Tracing Brazilian regions' CO2 emissions in domestic and global trade

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The current Brazilian position on climate change has been formalized with the law of National Climate Change Policy (PNMC, in Portuguese), established in December 2009, which provides a legal framework for national actions aimed at mitigation and adaptation. Within PNMC, the country has defined its national voluntary reduction targets for greenhouse gases emissions, with reductions between 36.1% and 38.9% of projected emissions by 2020. The distribution of the corresponding mitigation efforts by regions is of great concern in a large country like Brazil, with substantial regional variation in economic development, physical geography, production system, and energy consumption. In fact, most of Brazilian states have established public policies on climate change. Out of the 27 states, four have mandatory targets for reducing greenhouse gas emissions: São Paulo and Rio de Janeiro, in the most developed Southeast region; Mato Grosso do Sul, in the Central-West region; as well as Paraíba, in the Northeast region. In this context, questions raised in the literature on global climate change, such as the environmental responsibility for emissions embodied in trade, also apply at the regional level, and perhaps even to a larger extent. In order to analyze at regional level the current relationship between Brazil's CO2 emissions and domestic and global value chains, in this study we adopt a new framework that combines a world input-output table (WIOT) with an inter-regional input-output table (IRIOT). In our approach, we have chosen not to take one of the datasets (say the WIOT) as a starting point and adapt the other dataset (i.e. the IRIOT) accordingly, instead we construct input coefficients for which both datasets are used. For the empirical application, we use the WIOT for 2008 that was constructed in the World Input-Output Database (WIOD) project. It is a full inter-country input-output table covering 40 countries and the rest of the world as a 41st country. Our IRIOT for 2008 covers the 27 Brazilian states. Both the WIOT and the IRIOT were aggregated to 28 compatible industries. Also, a new database is compiled on Brazilian states' energy use (by fuel) and related CO2 emissions at sectoral level, based on states' official energy balances. We are able to evaluate the CO2 emissions in each of the 27 Brazilian states, considering their respective intra-regional productive structure, energy use, as well as their trade with other states or foreign countries. In this way, our results reveal how CO2 emissions are produced in Brazilian regions by means of domestic and global value chains.

Keywords: CO2 emissions, input-output analysis, global value chains
JEL Codes: Q56, C67, R15

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1. Introduction

The Brazilian position on climate change has been formalized with the law of National Climate Change Policy (PNMC, in Portuguese – Law nº 12 187, dated December 29th, 2009) which provides a legal framework for national actions aimed at mitigation and adaptation. Within PNMC, the country has defined its national voluntary reduction targets for greenhouse gases emissions, with reductions between 36.1% and 38.9% of projected emissions by 2020. As indicated by Seroa da Motta (2011), sectoral mitigation percentages were adopted in the correspondence from Brazil for the Copenhagen Accord in 2010: out of the 38.9% national target, deforestation would be reduced by 24.7%, and the remaining 15.2% would be divided between energy use (7.7%), agriculture and cattle raising (6.1%), and other sectors (0.4%).

The distribution of the corresponding mitigation efforts by regions is of great concern in a large country like Brazil, with substantial regional variation in economic development, physical geography, production system, and energy consumption. In fact, most of Brazilian states have established public policies on climate change. According to NESA-USP, as of February 2015, out of the 27 states 16 have established policies and four are underway, having initiated draft legislation. Four states have mandatory targets for reducing greenhouse gas emissions: São Paulo and Rio de Janeiro, in the most developed Southeast region; Mato Grosso do Sul, in the Central-West region; as well as Paraíba, in the Northeast region. There are also advancements in municipal climate change policies, the two most populous cities, São Paulo and Rio de Janeiro, have established mandatory targets. The table below summarizes the targets established by federal, state, and municipal laws related to climate change.

