry and innovative manufacturing industry. In this context, we focused our analysis on the innovative industrial group, since this sector stands out for its capacity to stimulate the creation and diffusion of technological change in the economy.

Since there is a connection between the output share of manufacturing industries and the pace of economic growth, in Chapter 2 we presented some essential aspects of the process of economic growth of the Brazilian economy. We focused our exposition mainly on the behavior of the level of activity, capital accumulation, and their sectoral patterns. Furthermore, we introduced the discussion of the deindustrialization process and the trend towards a

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[88] A previous version of this methodology for the Brazilian economy for the period of 2000-2009 can be found in by Neves (2013).

regressive specialization, by presenting some information on disaggregated value-added, gross output, employment, labor productivity and the sectoral composition of Brazilian exports.

Most of the indicators presented in Chapter 2 can be affected by changes in relative prices. Based on the database constructed for the thesis, we analyzed the composition of gross output and exports by sector in volume units (excluding the relative price effect). Moreover, in order to overcome some of the limitations of these indicators discussed in chapter 1, we also presented and discussed in Chapter 4 indicators related to the Brazilian external and domestic competitiveness (as the market share of the Brazilian exports in world markets and the market share of imports in total demand), indicators capturing the interindustry relations based on input-output information (backward and forward linkages), and changes in labor productivity.

The use of these indicators is complemented by the structural decomposition analysis of gross output growth. By taking into account the effect of relative prices changes, we proposed a two-level structural decomposition analysis. The first decomposition level captures the influence of relative prices and volume changes on the gross output vector in total units. In the second level of the decomposition, we identified the main factors determining the changes in gross output in volume units, by isolating the changes in relative prices in intermediate and final demand components. Thus, as we saw, the decomposition provides a more accurate way to assess the growth contribution of the various factors involved in the decomposition exercise. We analyzed the contribution to gross output growth from the following source of changes: trade pattern (in intermediate and final demands), technological change and final demand.

Our contribution to the debate on the processes of deindustrialization and regressive specialization is that we show that these processes were less intense and continuous than argued by the dominant literature. In this connection, we verified that the importance of the innovative industry group is underestimated because of the reduction in relative prices of the products of this industrial group. Between 2000-2014 there was a small increase in the gross output share of the innovative industry in volume units and also a (small) increase of the density of interindustry relations, both in terms of the potential and effective backward and forward linkages indicators. Regarding the decomposition analysis, the IM industrial group was the third most important sector in explaining gross output growth, getting behind the MQC industrial group and "Other sectors." This is compatible with the structure of the Brazilian economy since the latter has a big internal market and is rich in natural resources, so these sectors are important to explain the Brazilian gross output structure. However, there are some warning signs in the results, such as the loss of competitiveness of the IM group. We observed penetration of imported products into the domestic markets for the IM group. Also, the IM group featured a low labor productivity growth in the period, having a null contribution to the overall rate of growth of labor productivity.

We also fruitfully analyzed the performance of the IM group considering some sub-periods. In the period of 2003-2008, the IM group featured an increase in its share on gross output, a significant contribution to gross output growth, an increase in the BL and FL indicators, and, also, a good performance in terms of the technological change and contribution to the growth of overall labor productivity. The situation was different between 2010 and 2014. In the latter period, there was a reversion in the sign of the change of all the indicators of the IM group just mentioned. We attribute such reversion to changes in the pattern of capital accumulation and economic growth and to the decrease of the competitiveness in external markets due to its price and non-price determinants.

Regarding the competitiveness in domestic markets, there was an increase in import penetration along the period from 2000 to 2014. Nonetheless, the intensity of the process of import penetration was greater from 2003 to 2008 compared to 2010-2014. Between 2003 and 2008, the loss of competitiveness was concentrated in the final demand, and the data indicates that the real appreciation of the exchange rate and the level of economic activity observed in the period may have contributed to the result. In the case of 2010-2014, the penetration of imports was higher for the intermediate demand, and although there was a real depreciation in the exchange rate, it maintained in a lower level compared to the beginning of the 2000s. The intensification of the process of import penetration seems to be the result of the increased competition in external and domestic markets after the 2008 crisis combined with the poor performance of the IM group in terms of its rate of growth of labor productivity and low innovation capacity to innovate (and other non-price competition factors) of the enterprises operating in the sector.

When we analyzed the Brazilian exports, we verified that there was indeed a process of regressive specialization between 2000 and 2014, with a reduction of the share of exports associated with the IM group. However, this effect is less intense when we analyze the composition of exports in volume units than in total units, especially due to the price effect in the MQC group. However, it is necessary to qualify such a result when we take into account the arguments discussed in Chapter 1. The structure of exports depends on the dimension of the natural resource base of a country, and in the case of Brazil, it has a great territorial extension and an important reserve of extractive and mineral resources. Hence, it is expected that these resource-based exports have a higher share in the Brazilian exports. Moreover, exports have a small participation in the total final demand of the Brazilian economy, implying that domestic demand is more relevant to explain the Brazilian productive structure.

The intensity of the regressive specialization hypothesis also depends on the sub-period analyzed. Between 2003 and 2008 there was a slight reduction of the share of the IM group in Brazilian exports and a relatively good performance in terms of the growth of the IM group exports in volume units. However, the process of regressive specialization was more prominent after the world crisis, in the period 2010-2014. There was a more significant reduction, though not linear, of the share of the IM group in Brazilian exports and its contribution in volume units to the growth of the gross output. The relatively poor performance of the IM group in the period investigated seems to be due to the increased international competition in the post-crisis, especially the competition related to the penetration of imports from China in Latin American markets.

We must have to qualify that all the results are based on the IOT model and its hypothesis, specially homogeneity and proportionality, as mentioned in Chapter 3. Also, the results are based on the estimative of IOT series, which is an approximation of the real values of the sectoral flows of goods and services. There are several issues and criticisms about the IOT updating methodology, but the database developed in this thesis seeks to deal with these problems methodological problems, offering the academic community a consistent estimate of IOT for the Brazilian economy between 2010-2015 in the SNA 2010. However, as we used the IOT 2010 to estimate the IOT from 2000 to 2014, the analysis of structural change may have some distortions. In addition, the change in the system of national accounts after 2010 can also affect the results, even though we used the official retropoled information published by IBGE. A good exercise to investigate if the updating methodology generates goods estimates is to compare the official IOT 2015 published by IBGE with an estimation of the IOT 2015 estimated using the IOT 2010.

Another limitation is the sectoral classification utilized in this work. Although it has the objective to capture technological diffusion and technical progress, we are aware that it may be insufficient to capture these flows. Besides the IM group includes industries based on sophisticated technology and production organization method, it also has some durable goods that may not contribute properly to the technical progress. Another crucial limitation of this classification is that it does not consider the sectoral insertion in the GVCs. The global production is still more decentralized, and the countries are specializing in some tasks depending on their competitiveness. Even more, the tasks of research and development are usually concentrated in developed countries, and even if the innovative sector can increase its share, the countries where the production is settled may not appropriate the technological diffusion. Moreover, some part of the generated value added can be sent abroad as payment of royalties. One possible way of improving this classification is using external information, such as the technological and capital flows matrices between the sectors of the economy, using the empirical applications for the Brazilian economy by Queiroz (2018) and Miguez (2016).

Therefore, although we admit that our analysis may present some limitations, we argue that the processes of deindustrialization and regressive specialization in the Brazilian economy of the 2000s were less intense and continuous than the dominant interpretation of these processes (see, e.g., OREIRO, FEIJÓ, 2010; CANO, 2014; BRESSER-PEREIRA, 2016) suggests. We sustain that, in general, these processes became more intense in the period after the world crisis of 2008, with the sole exception of the behavior of the domestic market competitiveness indicator. In particular, the latter characterization represents well the experience of the IM group in the period investigated, which we argued should be the focus of the analysis of structural change. However, although the processes of deindustrialization and regressive specialization in the case of the IM group were less intense and continuous if the trend of the various indicators that we observed in the period 2010-2014 is maintained the performance and role of this industrial group in the Brazilian economy can be compromised.

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APPENDIX A – STATISTICAL INFORMATION OF CHAPTER 1

Table A. 1 - Demand side growth accounting for the Brazilian economy, 2000-2015 and selected periods (pp)

Year	Household consumption	GFCF	Government expenditures	Exports	Inventories	GDP
2001	0.36	0.11	0.44	0.81	-0.33	1.39%
2002	1.54	0.18	0.81	0.79	-0.40	2.92%
2003	-0.17	-0.63	0.33	1.34	0.28	1.14%
2004	2.05	1.12	0.75	1.75	0.10	5.76%
2005	2.11	-0.02	0.30	1.22	-0.40	3.20%
2006	2.17	0.54	0.60	0.54	0.11	3.96%
2007	2.92	1.45	0.67	0.65	0.37	6.07%
2008	2.99	1.41	0.27	0.14	0.28	5.09%
2009	2.48	-0.20	0.50	-1.08	-1.81	-0.10%
2010	2.48	2.22	0.65	0.91	1.26	7.53%
2011	2.23	1.06	0.37	0.41	-0.10	3.97%
2012	1.87	0.16	0.40	0.02	-0.53	1.92%
2013	1.67	0.94	0.25	0.15	-0.01	3.00%
2014	1.28	-0.64	0.15	-0.14	-0.15	0.50%
2015	-1.27	-2.04	-0.24	0.72	-0.72	-3.55%

Source: Author’s calculations based on information from the SNA/IBGE.

Table A. 2 – Final demand contribution to growth by demand components for the Brazilian economy, 2000-2015 and selected periods (pp)

Year	Household consumption	GFCF	Government expenditures	Exports	Inventories	Total Demand
2001	0.50	0.24	0.49	0.94	-0.36	1.81
2002	0.82	-0.27	0.74	0.68	-1.00	0.97
2003	-0.34	-0.71	0.32	1.57	0.24	1.08
2004	2.43	1.41	0.74	2.26	0.33	7.17
2005	2.66	0.34	0.37	1.60	-0.79	4.19
2006	3.20	1.14	0.67	0.87	0.32	6.19
2007	3.85	2.06	0.77	0.92	0.78	8.38
2008	3.87	2.21	0.39	0.23	0.61	7.31
2009	2.66	-0.41	0.55	-1.38	-2.70	-1.28
2010	3.86	3.41	0.77	1.31	2.00	11.36
2011	2.90	1.40	0.42	0.53	-0.15	5.10
2012	2.11	0.16	0.43	0.03	-0.72	2.00
2013	2.13	1.21	0.28	0.29	0.05	3.96
2014	1.39	-0.88	0.15	-0.26	-0.29	0.11
2015	-2.03	-2.77	-0.28	0.75	-1.17	-5.48

Source: Author’s calculations based on information from the SNA/IBGE.

Table A. 3 – Negative import's contribution to growth by demand components for the Brazilian economy, 2000-2015 and selected periods (pp)

Year	Household consumption	GFCF	Government expenditures	Exports	Inventories	Imports
2001	-0.13	-0.13	-0.06	-0.13	0.03	-0.42%
2002	0.72	0.45	0.07	0.11	0.61	1.95%
2003	0.17	0.08	0.01	-0.23	0.03	0.06%
2004	-0.37	-0.29	0.01	-0.51	-0.23	-1.41%
2005	-0.55	-0.36	-0.07	-0.38	0.38	-0.98%
2006	-1.02	-0.59	-0.08	-0.33	-0.21	-2.23%
2007	-0.93	-0.61	-0.10	-0.26	-0.41	-2.31%
2008	-0.88	-0.80	-0.12	-0.09	-0.33	-2.21%
2009	-0.19	0.21	-0.05	0.30	0.89	1.17%
2010	-1.37	-1.19	-0.12	-0.40	-0.74	-3.83%
2011	-0.67	-0.34	-0.05	-0.12	0.06	-1.12%
2012	-0.24	0.00	-0.03	0.00	0.19	-0.08%
2013	-0.46	-0.27	-0.03	-0.13	-0.06	-0.95%
2014	-0.11	0.25	0.00	0.11	0.14	0.39%
2015	0.76	0.73	0.04	-0.03	0.45	1.94%

Source: Author's calculations based on information from the SNA/IBGE.

APPENDIX B – CORRESPONDENCE TABLES

Table B. 1 - Correspondence table - SNA 2010 (51 sectors) to 42 sectors

Code 51 sectors SNA 2010	Description 51 sectors SNA 2010	GIC Code 42 sectors	Description GIC 42 sectors
SNA 01	Agriculture forestry logging	GIC_A 01	Agriculture, forestry, livestock and fisheries
SNA 02	Livestock and fisheries	GIC_A 01	Agriculture, forestry, livestock and fisheries
SNA 03	Oil and natural gas	GIC_A 02	Extraction of oil and gas, including support activities
SNA 04	Extraction of iron ore	GIC_A 03	Extraction of iron ore, including processing and agglomeration
SNA 05	Other mining and quarrying	GIC_A 04	Other mining and quarrying
SNA 06	Food and drinks	GIC_A 05	Food and drinks
SNA 07	Manufacture of tobacco products	GIC_A 06	Manufacture of tobacco products
SNA 08	Manufacture of textiles	GIC_A 07	Manufacture of textiles
SNA 09	Clothing articles and accessories	GIC_A 08	Manufacture of footwear and leather goods
SNA 10	Leather and shoe artifacts	GIC_A 09	Manufacture of wearing apparel and accessories
SNA 11	Wood products - exclusive furniture	GIC_A 10	Manufacture of wood products
SNA 12	Manufacture of pulp, paper and paper products	GIC_A 11	Manufacture of pulp, paper and paper products
SNA 13	Newspapers magazines disks	GIC_A 12	Printing and reproduction of recordings
SNA 14	Oil refining and coke	GIC_A 13	Oil refining and coking plants
SNA 15	Alcohol	GIC_A 14	Manufacture of biofuels
SNA 16	Chemicals products	GIC_A 15	Manufacture of other organic and inorganic chemicals, resins and elastomers
SNA 17	Manufacture of resins and elastomers	GIC_A 15	Manufacture of other organic and inorganic chemicals, resins and elastomers
SNA 18	Pharmaceutical products	GIC_A 16	Pharmaceutical products
SNA 19	Pesticides	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
SNA 20	Perfumery hygiene and cleaning	GIC_A 17	Perfumery hygiene and cleaning
SNA 21	Paints, varnishes and enamels	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
SNA 22	Miscellaneous chemical products and preparations	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
SNA 23	Rubber & Plastics	GIC_A 19	Rubber & Plastics
SNA 24	Cement and other non-metallic mineral products	GIC_A 20	Cement and other non-metallic mineral products
SNA 25	Manufacture of steel and its derivatives	GIC_A 21	Manufacture of steel and its derivatives
SNA 26	Metallurgy of nonferrous metals	GIC_A 22	Metallurgy of nonferrous metals
SNA 27	Metal products - exclusive machinery and equipment	GIC_A 23	Metal products - exclusive machinery and equipment
SNA 28	Machinery and equipment including maintenance and repairs	GIC_A 24	Furniture and products of various industries & Machinery and equipment
SNA 29	Appliances and electronic material	GIC_A 25	Household appliances and electronic material
SNA 30	Office machines and equipment	GIC_A 24	Furniture and products of various industries & Machinery and equipment
SNA 31	Automobiles trucks and buses	GIC_A 26	Automobiles trucks and buses
SNA 32	Parts and accessories for motor vehicles	GIC_A 27	Parts and accessories for motor vehicles
SNA 33	Other transportation equipment	GIC_A 28	Other transportation equipment
SNA 34	Furniture and products of various industries	GIC_A 24	Furniture and products of various industries & Machinery and equipment
SNA 35	Electricity and gas, water, sewage and urban cleaning	GIC_A 29	Electricity generation and distribution gas water sewage and urban cleaning
SNA 36	Construction	GIC_A 30	Construction
SNA 37	Trade	GIC_A 31	Trade
SNA 38	Transporting warehousing and mail	GIC_A 32	Transporting warehousing and mail
SNA 39	Information services	GIC_A 34	Information services
SNA 40	Financial intermediation insurance and supplementary pension and related services	GIC_A 35	Financial intermediation insurance and supplementary pension and related services
SNA 41	Real estate activities and rentals	GIC_A 36	Real estate activities and rentals
SNA 42	Maintenance and repair services	GIC_A 37	Business and family services and maintenance services
SNA 43	Accommodation and food services	GIC_A 33	Accommodation and food services
SNA 44	Business services	GIC_A 37	Business and family services and maintenance services
SNA 45	Private education	GIC_A 40	Private education
SNA 46	Private health	GIC_A 42	Private health
SNA 47	Services provided to families and associations	GIC_A 37	Business and family services and maintenance services
SNA 48	Domestic services	GIC_A 37	Business and family services and maintenance services
SNA 49	Public education	GIC_A 39	Public education
SNA 50	Public health	GIC_A 41	Public health
SNA 51	Public administration and social security	GIC_A 38	Public administration, defense and social security

Source: Author’s elaboration based on information from the SNA/IBGE.

Table B. 2 - Correspondence table - SNA 2000 (55 sectors) to 42 sectors

Code 56 sectors SNA 2000	Description 56 sectors SNA 2000	GIC Code 42 sectors	Description GIC 42 sectors
0101	Agriculture, forestry, logging	GIC_A 01	Agriculture, forestry, livestock and fisheries
0102	Livestock and fisheries	GIC_A 01	Agriculture, forestry, livestock and fisheries
0201	Oil and natural gas	GIC_A 02	Extraction of oil and gas, including support activities
0202	Extraction of iron ore	GIC_A 03	Extraction of iron ore, including processing and agglomeration
0203	Other mining and quarrying	GIC_A 04	Other mining and quarrying
0301	Food and drinks	GIC_A 05	Food and drinks
0302	Manufacture of tobacco products	GIC_A 06	Manufacture of tobacco products
0303	Manufacture of textiles	GIC_A 07	Manufacture of textiles
0304	Clothing articles and accessories	GIC_A 08	Manufacture of footwear and leather goods
0305	Leather and shoe artifacts	GIC_A 09	Manufacture of wearing apparel and accessories
0306	Wood products - exclusive furniture	GIC_A 10	Manufacture of wood products
0307	Manufacture of pulp, paper and paper products	GIC_A 11	Manufacture of pulp, paper and paper products
0308	Newspapers, Magazines, Disks	GIC_A 12	Printing and reproduction of recordings
0309	Oil refining and coke	GIC_A 13	Oil refining and coking plants
0310	Alcohol	GIC_A 14	Manufacture of biofuels
0311	Chemicals products	GIC_A 15	Manufacture of other organic and inorganic chemicals, resins and elastomers
0312	Manufacture of resins and elastomers	GIC_A 15	Manufacture of other organic and inorganic chemicals, resins and elastomers
0313	Pharmaceutical products	GIC_A 16	Pharmaceutical products
0315	Perfumery, hygiene and cleaning	GIC_A 17	Perfumery hygiene and cleaning
0314	Pesticides	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
0316	Paints, varnishes, enamels and lacquers	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
0317	Miscellaneous chemical products and preparations	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
0318	Rubber & Plastics	GIC_A 19	Rubber & Plastics
0319	Cement	GIC_A 20	Cement and other non-metallic mineral products
0320	Other non-metallic mineral products	GIC_A 20	Cement and other non-metallic mineral products
0321	Manufacture of steel and its derivatives	GIC_A 21	Manufacture of steel and its derivatives
0322	Metallurgy of nonferrous metals	GIC_A 22	Metallurgy of nonferrous metals
0323	Metal products - exclusive machinery and equipment	GIC_A 23	Metal products - exclusive machinery and equipment
0324	Machinery and equipment, including maintenance and repairs	GIC_A 24	Furniture and products of various industries & Machinery and equipment
0326	Office machines and computer equipment	GIC_A 24	Furniture and products of various industries & Machinery and equipment
0328	Electronic material and communications equipment	GIC_A 24	Furniture and products of various industries & Machinery and equipment
0329	Medical / Hospital Instruments, Measurement & Optics	GIC_A 24	Furniture and products of various industries & Machinery and equipment
0334	Furniture and products of various industries	GIC_A 24	Furniture and products of various industries & Machinery and equipment
0325	Home appliances	GIC_A 25	Household appliances and electronic material
0327	Electrical machinery, apparatus and equipment	GIC_A 25	Household appliances and electronic material
0330	Automobiles, trucks and commercial vehicles	GIC_A 26	Automobiles trucks and buses
0331	Trucks and buses	GIC_A 26	Automobiles trucks and buses
0332	Parts and accessories for motor vehicles	GIC_A 27	Parts and accessories for motor vehicles
0333	Other transportation equipment	GIC_A 28	Other transportation equipment
0401	Electricity and gas, water, sewage and urban cleaning	GIC_A 29	Electricity generation and distribution gas water sewage and urban cleaning
0501	Construction	GIC_A 30	Construction
0601	Trade	GIC_A 31	Trade
0701	Transport, storage and mail	GIC_A 32	Transporting warehousing and mail
1102	Accommodation and food services	GIC_A 33	Accommodation and food services
0801	Information services	GIC_A 34	Information services
0901	Financial intermediation and insurance	GIC_A 35	Financial intermediation insurance and supplementary pension and related services
1001	Real estate activities and rentals	GIC_A 36	Real estate activities and rentals
1101	Maintenance and repair services	GIC_A 37	Business and family services and maintenance services
1103	Business services	GIC_A 37	Business and family services and maintenance services
1106	Services provided to families and associations	GIC_A 37	Business and family services and maintenance services
1107	Domestic services	GIC_A 37	Business and family services and maintenance services
1203	Public administration, defense and social security	GIC_A 38	Public administration, defense and social security
1201	Public education	GIC_A 39	Public education
1104	Private education	GIC_A 40	Private education
1202	Public health	GIC_A 41	Public health
1105	Private health	GIC_A 42	Private health

Source: Author's elaboration based on information from the SNA/IBGE.

Table B. 3 - Correspondence table - SNA 2010 (68 sectors) to 42 sectors

Code 58 sectors SNA 2010	Description 68 sectors SNA 2010	GIC Code 42 sectors	Description GIC 42 sectors
0191	Agriculture, including support for agriculture and post-harvest	GIC_A 01	Agriculture, forestry, livestock and fisheries
0192	Livestock, including support for livestock	GIC_A 01	Agriculture, forestry, livestock and fisheries
0280	Forest production; fisheries and aquaculture	GIC_A 01	Agriculture, forestry, livestock and fisheries
0680	Extraction of oil and gas, including support activities	GIC_A 02	Extraction of oil and gas, including support activities
0791	Extraction of iron ore, including processing and agglomeration	GIC_A 03	Extraction of iron ore, including processing and agglomeration
0580	Extraction of coal and non-metallic minerals	GIC_A 04	Other mining and quarrying
0792	Extraction of non-ferrous metal ores, including	GIC_A 04	Other mining and quarrying
1091	Slaughter and meat products, including dairy products and fishery products	GIC_A 05	Food and drinks
1092	Manufacture and refining of sugar	GIC_A 05	Food and drinks
1093	Other Food Products	GIC_A 05	Food and drinks
1100	Manufacture of beverages	GIC_A 05	Food and drinks
1200	Manufacture of tobacco products	GIC_A 06	Manufacture of tobacco products
1300	Manufacture of textiles	GIC_A 07	Manufacture of textiles
1400	Manufacture of wearing apparel and accessories	GIC_A 08	Manufacture of footwear and leather goods
1500	Manufacture of footwear and leather goods	GIC_A 09	Manufacture of wearing apparel and accessories
1600	Manufacture of wood products	GIC_A 10	Manufacture of wood products
1700	Manufacture of pulp, paper and paper products	GIC_A 11	Manufacture of pulp, paper and paper products
1800	Printing and reproduction of recordings	GIC_A 12	Printing and reproduction of recordings
1991	Oil refining and coking plants	GIC_A 13	Oil refining and coking plants
1992	Manufacture of biofuels	GIC_A 14	Manufacture of biofuels
2091	Manufacture of organic and inorganic chemicals, resins and elastomers	GIC_A 15	Manufacture of other organic and inorganic chemicals, resins and elastomers
2100	Manufacture of pharmaceutical and pharmacokinetic products	GIC_A 16	Pharmaceutical products
2093	Manufacture of cleaning products, cosmetics / perfumes and toilet preparations	GIC_A 17	Perfumery hygiene and cleaning
2092	Manufacture of pesticides, disinfectants, dyes and various chemicals	GIC_A 18	Manufacture of pesticides, disinfectants, paints and various chemicals
2200	Manufacture of rubber and plastic products	GIC_A 19	Rubber & Plastics
2300	Manufacture of non-metallic mineral products	GIC_A 20	Cement and other non-metallic mineral products
2491	Production of pig iron / ferrous alloys, steel and seamless steel tubes	GIC_A 21	Manufacture of steel and its derivatives
2492	Metallurgy of non-ferrous metals and metal smelting	GIC_A 22	Metallurgy of nonferrous metals
2500	Manufacture of metal products, except machinery and equipment	GIC_A 23	Metal products - exclusive machinery and equipment
2600	Manufacture of computer, electronic and optical products	GIC_A 24	Furniture and products of various industries & Machinery and equipment
2800	Manufacture of machinery and mechanical equipment	GIC_A 24	Furniture and products of various industries & Machinery and equipment
3180	Manufacture of furniture and products of various industries	GIC_A 24	Furniture and products of various industries & Machinery and equipment
3300	Maintenance, repair and installation of machinery and equipment	GIC_A 24	Furniture and products of various industries & Machinery and equipment
2700	Manufacture of electrical machinery and equipment	GIC_A 25	Household appliances and electronic material
2991	Manufacture of cars, trucks and buses, except parts	GIC_A 26	Automobiles trucks and buses
2992	Manufacture of parts and accessories for motor vehicles	GIC_A 27	Parts and accessories for motor vehicles
3000	Manufacture of other transport equipment, except motor vehicles	GIC_A 28	Other transportation equipment
3500	Electricity, natural gas and other utilities	GIC_A 29	Electricity generation and distribution gas water sewage and urban cleaning
3680	Water, sewage and waste management	GIC_A 29	Electricity generation and distribution gas water sewage and urban cleaning
4180	Construction	GIC_A 30	Construction
4500	Trade and repair of motor vehicles and motorcycles	GIC_A 31	Trade
4680	Wholesale and retail trade, except motor vehicles	GIC_A 31	Trade

(continued)

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Code 58 sectors SNA 2010	Description 68 sectors SNA 2010	GIC Code 42 sectors	Description GIC 42 sectors
4900	Ground transportation	GIC_A 32	Transporting warehousing and mail
5000	Water transportation	GIC_A 32	Transporting warehousing and mail
5100	Air Transport	GIC_A 32	Transporting warehousing and mail
5280	Storage, auxiliary transport and mail activities	GIC_A 32	Transporting warehousing and mail
5500	Accommodation	GIC_A 33	Accommodation and food services
5600	Food services	GIC_A 33	Accommodation and food services
5800	Print-integrated editing and editing	GIC_A 34	Information services
5980	Television, radio, cinema and sound / image recording / editing activities	GIC_A 34	Information services
6100	Telecommunications	GIC_A 34	Information services
6280	Development of systems and other information services	GIC_A 34	Information services
6480	Financial intermediation, insurance and supplementary pension plans	GIC_A 35	Financial intermediation insurance and supplementary pension and related services
6800	Real estate activities	GIC_A 36	Real estate activities and rentals
6980	Legal, accounting, consulting and corporate headquarters activities	GIC_A 37	Business and family services and maintenance services
7180	Architectural, engineering, testing / technical analysis and R & D services	GIC_A 37	Business and family services and maintenance services
7380	Other professional, scientific and technical activities	GIC_A 37	Business and family services and maintenance services
7700	Non-Real Estate Rentals and Management of Intellectual Property Assets	GIC_A 37	Business and family services and maintenance services
7880	Other administrative activities and complementary services	GIC_A 37	Business and family services and maintenance services
8000	Surveillance, security and research activities	GIC_A 37	Business and family services and maintenance services
9080	Artistic, creative and entertainment activities	GIC_A 37	Business and family services and maintenance services
9480	Associations and other personal services	GIC_A 37	Business and family services and maintenance services
9700	Domestic services	GIC_A 37	Business and family services and maintenance services
8400	Public administration, defense and social security	GIC_A 38	Public administration, defense and social security
8591	Public education	GIC_A 39	Public education
8592	Private education	GIC_A 40	Private education
8691	Public health	GIC_A 41	Public health
8692	Private health	GIC_A 42	Private health

Source: Author’s elaboration based on information from the SNA/IBGE.

Table B. 4 - Correspondence table - SNA 2010 (107 products) to 91 products

Code 107 products SNA 2010	Description 107 products SNA 2010	GIC Code 91 products	Description GIC 91 products
SNA 01	Rice in shell	GIC 01	Rice, wheat and other cereals
SNA 02	Corn on the cob	GIC 02	Corn on the cob
SNA 03	Wheat and other cereals	GIC 01	Rice, wheat and other cereals
SNA 04	Sugar cane	GIC 04	Sugar cane
SNA 05	Soy beans	GIC 05	Soy beans
SNA 06	Other agricultural products and services	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
SNA 07	Manioc	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
SNA 08	Smoke on sheet	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
SNA 09	Herbaceous cotton	GIC 03	Herbaceous cotton, other temporary crops
SNA 10	Citrus fruits	GIC 06	Orange
SNA 11	Coffee beans	GIC 07	Coffee beans
SNA 12	Products of forestry and forestry	GIC 13	Products from forestry exploration and forestry
SNA 13	Bovine animals and other live animals	GIC 09	Bovine animals and other live animals, animal products, and hunting
SNA 14	Milk of cow and other animals	GIC 10	Milk of cow and other animals
SNA 15	Live swine	GIC 11	Swine
SNA 16	Live birds	GIC 12	Poultry and eggs
SNA 17	Eggs, hen and other birds	GIC 12	Poultry and eggs
SNA 18	Fishing and aquaculture	GIC 14	Fisheries and aquaculture (fish, crustaceans and molluscs)
SNA 19	Oil and natural gas	GIC 17	Oil, natural gas and support services
SNA 20	Iron ore	GIC 18	Iron ore
SNA 21	Mineral coal	GIC 15	Mineral coal
SNA 22	Non-ferrous metal ores	GIC 19	Non-ferrous metal ores
SNA 23	Non-metallic minerals	GIC 16	Non-metallic minerals
SNA 24	Slaughter and preparation of meat products	GIC 20	Meat of bovine animals and other prod. of meat
SNA 25	Fresh, chilled or frozen pigmeat	GIC 21	Pork meat
SNA 26	Fresh, chilled or frozen poultry meat	GIC 22	Poultry meat
SNA 27	Fish industrialized	GIC 23	Industrialized fish
SNA 28	Canned fruits, vegetables and other vegetables	GIC 27	Canned fruits, vegetables, other vegetables and fruit juices
SNA 29	Raw soybean oil and cakes, bagasse and soybean meal	GIC 28	Oils and fats, vegetable and animal
SNA 30	Other oils and vegetable fats and animal excluding maize	GIC 28	Oils and fats, vegetable and animal
SNA 31	Refined soybean oil	GIC 28	Oils and fats, vegetable and animal
SNA 32	Cold, sterilized and pasteurized milk	GIC 24	Cold, sterilized and pasteurized milk
SNA 33	Dairy products and ice creams	GIC 25	Other Dairy Products
SNA 34	Processed rice and derived products	GIC 30	Processed rice and rice products
SNA 35	Wheat flour and by-products	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
SNA 36	Cassava flour and others	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
SNA 37	Oils of maize, vegetable starches and	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
SNA 38	Products of sugar refineries and refineries	GIC 26	Sugar
SNA 39	Ground roasted coffee	GIC 29	Coffee benefited
SNA 40	Other Food Products	GIC 32	Other Food Products
SNA 41	Drinks	GIC 33	Drinks
SNA 42	Smoke products	GIC 34	Smoke products
SNA 43	Processing of cotton and other textiles and spinning	GIC 35	Yarn and textile fibers benefited
SNA 44	Manufacture of other textile products	GIC 36	Manufacture of other textile products
SNA 45	Clothing articles and accessories	GIC 37	Clothing articles and accessories
SNA 46	Leather preparation and manufacture of artifacts - exclusive footwear	GIC 38	Footwear and leather goods
SNA 47	Manufacture of footwear	GIC 38	Footwear and leather goods
SNA 48	Wood products - exclusive furniture	GIC 39	Wood products, except furniture
SNA 49	Pulp and paper pulp	GIC 40	Cellulose
SNA 50	Paper and cardboard, packaging and articles	GIC 41	Paper, paperboard, packaging and paper articles
SNA 51	Newspapers, magazines, records and other recorded products	GIC 42	Printing and reproduction services
SNA 52	Liquefied petroleum gas	GIC 45	Other Petroleum Refining Products
SNA 53	Automotive Gasoline	GIC 45	Other Petroleum Refining Products

(continued)

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Code 107 products SNA 2010	Description 107 products SNA 2010	GIC Code 91 products	Description GIC 91 products
SNA 54	Gasoalcool	GIC 43	Gasoalcool
SNA 55	Fuel oil	GIC 44	Fuel oil
SNA 56	Diesel oil	GIC 45	Other Petroleum Refining Products
SNA 57	Other products from oil refining and coke	GIC 45	Other Petroleum Refining Products
SNA 58	Alcohol	GIC 46	Ethanol and other biofuels
SNA 59	Inorganic Chemicals	GIC 47	Inorganic Chemicals
SNA 60	Organic Chemicals	GIC 48	Organic Chemicals
SNA 61	Manufacture of resins and elastomers	GIC 49	Resins, elastomers and artificial fibers. and synthetic
SNA 62	Pharmaceutical products	GIC 54	Pharmaceutical products
SNA 63	Pesticides	GIC 50	Agricultural detergents and household cleaning products
SNA 64	Perfumery, soaps and cleaning supplies	GIC 53	Perfumery, soaps and cleaning supplies
SNA 65	Paints, varnishes, enamels and lacquers	GIC 52	Paints, varnishes, enamels and lacquers
SNA 66	Miscellaneous chemical products and preparations	GIC 51	Miscellaneous chemical products
SNA 67	Rubber articles	GIC 55	Rubber articles
SNA 68	Plastic articles	GIC 56	Plastic articles
SNA 69	Cement	GIC 57	Cement
SNA 70	Other non-metallic mineral products	GIC 58	Other non-metallic mineral products
SNA 71	Pig-iron and ferro-alloys	GIC 59	Pig iron and ferro-alloys
SNA 72	Semi-finished products, flat rolled, long and steel tubes	GIC 60	Semi-finished products, flat rolled, long and steel tubes
SNA 73	Non-ferrous metal metallurgy products	GIC 61	Non-ferrous metal metallurgy products
SNA 74	Castings of steel	GIC 62	Castings, steel and non-ferrous metals
SNA 75	Metal products - exclusive machinery and equipment	GIC 63	Metal products, excl. machines and equipment
SNA 76	Machines and equipment	GIC 68	Machines and equipment
SNA 77	Home appliances	GIC 67	Home appliances
SNA 78	Office machines and computer equipment	GIC 65	Office machines and equipment computer science
SNA 79	Electrical machinery, apparatus and equipment	GIC 66	Electrical machinery, apparatus and equipment
SNA 80	Electronic material and communications equipment	GIC 64	Electronic material and communications equipment
SNA 81	Medical / Hospital Instruments, Measurement & Optics	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various industries
SNA 82	Automobiles, trucks and commercial vehicles	GIC 69	Automobiles, trucks and commercial vehicles
SNA 83	Trucks and buses	GIC 70	Trucks and buses, incl. cabins, bodies and trailers, parts and accessories
SNA 84	Parts and accessories for motor vehicles	GIC 70	Trucks and buses, incl. cabins, bodies and trailers, parts and accessories
SNA 85	Other transportation equipment	GIC 71	Aircraft, boats and other transport equipment
SNA 86	Furniture and decorations, garden	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various industries
SNA 87	Electricity and gas, water, sewage and urban cleaning	GIC 73	Electricity and gas, water, sewage and urban cleaning
SNA 88	Construction	GIC 74	Construction
SNA 89	Trade	GIC 75	Trade
SNA 90	Cargo transport	GIC 76	Transport and storage
SNA 91	Passenger transport	GIC 76	Transport and storage
SNA 92	post office	GIC 77	Courier and other delivery services
SNA 93	Information services	GIC 79	Information services
SNA 94	Financial intermediation and insurance	GIC 80	Financial intermediation, insurance and supplementary pension plans
SNA 95	Real estate services and rentals	GIC 81	Effective rent and real estate services
SNA 96	Imputed rent	GIC 82	Imputed rent
SNA 97	Maintenance and repair services	GIC 90	Maintenance of computers, telephones and household objects
SNA 98	Accommodation and food services	GIC 78	Accommodation and food services
SNA 99	Business services	GIC 83	Business and family services
SNA 100	Merchant education	GIC 86	Private education
SNA 101	Mercantile Health	GIC 88	Private health
SNA 102	Services provided to families	GIC 83	Business and family services
SNA 103	Associated services	GIC 89	Employers' organizations, trade unions and other associative services
SNA 104	Domestic services	GIC 91	Domestic services
SNA 105	Public education	GIC 85	Public education
SNA 106	Public health	GIC 87	Public health
SNA 107	Public service and social security	GIC 84	Public service and social security

Source: Author’s elaboration based on information from the SNA/IBGE.

Table B. 5 - Correspondence table - SNA 2000 (110 products) to 91 products

Code 110 products SNA 2000	Description 110 products SNA 2000	GIC Code 91 products	Description GIC 91 products
010101	Rice in shell	GIC 01	Rice, wheat and other cereals
010102	Corn on the cob	GIC 02	Corn on the cob
010103	Wheat and other cereals	GIC 01	Rice, wheat and other cereals
010104	Sugar cane	GIC 04	Sugar cane
010105	Soy beans	GIC 05	Soy beans
010106	Other agricultural products and services	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
010107	Manioc	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
010108	Smoke on sheet	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
010109	Herbaceous cotton	GIC 03	Herbaceous cotton, other temporary crops
010110	Citrus fruits	GIC 06	Orange
010111	Coffee beans	GIC 07	Coffee beans
010112	Products of forestry and forestry	GIC 13	Products from forestry exploration and forestry
010201	Bovine animals and other live animals	GIC 09	Bovine animals and other live animals, animal products, and hunting
010202	Milk of cow and other animals	GIC 10	Milk of cow and other animals
010203	Live swine	GIC 11	Swine
010204	Live birds	GIC 12	Poultry and eggs
010205	Eggs, hen and other birds	GIC 12	Poultry and eggs
010206	Fishing and aquaculture	GIC 14	Fisheries and aquaculture (fish, crustaceans and molluscs)
020101	Oil and natural gas	GIC 17	Oil, natural gas and support services
020201	Iron ore	GIC 18	Iron ore
020301	Mineral coal	GIC 15	Mineral coal
020302	Non-ferrous metal ores	GIC 19	Non-ferrous metal ores
020303	Non-metallic minerals	GIC 16	Non-metallic minerals
030101	Slaughter and preparation of meat products	GIC 20	Meat of bovine animals and other prod. of meat
030102	Fresh, chilled or frozen pigmeat	GIC 21	Pork meat
030103	Fresh, chilled or frozen poultry meat	GIC 22	Poultry meat
030104	Fish industrialized	GIC 23	Industrialized fish
030105	Canned fruits, vegetables and other vegetables	GIC 27	Canned fruits, vegetables, other vegetables and fruit juices
030106	Raw soybean oil and cakes, bagasse and soybean meal	GIC 28	Oils and fats, vegetable and animal
030107	Other oils and vegetable fats and animal excluding maize	GIC 28	Oils and fats, vegetable and animal
030108	Refined soybean oil	GIC 28	Oils and fats, vegetable and animal
030109	Cold, sterilized and pasteurized milk	GIC 24	Cold, sterilized and pasteurized milk
030110	Dairy products and ice creams	GIC 25	Other Dairy Products
030111	Processed rice and derived products	GIC 30	Processed rice and rice products
030112	Wheat flour and by-products	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
030113	Cassava flour and others	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
030114	Oils of maize, vegetable starches and	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
030115	Products of sugar refineries and refineries	GIC 26	Sugar
030116	Ground roasted coffee	GIC 29	Coffee benefited
030117	Soluble coffee	GIC 32	Other Food Products
030118	Other Food Products	GIC 32	Other Food Products
030119	Drinks	GIC 33	Drinks
030201	Smoke products	GIC 34	Smoke products
030301	Processing of cotton and other textiles and spinning	GIC 35	Yarn and textile fibers benefited
030302	Weaving	GIC 36	Manufacture of other textile products
030303	Manufacture of other textile products	GIC 36	Manufacture of other textile products
030401	Clothing articles and accessories	GIC 37	Clothing articles and accessories
030501	Leather preparation and manufacture of artifacts - exclusive footwear	GIC 38	Footwear and leather goods
030502	Manufacture of footwear	GIC 38	Footwear and leather goods
030601	Wood products - exclusive furniture	GIC 39	Wood products, except furniture
030701	Pulp and paper pulp	GIC 40	Cellulose

(continued)

(continued)