Table 1. Subnational policies with mandatory targets for reducing greenhouse gas emissions

Government level	Policy	Law	Targets	Baseline
Federal	National Policy on Climate Change	nº 12 187 / 2009	36.1% and 38.9%	Projected emissions by 2020
State	State Policy on Climate Change of São Paulo	nº 13 798 / 2009	20% by 2020	Based on the inventory of 2005
	State Policy on Climate Change of Rio de Janeiro	Decreto nº 43 216 / 2011	Reducing emissions intensity (tCO2e / GDP) by 2030	Based on the inventory of 2005
	State Policy on Climate Change of Paraíba	nº 9 336 / 2011	36.1% and 38.9%	Projected emissions by 2020
	State Policy on Climate Change of Mato Grosso do Sul	nº 4.555 / 2014	20% by 2020	Based on the inventory 2005
Municipal	Municipal Policy on Climate Change of São Paulo	nº 14 933 / 2009	30% by 2012	Based on the inventory of 2005
	Municipal Policy on Climate Change of Rio de Janeiro	nº 5.248 / 2011	8% by 2012, 16% by 2016, 20% by 2020	Based on the inventory of 2005

Source: Romeiro and Parente (2011); NESA (2015).

Although these policies indicate advances toward a less intensive effect on climate change, there is room for improvement in the regulatory aspects. According to Romeiro and Parente (2011) the main obstacles include the lack of convergence of actions implemented in the various states in Brazil. There are distinct targets and strategies in the three spheres of the country – federal, state and municipal – which makes the standardization of mitigation measures and its respective monitoring more difficult and less effective.

It is also noticeable that policy settings within all levels of government fail to consider many important aspects of the climate issue. Among them, there is the relationship between trade and greenhouse gases emissions. Questions raised in the literature on global climate change, such as the environmental responsibility for emissions embodied in trade (e.g. WIEBE et al (2012); NAKANO et al (2010); SERRANO & DIETZENBACHER (2010); PETERS & HERTWICH (2008)), also apply at the regional level, and perhaps even to a larger extent.

This paper analyses the relationship between Brazilian states' CO2 emissions and inter-regional and international trade. In doing so, we aim to contribute to policies that account for such inter-relationships among regions. Besides this Introduction, this paper is organized as follows: section 2 presents the methodology used in the empirical analysis, as well as the newly compiled database. Results are then analyzed in section 3. Then, the last section presents some our concluding remarks.

2. Methodology

In this section, we present our data, as well as our methodological procedure for the empirical analysis.

2.1. Estimating the country-state input-output table

In order to analyze at regional level the current relationship between Brazil's CO2 emissions and domestic and global value chains, in this study we adopt the framework proposed by Dietzenbacher et al. (2013) for combining a world input-output table (WIOT) with an inter-regional input-output table (IRIOT), thus estimating a country-state input-output table for Brazil. In this approach, we do not to take one of the datasets (say the WIOT) as a starting point and adapt the other dataset (i.e. the IRIOT) accordingly, instead we construct input coefficients for which both datasets are used.

For the empirical application, we will use the WIOT for 2008 that was constructed in the WIOD project (see Dietzenbacher et al., 2013).[2] It is a full inter-country input-output table covering 40 countries and the rest of the world as a 41st country.[3] One of the countries included is Brazil. The IRIOT for 2008 is for Brazil and covers the 27 Brazilian states (Guilhoto et al., 2010). Both the WIOT and the IRIOT were aggregated to 28 compatible industries.

[2] The full database from the WIOD project (including a time series of WIOTs) is publicly and free of charge available at: http://www.wiod.org/database/index.htm.

[3] The countries in the WIOD's world input-output tables are: Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Taiwan, Turkey, United Kingdom, and USA (Dietzenbacher *et al*, 2013).

2.2. CO2 emissions data for Brazilian states

In this paper, we account for CO2 emissions due to fossil fuels[4] in the economic sectors. It also embodies the CO2 emissions that are generated in thermal power plants, as well as that from the use of coke in iron and steel mills. Adopting a bottom-up approach, we were able to obtaining the levels of CO2 emissions by industry at the state level in Brazil. For the other countries in our model, we have considered the data on CO2 emission from the WIOD project.