Code 110 products SNA 2000	Description 110 products SNA 2000	GIC Code 91 products	Description GIC 91 products
030702	Paper and cardboard, packaging and articles	GIC 41	Paper, paperboard, packaging and paper articles
030801	Newspapers, magazines, records and other recorded products	GIC 42	Printing and reproduction services
030901	Liquefied petroleum gas	GIC 45	Other Petroleum Refining Products
030902	Automotive Gasoline	GIC 45	Other Petroleum Refining Products
030903	Gasoalcool	GIC 43	Gasoalcool
030904	Fuel oil	GIC 44	Fuel oil
030905	Diesel oil	GIC 45	Other Petroleum Refining Products
030906	Other products from oil refining and coke	GIC 45	Other Petroleum Refining Products
031001	Alcohol	GIC 46	Ethanol and other biofuels
031101	Inorganic Chemicals	GIC 47	Inorganic Chemicals
031102	Organic Chemicals	GIC 48	Organic Chemicals
031201	Manufacture of resins and elastomers	GIC 49	Resins, elastomers and artificial fibers. and synthetic
031301	Pharmaceutical products	GIC 54	Pharmaceutical products
031401	Pesticides	GIC 50	Agricultural detergents and household cleaning products
031501	Perfumery, soaps and cleaning supplies	GIC 53	Perfumery, soaps and cleaning supplies
031601	Paints, varnishes, enamels and lacquers	GIC 52	Paints, varnishes, enamels and lacquers
031701	Miscellaneous chemical products and preparations	GIC 51	Miscellaneous chemical products
031801	Rubber articles	GIC 55	Rubber articles
031802	Plastic articles	GIC 56	Plastic articles
031901	Cement	GIC 57	Cement
032001	Other non-metallic mineral products	GIC 58	Other non-metallic mineral products
032101	Pig-iron and ferro-alloys	GIC 59	Pig iron and ferro-alloys
032102	Semi-finished products, flat rolled, long and steel tubes	GIC 60	Semi-finished products, flat rolled, long and steel tubes
032201	Non-ferrous metal metallurgy products	GIC 61	Non-ferrous metal metallurgy products
032202	Castings of steel	GIC 62	Castings, steel and non-ferrous metals
032301	Metal products - exclusive machinery and equipment	GIC 63	Metal products, excl. machines and equipment
032401	Machinery and equipment, including maintenance and repairs	GIC 68	Machines and equipment
032501	Home appliances	GIC 67	Home appliances
032601	Office machines and computer equipment	GIC 65	Office machines and equipment computer science
032701	Electrical machinery, apparatus and equipment	GIC 66	Electrical machinery, apparatus and equipment
032801	Electronic material and communications equipment	GIC 64	Electronic material and communications equipment
032901	Medical / Hospital Instruments, Measurement & Optics	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various industries
033001	Automobiles, trucks and commercial vehicles	GIC 69	Automobiles, trucks and commercial vehicles
033101	Trucks and buses	GIC 70	Trucks and buses, incl. cabins, bodies and trailers, parts and accessories
033201	Parts and accessories for motor vehicles	GIC 70	Trucks and buses, incl. cabins, bodies and trailers, parts and accessories
033301	Other transportation equipment	GIC 71	Aircraft, boats and other transport equipment
033401	Furniture and decorations, garden	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various industries
033402	Recycled scraps	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various industries
040101	Electricity and gas, water, sewage and urban cleaning	GIC 73	Electricity and gas, water, sewage and urban cleaning
050101	Construction	GIC 74	Construction
060101	Trade	GIC 75	Trade
070101	Cargo transport	GIC 76	Transport and storage
070102	Passenger transport	GIC 76	Transport and storage
070103	post office	GIC 77	Courier and other delivery services
080101	Information services	GIC 79	Information services
090101	Financial intermediation and insurance	GIC 80	Financial intermediation, insurance and supplementary pension plans
100101	Real estate services and rentals	GIC 81	Effective rent and real estate services
100102	Imputed rent	GIC 82	Imputed rent
110101	Maintenance and repair services	GIC 90	Maintenance of computers, telephones and household objects

(continued)

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Code 110 products SNA 2000	Description 110 products SNA 2000	GIC Code 91 products	Description GIC 91 products
110201	Accommodation and food services	GIC 78	Accommodation and food services
110301	Business services	GIC 83	Business and family services
110401	Merchant education	GIC 86	Private education
110501	Mercantile Health	GIC 88	Private health
110601	Services provided to families	GIC 83	Business and family services
110602	Associated services	GIC 89	Employers' organizations, trade unions and other associative services
110701	Domestic services	GIC 91	Domestic services
120101	Public education	GIC 85	Public education
120201	Public health	GIC 87	Public health
120301	Public service and social security	GIC 84	Public service and social security

Source: Author’s elaboration based on information from the SNA/IBGE.

Table B. 6 - Correspondence table - SNA 2010 (128 products) to 91 products

Code 128 products SNA 2010	Description 128 products SNA 2010	GIC Code 91 products	Description GIC 91 products
01911	Rice, wheat and other cereals	GIC 01	Rice, wheat and other cereals
01912	Corn on the cob	GIC 02	Corn on the cob
01913	Herbaceous cotton, other temporary crops	GIC 03	Herbaceous cotton, other temporary crops
01914	Sugar cane	GIC 04	Sugar cane
01915	Soy beans	GIC 05	Soy beans
01916	Other temporary crops products and services	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
01917	Orange	GIC 06	Orange
01918	Coffee beans	GIC 07	Coffee beans
01919	Other products of permanent agriculture	GIC 08	Cassava, leaf tobacco and other products and services of temporary and permanent crops
01921	Bovine animals and other live animals, prods. animal, hunting and serv.	GIC 09	Bovine animals and other live animals, animal products, and hunting
01922	Milk of cow and other animals	GIC 10	Milk of cow and other animals
01923	Swine	GIC 11	Swine
01924	Poultry and eggs	GIC 12	Poultry and eggs
02801	Products of forestry and forestry	GIC 13	Products from forestry exploration and forestry
02802	Fisheries and aquaculture (fish, crustaceans and molluscs)	GIC 14	Fisheries and aquaculture (fish, crustaceans and molluscs)
05801	Mineral coal	GIC 15	Mineral coal
05802	Non-metallic minerals	GIC 16	Non-metallic minerals
06801	Oil, natural gas and support services	GIC 17	Oil, natural gas and support services
07911	Iron ore	GIC 18	Iron ore
07921	Non-ferrous metal ores	GIC 19	Non-ferrous metal ores
10911	Meat of bovine animals and other prod. of meat	GIC 20	Meat of bovine animals and other prod. of meat
10912	Pork meat	GIC 21	Pork meat
10913	Poultry meat	GIC 22	Poultry meat
10914	Fish industrialized	GIC 23	Industrialized fish
10915	Cold, sterilized and pasteurized milk	GIC 24	Cold, sterilized and pasteurized milk
10916	Other Dairy Products	GIC 25	Other Dairy Products
10921	Sugar	GIC 26	Sugar
10931	Canned fruits, vegetables, other vegetables and fruit juices	GIC 27	Canned fruits, vegetables, other vegetables and fruit juices
10932	Oils and fats, vegetable and animal	GIC 28	Oils and fats, vegetable and animal
10933	Coffee benefited	GIC 29	Coffee benefited
10934	Processed rice and rice products	GIC 30	Processed rice and rice products
10935	Products derived from wheat, manioc or maize	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
10936	Balanced animal feed	GIC 31	Products derived from wheat, manioc or maize, including balanced animal feed
10937	Other Food Products	GIC 32	Other Food Products
11001	Drinks	GIC 33	Drinks
12001	Smoke products	GIC 34	Smoke products
13001	Yarn and textile fibers benefited	GIC 35	Yarn and textile fibers benefited
13002	Fabrics	GIC 36	Manufacture of other textile products
13003	Textile products for domestic use and other textile	GIC 36	Manufacture of other textile products
14001	Clothing articles and accessories	GIC 37	Clothing articles and accessories
15001	Footwear and leather goods	GIC 38	Footwear and leather goods
16001	Wood products, except furniture	GIC 39	Wood products, except furniture
17001	Cellulose	GIC 40	Cellulose
17002	Paper, paperboard, packaging and paper articles	GIC 41	Paper, paperboard, packaging and paper articles
18001	Printing and reproduction services	GIC 42	Printing and reproduction services
19911	Aviation fuels	GIC 45	Other Petroleum Refining Products
19912	Gasoalcool	GIC 43	Gasoalcool
19913	Naphtha for petrochemicals	GIC 45	Other Petroleum Refining Products
19914	Fuel oil	GIC 44	Fuel oil

(continued)

(continued)

Code 128 products SNA 2010	Description 128 products SNA 2010	GIC Code 91 products	Description GIC 91 products
19915	Diesel - biodiesel	GIC 45	Other Petroleum Refining Products
19916	Other Petroleum Refining Products	GIC 45	Other Petroleum Refining Products
19921	Ethanol and other biofuels	GIC 46	Ethanol and other biofuels
20911	Inorganic Chemicals	GIC 47	Inorganic Chemicals
20912	Fertilizers and fertilizers	GIC 47	Inorganic Chemicals
20913	Organic Chemicals	GIC 48	Organic Chemicals
20914	Resins, elastomers and artificial fibers. and synthetic	GIC 49	Resins, elastomers and artificial fibers. and synthetic
20921	Agricultural detergents and household cleaning products	GIC 50	Agricultural detergents and household cleaning products
20922	Miscellaneous chemical products	GIC 51	Miscellaneous chemical products
20923	Paints, varnishes, enamels and lacquers	GIC 52	Paints, varnishes, enamels and lacquers
20931	Perfumery, soaps and cleaning supplies	GIC 53	Perfumery, soaps and cleaning supplies
21001	Pharmaceutical products	GIC 54	Pharmaceutical products
22001	Rubber articles	GIC 55	Rubber articles
22002	Plastic articles	GIC 56	Plastic articles
23001	Cement	GIC 57	Cement
23002	Articles of cement, plaster and similar	GIC 58	Other non-metallic mineral products
23003	Glass, ceramics and other prod. of non-metallic minerals	GIC 58	Other non-metallic mineral products
24911	Pig iron and ferro-alloys	GIC 59	Pig iron and ferro-alloys
24912	Semi-finished products, flat rolled, long and steel tubes	GIC 60	Semi-finished products, flat rolled, long and steel tubes
24921	Non-ferrous metal metallurgy products	GIC 61	Non-ferrous metal metallurgy products
24922	Castings, steel and non-ferrous metals	GIC 62	Castings, steel and non-ferrous metals
25001	Metal products, excl. machines and equipment	GIC 63	Metal products, excl. machines and equipment
26001	Electronic components	GIC 64	Electronic material and communications equipment
26002	Office machines and equipment computer science	GIC 65	Office machines and equipment computer science
26003	Electronic material and equip. communications	GIC 64	Electronic material and communications equipment
26004	Equip. of measurement, testing and control, optical and electromedical	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various
27001	Electrical machinery, apparatus and equipment	GIC 66	Electrical machinery, apparatus and equipment
27002	Home appliances	GIC 67	Home appliances
28001	Tractors and other agricultural machinery	GIC 68	Machines and equipment
28002	Machines for mineral extraction and construction	GIC 68	Machines and equipment
28003	Other machines and mechanical equipment	GIC 68	Machines and equipment
29911	Automobiles, trucks and commercial vehicles	GIC 69	Automobiles, trucks and commercial vehicles
29912	Trucks and buses, incl. cabins, bodies and trailers	GIC 70	Trucks and buses, incl. cabins, bodies and trailers, parts and accessories
29921	Parts and accessories for motor vehicles	GIC 70	Trucks and buses, incl. cabins, bodies and trailers, parts and accessories
30001	Aircraft, boats and other transport equipment	GIC 71	Aircraft, boats and other transport equipment
31801	Furniture	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various
31802	Products of various industries	GIC 72	Equip. measuring, testing and control, optical and electromedical, furniture and other products of various
33001	Maintenance, repair and installation of machinery and equipment	GIC 68	Machines and equipment
35001	Electricity, gas and other utilities	GIC 73	Electricity and gas, water, sewage and urban cleaning
36801	Water, sewage, recycling and waste management	GIC 73	Electricity and gas, water, sewage and urban cleaning
41801	Buildings	GIC 74	Construction
41802	Infrastructure Works	GIC 74	Construction
41803	Specialized construction services	GIC 74	Construction
45001	Trade and repair of vehicles	GIC 75	Trade
46801	Wholesale and retail trade, except motor vehicles	GIC 75	Trade
49001	Ground transportation of cargo	GIC 76	Transport and storage

(continued)

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Code 128 products SNA 2010	Description 128 products SNA 2010	GIC Code 91 products	Description GIC 91 products
49002	Ground transportation of passengers	GIC 76	Transport and storage
50001	Water transportation	GIC 76	Transport and storage
51001	Air Transport	GIC 76	Transport and storage
52801	Warehousing and ancillary services to transport	GIC 76	Transport and storage
52802	Courier and other delivery services	GIC 77	Courier and other delivery services
55001	Hotel and similar accommodation services	GIC 78	Accommodation and food services
56001	Food services	GIC 78	Accommodation and food services
58001	Books, newspapers and magazines	GIC 79	Information services
59801	Film, music, radio and television services	GIC 79	Information services
61001	Telecommunications, pay TV and other services. related	GIC 79	Information services
62801	Development of systems and other information services	GIC 79	Information services
64801	Financial intermediation, insurance and supplementary pension plans	GIC 80	Financial intermediation, insurance and supplementary pension plans
68001	Effective rent and real estate services	GIC 81	Effective rent and real estate services
68002	Imputed rent	GIC 82	Imputed rent
69801	Legal services, accounting and consulting	GIC 83	Business and family services
71801	Research and Development	GIC 83	Business and family services
71802	Architectural and engineering services	GIC 83	Business and family services
73801	Advertising and other technical services	GIC 83	Business and family services
77001	Non-rented Rentals. and management of intellectual property assets	GIC 83	Business and family services
78801	Condos and services for buildings	GIC 83	Business and family services
78802	Other administrative services	GIC 83	Business and family services
80001	Surveillance, security and investigation services	GIC 83	Business and family services
84001	Collective services of public administration	GIC 84	Public service and social security
84002	Social welfare and welfare services	GIC 84	Public service and social security
85911	Public education	GIC 85	Public education
85921	Private education	GIC 86	Private education
86911	Public health	GIC 87	Public health
86921	Private health	GIC 88	Private health
90801	Arts, culture, sports and recreation services	GIC 83	Business and family services
94801	Employers' organizations, trade unions and other associative services	GIC 89	Employers' organizations, trade unions and other associative services
94802	Maintenance of computers, telephones and household objects	GIC 90	Maintenance of computers, telephones and household objects
94803	Personal Services	GIC 83	Business and family services
97001	Domestic services	GIC 91	Domestic services

Source: Author’s elaboration based on information from the SNA/IBGE.

APPENDIX C - A METHODOLOGY FOR ESTIMATING A SERIES OF INPUT-OUTPUT TABLES FOR BRAZIL FROM 2000 TO 2015

C.1 IOT estimation/updating methodological procedure

During the estimation and updating process, we use two main sources of data, which are SUT and the IOT, both published by IBGE. As usual, IBGE constructs SUT based on the principle of balance between supply and demand, so the total supply is equal to the total demand, both valued at purchasers' prices. They publish the information with two-years delay, in current prices, and in previous year prices. In the Supply Table, there is the information of product's whole supply, including total supply at consumer prices and its constituent vectors (trade and transportation margin, taxes and total supply at producers' prices), the make matrix and also the imports by product (adjusted CIF-FOB[89]). Based on the Supply Table, we can calculate the gross output by product at purchasers' prices ($\mathbf{q^{pu}}, m \times 1$) as the sum of gross output by product at producer's prices ($\mathbf{q}$, $m \times 1$), transportation ($\mathbf{t^r}$, $m \times 1$) and trade margins ($\mathbf{t^a}, m \times 1$), taxes ($\mathbf{t^x}, m \times 1$) and imports ($\mathbf{m}, m \times 1$). So, we have:

$$\mathbf{q^{pu}} = \mathbf{q} + \mathbf{t^r} + \mathbf{t^a} + \mathbf{t^x} + \mathbf{m} \qquad (C.\ 1).$$

In the Use Table, we have the total intermediate and final demand valued at purchasers' prices, indicating the destination of the production in the economy. The production is used for the intermediate ($\mathbf{u^{pu}}, m \times 1$) or final demand ($\mathbf{f^{pu}}, m \times 1$), both in purchaser's prices. So,

$$\mathbf{q^{pu}} = \mathbf{u^{pu}} + \mathbf{f^{pu}} \qquad (C.\ 2).$$

The intermediate demand vector is the aggregation form of the intermediate demand use matrix ($\mathbf{U^{pu}}, m \times n$) in purchaser's prices:

$$\mathbf{u^{pu}} = \mathbf{U^{pu}i} \qquad (C.\ 3).$$

The final demand vector is the sum of the final demand use matrix ($\mathbf{F^{pc}}, 6 \times n$) in purchaser's prices:

$$\mathbf{f^{pc}} = \mathbf{F^{pu}i} \qquad (C.\ 4).$$

The six elements in the final demand are exports, government consumption, consumption of non-profit institutions serving households (NPISH), household consumption, GFCF, and inventories.

We express the complete Use Table mathematically in purchaser's price ($\mathbf{UT^{pu}}$) published by IBGE as follows:

$$\mathbf{UT^{pu}} = [\mathbf{U^{pu}} \mid \mathbf{u^{pu}} \mid \mathbf{F^{pu}} \mid \mathbf{f^{pu}}] \qquad (C.\ 5).$$

The information in $\mathbf{UT^{pu}}$ is not disaggregated by the origin (domestic or imported demand). In fact, $\mathbf{UT^{pu}}$ represents the aggregation of the use table of domestic demand in producer's prices ($\mathbf{UT^{pr}}$), indirect taxes ($\mathbf{UT^{tx}}$), imports ($\mathbf{UT^{pr}_m}$), and trade ($\mathbf{UT^{ta}}$) and transportation ($\mathbf{UT^{tr}}$ margins. So, we express $\mathbf{U^{pu}}$ as:

$$\mathbf{UT^{pu}} = \mathbf{UT^{pr}} + \mathbf{UT^{tr}} + \mathbf{UT^{ta}} + \mathbf{UT^{tx}} + \mathbf{UT^{pr}_m} \qquad (C.\ 6).$$

Among these matrices, IBGE only publishes the $\mathbf{UT^{pu}}$ yearly in the SUT, but the relevant matrix to the IO model is $\mathbf{UT^{pr}}$.

So, the estimation process has basically to principal objectives: i) obtain data the Use Table in producer's prices (received by the producer for the sale of a product, that is, "at the factory door.") used to calculate the technical coefficients of production properly and ii) the origin of the intermediate and final demand in the Use Table.

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[89] FOB – Free on Board (or Freight on Board) and CIF – Cost, Insurance and Freight.

C.1.1 First step: constructing the structural information

The main obstacle in the construction of the IOT for Brazil is estimating the table of uses of domestic supply at basic prices ($\mathbf{UT^{pr}}$), which contains the intermediate and the final demand, defined similarly to the use table in purchaser's price. Based on (C.5), we can calculate $\mathbf{UT^{pr}}$ deducting the indirect taxes, imports at prices and doing the properly allocation of trade and transport margins. All this tables have the same structure of $\mathbf{UT^{pu}}$**,** as presented in (C.4)**.** So, mathematically, we have:

$$\mathbf{UT^{pr}} = \mathbf{UT^{pc}} - \mathbf{UT^{tx}} - \mathbf{UT^{ta}} - \mathbf{UT^{tr}} - \mathbf{UT^{m}} \qquad \textit{(C. 7).}$$

To estimate the Use table and the other ones for the years not published by IBGE, we use an adaptation of the methodology that Grijó and Bêrni (2006) proposes, using structural information of an IOT from a base year to properly obtain an initial estimative. They are called '*mark-downs'* and represent the ratios of use table in producer's prices and the "passing tables" in the total use table in purchaser's prices, as follows:

$$\begin{aligned} \vartheta_{ij}^{pr} &= \frac{ut_{ij}^{pr}}{ut_{ij}^{pu}}; \\ \vartheta_{ij}^{ta} &= \frac{ut_{ij}^{ta}}{ut_{ij}^{pu}}; \\ \vartheta_{ij}^{tr} &= \frac{ut_{ij}^{tr}}{ut_{ij}^{pu}}; \\ \vartheta_{ij}^{tx} &= \frac{ut_{ij}^{tx}}{ut_{ij}^{pu}}; \\ \vartheta_{ij}^{m} &= \frac{ut_{ij}^{m}}{ut_{ij}^{pu}} \end{aligned} \qquad \textit{(C. 8).}$$

where $\mathbf{\Theta} = \vartheta_{ij}$ is a generic mark-down matrix, and ϑ_{ij} represents the mark-down for product *i* and industry *j*.

In the commodities related to trade and transportation, Grijó and Bêrni (2006) suggest doing a procedure to calculate the mark-downs and avoid double accounting. This step is necessary because "Trade" and "Transportation" are products in the IOT structure, but they are also calculated separately in the system, in the Trade and Transportation margins. We must diminish the row sum of all products in Trade/Transportation margin table, excluding the product Trade/Transportation from the totals from the products "Trade" and "Transportation" in the domestic use table in producer's prices. With that, we have an adjusted $\mathbf{UT^{pr}}$, and based on that we construct the mark-downs[90].

C.1.2 Second step: estimating IOT based on structural data and SUT

To estimate the IOT, we adopt the hypothesis that the mark-downs are inflexible trough a short period. This way, we calculate a first estimative of the IOT using the structural information of the mark-downs but applying it to the vectors that IBGE publishes in the Supply table. This way, we have:

$$\widetilde{\mathbf{UT}}_t^{\mathbf{pr}} = \mathbf{\Theta}_{t^*}^{\mathbf{pr}} \otimes \mathbf{q}_t \qquad \textit{(C. 9)}$$

[90] After all the estimation procedure, the trade and transport margins have to be reincorporate in the IOT to have its full balance equivalent to the information is released.

$$\widetilde{\mathbf{UT}}_t^{\ \mathbf{ta}} = \mathbf{\Theta}_{t^*}^{\mathbf{ta}} \otimes \mathbf{t}_t^{\mathbf{a}}$$
$$\widetilde{\mathbf{UT}}_t^{\ \mathbf{tr}} = \mathbf{\Theta}_{t^*}^{\mathbf{tr}} \otimes \mathbf{t}_t^{\mathbf{r}}$$
$$\widetilde{\mathbf{UT}}_t^{\ \mathbf{tx}} = \mathbf{\Theta}_{t^*}^{\mathbf{tx}} \otimes \mathbf{t}_t^{\mathbf{x}}$$
$$\widetilde{\mathbf{UT}}_t^{\ \mathbf{m}} = \mathbf{\Theta}_{t^*}^{\mathbf{m}} \otimes \mathbf{m}_t$$

where $\widetilde{\mathbf{UT}}_t^{\ \mathbf{pr}}$, $\widetilde{\mathbf{UT}}_t^{\ \mathbf{ta}}$, $\widetilde{\mathbf{UT}}_t^{\ \mathbf{tr}}$, $\widetilde{\mathbf{UT}}_t^{\ \mathbf{tx}}$ and $\widetilde{\mathbf{UT}}_t^{\ \mathbf{m}}$ are estimates for the year t of each respective table, based on the information in SUT and in a base matrix form the year t^* and $\mathbf{\Theta} = \vartheta_{ij}$ is a generic mark-down matrix, and ϑ_{ij} represents the mark down for product *i* and industry *j*.

In the empirical application of the method, we observe the existence of structural mismatches between the data for the base year and the year to be updated. This fact occurs in the following cases: *(a)* ut_{ij}^{pc} is null in the base year (t^*) and positive in the reference year for the update (t); *(b)* the value one element in the Supply table (q_{ij}, t_{ij}^r, t_{ij}^a, t_{ij}^x, m_{ij}) is null in the base year (t^*) and positive in t. For the proper estimation, in these cases, we adopt some procedures: *(a)* use the ratio of q_i, t_i^r, t_i^a, t_i^x, m_j (each element in the Supply table by product) in the total supply at consumer's prices q_j^{pc}; (b) we use the ratio between the use table in purchaser's prices ut_{ij}^{pc} and the supply table in purchaser's prices q_{ij}^{pc}, for all product i and industry j that presents the mismatch.

Using the adjusted mark-downs and the information of SUTs, we finally have the first estimated IOT series based on structural information.

C.1.3 Third step: IOT balancing and final estimation

Once we have IOT estimations, it is probable that will have some discrepancy between the $\widetilde{\mathbf{UT}}_t^{\mathbf{pu}}$ estimated by the sum of $\widetilde{\mathbf{UT}}_t^{\mathbf{pr}}$, $\widetilde{\mathbf{UT}}_t^{\mathbf{ta}}$, $\widetilde{\mathbf{UT}}_t^{\mathbf{tr}}$, $\widetilde{\mathbf{UT}}_t^{\mathbf{tx}}$, $\widetilde{\mathbf{UT}}_t^{\mathbf{m}}$ and the $\mathbf{UT}^{\mathbf{pu}}$ available in SUT for t. The specialized literature recommends to use a RAS method to balance this disajustments (MILLER and BLAIR, 2009). We apply this method by product, and since the RAS is a method of biproportional adjustment between matrices, it allocates the difference based on row and column multipliers. The method calculates them based on the original information in $\mathbf{UT}^{\mathbf{pu}}$, in a way that guarantees the identity by product and industry, so we have $\widetilde{\mathbf{UT}}_t^{\mathbf{pu}} = \mathbf{UT}^{\mathbf{pu}}$.

There are different types of RAS methods in the IO literature. Among them, we use the generalized RAS (GRAS). Günlük¸ Senesen and Bates (1988) originally proposed the method and was rigorously later formalized by Junius and Oosterhaven (2003). Still, one of the main problems of the preliminary version of this method is the existence of negative numbers and the presence of a resource or use in which its rows and columns are equal to zero. In this sense, we use the GRAS suggested by Temurshoev, Miller, and Bouwmeester (2013). This version proposes an algorithm through which it makes possible the application of the method even when there are rows/columns equal to zero and/or negative elements.

We should note that after the proper balancing via RAS, the mark-downs previously calculated using the IOT base matrix will be different for each estimated and adjusted IOT. This way, the different estimates will contain different structures.

C.2 IOT estimation/updating methodological procedure

C.2.1 Estimating IOT 2011 to 2014

As mentioned earlier, IBGE publishes IOT 2010 at the most disaggregate level with 67 activities and 127 products. However, IBGE discloses SUT in the largest breakdown containing 68 activities and 128 products (or 51 activities and 107 products for the retropolated series). To adapt the two bases, we aggregate two products in SUT, which are 'Trade and repair of vehicles' and 'Wholesale and retail trade, except motor vehicles' in the product 'Wholesale and retail trade.' For the industries, we aggregate 'Trade and repair of motor vehicles and motorcycles' and 'Wholesale and retail trade, except motor vehicles,' in the industry 'Wholesale and retail trade.'

We also aggregated the products related to transports, in the IOT 2010 and SUT 2011-2014. We justify that based on the way IBGE (2016)[91] do the CIF-FOB adjustment. The products we aggregated were: 'Ground transportation of cargo,' 'Inland passenger transportation,' 'Water transport,' 'Air transport,' 'Warehousing and ancillary services to transportation.' We call this aggregation as 'Transport, storage and ancillary services to transport.' After that, all estimated IOT will have a maximum aggregation level of 67 industries and 123 products.

We also make a CIF-FOB adjustment because IBGE (2016) deals with it is different in SUT and IOT. In SUT 2010 IBGE (2016) considers CIF-FOB adjustment as a negative import. But in the IOT considers the portion corresponding to domestic producers as exports, following the recommendation of SNA 2008 (UN, 2008). Therefore, the total imports and imports for transport services in IOT 2010 is higher than that obtained in the SUT 2010. The total balance by product of these data is not affected. However, there is a change in the composition between exports and imports.

To incorporate these changes, we adjusted the product 'Transport, storage, and ancillary services to transportation' in the SUT 2011-2014. First, we calculated the difference between the imports' CIF-FOB adjustment in the SUT and IOT for 2010 and made it as a ratio of total CIF-FOB adjustment in the IOT 2010. Then we multiplied this ratio (0.7079) by the annual information of the total imports of 'Transport, storage, and ancillary services to transportation,' obtaining the new value of 'negative imports.' For the maintenance of the total balance, we attribute the remainder (0.2921) to this product's exports. After that, we calculated new totals in the SUT. In the Supply table it affects the value of imports and the total supply in producer's prices; and at the Use, table affects the Exports, Final and Total[92].

We made the IOT estimation for 2011-2014 according to the methodology presented in section 3. We first estimate for the level of 123 products and 67 activities. Subsequently, to obtain the series compatible with the whole period, these matrices were grouped at the aggregation level 42 activities and 91 products. For 2015 we used the official IOT 2015 published by IBGE and aggregated it to the compatible level. Thus, we have the series from 2010-2015 presented at the two levels of disaggregation (123×67, and 91×42).

2.2 Estimating IOT 2000-2009

The first step to estimate the IOT to 2000-2009 is aggregating the retropolated SUT 2000-2009 in the common level, with 42 industries and 91 products. After that, to obtain the

[91] In the import data, IBGE considers freight as deducting from the supply, with negative values. As there are redistributions among the transportations commodities, the total for some commodities were negative. This disturb the calculation of mark-downs. So, in order to have a positive value for the total imports of these products (imports of goods and services plus CIF/FOB adjustment) we aggregated these commodities.

[92] For SUT 2014 IBGE publishes only the net total of the imports, without disaggregating the CIF-FOB adjustment. Without this information, we are not able to reallocate between imports (negative) and exports (positive). Therefore, we estimated the CIF-FOB adjustment based on the proportions of the CIF-FOB adjustment in the total imports at 2013, the last year where IBGE publishes the information.

structural data, we aggregate IOT 2010 at the same level. We also made the previously cited procedures of the CIF-FOB adjustment between imports and exports for the product ‘Transport and storage. After that, we estimated the preliminary version of IOT for 2000-2009 and them applied the GRAS method for the proper balance.

We observed a problem in this estimation the product ‘Herbaceous cotton, other temporary crops.’ The value of the estimate obtained using the IOT 2010 mark-downs structure does not generate a GRAS convergent series, for 2000 to 2004. The reason is that in 2000 Brazil did not import any of this product, so the values are equal to zero. For this case, we manually zeroed the imports value of this product and made RAS for the other components (use table in producer’s prices, trade and transport margins and net taxes).

For 2001 to 2004 the problem arises from the structure of taxes. The structure of taxes for this product in 2010 is very different from the existing one between 2001 and 2004. The preliminary results for tax estimation using IOT 2010 are positive, while the total available in the SUT of this product is negative. Since there is no negative mark-down for any industry and final demand for this product, the method GRAS is not able to balance the matrix. For this product specifically, we used the mark-downs calculated using the MIP 2005, since in 2000 there is no importation of this product and it is not possible to obtain mark-downs for all terms.

APPENDIX D – INPUT-OUTPUT TABLES DEFLATION

D.1 Market shares matrix and technical coefficients

As the example has a different number of industries and products, the Use Table particularly must be put in a square dimension to calculate the technical coefficients and present them as usual in the IO model. We do that using a market shares matrix ($\mathbf{D}$), that is the proportion of total product output that was produced by each industry ($\mathbf{D} = \mathbf{V}\hat{\mathbf{q}}^{-1}$). Since we calculate the market shares matrix using the information of total production by product, it is the same for all the methods for all the periods. Another way to think that is the additivity by buying industries is valid for all methods. So, the market share matrix for current prices, constant prices and double deflation method are:

Figure D. 1 – Market shares matrix for all periods and methods

Period 00				**Period 01**				**Period 02**			
	C1	**C2**	**C3**		**C1**	**C2**	**C3**		**C1**	**C2**	**C3**
S1	0.5556	0.3333	0.3279	**S1**	0.5476	0.3243	0.4103	**S1**	0.6271	0.3636	0.4057
S2	0.4444	0.6667	0.6721	**S2**	0.4524	0.6757	0.5897	**S2**	0.3729	0.6364	0.5943

Source: Author's elaboration.

By pre-multiplying the market shares matrix by the technical coefficients, we express them in an industry by industry dimension (2x2) as:

Figure D. 2 – Technical coefficients for period 00, 01 and 02, industry by industry – Current prices

p00q00			**p01q01**			**p02q02**		
	S1	**S2**		**S1**	**S2**		**S1**	**S2**
S1	0.2189	0.1572	**S1**	0.2348	0.2436	**S1**	0.2107	0.2702
S2	0.3447	0.3025	**S2**	0.3349	0.4085	**S2**	0.2643	0.4072

Source: Author's elaboration.

Figure D. 3 – Technical coefficients for period 00, 01 and 02, industry by industry – constant prices

p00q00			**p00q01**			**p00q02**		
	S1	**S2**		**S1**	**S2**		**S1**	**S2**
S1	0.2189	0.1572	**S1**	0.2348	0.2436	**S1**	0.2107	0.2702
S2	0.3447	0.3025	**S2**	0.3349	0.4085	**S2**	0.2643	0.4072

Source: Author's elaboration.

Figure D. 4 – Technical coefficients for period 00, 01 and 02, industry by industry – double deflation method

p00q00			**p00q01**			**p00q02**		
	S1	**S2**		**S1**	**S2**		**S1**	**S2**
S1	0.2189	0.1572	**S1**	0.2348	0.2436	**S1**	0.2080	0.2723
S2	0.3447	0.3025	**S2**	0.3349	0.4085	**S2**	0.2603	0.4127

Source: Author's elaboration.

As we previously mentioned, there is a difference between the current prices/constant prices from the double-deflation method. We present this difference in the absolute and proportional way in the next figure.

Figure D. 5 – Difference form technical coefficients in total and volume, absolute and proportional (in column sum), p00q02

	Absolute difference			Proportional difference		
	S1	**S2**	**Sum**	**S1**	**S2**	**Sum**
S1	0.0028	-0.0021	0.0007	1.31%	-0.76%	0.15%
S2	0.0040	-0.0055	-0.0016	1.49%	-1.35%	-0.23%
Sum	0.0067	-0.0076	-0.0009	1.41%	-1.12%	-0.07%

Source: Author's elaboration.

It shows that there is a sub estimation of S2 purchases of S1 and S2 multipliers inside the IO model.

D.2 Empirical application: cell-specific price indices for the Brazilian economy

We calculated the cell-specific deflator for the Make matrix and Use table (in purchaser's prices) between 2000 and 2015, using the official data published by IBGE. In this process of empirical application of the price indices, we found four possible mathematical situations, considering that the numerator and the denominator can assume values different from zero or null values:

- **Case 1 - price index different from zero** – when both numerator and denominator have values different from zero, so $p_{ij}^{k}q_{ij}^{k} \neq 0$ and $p_{ij}^{k-1}q_{ij}^{k} \neq 0$: in this case, the price index exists and is different from zero, so $\lambda_{ij}^{k,k-1} \neq 0$;
- **Case 2 - price index equal to one** – when both values are zero, so $p_{ij}^{k}q_{ij}^{k} = 0$ e $p_{ij}^{k-1}q_{ij}^{k} = 0$. This in fact represents that there is no valid information for this combination of product and industry/final demand. In this case, we set $\lambda_{ij}^{k,k-1} = 1$;
- **Case 3 - price index is indeterminate** – when the numerator is different from zero ($p_{ij}^{k}q_{ij}^{k} \neq 0$) and the denominator is zero ($p_{ij}^{k-1}q_{ij}^{k} = 0$). In this case, it is not possible to calculate the price index, due to the indeterminacy of the ratio.
- **Case 4 - price index is zero** – when the numerator has a null value ($p_{ij}^{k}q_{ij}^{k} = 0$) and the denominator is different from zero ($p_{ij}^{k-1}q_{ij}^{k} \neq 0$). In this case, the price index is zero, and we lose the positive information.

For the two last cases, there is not an economic explanation. These cases might be a problem in the data provided form IBGE. For example, since IBGE sometimes round the values, it is possible that some positive values, but that is less than one sometimes became zero in the published data. We expect that when the values of the numerator in Case 3 or the denominator in Case 4 have a short magnitude. However, there are some cases that this not happens and may be a mistake in the data[93], for example, due to inexistent price deflators or the process of estimation balance.

With the objective to overcome that limitation, we propose an adjustment in the SUT in previous' year prices, using the structure present in the SUT in current prices.

[93] For example, let us take the example of the Use table in the pair year 2002-2001, for the product 'Organizações patronais, sindicais e outros serviços associativos' selling to 'Private health'. The value in 2001 and 2002 is zero ($p^{2001}q^{2001} = p^{2002}q^{2002} = 0$). However, the value of $p^{2001}q^{2002}$ is 309 (1 000 000 R$). For this case, we have a price index equal to zero, but may not have any economic meaning.

For this adjustment, we estimate a mark-down (ϑ_{ij}^{τ}) of each cell in the Make matrix and Use Table, that consist in the ratio of product i and industry/final demand j in relation to the total of the industry j, but in current prices, like:

$$\vartheta_{ij}^{t} = \frac{(p^t q^t)_{ij}}{\sum_j (p^t q^t)_{ij}}$$

with $0 < \vartheta_{ij}^{t} < 1$.

So, we estimate the new adjusted value only for the cells in Case 3 and 4, applying the mark-down in the industry/final demand total (in previous' year prices).

$$(p^{t-1} q^t)_{ij}^{ajust} = \vartheta_{ij}^{t} \times \sum_i (p^{t-1} q^t)_{ij}$$

This way, we substitute the zero value in the denominator $(p^{t-1} q^t)_{ij}$ when the price index is indeterminate (Case 3) by a value different from zero. On the other side, we substitute the value different from zero in the denominator in Case 4 for a zero value.

In the process of that adjustment, the IOT loses its consistency in the column and row totals. To return that consistency, we apply a GRAS method, proposed by Termushoev, Miller, and Bowmaster (2013) to balance the tables. We set the original previous' year totals for row and column as a restriction.

In Table D.1 we have for all pair of years the numbers of Cases 3 and 4 for Make and Use Table.

Table D. 1 - Number of Cases 3 and 4 for Brazilian Supply and Use Table, 2000 to 2015

Period	Use Table		Make matrix	
	Case 3	Case 4	Case 3	Case 4
2001p2000	0	0	1	6
2002p2001	2	0	1	7
2003p2002	0	0	4	15
2004p2003	0	0	1	7
2005p2004	0	0	0	2
2006p2005	0	0	2	3
2007p2006	1	0	1	0
2008p2007	0	0	2	4
2009p2008	1	0	12	248
2010p2009	2	23	76	0
2011p2010	0	1	39	49
2012p2011	0	1	8	0
2013p2012	0	1	3	46
2014p2013	0	0	7	202
2015p2014	0	0	6	5

Source: Author's calculations based on information from the SNA/IBGE.

As we estimated before the IOT at previous' year prices, we have to estimate this tables for all the series again but using these modified SUTs. The procedure is the same explained earlier.

After that, we calculated these deflators for all elements present in $\mathbf{V}$, $\mathbf{UT_t^{pu}}$, $\mathbf{UT_n^{pr}}$, $\mathbf{UT_m^{pr}}$ and $\mathbf{UT_t^{pr}}$.

APPENDIX E – MULTISECTORAL CORRESPONDENCE TABLE

Table E. 1 – Correspondence Table of 11 sectors to 42 sectors[1]

11 Sectors	42 Sectors
Agriculture, fishing and related	Agriculture, forestry, livestock and fisheries
Industrial Commodities Group	Extraction of oil and gas, including support activities
	Extraction of iron ore, including processing and agglomeration
	Other mining and quarrying
	Oil refining and coking plants
	Manufacture of biofuels
	Manufacture of other organic and inorganic chemicals, resins and elastomers
	Cement and other non-metallic mineral products
	Manufacture of steel and its derivatives
	Metallurgy of nonferrous metals
	Metal products - exclusive machinery and equipment
Processed Agricultural Commodities Group	Manufacture of tobacco products
	Manufacture of wood products
	Manufacture of pulp, paper and paper products
Traditional Industry Group	Food and drinks
	Manufacture of textiles
	Manufacture of wearing apparel and accessories
	Manufacture of footwear and leather goods
	Printing and reproduction of recordings
	Perfumery hygiene and cleaning
	Manufacture of pesticides, disinfectants, paints and various chemicals
	Rubber & Plastics
	Furniture and products of various industries & Machinery and equipment[2]
Innovative Industry Group	Pharmaceutical products
	Furniture and products of various industries & Machinery and equipment[2]
	Household appliances and electronic material
	Automobiles trucks and buses
	Parts and accessories for motor vehicles
	Other transportation equipment
Public utility	Electricity generation and distribution gas water sewage and urban cleaning
Construction	Construction
Trade, accommodation and food	Trade
	Accommodation and food services
Transport, storage and communication	Transporting warehousing and mail
	Information services
Financial intermediation, insurance and real estate services	Financial intermediation insurance and supplementary pension and related services
	Real estate activities and rentals
Community, social and personal services	Business and family services and maintenance services
	Public administration, defense and social security
	Public education
	Private education
	Public health
	Private health

[1]To make comparable all the years analyzed in this piece, as occurred a change in Brazilian's National System Account, this correspondence table is based on other correspondence tables (see Appendix B). The first one relates the data retropolated for 2000 and 2009, with 51 sectors corresponding to 42 sectors. The second one relates the new sector classification published data (67 sectors), that also was translated to 42 sectors. All the correspondences were done taking into consideration the official Brazilian SNA classification standards

As is not possible to disaggregate the aggregated sector "Furniture and products of various industries & Machinery and equipment", it was applied a proportion of 19.82% to the ***Traditional manufacturing industry*** and its complement to the ***Innovative manufacturing Industry***. This represents the *Furniture and products of various industries*' production proportion in the aggregated sector when the disagreed information is provided, for the year 2010.