First, we have departed from the Brazilian Energy Balance (EPE, 2009) and reconciled the data from state energy balances accordingly. For the year 2008, official energy balances are available for the following states: Alagoas, Bahia, Goiás, Minas Gerais, Rio de Janeiro, São Paulo, Paraná, and Rio Grande do Sul. For Ceará and Espírito Santo, we have considered the participation in the national energy use and sectors' fuel structure from the energy balances of 2007 and 2010, respectively.

Following Montoya et al. (2014), the data on fossil fuel use (in tOE) from the energy balances was then reconciled with the industry classification of Brazil's IRIOT. Next, we have estimated the corresponding CO2 emissions by adopting the carbon emission factors and oxidation fractions from the Brazilian Inventory of Anthropogenic Emissions and Removals of Greenhouse Gases (Ministry of Science and Technology, 2010).

In our application, the CO2 emissions due to households' direct use of fossil fuels are disregarded (approximately 9% of the national emissions). Instead, we focus on the emissions that are generated by the various economic industries in their productive activities.

2.3. Trade in CO2 emissions (TiVE)

To investigate the inter-regional (and international) spillover of CO2 emissions, we adapt and apply the concept of trade in value added (TiVA) (Guilhoto and Imori, 2014; Meng et al. 2013a) for our country-state input-output system.

From the basic Leontief model, the total output of an economy can be expressed as the sum of intermediate consumption and final consumption (Miller and Blair (2009)) as

$$X = AX + Y \tag{1}$$
$$(I - A)^{-1} = B \tag{2}$$
$$X = BY \tag{3}$$

where X is the $n \times 1$ total output vector (n is the number of industries in the system), A is the $n \times n$ direct input coefficients matrix, Y is the $n \times 1$ final demand vector, and B is the Leontief inverse matrix.

Considering C as the $n \times n$ diagonal matrix of CO2 emissions coefficients, we can describe the CO2 emissions related input-output model as:

$$V = CX \tag{4}$$

[4] The following fuels were taken into account: natural gas, steam coal, metallurgical coal, diesel oil, fuel oil, gasoline, LPG, kerosene, gas coke, coal coke, other oil by-products, and coal tar.

from (3):

$$V = CBY \tag{5}$$
$$CB = G \tag{6}$$
$$V = GY \tag{7}$$

where C is the $n \times 1$ CO2 emissions vector, and G is the CO2 emissions related Leontief inverse.

In our empirical analysis, we applied a state-country input-output model. In this case, the above system can be expanded, considering r states / countries, in such a way that it is possible to estimate the contribution of the final demand in each state / country to the total CO2 emission of a given state / country country. In this way, the dimensions of the above matrices become: a) *X*, *Y* and *V*, size [(*r.n)* x *r*]; b) *A*, *B* and *G*, size (*r.n)*x*(r.n).*

With the aim of analyzing the state / country interdependence in terms of CO2 emission, the matrix *G* above can be decomposed as follows:

$$\begin{bmatrix} G^{11} & \vdots & G^{1r} \\ \cdots & \ddots & \cdots \\ G^{r1} & \vdots & G^{rr} \end{bmatrix} = \begin{bmatrix} G^{11} & \vdots & 0 \\ \cdots & \ddots & \cdots \\ 0 & \vdots & G^{rr} \end{bmatrix} + \begin{bmatrix} 0 & \vdots & G^{1r} \\ \cdots & \ddots & \cdots \\ G^{r1} & \vdots & 0 \end{bmatrix} \tag{8}$$

In equation (8), the elements of the first term of the sum can be regarded as intra-regional effects, representing impacts on the CO2 emissions of sectors of a region due to exogenous changes in final demand of the same region. On the other hand, the elements of the second term of the sum can be regarded as spillover effects, representing impacts on the CO2 emissions of sectors of a region due to exogenous changes in final demand of the other region.