Table E. 2 – Sectoral gross output share in total units for 42 sectors, selected periods

Code GIC	Description 42 industries	2000	2003	2008	2010	2014
GIC_A01	Agriculture, forestry, livestock and fisheries	4.32	5.50	4.70	4.13	4.40
GIC_A02	Extraction of oil and gas, including support activities	1.17	1.63	2.14	1.78	2.19
GIC_A03	Extraction of iron ore, including processing and agglomeration	0.34	0.44	0.65	0.86	0.72
GIC_A04	Other mining and quarrying	0.32	0.33	0.41	0.37	0.32
GIC_A05	Food and drinks	6.08	6.72	6.29	5.89	5.99
GIC_A06	Manufacture of tobacco products	0.21	0.22	0.20	0.20	0.16
GIC_A07	Manufacture of textiles	0.97	0.92	0.67	0.61	0.49
GIC_A08	Manufacture of footwear and leather goods	1.01	0.74	0.76	0.73	0.63
GIC_A09	Manufacture of wearing apparel and accessories	0.62	0.64	0.47	0.44	0.42
GIC_A10	Manufacture of wood products	0.41	0.46	0.35	0.32	0.29
GIC_A11	Manufacture of pulp, paper and paper products	1.02	1.04	0.84	0.85	0.74
GIC_A12	Printing and reproduction of recordings	0.41	0.34	0.30	0.26	0.21
GIC_A13	Oil refining and coking plants	3.32	4.05	3.95	3.44	3.69
GIC_A14	Manufacture of biofuels	0.32	0.41	0.37	0.37	0.36
GIC_A15	Manufacture of other organic and inorganic chemicals, resins and elastomers	1.78	2.20	1.95	1.35	1.37
GIC_A16	Pharmaceutical products	0.70	0.64	0.62	0.62	0.57
GIC_A17	Perfumery hygiene and cleaning	0.50	0.45	0.42	0.40	0.39
GIC_A18	Manufacture of pesticides, disinfectants, paints and various chemicals	0.80	0.83	0.77	0.71	0.66
GIC_A19	Rubber & Plastics	1.21	1.21	1.13	1.10	1.04
GIC_A20	Cement and other non-metallic mineral products	0.95	1.01	0.94	0.97	0.95
GIC_A21	Manufacture of steel and its derivatives	1.14	1.52	1.92	1.39	1.09
GIC_A22	Metallurgy of nonferrous metals	0.59	0.67	0.66	0.57	0.52
GIC_A23	Metal products - exclusive machinery and equipment	1.04	1.11	1.32	1.15	0.96
GIC_A24	Furniture and products of various industries & Machinery and equipment	4.15	4.03	4.16	3.87	3.61
GIC_A25	Household appliances and electronic material	0.75	0.77	0.94	0.89	0.72
GIC_A26	Automobiles trucks and buses	1.63	1.77	2.35	2.38	1.75
GIC_A27	Parts and accessories for motor vehicles	0.89	1.08	1.23	1.23	0.81
GIC_A28	Other transportation equipment	0.45	0.57	0.66	0.50	0.49
GIC_A29	Electricity generation and distribution gas water sewage and urban cleaning	3.06	3.14	2.86	2.97	2.75
GIC_A30	Construction	6.88	5.45	5.55	6.78	6.70
GIC_A31	Trade	7.46	7.72	9.15	9.80	10.75
GIC_A32	Transporting warehousing and mail	4.34	4.43	4.69	4.78	4.95
GIC_A33	Accommodation and food services	2.10	1.88	1.91	2.13	2.47
GIC_A34	Information services	4.16	4.01	4.04	3.81	3.47
GIC_A35	Financial intermediation insurance and supplementary pension and related services	5.22	5.12	4.88	5.50	5.12
GIC_A36	Real estate activities and rentals	6.59	5.33	4.42	4.49	5.12
GIC_A37	Business and family services and maintenance services	9.11	8.08	8.09	8.45	8.69
GIC_A38	Public administration, defense and social security	7.14	7.00	7.01	7.34	6.83
GIC_A39	Public education	2.35	2.14	2.25	2.41	2.87
GIC_A40	Private education	1.12	1.07	0.85	0.86	1.01
GIC_A41	Public health	1.30	1.33	1.41	1.57	1.69
GIC_A42	Private health	2.06	1.94	1.72	1.73	2.04
Total		***100.00***	***100.00***	***100.00***	***100.00***	***100.00***

Source: Author’s calculations based on information from the SNA/IBGE.

Table E. 3 – Sectoral gross output share in total units for 42 sectors, selected periods

Code GIC	Description 42 industries	2000	2003	2008	2010	2014
GIC_A01	Agriculture, forestry, livestock and fisheries	3.93	4.54	4.28	4.13	2.21
GIC_A02	Extraction of oil and gas, including support activities	1.48	1.79	1.67	1.78	0.90
GIC_A03	Extraction of iron ore, including processing and agglomeration	0.71	0.72	0.89	0.86	0.43
GIC_A04	Other mining and quarrying	0.42	0.41	0.40	0.37	0.19
GIC_A05	Food and drinks	6.41	6.57	6.09	5.89	2.72
GIC_A06	Manufacture of tobacco products	0.26	0.27	0.24	0.20	0.09
GIC_A07	Manufacture of textiles	0.82	0.71	0.70	0.61	0.23
GIC_A08	Manufacture of footwear and leather goods	1.19	0.94	0.80	0.73	0.33
GIC_A09	Manufacture of wearing apparel and accessories	0.71	0.65	0.49	0.44	0.19
GIC_A10	Manufacture of wood products	0.51	0.49	0.34	0.32	0.16
GIC_A11	Manufacture of pulp, paper and paper products	0.87	0.89	0.87	0.85	0.42
GIC_A12	Printing and reproduction of recordings	0.31	0.30	0.28	0.26	0.11
GIC_A13	Oil refining and coking plants	3.81	3.86	3.57	3.44	1.98
GIC_A14	Manufacture of biofuels	0.28	0.33	0.38	0.37	0.20
GIC_A15	Manufacture of other organic and inorganic chemicals, resins and elastomers	1.78	1.83	1.36	1.35	0.64
GIC_A16	Pharmaceutical products	0.60	0.55	0.60	0.62	0.31
GIC_A17	Perfumery hygiene and cleaning	0.43	0.41	0.40	0.40	0.21
GIC_A18	Manufacture of pesticides, disinfectants, paints and various chemicals	0.86	0.70	0.74	0.71	0.34
GIC_A19	Rubber & Plastics	1.29	1.20	1.13	1.10	0.49
GIC_A20	Cement and other non-metallic mineral products	1.10	0.97	1.00	0.97	0.48
GIC_A21	Manufacture of steel and its derivatives	1.76	1.80	1.57	1.39	0.61
GIC_A22	Metallurgy of nonferrous metals	0.65	0.65	0.59	0.57	0.26
GIC_A23	Metal products - exclusive machinery and equipment	1.14	1.15	1.15	1.15	0.54
GIC_A24	Furniture and products of various industries & Machinery and equipment	4.11	3.79	4.18	3.87	2.00
GIC_A25	Household appliances and electronic material	0.84	0.89	0.97	0.89	0.39
GIC_A26	Automobiles trucks and buses	1.61	1.61	2.24	2.38	0.92
GIC_A27	Parts and accessories for motor vehicles	1.23	1.14	1.28	1.23	0.45
GIC_A28	Other transportation equipment	0.29	0.38	0.54	0.50	0.27
GIC_A29	Electricity generation and distribution gas water sewage and urban cleaning	2.96	2.90	2.92	2.97	1.59
GIC_A30	Construction	6.94	6.15	6.21	6.78	3.50
GIC_A31	Trade	9.30	8.78	9.51	9.80	5.09
GIC_A32	Transporting warehousing and mail	4.78	4.76	4.79	4.78	2.54
GIC_A33	Accommodation and food services	2.03	2.07	2.11	2.13	1.14
GIC_A34	Information services	3.44	3.82	3.87	3.81	2.21
GIC_A35	Financial intermediation insurance and supplementary pension and related services	4.09	3.92	4.89	5.50	2.82
GIC_A36	Real estate activities and rentals	4.39	4.77	4.57	4.49	2.41
GIC_A37	Business and family services and maintenance services	8.62	8.33	8.35	8.45	4.41
GIC_A38	Public administration, defense and social security	7.23	7.44	7.19	7.34	3.76
GIC_A39	Public education	3.12	3.20	2.59	2.41	1.08
GIC_A40	Private education	0.90	0.98	0.88	0.86	0.49
GIC_A41	Public health	1.34	1.51	1.48	1.57	0.83
GIC_A42	Private health	1.96	1.93	1.79	1.73	0.86
Total		***100.00***	***100.00***	***100.00***	***100.00***	***100.00***

Source: Author’s calculations based on information from the SNA/IBGE.

APPENDIX F – STRUCTURAL DECOMPOSITION ANALYSIS

In this appendix, we detail some definitions for the structural decomposition's second level presented in Chapter 3. We disaggregate the gross output growth in the contribution of domestic technical coefficients $\breve{\mathbf{A}}_\mathbf{d}$, the domestic final demand $\breve{\mathbf{f}}_\mathbf{d}$, total relative prices $\breve{\mathbf{x}}^\mathbf{p}$ and inventories $\breve{\mathbf{s}}$:

$$\frac{\Delta \mathbf{x}^\mathbf{v}}{x_0} = \frac{\breve{\mathbf{A}}_\mathbf{d}}{x_0} + \frac{\breve{\mathbf{f}}_\mathbf{d}}{x_0} + \frac{\breve{\mathbf{x}}^\mathbf{p}}{x_0} + \frac{\breve{\mathbf{s}}}{x_0} \tag{F. 1}$$

with:

$$\breve{\mathbf{A}}_\mathbf{d} = \frac{1}{2}\left[\tilde{\mathbf{Z}}_1\left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\Delta\mathbf{A}_\mathbf{d}(\hat{\mathbf{x}}^\mathbf{p}{}_1 + \hat{\mathbf{x}}^\mathbf{p}{}_0)\right]\right]\tilde{\mathbf{Z}}_0\right]\left(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\right) \tag{F. 2}$$

$$\breve{\mathbf{f}}_\mathbf{d} = \frac{1}{2}\left(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0\right)\left[\frac{1}{2}\left(\hat{\mathbf{x}}^\mathbf{p}{}_1^{-1} + \hat{\mathbf{x}}^\mathbf{p}{}_0^{-1}\right)\Delta\mathbf{f}_\mathbf{d}\right] \tag{F. 3}$$

$$\begin{aligned}\breve{x}^\mathbf{p} = {} & \frac{1}{2}\left[\tilde{\mathbf{Z}}_1\left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\left(\mathbf{A}_{\mathbf{d}_1} + \mathbf{A}_{\mathbf{d}_0}\right)\Delta\hat{\mathbf{x}}^\mathbf{p}\right]\right]\tilde{\mathbf{Z}}_0\right]\left(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\right) \\ & + \frac{1}{2}\left[\tilde{\mathbf{Z}}_1\left[\frac{1}{2}\Delta\left(\hat{\mathbf{x}}^{\mathbf{p}-1}\right)\left(\mathbf{A}^*_{\mathbf{d}_1} + \mathbf{A}^*_{\mathbf{d}_0}\right)\right]\tilde{\mathbf{Z}}_0\right]\left(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\right) \\ & + \frac{1}{2}\left(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0\right)\left[\frac{1}{2}\Delta\left(\hat{\mathbf{x}}^{\mathbf{p}-1}\right)\left(\mathbf{f}_{\mathbf{d}_1} + \mathbf{f}_{\mathbf{d}_0}\right)\right]\end{aligned} \tag{F. 4}$$

$$\breve{s} = \frac{1}{2}\Delta\left(\hat{\mathbf{x}}^{\mathbf{p}-1}\right)\left(\mathbf{s}_{\mathbf{d}_1} + \mathbf{s}_{\mathbf{d}_0}\right) + \frac{1}{2}\left(\hat{\mathbf{x}}^\mathbf{p}{}_1^{-1} + \hat{\mathbf{x}}^\mathbf{p}{}_0^{-1}\right)\Delta\mathbf{s}_\mathbf{d} \tag{F. 5}$$

The following section presents the elements that form each variable presented in Figure 48 in the text (p.109), expressing the final disaggregation between volume and relative prices.

VOLUME EFFECT

- **Domestic input coefficients**

  We express the changes in the matrix of domestic coefficients ($\breve{\mathbf{A}}_\mathbf{d}{}^\mathbf{v}$) by the difference of total ($\breve{\mathbf{A}}^\mathbf{v}$) and imported coefficients ($\breve{\mathbf{A}}_\mathbf{m}{}^\mathbf{v}$).

$$\breve{\mathbf{A}}_\mathbf{d}{}^\mathbf{v} = \breve{\mathbf{A}}^\mathbf{v} - \breve{\mathbf{A}}_\mathbf{m}{}^\mathbf{v} \tag{F. 6}$$

  Notice that we denote $\mathbf{A}^\mathbf{v}_\mathbf{d}$, $\mathbf{A}^\mathbf{v}, \mathbf{A}^\mathbf{v}_\mathbf{m}$, but as IBGE express the transitional matrix in the dimension product-by-industry, it, in fact, represents the chance in $\mathbf{B}^\mathbf{v}_\mathbf{d}$, $\mathbf{B}^\mathbf{v}, \mathbf{B}^\mathbf{v}_\mathbf{m}$.

$$\breve{\mathbf{A}}^\mathbf{v} = \frac{1}{2}\left[\tilde{\mathbf{Z}}_1\left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\left[\frac{1}{2}\left[(\mathbf{D}_1 + \mathbf{D}_0)\left(\frac{1}{2}\left((\mathbf{B}^\mathbf{p}{}_1 + \mathbf{B}^\mathbf{p}{}_0) \otimes \Delta\mathbf{B}^\mathbf{v}\right)\right)\right]\right](\hat{\mathbf{x}}^\mathbf{p}{}_1 + \hat{\mathbf{x}}^\mathbf{p}{}_0)\right]\right]\tilde{\mathbf{Z}}_0\right]\left(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\right) \tag{F. 7}$$

$$\breve{\mathbf{A}}_\mathbf{m}{}^\mathbf{v} = \frac{1}{2}\left[\tilde{\mathbf{Z}}_1\left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\left[\frac{1}{2}\left[(\mathbf{D}_1 + \mathbf{D}_0)\left(\frac{1}{2}\left((\mathbf{B}^\mathbf{p}_{\mathbf{m}_1} + \mathbf{B}^\mathbf{p}_{\mathbf{m}_0}) \otimes \Delta\mathbf{B}^\mathbf{v}_\mathbf{m}\right)\right)\right]\right](\hat{\mathbf{x}}^\mathbf{p}{}_1 + \hat{\mathbf{x}}^\mathbf{p}{}_0)\right]\right]\tilde{\mathbf{Z}}_0\right]\left(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\right) \tag{F. 8}$$

Disaggregating $\breve{\mathbf{A}}_\mathbf{m}{}^\mathbf{v}$ to capture disaggregate the contribution of competitive imports (trade pattern) and the imports that are induced by technological change, we have:

$$\breve{\mathbf{A}}_{\mathbf{m}}^{\mathbf{v}} = \underbrace{\breve{\mathbf{A}}_{\mathbf{m_1}}^{\mathbf{v}} - \breve{\breve{\mathbf{A}}}_{\mathbf{m_0}}^{\mathbf{v}}}_{trade\ pattern} - \underbrace{\left(\breve{\mathbf{A}}_{\mathbf{m_0}}^{\mathbf{v}} - \breve{\breve{\mathbf{A}}}_{\mathbf{m_0}}^{\mathbf{v}}\right)}_{technogical\ change} \qquad (F. 9)$$

$$\breve{\mathbf{A}}_{\mathbf{m_t}}^{\mathbf{v}} = \frac{1}{2}\left[\tilde{\mathbf{Z}}_1 \left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\left[\frac{1}{2}\left[(\mathbf{D}_1 + \mathbf{D}_0)\left(\frac{1}{2}\left((\mathbf{B}_{\mathbf{m_1}}^{\mathbf{p}} + \mathbf{B}_{\mathbf{m_0}}^{\mathbf{p}}) \otimes \mathbf{B}_{\mathbf{m}_t}^{\mathbf{v}}\right)\right)\right]\right](\hat{\mathbf{x}}^{\mathbf{p}}{}_1 + \hat{\mathbf{x}}^{\mathbf{p}}{}_0)\right]\right]\tilde{\mathbf{Z}}_0\right](\tilde{\mathbf{f}}_{\mathbf{d_1}} + \tilde{\mathbf{f}}_{\mathbf{d_0}}) \qquad (F. 10)$$

$$\breve{\breve{\mathbf{A}}}_{\mathbf{m_0}}^{\mathbf{v}} = \frac{1}{2}\left[\tilde{\mathbf{Z}}_1 \left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\left[\frac{1}{2}\left[(\mathbf{D}_1 + \mathbf{D}_0)\left(\frac{1}{2}\left((\mathbf{B}_{\mathbf{m_1}}^{\mathbf{p}} + \mathbf{B}_{\mathbf{m_0}}^{\mathbf{p}}) \otimes \breve{\mathbf{B}}_{\mathbf{m0}}^{\mathbf{v}}\right)\right)\right]\right](\hat{\mathbf{x}}^{\mathbf{p}}{}_1 + \hat{\mathbf{x}}^{\mathbf{p}}{}_0)\right]\right]\tilde{\mathbf{Z}}_0\right](\tilde{\mathbf{f}}_{\mathbf{d_1}} + \tilde{\mathbf{f}}_{\mathbf{d_0}}) \qquad (F. 11)$$

- **Final demand**

Domestic final demand contribution is formed by the sum of the contributions of each demand component, disaggregated in consumption (*c*), which includes private and government consumption, gross fixed capital formation (*k*), and external demand (*e*).

$$\breve{\mathbf{f}}_{\mathbf{d}}^{\mathbf{v}} = \breve{\mathbf{c}}_{\mathbf{d}}^{\mathbf{v}} + \breve{\mathbf{k}}_{\mathbf{d}}^{\mathbf{v}} + \breve{\mathbf{g}}_{\mathbf{d}}^{\mathbf{v}} + \breve{\mathbf{e}}_{\mathbf{d}}^{\mathbf{v}} \qquad (F. 12)$$

In the disaggregation of demand source, we define de domestic demand for a generic *h* component of final demand as the difference of total and imported final demand. In this way, we obtain the contribution to gross output growth for domestic demand ($\breve{\mathbf{h}}_{\mathbf{d}}^{\mathbf{v}}$) also by the difference of total ($\breve{\mathbf{h}}^{\mathbf{v}}$) and final demand contribution ($\breve{\mathbf{h}}_{\mathbf{m}}^{\mathbf{v}}$).

$$\breve{\mathbf{h}}_{\mathbf{d}}^{\mathbf{v}} = \breve{\mathbf{h}}^{\mathbf{v}} - \breve{\mathbf{h}}_{\mathbf{m}}^{\mathbf{v}} \qquad (F. 13)$$

Notice that we denote the contributions $\breve{\mathbf{h}}_{\mathbf{d}}^{\mathbf{v}}, \breve{\mathbf{h}}^{\mathbf{v}}, \breve{\mathbf{h}}_{\mathbf{m}}^{\mathbf{v}}$ are at the sectoral level, but in fact, the changes in these variables represents the variation in the product level, but distributed among industries using the market shares matrix. The decompositions for these variables are:

$$\breve{\mathbf{h}}^{\mathbf{v}} = \frac{1}{2}(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0)\left[\frac{1}{2}\left(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\right)\left[\frac{1}{2}\left[(\mathbf{D}_1 + \mathbf{D}_0)\left(\frac{1}{2}\left(\left(\hat{\mathbf{h}}_{\mathbf{q_1}}^{\mathbf{p}} + \hat{\mathbf{h}}_{\mathbf{q_0}}^{\mathbf{p}}\right)\Delta\mathbf{h}_{\mathbf{q}}^{\mathbf{v}}\right)\right)\right]\right]\right] \qquad (F. 14)$$

$$\breve{\mathbf{h}}_{\mathbf{m}}^{\mathbf{v}} = \frac{1}{2}(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0)\left[\frac{1}{2}\left(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\right)\left[\frac{1}{2}\left[(\mathbf{D}_1 + \mathbf{D}_0)\left(\frac{1}{2}\left(\left(\hat{\mathbf{h}}_{\mathbf{qm_1}}^{\mathbf{p}} + \hat{\mathbf{h}}_{\mathbf{qm_0}}^{\mathbf{p}}\right)\Delta\mathbf{h}_{\mathbf{mq}}^{\mathbf{v}}\right)\right)\right]\right]\right] \qquad (F. 15)$$

- **Market share matrix**

As we express the transitional matrix at product-by-industry dimension, the variation of the market shares matrix includes its variation sized by all the variables on the model (change on intermediate and final demand, excluded inventories). As this matrix does not have an essential economic meaning, its change is not open by domestic and imported.

$$\breve{\mathbf{D}}^{\mathbf{v}} = \frac{1}{2}\left[\tilde{\mathbf{Z}}_1\left[\frac{1}{2}\left(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\right)\left[\frac{1}{2}\left[\frac{1}{2}\left[\frac{1}{2}\left((\mathbf{D}_1^{\mathbf{p}} + \mathbf{D}_0^{\mathbf{p}}) \otimes \Delta\mathbf{D}^{\mathbf{v}}\right)(\mathbf{A}_{\mathbf{d}_1} + \mathbf{A}_{\mathbf{d}_0})\right]\right](\hat{\mathbf{x}}^{\mathbf{p}}{}_1 + \hat{\mathbf{x}}^{\mathbf{p}}{}_0)\right]\right]\tilde{\mathbf{Z}}_0\right](\tilde{\mathbf{f}}_{\mathbf{d_1}} + \tilde{\mathbf{f}}_{\mathbf{d_0}}) \qquad (F. 16)$$

$$+\frac{1}{2}(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0)\left[\frac{1}{2}\left(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\right)\left[\frac{1}{2}\left[\left(\frac{1}{2}\left((\mathbf{D}_1^{\mathbf{p}} + \mathbf{D}_0^{\mathbf{p}}) \otimes \Delta\mathbf{D}^{\mathbf{v}}\right)\right)(\tilde{\mathbf{f}}_{\mathbf{d_1}} + \tilde{\mathbf{f}}_{\mathbf{d_0}})\right]\right]\right]$$