In a state-country input-output framework, equation (7) can be represented as:

$$\begin{bmatrix} v_{11}^{11} & \vdots & v_{1n}^{1r} \\ \cdots & \ddots & \cdots \\ v_{n1}^{r1} & \vdots & v_{nn}^{rr} \end{bmatrix} = \begin{bmatrix} G^{11} & \vdots & G^{1r} \\ \cdots & \ddots & \cdots \\ G^{r1} & \vdots & G^{rr} \end{bmatrix} \begin{bmatrix} y_{11}^{11} & \vdots & y_{1n}^{1r} \\ \cdots & \ddots & \cdots \\ y_{n1}^{r1} & \vdots & y_{nn}^{rr} \end{bmatrix} \tag{9}$$

$$\begin{bmatrix} V^{\bullet 1} & \cdots & V^{\bullet r} \end{bmatrix} = \begin{bmatrix} G^{11} & \vdots & G^{1r} \\ \cdots & \ddots & \cdots \\ G^{r1} & \vdots & G^{rr} \end{bmatrix} \begin{bmatrix} Y^{\bullet 1} & \cdots & Y^{\bullet r} \end{bmatrix} \tag{10}$$

In the above equation, considering for example region *1*, the vector $V^{\bullet 1}$ [(*r.n)* x *1*] represents the contribution of region *1* to the total CO2 emissions in each one of the *r* states / countries and *n* sectors considered in the model, given the final demand $Y^{\bullet 1}$ of this region.

Thus the vector $V^{\bullet 1}$ in equation (10) comprehends the inflows / imports[5] of CO2 emissions of region *1* from other states / countries (besides its own contribution for its own value added, given by the elements from *1* to *n*). For example, the elements from *n+1* to *2n* correspond to its inflows / imports of CO2 emissions from each of the *n* sectors of region *2* (accordingly, the outflows / exports of CO2 emissions from region *2* to region *1*).

2.4. Decomposition of outflows and exports in CO2 emissions

Adapting from Meng *et al*. (2013b), in order to measure the position and degree of participation of the domestic regions in both domestic and global value chains in terms of emission, we can decompose their exports of CO2 emission into three parts, as follows (considering *E* as the exporting region, and *R* as the destination region):

- $\mathrm{c}^{E}\mathrm{L}^{EE}\mathrm{y}^{ER}$: CO2 emissions embodied in *E*'s direct exports of final products to *R*;
- $\mathrm{c}^{E}\mathrm{L}^{ER}\mathrm{y}^{RR}$: CO2 emissions embodied in *E*'s exports of intermediate products that are directly imported by *R* and that end up in *R*'s final demand;
- $\sum_{i\neq E}\mathrm{c}^{E}\mathrm{L}^{Ei}\mathrm{y}^{iR}$: CO2 emissions embodied in *E*'s exports of intermediate products to other regions than *R* and that end up in *R*'s final demand (indirect exports).

3. Results

3.1. CO2 emissions in Brazilian states

Table 2 below presents the CO2 emissions due to fossil fuels for selected countries in 2008. It disregards the CO2 emissions due to households' direct consumption of fossil fuels, in order to focus attention on the emissions that are attributable to economic industries. In that year, Brazil produced 1.2% of CO2 emissions due to fossil fuels in the world. Among the BRICs, Brazil presented the lower emissions. China's emissions were outstanding, representing 20% of the world total, against 12% from EU27 and 16% of the USA.

In order to evaluate the average CO2 intensity of each economy, the last column of Table 2 presents the ratio between the CO2 emissions and the total value added of the country in 2008. The Brazilian economy was less intensive in CO2 due to fossil fuels than the world average (0.34 Gg of CO2 per US$ million in 2008) and all the developing countries depicted in Table 2. The other three BRICs presented CO2 intensities much larger than the world average in 2008.

[5] In this paper, we distinguish between "inflows" / "outflows", regarding trade among domestic states, and "imports" / "exports", regarding trade between states and foreign countries, or between foreign countries.