PRICE EFFECT (ρ)

- **Total prices**

  Represents the effect of total relative prices ($\hat{\mathbf{x}}^{\mathbf{p}}$) in volume contribution to gross output in volume.

$$\breve{\mathbf{x}}^{\mathbf{p}} = \frac{1}{2}\Big[\tilde{\mathbf{Z}}_1 \Big[\frac{1}{2}\big(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\big)\Big[\frac{1}{2}(\mathbf{A}_{\mathbf{d}_1} + \mathbf{A}_{\mathbf{d}_0})\Delta\hat{\mathbf{x}}^{\mathbf{p}}\Big]\Big]\tilde{\mathbf{Z}}_0\Big]\big(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\big) + \frac{1}{2}\Big[\tilde{\mathbf{Z}}_1\Big[\frac{1}{2}\Delta\big(\hat{\mathbf{x}}^{\mathbf{p}-1}\big)\big(\mathbf{A}^*_{\mathbf{d}_1} + \mathbf{A}^*_{\mathbf{d}_0}\big)\Big]\tilde{\mathbf{Z}}_0\Big]\big(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\big) + \frac{1}{2}\big(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0\big)\Big[\frac{1}{2}\Delta\big(\hat{\mathbf{x}}^{\mathbf{p}-1}\big)\big(\mathbf{f}_{\mathbf{d}_1} + \mathbf{f}_{\mathbf{d}_0}\big)\Big] \quad \text{(F. 17)}$$

- **Domestic input coefficients prices ($\breve{\mathbf{A}}_{\mathbf{d}}{}^{\mathbf{p}}$)**

  It corresponds to the contribution of relative price changes in $\mathbf{A}_{\mathbf{d}}$ relative to changes in $\mathbf{B}^{\mathbf{p}}_{\mathbf{d}}$, weighted by the market share matrix. It is obtained by difference from the changes in relative prices in total and imported technical coefficients:

$$\breve{\mathbf{A}}_{\mathbf{d}}{}^{\mathbf{p}} = \breve{\mathbf{A}}^{\mathbf{p}} - \breve{\mathbf{A}}_{\mathbf{m}}{}^{\mathbf{p}} \quad \text{(F. 18)}$$

$$\breve{\mathbf{A}}^{\mathbf{p}} = \frac{1}{2}\Big[\tilde{\mathbf{Z}}_1\Big[\frac{1}{2}\big(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\big)\Big[\frac{1}{2}\Big[\frac{1}{2}\Big[(\mathbf{D}_1 + \mathbf{D}_0)\Big(\frac{1}{2}\big(\Delta\mathbf{B}^{\mathbf{p}} \otimes (\mathbf{B}^{\mathbf{v}}{}_1 + \mathbf{B}^{\mathbf{v}}{}_0)\big)\Big)\Big]\Big](\hat{\mathbf{x}}^{\mathbf{p}}{}_1 + \hat{\mathbf{x}}^{\mathbf{p}}{}_0)\Big]\Big]\tilde{\mathbf{Z}}_0\Big]\big(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\big) \quad \text{(F. 19)}$$

$$\breve{\mathbf{A}}_{\mathbf{m}}{}^{\mathbf{p}} = \frac{1}{2}\Big[\tilde{\mathbf{Z}}_1\Big[\frac{1}{2}\big(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\big)\Big[\frac{1}{2}\Big[\frac{1}{2}\Big[(\mathbf{D}_1 + \mathbf{D}_0)\Big(\frac{1}{2}\big(\Delta\mathbf{B}^{\mathbf{p}}_{\mathbf{m}} \otimes (\mathbf{B}^{\mathbf{v}}_{\mathbf{m}_1} + \mathbf{B}^{\mathbf{v}}_{\mathbf{m}_0})\big)\Big)\Big]\Big](\hat{\mathbf{x}}^{\mathbf{p}}{}_1 + \hat{\mathbf{x}}^{\mathbf{p}}{}_0)\Big]\Big]\tilde{\mathbf{Z}}_0\Big]\big(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\big) \quad \text{(F. 20)}$$

- **Final demand prices**

The relative price change of final demand ($\breve{\mathbf{f}}^{\mathbf{p}}_{\mathbf{d}}$) represents the sum of the relative price changes of the demand components ($\breve{\mathbf{c}}^{\mathbf{p}}_{\mathbf{d}}, \breve{\mathbf{k}}^{\mathbf{p}}_{\mathbf{d}}, \breve{\mathbf{g}}^{\mathbf{p}}_{\mathbf{d}}, \breve{\mathbf{e}}^{\mathbf{p}}_{\mathbf{d}}$), such as in:

$$\breve{\mathbf{f}}^{\mathbf{p}}_{\mathbf{d}} = \breve{\mathbf{c}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{k}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{g}}^{\mathbf{p}}_{\mathbf{d}} + \breve{\mathbf{e}}^{\mathbf{p}}_{\mathbf{d}} \quad \text{(F. 21)}$$

Since we do not have the objective to analyze the changes by the source of demand, we do not disaggregate this information in domestic and imported. So, the decompositions for a generic h component of demand is:

$$\breve{\mathbf{h}}^{\mathbf{p}}_{\mathbf{d}} = \frac{1}{2}\big(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0\big)\Big[\frac{1}{2}\big(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\big)\Big[\frac{1}{2}\Big[(\mathbf{D}_1 + \mathbf{D}_0)\Big(\frac{1}{2}\Big(\Delta\hat{\mathbf{h}}^{\mathbf{p}}_{\mathbf{dq}}\big(\mathbf{h}^{\mathbf{v}}_{\mathbf{dq}_1} + \mathbf{h}^{\mathbf{v}}_{\mathbf{dq}_0}\big)\Big)\Big)\Big]\Big]\Big] \quad \text{(F. 22)}$$

- **Market share matrix prices**

  Corresponds to the changes in the market share matrix related to prices, weighted by intermediate and final demand

$$\breve{\mathbf{D}}^{\mathbf{p}} = \frac{1}{2}\Big[\tilde{\mathbf{Z}}_1\Big[\frac{1}{2}\big(\hat{\mathbf{x}}_1^{\mathbf{p}-1} + \hat{\mathbf{x}}_0^{\mathbf{p}-1}\big)\Big[\frac{1}{2}\Big[\frac{1}{2}\Big[\frac{1}{2}\Big(\big(\Delta\mathbf{D}^{\mathbf{p}} \otimes (\mathbf{D}^{\mathbf{v}}_1 + \mathbf{D}^{\mathbf{v}}_0)\big)\Big)\big(\mathbf{A}_{\mathbf{d}_1} + \mathbf{A}_{\mathbf{d}_0}\big)\Big]\Big](\hat{\mathbf{x}}^{\mathbf{p}}{}_1 + \hat{\mathbf{x}}^{\mathbf{p}}{}_0)\Big]\Big]\tilde{\mathbf{Z}}_0\Big]\big(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\big) + \frac{1}{2}\big(\tilde{\mathbf{Z}}_1 + \tilde{\mathbf{Z}}_0\big)\Big[\frac{1}{2}\big(\hat{\mathbf{x}}^{\mathbf{p}}{}_1^{-1} + \hat{\mathbf{x}}^{\mathbf{p}}{}_0^{-1}\big)\Big[\frac{1}{2}\Big[\Big(\frac{1}{2}\big(\Delta\mathbf{D}^{\mathbf{p}} \otimes (\mathbf{D}^{\mathbf{v}}_1 + \mathbf{D}^{\mathbf{v}}_0)\big)\Big)\big(\tilde{\mathbf{f}}_{\mathbf{d}_1} + \tilde{\mathbf{f}}_{\mathbf{d}_0}\big)\Big]\Big]\Big] \quad \text{(F. 23)}$$

We express the *relative prices contribution* to gross output in volume as follows, based on the previous definitions:

$$\boldsymbol{\rho} = \underbrace{\left(\breve{\mathbf{A}}^{\mathbf{p}} - \breve{\mathbf{A}}_{\mathbf{m}}{}^{\mathbf{p}}\right)}_{\substack{intermediate\\ demand\ relative\\ prices\ changes}} + \underbrace{\breve{\mathbf{c}}_{\mathbf{d}}^{\mathbf{p}} + \breve{\mathbf{k}}_{\mathbf{d}}^{\mathbf{p}} + \breve{\mathbf{g}}_{\mathbf{d}}^{\mathbf{p}} + \breve{\mathbf{e}}_{\mathbf{d}}^{\mathbf{p}}}_{\substack{final\ demand\\ relative\ prices\\ changes}} + \underbrace{\breve{\mathbf{x}}^{\mathbf{p}}}_{\substack{total\\ relative\ prices\\ changes}} + \underbrace{\breve{\mathbf{D}}^{\mathbf{p}}}_{\substack{market\ shares\\ relative\ prices\\ changes}} \qquad (F.\ 24)$$

APPENDIX G – LINKAGE INDICATORS

The basic synthesis indicators calculated from the impact matrix are the backward linkage and forward linkage, hereinafter referred to as BL and FL respectively, also known as Hirschman-Rasmussen.

The traditional linkages are calculated using the domestic impact matrix represented by the Leontief inverse ($\mathbf{Z} = (\mathbf{I} - \mathbf{A_d})^{-1}$), using the domestic input requirements ($\mathbf{A_d}$). However, here, we also propose using another impact matrix, calculated with the total inputs, formed by the domestic and the imported one. The extended Leontief inverse matrix ($\mathbf{Z_T}$) is:

$$\mathbf{Z_T} = (\mathbf{I} - \mathbf{A})^{-1} \qquad \textit{(G. 1)}$$

where $\mathbf{A} = \mathbf{A_d} + \mathbf{A_m}$, and $\mathbf{A_m}$ represents the imported inputs requirements.

The set of BL indicators is obtained from the impact matrix as follows:

$$\mathbf{bl} = \mathbf{i}'\mathbf{\Psi} \qquad \textit{(G. 2)}$$

where $\mathbf{\Psi}$ is a generic impact matrix and $\mathbf{i}$ is the unit vector which is summation operator denote the sum of the rows. According to Rasmussen (1956, p. 134), this indicator indicates “an estimate of the direct and indirect increase in output to be supplied by an industry chosen at random j (j = 1, n) increases by one unit”. By the other side, the expanded Leontief inverse would represent the *potential effect* in expansion in the need of inputs if the domestic demand were able to fulfill the all intermediate demand. This interpretation is posible because the imports in the input-output model are considered competitive.

The components of the vector $\mathbf{bl}$ are the BL indicators of an activity sector, that is:

$$\mathrm{bl_j} = \mathbf{i}'\mathbf{\Psi}\mathbf{e_j} = \sum\nolimits_{\mathbf{i}} \psi_{\mathbf{ij}} \qquad \textit{(G. 3)}$$

where $\mathbf{e_j}$ is the vector whose j-th component is equal to one and the other components have a null value. Thus, the indicator $\mathbf{bl_j}$ represents the impact of a unitary change in final demand by the production of one sector j on all sectors. This indicator allows visualize how much a sector is dependent on the rest of the economy, having the ability to measure the backward linkages needed to produce an additional unit of its product.

The FL indicators are given by:

$$\mathbf{fl} = \mathbf{\Psi}\mathbf{i} \qquad \textit{(G. 4).}$$

In the case of the domestic Leontief inverse matrix, as FL is the sum of the impact matrix columns, it shows how much activity must produce to satisfy an increase in the domestic final demand of all sectors of the economy. In this term, $\mathrm{fl}_\mathbf{i}$ it indicates how sensitive sector $\mathbf{i}$ is to the variations in demand of the economy and reveals the degree of the sector’s dependence on economy.

$$\mathrm{fl}_\mathbf{i} = \mathbf{e}'_\mathbf{i}\mathbf{\Psi}\mathbf{i} = \sum\nolimits_{\mathbf{j}} \psi_{\mathbf{ij}} \qquad \textit{(G. 5).}$$

The two basic indicators BL and FL presented above are sensitive to the number of activities present in the matrix, so they do not allow the comparison between matrices of different dimensions. One solution to this is calculating the BL and FL average, dividing the basic indicators by the number of sectors (n):

$$\overline{\mathrm{bl}}_\mathbf{j} = \left(\frac{1}{n}\right)\mathrm{bl}_\mathbf{j} \qquad \textit{(G. 6)}$$

$$\overline{\mathrm{fl}}_\mathbf{i} = \left(\frac{1}{n}\right)\mathrm{fl}_\mathrm{i} \qquad \textit{(G. 7)}$$

APPENDIX H –DECOMPOSITION FOR THE LABOR PRODUCTIVITY GROWTH

Here we briefly present the Generalized Exactly Additive Decomposition for the labor productivity growth, based on Diewert (2013). For applications to the Brazilian economy and reviews of other methods, see Fevereiro and Freitas (2015) and Kupfer and Miguez (2017).

We define the industry j labor productivity (Γ_{j_t}) as the share of sectoral real value added (volume units)($Y_{j_t}^v$) by the labor input in each sector, as follows (L_{j_t}):

$$\Gamma_{j_t} = \frac{Y_{j_t}^v}{L_{j_t}} \quad (H.\ 1)$$

where t indicates the year, and we will denote 0 for the initial year and 1 for the final year; j=1, 2…, J, which represents the number of sectors.

To proper aggregate the sectoral productivity to obtain the total's economy productivity, since each sector is measured in its own volume units, we need to weight the value added by their relative prices, so they can be comparable in real terms across periods.

The value added relative price is the relation of the sectoral price index ($Y_{j_t}^p$) in relation total deflator (Y_t^p). This way, the aggregated productivity (Γ_t) is:

$$\Gamma_t = \sum_{j=1}^{J} \frac{Y_{j_t}^p}{Y_t^p} \frac{Y_{j_t}^v}{L_t} \quad (H.\ 2)$$

where L_t is the *economy wide labor input.*
Defining the value added relative price (y_j^p) as follows:

$$y_j^p \equiv \frac{Y_{j_t}^p}{Y_t^p} \quad (H.\ 3),$$

the aggregated productivity can be rewritten as:

$$\Gamma_t = \sum_{j=1}^{J} y_j^p \frac{Y_{j_t}^v}{L_t} \quad (H.\ 4).$$

The economy wide labor input is the sum of the labor input in each sector, as follows:

$$L_t = \sum_{j=1}^{J} L_{j_t} \quad (H.\ 5).$$

Defining $s_{L_{j_t}}$ as the share of labor used by industry j in period t, we have:

$$s_{L_{j_t}} = \frac{L_{j_t}}{L_t} \quad (H.\ 6).$$

Multiplying and diving (H.5) by $\frac{L_{j_t}}{L_{j_t}}$ to express the total labor productivity as a function of sectoral productivity, we have:

$$\Gamma_t = \sum_{j=1}^{J} y_j^p \frac{L_{j_t}}{L_t} \frac{Y_{j_t}^v}{L_{j_t}} \quad (H.\ 7).$$

Putting ($s_{L_{j_t}}$) in the previous equation and defining $\Gamma_{j_t} = \frac{Y_{j_t}^v}{L_{j_t}}$ as the sectoral productivity in real terms, we have:

$$\Gamma_t = \sum_{j=1}^{J} y_{j_t}^p s_{L_{j_t}} \Gamma_{j_t} \quad (H.\ 8).$$

Diwert (2013) proposes an advance in the decomposition of Tang and Wang (2004) to "isolate the separate effects of changes in industry real output prices and industry labour input shares"(p.3). For that, they define the value added share of industry j in total value added for a period ($s_{Y_{j_t}}$), as the follow equation:

$$s_{Y_{j_t}} = \frac{Y_{j_t}^{p} Y_{j_t}^{v}}{\sum_{j=1}^{J} Y_t^p Y_t^v} = \frac{y_{j_t}^{p} Y_{j_t}^{v}}{\sum_{j=1}^{J} y_t^p Y_t^v} \quad (H.\ 9),$$

remembering that $y_j^p \equiv \frac{Y_{j_t}^p}{Y_t^p}$ and $y_t^p \equiv \frac{Y_t^p}{Y_t^p} \equiv 1$.

For a further step, Diewert (2013) notice that:

$$y_{j_t}^p s_{L_{j_t}} \Gamma_{j_t} = y_{j_t}^p \left(\frac{L_{j_t}}{L_t}\right)\left(\frac{Y_{j_t}^v}{L_{j_t}}\right) = y_{j_t}^p \frac{Y_{j_t}^v}{L_t} \quad (H.\ 10).$$

The *aggregate labor productivity growth* (plus 1) going from period 0 to 1, $\frac{\Gamma_1}{\Gamma_0}$ is equal to:

$$\frac{\Gamma_1}{\Gamma_0} = \frac{\sum_{j=1}^{J} y_{j_1}^p s_{L_{j_1}} \Gamma_{j_1}}{\sum_{j=1}^{J} y_{j_0}^p s_{L_{j_0}} \Gamma_{j_0}} \quad (H.\ 11).$$

Reorganizing, we have:

$$\frac{\Gamma_1}{\Gamma_0} = \frac{\sum_{j=1}^{J} \left(\frac{y_{j_1}^p}{y_{j_0}^p}\right)\left(\frac{s_{L_{j_1}}}{s_{L_{j_0}}}\right)\left(\frac{\Gamma_{j_1}}{\Gamma_{j_0}}\right)\left(\frac{y_{j_0}^p Y_{j_0}^v}{L_0}\right)}{\sum_{j=1}^{J}\left(\frac{y_0^p Y_0^v}{L_0}\right)} \quad (H.\ 12).$$

Using (H.10) in (H.12), we have:

$$\frac{\Gamma_1}{\Gamma_0} = \sum_{j=1}^{J} \left(\frac{y_{j_1}^p}{y_{j_0}^p}\right)\left(\frac{s_{L_{j_1}}}{s_{L_{j_0}}}\right)\left(\frac{\Gamma_{j_1}}{\Gamma_{j_0}}\right) s_{Y_{j_0}} \quad (H.\ 13).$$

Before analyzing the decomposition, Diewert (2013) define the aggregate labor productivity growth rate (G_t^Γ), the sectoral labor productivity growth rates (γ_j),the sectoral real output price growth rates (ρ_j) and the sectoral labor input share growth rates (σ_j) for periods 0 and 1 as:

$$G_t^\Gamma \equiv \left(\frac{\Gamma_1}{\Gamma_0}\right) - 1 \quad (H.\ 14)$$

$$\gamma_j \equiv \left(\frac{\Gamma_{j_1}}{\Gamma_{j_0}}\right) - 1 \quad (H.\ 15)$$

$$\rho_j \equiv \left(\frac{y_{j_1}^p}{y_{j_0}^p}\right) - 1 \quad (H.\ 16)$$

$$\sigma_j \equiv \left(\frac{s_{L_{j_1}}}{s_{L_{j_0}}}\right) - 1 \quad (H.\ 17)$$

Replacing the above equations in (H.13), we have:

$$G_t^\Gamma = \sum_{j=1}^{J} s_{Y_{j_0}} \{[1+\gamma_j][1+\rho_j][1+\sigma_j] - 1\} \quad (H.\ 18).$$

$$G_t^\Gamma = \sum_{j=1}^{J} s_{Y_{j_0}} \{\gamma_j + \rho_j + \sigma_j + \gamma_j\rho_j + \gamma_j\sigma_j + \rho_j\sigma_j + \gamma_j\rho_j\sigma_j\} \quad (H.\ 19).$$

Isolating the effets, Diewert (2013) proposes this final decomposition:

$$G_t^{\Gamma} = \overbrace{\sum_{j=1}^{J} s_{Y_{j_0}} \gamma_j}^{direct\ effect} + \overbrace{\sum_{j=1}^{J} s_{Y_{j_0}} \rho_n}^{price\ effect} + \overbrace{\sum_{j=1}^{J} s_{Y_{j_0}} \sigma_j}^{labor\ composition\ effect} + \left(\underbrace{\sum_{j=1}^{J} s_{Y_{j_0}} \gamma_j \rho_j + \sum_{j=1}^{J} s_{Y_{j_0}} \gamma_j \sigma_j + \sum_{j=1}^{J} s_{Y_{j_0}} \rho_j \sigma_j + \sum_{j=1}^{J} s_{Y_{j_0}} \gamma_j \rho_j \sigma_j}_{interactive\ effect} \right) \quad (H.\ 20).$$

The *direct effect* represents the growth in the labor productivity of industry *n*, considering that relative prices and labor composition remains unchanged. The *labor composition effect* consists in the changes in the impact of changes in the labor use structure. The *price effect* corresponds to the changes in the rate of growth in the real output price of industry n, when the labor composition and real sectoral labor productivity remains constant. And finally, the *interactive effect* is the effect of interaction terms, to guarantee the total decomposition consistency. We do not attribute any economic meaning to this term. It is important to notice that the price and the labor composition effects do not have a meaning in the analysis of isolated industry, because they are a result of changing proportions and relative prices among all industries. Hence, a positive effect for one industry corresponds to negative effect in one or more industries.