Table 2. CO2 emissions (Gg) due to fossil fuels and value added (2008 US$ million) in 2008, selected countries

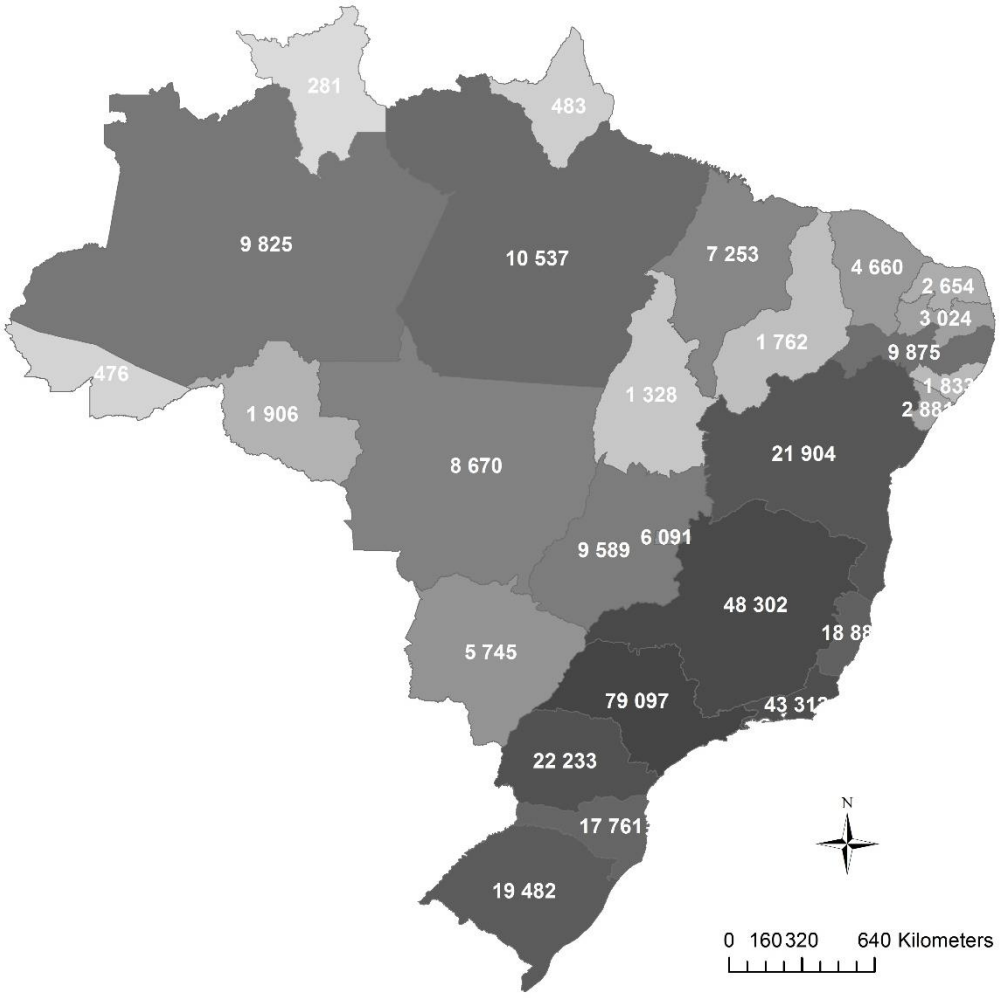
Country	CO2 emissions (Gg)	Value added (2008 US$ million)	CO2 emissions / value added
Brazil	326,230	1,545,981	0.21
China	5,490,880	4,607,404	1.19
India	1,265,525	1,295,899	0.98
Russia	1,332,766	1,512,840	0.88
Mexico	324,155	1,097,027	0.30
Canada	396,510	1,458,848	0.27
EU27	3,141,532	17,563,315	0.18
Germany	630,413	3,481,063	0.18
Spain	234,982	1,543,022	0.15
France	246,119	2,726,567	0.09
United Kingdom	430,240	2,584,992	0.17
Italy	350,154	2,199,609	0.16
Other EU27	1,484,605	6,571,084	0.23
Japan	960,528	4,817,287	0.20
Korea	482,798	917,213	0.53
USA	4,357,361	14,444,868	0.30
Taiwan	267,873	395,786	0.68
Other countries + RoW	5,422,650	10,210,380	0.53

Source: Research data.

The Brazilian states' CO2 emissions due to fossil fuels in 2008 that were estimated in accordance to section 2.2 are represented in Figure 1. In that, it is clear that the Brazilian CO2 emissions due to fossil fuels are largely concentrated in the states of Southeast and South region, and Bahia in the Northeast region. These states produced 75% of the national total in 2008 (and São Paulo's share alone corresponded to more than 20%).