APPENDIX I – STRUCTURAL DECOMPOSITION ANALYSIS RESULTS

Table I. 1 – Annual contribution of volume and relative prices to gross output change for Brazil, 2000-2014

Sectors	VOLUME																						RELA-TIVE PRICES	TOTAL Gross output change
	Volume contribution															Relative prices contribution					Inven-tories	Total		
	Trade pattern						Technological change			Final demand				Market share	Total	Relative prices	Inter-mediate demand	Final demand	Market share	Total				
	Inter	Final				Sub-total	Total	Imports	Domestic															
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal											
Agriculture, fishing and related	0.00	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.00	0.00	0.07	0.01	0.08	0.16	0.00	0.15	0.03	-0.02	0.00	0.00	0.00	0.01	0.17	-0.03	0.14
MQC	-0.12	-0.02	-0.01	0.00	-0.04	-0.15	0.01	0.00	0.00	0.19	0.10	0.15	0.44	0.01	0.30	-0.15	0.15	-0.01	0.00	-0.01	0.01	0.30	0.14	0.44
AC	-0.03	-0.02	0.00	0.00	-0.02	-0.05	-0.02	0.00	-0.02	0.11	0.01	0.07	0.20	-0.01	0.12	-0.06	0.04	0.04	-0.01	0.01	0.00	0.13	0.06	0.19
TM	-0.05	-0.04	-0.01	0.00	-0.05	-0.10	-0.02	0.00	-0.01	0.09	0.04	0.01	0.15	0.00	0.03	-0.01	0.02	0.00	-0.01	0.00	-0.01	0.03	0.01	0.04
IM	-0.06	-0.06	-0.06	0.00	-0.12	-0.17	0.00	0.00	0.00	0.20	0.16	0.04	0.40	-0.01	0.21	0.04	0.05	-0.06	0.00	0.02	0.00	0.23	-0.04	0.19
Public utility	-0.01	0.00	0.00	0.00	-0.01	-0.01	0.02	0.00	0.02	0.07	0.01	0.01	0.09	0.01	0.11	0.04	-0.02	-0.02	0.00	-0.01	0.00	0.10	-0.03	0.07
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	0.01	0.22	-0.01	0.20	0.01	0.01	-0.02	0.00	0.00	0.00	0.20	-0.01	0.19
Trade, accommodation and food	-0.04	-0.03	-0.01	0.00	-0.04	-0.08	0.00	0.00	0.00	0.37	0.07	0.04	0.49	0.00	0.42	-0.22	0.12	0.09	0.01	0.00	0.00	0.41	0.20	0.62
Transport, storage and communication	-0.05	-0.02	-0.01	0.00	-0.03	-0.08	0.04	0.00	0.03	0.23	0.09	0.06	0.38	0.00	0.33	0.09	-0.01	-0.06	0.00	0.01	0.00	0.34	-0.09	0.25
Financial intermediation, insurance and real estate services	-0.01	-0.01	0.00	0.00	-0.01	-0.02	-0.01	0.00	-0.01	0.47	0.02	0.03	0.53	0.00	0.50	0.27	-0.08	-0.20	0.00	-0.01	0.00	0.49	-0.27	0.22
Community, social and personal services	-0.06	-0.02	-0.01	0.00	-0.03	-0.09	0.04	0.00	0.03	0.57	0.07	0.07	0.71	0.01	0.66	-0.07	0.00	0.08	-0.01	-0.01	0.00	0.65	0.06	0.71
Total	**-0.42**	**-0.24**	**-0.12**	**0.00**	**-0.35**	**-0.78**	**0.05**	**-0.01**	**0.05**	**2.41**	**0.78**	**0.57**	**3.75**	**0.02**	**3.04**	**-0.04**	**0.25**	**-0.16**	**-0.03**	**0.01**	**0.01**	**3.06**	**-0.01**	**3.05**

Source: Author's calculations based on information from the SNA/IBGE.

Table I. 2 – Annual contribution of volume and relative prices to gross output change for Brazil, 2000-2003

Sectors	VOLUME																						RELA-TIVE PRICES	TOTAL Gross output change
	Volume contribution															Relative prices contribution					Inven-tories	Total		
	Trade pattern						Technological change			Final demand				Market share	Total	Relative prices	Inter-mediate demand	Final demand	Market share	Total				
	Inter	Final				Sub-total	Total	Imports	Domestic															
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal											
Agriculture, fishing and related	0.00	0.10	0.00	0.00	0.10	0.11	-0.02	0.00	-0.01	-0.01	0.01	0.17	0.17	0.00	0.26	-0.16	0.12	-0.02	0.00	-0.06	0.11	0.31	0.16	0.47
MQC	0.13	0.02	0.00	0.00	0.02	0.15	0.03	-0.01	0.02	-0.06	-0.04	0.34	0.23	0.09	0.49	-0.70	0.39	0.15	-0.05	-0.21	0.01	0.30	0.69	0.98
AC	-0.19	0.00	0.00	0.00	0.00	-0.19	-0.02	0.01	-0.01	-0.07	-0.01	0.27	0.19	0.00	-0.01	-0.19	0.28	0.13	-0.01	0.21	-0.03	0.17	0.19	0.36
TM	-0.05	0.00	0.00	0.00	0.00	-0.05	-0.05	0.01	-0.04	-0.11	-0.02	0.07	-0.06	0.00	-0.15	-0.11	0.17	0.03	-0.01	0.07	-0.09	-0.16	0.11	-0.05
IM	-0.05	-0.02	0.01	0.00	-0.01	-0.06	-0.03	0.02	-0.01	-0.02	-0.06	0.10	0.01	-0.01	-0.07	-0.18	0.20	0.16	-0.01	0.17	-0.06	0.05	0.18	0.22
Public utility	-0.01	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.01	0.00	0.03	0.02	0.01	0.02	-0.05	0.07	0.00	0.00	0.01	-0.01	0.02	0.05	0.07
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	-0.15	0.00	-0.14	-0.02	-0.17	0.23	0.01	-0.24	0.00	0.01	0.00	-0.16	-0.23	-0.39
Trade, accommodation and food	-0.02	0.01	0.00	0.00	0.01	-0.01	-0.03	0.01	-0.02	-0.07	-0.02	0.07	-0.01	0.01	-0.04	-0.15	0.19	0.01	0.00	0.06	-0.01	0.01	0.15	0.15
Transport, storage and communication	-0.08	-0.02	-0.02	0.00	-0.03	-0.11	0.04	0.00	0.04	0.12	0.03	0.07	0.23	0.02	0.17	0.15	-0.05	0.00	-0.01	0.10	-0.02	0.26	-0.16	0.10
Financial intermediation, insurance and real estate services	-0.01	0.00	0.00	0.00	0.00	-0.01	-0.10	0.02	-0.09	0.26	-0.01	0.05	0.31	0.01	0.21	0.56	0.09	-0.57	-0.02	0.05	-0.01	0.25	-0.55	-0.30
Community, social and personal services	-0.05	-0.01	0.00	0.00	-0.01	-0.06	-0.09	0.01	-0.09	0.40	0.01	0.06	0.48	0.02	0.35	0.57	-0.05	-0.45	-0.02	0.05	-0.02	0.38	-0.57	-0.19
Total	**-0.33**	**0.08**	**0.00**	**0.00**	**0.08**	**-0.25**	**-0.28**	**0.08**	**-0.20**	**0.45**	**-0.27**	**1.23**	**1.41**	**0.11**	**1.07**	**-0.04**	**1.42**	**-0.79**	**-0.12**	**0.47**	**-0.12**	**1.42**	**0.02**	**1.44**

Source: Author's calculations based on information from the SNA/IBGE.

Table I. 3 – Annual contribution of volume and relative prices to gross output change for Brazil, 2003-2008

Sectors	VOLUME																						RELA-TIVE PRICES	TOTAL Gross output change
	Volume contribution															Relative prices contribution					Inven-tories	Total		
	Trade pattern						Technological change			Final demand				Market share	Total	Relative prices	Inter-mediate demand	Final demand	Market share	Total				
	Inter	Final				Sub-total	Total	Imports	Domestic															
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal											
Agriculture, fishing and related	0.00	-0.01	0.00	0.00	-0.01	-0.01	0.01	0.00	0.01	0.11	0.01	0.06	0.19	0.00	0.19	0.10	-0.08	-0.04	-0.01	-0.02	0.00	0.17	-0.10	0.07
MQC	-0.34	-0.04	-0.03	0.00	-0.07	-0.41	-0.04	0.00	-0.03	0.27	0.20	0.27	0.74	-0.01	0.28	-0.44	0.50	-0.03	0.01	0.04	0.07	0.39	0.43	0.82
AC	0.00	-0.02	0.00	0.00	-0.02	-0.02	-0.04	0.00	-0.04	0.20	0.02	0.09	0.31	0.01	0.25	0.02	0.00	-0.07	-0.02	-0.07	0.04	0.23	-0.02	0.21
TM	-0.05	-0.04	-0.02	0.00	-0.07	-0.12	-0.01	0.00	-0.01	0.17	0.10	0.04	0.30	0.01	0.19	0.07	-0.04	-0.07	-0.01	-0.06	0.07	0.20	-0.07	0.14
IM	-0.07	-0.07	-0.12	0.00	-0.19	-0.26	-0.02	0.00	-0.02	0.33	0.41	0.20	0.94	0.00	0.67	0.08	0.02	-0.19	0.01	-0.07	0.10	0.70	-0.09	0.61
Public utility	-0.01	0.00	0.00	0.00	-0.01	-0.02	0.02	0.00	0.02	0.10	0.02	0.02	0.15	0.00	0.14	0.06	-0.05	-0.02	0.00	-0.01	0.01	0.14	-0.06	0.08
Construction	0.00	0.00	0.00	0.00	0.00	-0.01	0.01	0.00	0.01	0.02	0.23	0.01	0.25	0.01	0.26	-0.01	0.02	-0.01	0.00	0.00	0.00	0.26	0.01	0.27
Trade, accommodation and food	-0.04	-0.02	-0.02	0.00	-0.04	-0.08	0.00	0.00	0.00	0.47	0.15	0.09	0.72	-0.01	0.63	-0.16	0.13	-0.02	0.01	-0.04	0.03	0.62	0.16	0.77
Transport, storage and communication	-0.07	-0.02	-0.01	0.00	-0.04	-0.10	0.01	0.00	0.00	0.23	0.13	0.20	0.56	0.00	0.46	-0.04	0.11	-0.13	-0.01	-0.07	0.02	0.41	0.04	0.45
Financial intermediation, insurance and real estate services	0.00	-0.01	-0.01	0.00	-0.01	-0.01	0.00	0.00	0.00	0.56	0.04	0.07	0.68	0.01	0.67	0.43	-0.18	-0.29	0.00	-0.03	0.01	0.64	-0.43	0.22
Community, social and personal services	-0.07	-0.01	-0.01	0.00	-0.03	-0.10	0.04	0.00	0.03	0.63	0.10	0.15	0.89	0.00	0.82	-0.15	0.02	0.08	0.00	-0.05	0.02	0.78	0.15	0.93
Total	**-0.67**	**-0.25**	**-0.24**	**0.00**	**-0.49**	**-1.16**	**-0.02**	**-0.01**	**-0.03**	**3.10**	**1.43**	**1.20**	**5.72**	**0.01**	**4.55**	**-0.04**	**0.46**	**-0.77**	**-0.02**	**-0.37**	**0.37**	**4.54**	**0.02**	**4.57**

Source: Author’s calculations based on information from the SNA/IBGE.

Table I. 4 – Annual contribution of volume and relative prices to gross output change for Brazil, 2010-2014

Sectors	VOLUME																						RELA-TIVE PRICES	TOTAL Gross output change
	Volume contribution															Relative prices contribution					Inven-tories	Total		
	Trade pattern						Technological change			Final demand				Market share	Total	Relative prices	Inter-mediate demand	Final demand	Market share	Total				
	Inter	Final				Sub-total	Total	Imports	Domestic															
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal											
Agriculture, fishing and related	0.00	0.00	0.00	0.00	0.00	-0.01	0.01	0.00	0.01	0.08	0.00	0.06	0.14	0.00	0.14	-0.01	-0.02	0.05	0.00	0.01	0.00	0.15	0.01	0.17
MQC	-0.02	-0.01	0.00	0.00	-0.01	-0.03	0.14	-0.04	0.10	0.28	0.06	0.03	0.37	-0.01	0.43	0.03	-0.08	-0.12	0.04	-0.13	0.00	0.29	-0.02	0.26
AC	-0.01	-0.01	0.00	0.00	-0.01	-0.02	0.00	0.00	0.00	0.10	0.01	0.01	0.11	-0.03	0.07	-0.14	0.00	0.11	-0.01	-0.03	-0.03	0.01	0.14	0.15
TM	-0.01	-0.02	0.00	0.00	-0.02	-0.03	0.03	-0.02	0.02	0.10	0.03	-0.02	0.12	-0.01	0.09	-0.01	-0.03	-0.03	0.00	-0.07	-0.04	-0.02	0.01	-0.01
IM	-0.01	-0.01	0.00	0.00	-0.01	-0.02	0.06	-0.03	0.03	0.16	0.04	-0.03	0.17	-0.01	0.17	0.14	-0.08	-0.20	-0.03	-0.16	-0.05	-0.04	-0.14	-0.19
Public utility	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.07	0.01	0.00	0.08	0.01	0.13	0.10	-0.06	-0.06	0.00	-0.02	0.00	0.11	-0.09	0.01
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.19	0.01	0.21	-0.01	0.19	0.05	0.00	-0.05	-0.01	0.00	0.00	0.19	-0.05	0.14
Trade, accommodation and food	-0.02	-0.03	0.00	0.00	-0.03	-0.04	0.05	-0.01	0.04	0.39	0.04	0.02	0.45	0.01	0.45	-0.24	0.03	0.13	0.01	-0.06	-0.01	0.38	0.24	0.62
Transport, storage and communication	0.00	-0.01	0.00	0.00	-0.01	-0.01	0.12	-0.01	0.11	0.26	0.08	0.00	0.34	-0.01	0.43	0.22	-0.12	-0.14	0.00	-0.04	-0.01	0.38	-0.22	0.16
Financial intermediation, insurance and real estate services	-0.01	0.00	0.00	0.00	0.00	-0.01	0.07	-0.01	0.06	0.29	0.01	0.00	0.30	-0.01	0.35	0.02	-0.08	0.03	0.01	-0.02	0.00	0.32	-0.02	0.30
Community, social and personal services	-0.01	-0.01	0.00	0.00	-0.01	-0.02	0.14	-0.02	0.12	0.45	0.03	0.02	0.50	0.02	0.62	-0.18	-0.05	0.17	0.00	-0.06	-0.01	0.55	0.18	0.72
Total	**-0.09**	**-0.11**	**0.00**	**0.00**	**-0.11**	**-0.20**	**0.66**	**-0.14**	**0.52**	**2.19**	**0.50**	**0.11**	**2.79**	**-0.05**	**3.06**	**-0.04**	**-0.47**	**-0.10**	**0.02**	**-0.58**	**-0.17**	**2.31**	**0.02**	**2.33**

Source: Author’s calculations based on information from the SNA/IBGE.

Table I. 5 – Share of the contributions in the total gross output growth, 2000-2014

Sectors	VOLUME																						RELATIVE PRICES	TOTAL Gross output change
	Volume Contribution															Relative prices Contribution					Inventories	Total		
	Trade pattern						Technological change			Final demand				Market share	Total	Relative prices	Interme-diate demand	Final deman d	Market share	Total				
	Inter	Final				Subtotal	Total	Imports	Domestic															
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal											
Agriculture, fishing and related	-0.12	-0.24	-0.02	0.00	-0.26	-0.38	0.00	0.00	-0.01	2.37	0.24	2.73	5.34	-0.01	4.95	0.86	-0.64	0.08	-0.14	0.15	0.33	5.43	-0.88	4.55
MQC	-3.81	-0.81	-0.44	0.00	-1.25	-5.06	0.24	-0.08	0.16	6.37	3.16	4.86	14.39	0.43	9.92	-5.00	4.78	-0.21	0.08	-0.36	0.19	9.74	4.70	14.44
AC	-0.97	-0.63	-0.08	0.00	-0.71	-1.67	-0.61	0.03	-0.57	3.75	0.39	2.26	6.40	-0.21	3.95	-2.05	1.29	1.38	-0.42	0.21	0.01	4.17	1.98	6.15
TM	-1.54	-1.23	-0.40	0.00	-1.64	-3.18	-0.51	0.03	-0.48	3.10	1.46	0.21	4.77	-0.01	1.11	-0.27	0.56	-0.04	-0.18	0.07	-0.28	0.89	0.26	1.15
IM	-1.85	-1.91	-1.87	0.00	-3.78	-5.63	-0.11	0.02	-0.09	6.65	5.16	1.17	12.97	-0.43	6.82	1.32	1.50	-1.96	-0.06	0.81	0.03	7.67	-1.40	6.27
Public utility	-0.22	-0.12	-0.06	0.00	-0.18	-0.40	0.71	-0.03	0.67	2.31	0.36	0.37	3.05	0.19	3.51	1.17	-0.68	-0.64	-0.02	-0.18	-0.02	3.31	-1.15	2.16
Construction	-0.13	-0.02	-0.01	0.00	-0.03	-0.16	-0.03	0.00	-0.03	0.47	6.35	0.24	7.06	-0.17	6.69	0.33	0.41	-0.80	0.07	0.00	0.00	6.69	-0.34	6.35
Trade, accommodation and food	-1.18	-1.05	-0.27	0.00	-1.32	-2.50	0.05	0.01	0.06	12.03	2.45	1.47	15.94	0.12	13.62	-7.05	3.80	2.92	0.23	-0.10	0.04	13.56	6.66	20.22
Transport, storage and communication	-1.61	-0.72	-0.35	0.00	-1.07	-2.68	1.16	-0.05	1.11	7.53	2.91	1.91	12.35	0.02	10.80	2.83	-0.28	-1.98	-0.10	0.47	-0.02	11.25	-2.99	8.26
Financial intermediation, insurance and real estate services	-0.34	-0.25	-0.11	0.00	-0.36	-0.70	-0.25	-0.01	-0.27	15.50	0.80	1.05	17.36	0.13	16.53	8.82	-2.54	-6.58	-0.02	-0.31	-0.03	16.18	-8.97	7.22
Community, social and personal services	-2.11	-0.71	-0.23	0.00	-0.95	-3.06	1.15	-0.08	1.07	18.82	2.17	2.23	23.23	0.48	21.72	-2.39	0.02	2.54	-0.48	-0.31	-0.03	21.39	1.84	23.23
Total	**-13.88**	**-7.70**	**-3.84**	**0.00**	**-11.53**	**-25.41**	**1.79**	**-0.17**	**1.62**	**78.90**	**25.44**	**18.50**	**122.84**	**0.55**	**99.60**	**-1.43**	**8.20**	**-5.28**	**-1.03**	**0.45**	**0.23**	**#####**	**-0.28**	**100.00**

Source: Author's calculations based on information from the SNA/IBGE.