Table A1 in the Annex breaks down the states' emission by the 28 industries in our model. It is noticeable that there is great variation among states concerning the industry profile of their emissions. At national level, the Transport sector produced the largest amount of CO2 emissions due to fossil fuels (40% of total). This sector predominance in emissions was also verified in 22 out of the 27 states. Important exceptions are Pará, Espírito Santo, and Minas Gerais, where the largest share corresponded to the Basic Metals and Fabricated Metal industry (29%, 52%, and 37% of the state total respectively).

Figure 1. CO2 emissions (Gg) due to fossil fuels in 2008, Brazilian states



Source: Research data.

3.1. Brazilian states' inter-regional and international trade in CO2 emissions

In this subsection, we apply the concept of trade in CO2 emissions to our state-country model, relative to year 2008.

Table 3 summarizes the results for the Brazilian states. The first column presents the CO2 emissions that are generated in each state due to its own final demand. The next three columns indicate the CO2 emissions embodied in the domestic trade: the emissions generated in the state due to the final demand of other states (outflows), the emissions in other states due to the final demand of the row state (inflows), and the domestic trade balance (outflows *minus* inflows). The following columns present the CO2 emissions embodied in foreign trade: the emissions generated in the row states due to final demand of foreign countries (exports), the emission in foreign countries due to the state's final demand (imports), and the foreign trade balance (exports *minus* imports). The last three columns reorganize the results as production of CO2 emissions in the row state (own consumption, outflows, and exports) and as the CO2 emission that are generated worldwide to meet the row state's final demand (own consumption, inflows, and imports). Thus, the balance account in the last column corresponds to the sum of the domestic trade balance and the foreign trade balance.

From Table 3, we can notice that São Paulo is dominant in the inter-regional trade in CO2 emissions, responding for 21% of both outflows and inflows. However, comparing this with the results from the trade in value added analysis (Dietzenbacher et al., 2013) reveals that São Paulo's dominance is less intense in terms of emissions – the state responded for the larger share of 37% of outflows in value added.

On the other hand, Espírito Santo and Minas Gerais are more relevant as sources for trade in CO2 emission (than for trade in value added), both in domestic and in foreign markets. This is largely due to the large amounts of CO2 emission that are generated in their "Mining and Quarrying" and "Basic Metals and Fabricated Metal" sectors in response to the demands of other states / countries. Consequently, these two states stand out for presenting two surpluses in trade in CO2 emission (in inter-regional and international trade). For the same reason, Mato Grosso also stands out, but there the main source of trade in CO2 emissions is the Agriculture sector.

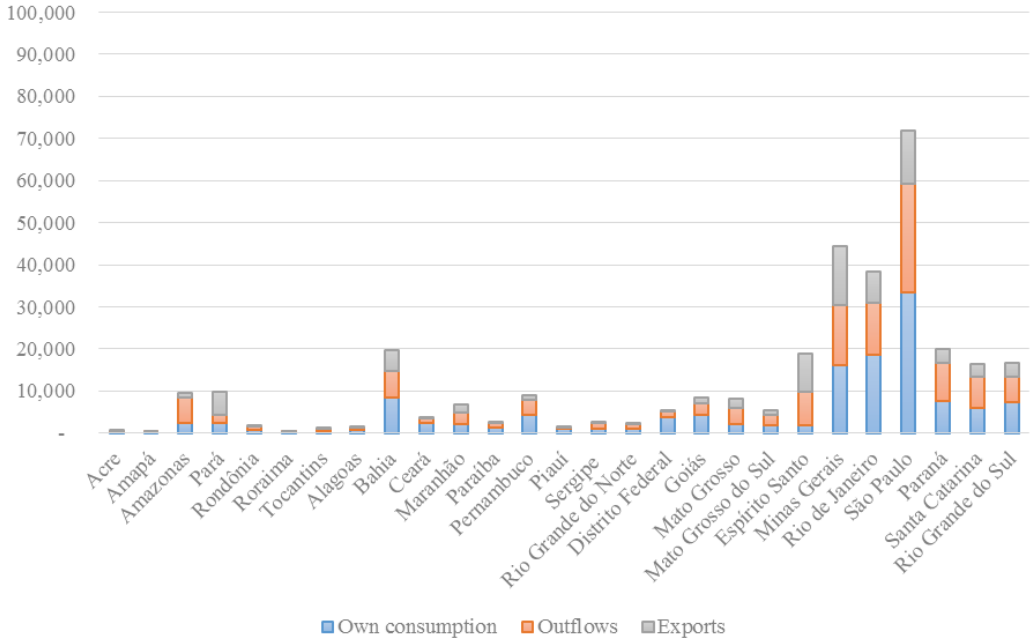
Table 3. Brazilian states' production, consumption, and trade in CO2 emissions (Gg)