Table I. 6 – Share of the contributions in the total gross output growth, 2000-2003

Sectors	VOLUME																						RELATIVE PRICES	TOTAL Gross output change
	Volume Contribution															Relative prices Contribution					Inventories	Total		
	Trade pattern						Technological change			Final demand				Market share	Total	Relative prices	Interme-diate demand	Final deman d	Market share	Total				
	Inter	Final				Subtotal	Total	Imports	Domestic															
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal											
Agriculture, fishing and related	0.24	7.08	0.04	0.00	7.11	7.36	-1.13	0.23	-0.90	-0.59	0.44	11.74	11.59	0.08	18.12	-11.37	8.28	-1.24	0.14	-4.18	7.38	21.32	11.24	32.56
MQC	8.87	1.16	0.14	0.00	1.30	10.17	1.92	-0.36	1.56	-4.25	-2.88	23.44	16.32	6.15	34.20	-48.44	26.94	10.65	-3.50	-14.36	0.71	20.56	47.85	68.41
AC	-13.05	-0.11	0.02	0.00	-0.10	-13.15	-1.39	0.49	-0.90	-5.04	-0.37	18.46	13.05	0.08	-0.91	-13.01	19.36	9.28	-0.92	14.70	-1.84	11.95	12.94	24.90
TM	-3.52	0.13	0.09	0.00	0.22	-3.30	-3.74	1.00	-2.75	-7.47	-1.66	5.18	-3.95	-0.07	-10.08	-7.98	11.81	2.11	-0.91	5.02	-6.23	-11.29	7.93	-3.36
IM	-3.41	-1.40	0.74	0.00	-0.66	-4.07	-2.36	1.67	-0.69	-1.61	-4.32	6.95	1.02	-0.99	-4.73	-12.59	14.06	10.90	-0.48	11.89	-3.99	3.17	12.38	15.54
Public utility	-0.88	0.20	0.01	0.00	0.21	-0.67	0.30	0.01	0.31	-0.55	-0.30	2.06	1.21	0.40	1.25	-3.49	4.82	-0.13	-0.30	0.89	-0.50	1.63	3.33	4.97
Construction	-0.04	-0.01	-0.02	0.00	-0.02	-0.06	0.15	-0.01	0.14	0.55	-10.34	-0.23	-10.02	-1.67	-11.60	15.91	0.87	-16.50	0.14	0.43	-0.07	-11.24	-15.85	-27.09
Trade, accommodation and food	-1.29	0.42	0.05	0.00	0.48	-0.82	-2.13	0.39	-1.74	-4.68	-1.44	5.13	-0.98	0.86	-2.68	-10.30	13.05	0.89	0.20	3.84	-0.75	0.42	10.12	10.54
Transport, storage and communication	-5.48	-1.07	-1.13	0.00	-2.21	-7.69	2.75	0.17	2.92	8.62	2.02	5.06	15.70	1.10	12.03	10.63	-3.24	0.21	-0.59	7.02	-1.09	17.95	-10.82	7.13
Financial intermediation, insurance and real estate services	-0.97	0.07	-0.02	0.00	0.06	-0.92	-7.29	1.11	-6.18	18.41	-0.56	3.36	21.22	0.42	14.54	38.57	6.19	-39.83	-1.28	3.65	-0.61	17.58	-38.19	-20.61
Community, social and personal services	-3.58	-0.63	-0.08	0.00	-0.71	-4.30	-6.58	0.65	-5.93	27.78	0.80	4.43	33.01	1.37	24.15	39.31	-3.37	-31.46	-1.07	3.41	-1.10	26.47	-39.46	-12.99
Total	**-23.11**	**5.85**	**-0.18**	**0.00**	**5.67**	**-17.44**	**####**	**5.37**	**-14.14**	**31.18**	**-18.61**	**85.59**	**98.16**	**7.72**	**74.29**	**-2.75**	**98.76**	**-55.11**	**-8.57**	**32.33**	**-8.09**	**98.53**	**1.47**	**100.00**

Source: Author's calculations based on information from the SNA/IBGE.

Table I. 7 – Share of the contributions in the total gross output growth, 2003-2008

Sectors	VOLUME																						RELATIVE PRICES	TOTAL Gross output change
	Volume Contribution															**Relative prices Contribution**					Inventories	Total		
	Trade pattern						Technological change			Final demand				Market share	**Total**	Relative prices	Interme-diate demand	Final deman d	Market share	**Total**				
	Inter	Final				Subtotal	Total	Imports	Domestic	Cons	GFCF	Ext	Subtotal											
		Cons	GFCF	Ext	Subtotal																			
Agriculture, fishing and related	-0.04	-0.25	-0.03	0.00	-0.28	-0.32	0.25	0.00	0.25	2.52	0.29	1.41	4.22	0.01	4.16	2.25	-1.69	-0.80	-0.14	-0.39	-0.03	3.74	-2.24	1.49
MQC	-7.53	-0.78	-0.72	0.00	-1.50	-9.03	-0.86	0.10	-0.76	5.87	4.45	5.91	16.22	-0.30	6.13	-9.69	11.05	-0.67	0.21	0.88	1.58	8.60	9.42	18.02
AC	-0.01	-0.42	-0.10	0.00	-0.53	-0.54	-0.82	0.00	-0.82	4.30	0.54	1.90	6.74	0.19	5.58	0.37	-0.01	-1.48	-0.43	-1.55	0.97	4.99	-0.37	4.62
TM	-1.16	-0.95	-0.54	0.00	-1.48	-2.64	-0.12	-0.03	-0.15	3.70	2.10	0.86	6.66	0.23	4.09	1.49	-0.94	-1.49	-0.27	-1.21	1.59	4.47	-1.49	2.98
IM	-1.44	-1.52	-2.63	0.00	-4.16	-5.60	-0.42	0.00	-0.41	7.27	9.07	4.33	20.66	-0.01	14.64	1.83	0.51	-4.07	0.19	-1.53	2.17	15.28	-1.87	13.41
Public utility	-0.27	-0.09	-0.08	0.00	-0.17	-0.44	0.36	-0.01	0.35	2.23	0.50	0.46	3.20	0.02	3.12	1.36	-1.16	-0.38	-0.02	-0.20	0.16	3.08	-1.34	1.74
Construction	-0.11	-0.01	-0.01	0.00	-0.03	-0.14	0.16	0.00	0.15	0.35	4.94	0.25	5.55	0.16	5.72	-0.17	0.42	-0.28	0.03	0.00	0.02	5.75	0.16	5.91
Trade, accommodation and food	-0.95	-0.54	-0.36	0.00	-0.89	-1.84	0.05	0.00	0.05	10.34	3.37	1.94	15.66	-0.16	13.71	-3.48	2.92	-0.49	0.24	-0.80	0.57	13.48	3.41	16.89
Transport, storage and communication	-1.44	-0.53	-0.28	0.00	-0.81	-2.25	0.11	-0.03	0.08	5.14	2.78	4.27	12.19	-0.03	9.99	-0.95	2.44	-2.85	-0.15	-1.50	0.46	8.95	0.92	9.86
Financial intermediation, insurance and real estate services	-0.01	-0.16	-0.14	0.00	-0.31	-0.32	-0.02	-0.07	-0.08	12.34	0.96	1.53	14.83	0.19	14.62	9.31	-3.88	-6.26	0.06	-0.76	0.20	14.05	-9.33	4.72
Community, social and personal services	-1.61	-0.32	-0.26	0.00	-0.58	-2.19	0.82	-0.08	0.73	13.81	2.26	3.32	19.38	-0.07	17.86	-3.27	0.44	1.83	-0.09	-1.10	0.40	17.16	3.19	20.35
Total	**-14.59**	**-5.58**	**-5.16**	**0.00**	**-10.74**	**-25.32**	**-0.48**	**-0.12**	**-0.60**	**67.88**	**31.25**	**26.18**	**125.31**	**0.23**	**99.62**	**-0.96**	**10.10**	**-16.92**	**-0.39**	**-8.17**	**8.09**	**99.54**	**0.46**	**100.00**

Source: Author's calculations based on information from the SNA/IBGE.

Table I. 8 – Share of the contributions in the total gross output growth, 2000-2014

Sectors	VOLUME																						RELATIVE PRICES	TOTAL Gross output change
	Volume Contribution															**Relative prices Contribution**					Inventories	Total		
	Trade pattern						Technological change			Final demand				Market share	**Total**	Relative prices	Interme-diate demand	Final deman d	Market share	**Total**				
	Inter	Final				Subtotal	Total	Imports	Domestic	Cons	GFCF	Ext	Subtotal											
		Cons	GFCF	Ext	Subtotal																			
Agriculture, fishing and related	-0.04	-0.25	-0.03	0.00	-0.28	-0.32	0.25	0.00	0.25	2.52	0.29	1.41	4.22	0.01	4.16	2.25	-1.69	-0.80	-0.14	-0.39	-0.03	3.74	-2.24	1.49
MQC	-7.53	-0.78	-0.72	0.00	-1.50	-9.03	-0.86	0.10	-0.76	5.87	4.45	5.91	16.22	-0.30	6.13	-9.69	11.05	-0.67	0.21	0.88	1.58	8.60	9.42	18.02
AC	-0.01	-0.42	-0.10	0.00	-0.53	-0.54	-0.82	0.00	-0.82	4.30	0.54	1.90	6.74	0.19	5.58	0.37	-0.01	-1.48	-0.43	-1.55	0.97	4.99	-0.37	4.62
TM	-1.16	-0.95	-0.54	0.00	-1.48	-2.64	-0.12	-0.03	-0.15	3.70	2.10	0.86	6.66	0.23	4.09	1.49	-0.94	-1.49	-0.27	-1.21	1.59	4.47	-1.49	2.98
IM	-1.44	-1.52	-2.63	0.00	-4.16	-5.60	-0.42	0.00	-0.41	7.27	9.07	4.33	20.66	-0.01	14.64	1.83	0.51	-4.07	0.19	-1.53	2.17	15.28	-1.87	13.41
Public utility	-0.27	-0.09	-0.08	0.00	-0.17	-0.44	0.36	-0.01	0.35	2.23	0.50	0.46	3.20	0.02	3.12	1.36	-1.16	-0.38	-0.02	-0.20	0.16	3.08	-1.34	1.74
Construction	-0.11	-0.01	-0.01	0.00	-0.03	-0.14	0.16	0.00	0.15	0.35	4.94	0.25	5.55	0.16	5.72	-0.17	0.42	-0.28	0.03	0.00	0.02	5.75	0.16	5.91
Trade, accommodation and food	-0.95	-0.54	-0.36	0.00	-0.89	-1.84	0.05	0.00	0.05	10.34	3.37	1.94	15.66	-0.16	13.71	-3.48	2.92	-0.49	0.24	-0.80	0.57	13.48	3.41	16.89
Transport, storage and communication	-1.44	-0.53	-0.28	0.00	-0.81	-2.25	0.11	-0.03	0.08	5.14	2.78	4.27	12.19	-0.03	9.99	-0.95	2.44	-2.85	-0.15	-1.50	0.46	8.95	0.92	9.86
Financial intermediation, insurance and real estate services	-0.01	-0.16	-0.14	0.00	-0.31	-0.32	-0.02	-0.07	-0.08	12.34	0.96	1.53	14.83	0.19	14.62	9.31	-3.88	-6.26	0.06	-0.76	0.20	14.05	-9.33	4.72
Community, social and personal services	-1.61	-0.32	-0.26	0.00	-0.58	-2.19	0.82	-0.08	0.73	13.81	2.26	3.32	19.38	-0.07	17.86	-3.27	0.44	1.83	-0.09	-1.10	0.40	17.16	3.19	20.35
Total	**-14.59**	**-5.58**	**-5.16**	**0.00**	**-10.74**	**-25.32**	**-0.48**	**-0.12**	**-0.60**	**67.88**	**31.25**	**26.18**	**125.31**	**0.23**	**99.62**	**-0.96**	**10.10**	**-16.92**	**-0.39**	**-8.17**	**8.09**	**99.54**	**0.46**	**100.00**

Source: Author's calculations based on information from the SNA/IBGE.

Table I. 9 – Annual contribution to gross output change for Brazil, 2000-2014 (Traditional decomposition)

Sectors	Trade pattern						Technological change			Final demand				Market share	Inventories	**TOTAL GROSS OUTPUT**
	Inter	Final				Subtotal	Matrix A	Imports	Subtotal							
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal			
Agriculture, fishing and related	0.02	0.00	0.00	0.00	0.00	0.02	-0.03	-0.02	-0.05	0.08	0.00	0.08	0.16	0.00	0.01	0.14
MQC	0.18	-0.01	-0.01	0.00	-0.02	0.16	0.10	-0.25	-0.15	0.16	0.09	0.15	0.41	0.02	0.01	0.44
AC	0.03	-0.01	0.00	0.00	-0.01	0.03	-0.01	-0.03	-0.04	0.16	0.01	0.06	0.22	-0.02	0.00	0.19
TM	0.05	-0.02	-0.01	0.00	-0.03	0.03	-0.04	-0.06	-0.10	0.08	0.04	0.00	0.12	-0.01	-0.01	0.04
IM	0.13	-0.02	-0.03	0.00	-0.06	0.07	-0.03	-0.12	-0.14	0.12	0.15	0.00	0.28	-0.01	0.00	0.19
Public utility	0.03	0.00	0.00	0.00	0.00	0.02	-0.01	-0.02	-0.03	0.05	0.01	0.01	0.07	0.00	0.00	0.07
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.17	0.00	0.19	0.00	0.00	0.19
Trade, accommodation and food	0.05	-0.01	0.00	0.00	-0.02	0.03	0.08	-0.06	0.03	0.43	0.08	0.03	0.55	0.01	0.00	0.62
Transport, storage and communication	0.05	-0.01	-0.01	0.00	-0.01	0.04	-0.02	-0.06	-0.08	0.18	0.07	0.04	0.29	0.00	0.00	0.25
Financial intermediation, insurance and real estate services	0.07	0.00	0.00	0.00	-0.01	0.07	-0.12	-0.05	-0.17	0.27	0.02	0.02	0.32	0.00	0.00	0.22
Community, social and personal services	0.05	-0.01	0.00	0.00	-0.01	0.03	-0.01	-0.07	-0.08	0.66	0.06	0.04	0.76	0.00	0.00	0.71
Total	**0.67**	**-0.10**	**-0.07**	**0.00**	**-0.17**	**0.50**	**-0.06**	**-0.74**	**-0.80**	**2.21**	**0.73**	**0.43**	**3.36**	**-0.01**	**0.01**	**3.05**

Source: Own elaboration based on the IOT in 2010's constant prices constructed in this work.

Table I. 10 – Annual contribution to gross output change for Brazil, 2000-2003 (Traditional decomposition)

Sectors	Trade pattern						Technological change			Final demand				Market share	Inventories	**TOTAL GROSS OUTPUT**
	Inter	Final				Subtotal	Matrix A	Imports	Subtotal							
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal			
Agriculture, fishing and related	0.13	0.01	0.00	0.00	0.01	0.13	0.11	-0.13	-0.02	0.02	0.01	0.21	0.25	0.00	0.11	0.47
MQC	1.18	0.01	0.00	0.00	0.01	1.19	0.50	-1.14	-0.64	-0.03	-0.10	0.52	0.39	0.04	0.01	0.98
AC	0.17	0.01	0.00	0.00	0.01	0.18	0.08	-0.17	-0.09	-0.02	-0.01	0.34	0.31	-0.01	-0.03	0.36
TM	0.34	0.01	0.00	0.00	0.01	0.35	0.09	-0.35	-0.26	-0.16	-0.03	0.15	-0.04	-0.01	-0.09	-0.05
IM	0.68	0.02	0.01	0.00	0.03	0.70	0.12	-0.66	-0.53	-0.06	0.00	0.19	0.14	-0.02	-0.06	0.22
Public utility	0.11	0.00	0.00	0.00	0.00	0.11	0.06	-0.12	-0.05	-0.02	-0.01	0.05	0.02	0.00	-0.01	0.07
Construction	0.02	0.00	0.00	0.00	0.00	0.02	0.01	-0.02	-0.01	0.00	-0.38	0.00	-0.38	-0.02	0.00	-0.39
Trade, accommodation and food	0.25	0.01	0.00	0.00	0.01	0.26	0.13	-0.24	-0.11	-0.12	-0.01	0.12	-0.01	0.02	-0.01	0.15
Transport, storage and communication	0.24	0.00	-0.01	0.00	-0.02	0.23	-0.05	-0.28	-0.33	0.07	-0.01	0.15	0.21	0.01	-0.02	0.10
Financial intermediation, insurance and real estate services	0.35	0.00	0.00	0.00	0.00	0.35	-0.06	-0.30	-0.36	-0.33	-0.02	0.08	-0.26	-0.01	-0.01	-0.30
Community, social and personal services	0.28	0.00	0.00	0.00	0.00	0.28	-0.16	-0.32	-0.47	-0.07	-0.03	0.12	0.01	0.00	-0.02	-0.19
Total	**3.74**	**0.06**	**0.00**	**0.00**	**0.06**	**3.80**	**0.83**	**-3.71**	**-2.87**	**-0.71**	**-0.58**	**1.93**	**0.64**	**-0.01**	**-0.12**	**1.44**

Source: Own elaboration based on the IOT in 2010's constant prices constructed in this work.

Table I. 11 – Annual contribution to gross output change for Brazil, 2003-2008 (Traditional decomposition)

Sectors	Trade pattern						Technological change			Final demand				Market share	Inventories	**TOTAL GROSS OUTPUT**
	Inter	Final				Subtotal	Matrix A	Imports	Subtotal							
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal			
Agriculture, fishing and related	0.07	0.00	0.00	0.00	0.00	0.07	-0.08	-0.06	-0.14	0.11	0.01	0.03	0.15	-0.01	0.00	0.07
MQC	0.56	-0.02	-0.02	0.00	-0.04	0.53	0.30	-0.74	-0.45	0.22	0.21	0.24	0.67	0.00	0.07	0.82
AC	0.11	0.00	0.00	0.00	0.00	0.11	-0.06	-0.09	-0.15	0.20	0.02	0.00	0.22	-0.01	0.04	0.21
TM	0.19	-0.02	-0.01	0.00	-0.04	0.16	-0.12	-0.18	-0.30	0.16	0.09	-0.04	0.20	0.00	0.07	0.14
IM	0.41	-0.04	-0.07	0.00	-0.10	0.31	-0.13	-0.34	-0.47	0.22	0.42	0.03	0.67	0.01	0.10	0.61
Public utility	0.07	0.00	0.00	0.00	0.00	0.07	-0.06	-0.06	-0.12	0.09	0.02	0.01	0.12	0.00	0.01	0.08
Construction	0.01	0.00	0.00	0.00	0.00	0.01	0.02	-0.01	0.01	0.02	0.22	0.00	0.24	0.01	0.00	0.27
Trade, accommodation and food	0.15	-0.01	-0.01	0.00	-0.02	0.13	0.08	-0.14	-0.06	0.48	0.17	0.02	0.67	0.00	0.03	0.77
Transport, storage and communication	0.20	-0.01	0.00	0.00	-0.01	0.19	0.04	-0.19	-0.15	0.22	0.14	0.05	0.40	-0.01	0.02	0.45
Financial intermediation, insurance and real estate services	0.17	0.00	0.00	0.00	-0.01	0.16	-0.22	-0.12	-0.34	0.31	0.05	0.02	0.38	0.01	0.01	0.22
Community, social and personal services	0.22	0.00	-0.01	0.00	-0.01	0.21	-0.03	-0.21	-0.24	0.78	0.11	0.05	0.95	-0.01	0.02	0.93
Total	**2.17**	**-0.10**	**-0.12**	**0.00**	**-0.23**	**1.94**	**-0.25**	**-2.16**	**-2.41**	**2.82**	**1.45**	**0.41**	**4.67**	**-0.01**	**0.37**	**4.57**

Source: Own elaboration based on the IOT in 2010's constant prices constructed in this work.

Table I. 12 – Annual contribution to gross output change for Brazil, 2010-2014 (Traditional decomposition)

Sectors	Trade pattern						Technological change			Final demand				Market share	Inventories	**TOTAL GROSS OUTPUT**
	Inter	Final				Subtotal	Matrix A	Imports	Subtotal							
		Cons	GFCF	Ext	Subtotal					Cons	GFCF	Ext	Subtotal			
Agriculture, fishing and related	0.05	-0.01	0.00	0.00	-0.01	0.04	0.00	-0.05	-0.06	0.10	-0.01	0.10	0.19	-0.01	0.00	0.17
MQC	0.70	-0.01	-0.01	0.00	-0.02	0.68	0.17	-0.87	-0.69	0.18	0.02	0.05	0.25	0.03	0.00	0.26
AC	0.07	-0.01	0.00	0.00	-0.01	0.06	0.01	-0.09	-0.08	0.20	0.00	0.03	0.23	-0.03	-0.03	0.15
TM	0.16	-0.02	0.00	0.00	-0.03	0.13	0.03	-0.21	-0.18	0.07	0.01	0.01	0.09	-0.01	-0.04	-0.01
IM	0.30	-0.02	-0.02	0.00	-0.04	0.26	0.01	-0.36	-0.35	0.04	-0.03	-0.01	0.00	-0.04	-0.05	-0.19
Public utility	0.06	0.00	0.00	0.00	0.00	0.05	-0.02	-0.06	-0.08	0.02	0.00	0.00	0.03	0.01	0.00	0.01
Construction	0.01	0.00	0.00	0.00	0.00	0.01	0.00	-0.01	-0.02	0.01	0.14	0.01	0.16	-0.01	0.00	0.14
Trade, accommodation and food	0.14	-0.03	0.00	0.00	-0.03	0.11	0.09	-0.18	-0.09	0.53	0.03	0.03	0.59	0.02	-0.01	0.62
Transport, storage and communication	0.16	-0.01	0.00	0.00	-0.02	0.14	0.03	-0.20	-0.17	0.13	0.05	0.02	0.21	-0.01	-0.01	0.16
Financial intermediation, insurance and real estate services	0.09	0.00	0.00	0.00	0.00	0.09	-0.01	-0.11	-0.12	0.32	0.01	0.01	0.34	0.00	0.00	0.30
Community, social and personal services	0.23	-0.02	0.00	0.00	-0.02	0.21	0.13	-0.29	-0.17	0.62	0.02	0.03	0.67	0.02	-0.01	0.72
Total	**1.96**	**-0.13**	**-0.04**	**0.00**	**-0.18**	**1.78**	**0.44**	**-2.44**	**-2.00**	**2.21**	**0.24**	**0.30**	**2.75**	**-0.03**	**-0.17**	**2.33**

Source: Own elaboration based on the IOT in 2010's constant prices constructed in this work.