	Intra-regional Trade	Interregional Trade			International Trade			Total		
	Own consump-tion	Outflows	Inflows	Balance	Exports	Imports	Balance	Produc-tion	Final demand	Balance
Acre	236	135	385	-251	31	160	-129	402	781	-380
Amapá	240	72	432	-360	123	226	-103	435	898	-463
Amazonas	2,361	5,985	1,786	4,200	1,163	3,580	-2,418	9,509	7,727	1,782
Pará	2,468	1,974	4,217	-2,243	5,332	2,111	3,221	9,774	8,796	978
Rondônia	745	716	1,155	-439	224	611	-387	1,684	2,510	-826
Roraima	146	83	214	-131	17	95	-78	246	455	-209
Tocantins	547	490	776	-286	143	419	-277	1,180	1,743	-563
Alagoas	765	547	1,122	-575	196	521	-324	1,509	2,408	-899
Bahia	8,488	6,296	7,084	-788	4,946	5,493	-547	19,730	21,065	-1,335
Ceará	2,501	1,044	3,342	-2,298	312	2,093	-1,781	3,857	7,936	-4,079
Maranhão	2,072	2,697	2,056	641	2,057	1,819	237	6,825	5,947	878
Paraíba	1,429	1,036	1,902	-866	164	1,074	-911	2,628	4,405	-1,777
Pernambuco	4,439	3,515	3,804	-288	947	2,827	-1,879	8,901	11,069	-2,168
Piauí	943	418	1,427	-1,009	109	656	-547	1,470	3,026	-1,555
Sergipe	971	1,381	1,037	344	317	579	-262	2,669	2,587	81
Rio Grande do Norte	1,070	960	1,754	-795	337	777	-440	2,367	3,602	-1,235
Distrito Federal	3,842	1,402	5,078	-3,676	211	2,669	-2,459	5,455	11,590	-6,135
Goiás	4,277	2,785	3,749	-963	1,433	2,786	-1,352	8,496	10,811	-2,316
Mato Grosso	2,254	3,772	2,005	1,767	2,274	1,043	1,230	8,300	5,303	2,997
Mato Grosso do Sul	1,958	2,470	1,538	933	936	1,302	-367	5,364	4,798	566
Espírito Santo	1,920	7,802	2,793	5,009	9,222	2,134	7,088	18,944	6,847	12,097
Minas Gerais	16,187	14,257	11,587	2,670	14,003	9,301	4,702	44,447	37,075	7,372
Rio de Janeiro	18,610	12,328	16,148	-3,820	7,302	10,833	-3,531	38,240	45,591	-7,351
São Paulo	33,548	25,628	25,247	381	12,581	33,255	-20,674	71,756	92,050	-20,294
Paraná	7,755	8,817	6,626	2,191	3,504	7,308	-3,804	20,076	21,689	-1,613
Santa Catarina	6,036	7,322	5,065	2,257	2,965	5,116	-2,151	16,324	16,217	107
Rio Grande do Sul	7,397	5,899	7,501	-1,603	3,369	7,194	-3,825	16,664	22,092	-5,428
Total	133,205	119,832	119,832	0	74,216	105,982	-31,766	327,253	359,018	-31,766

Source: Research data.

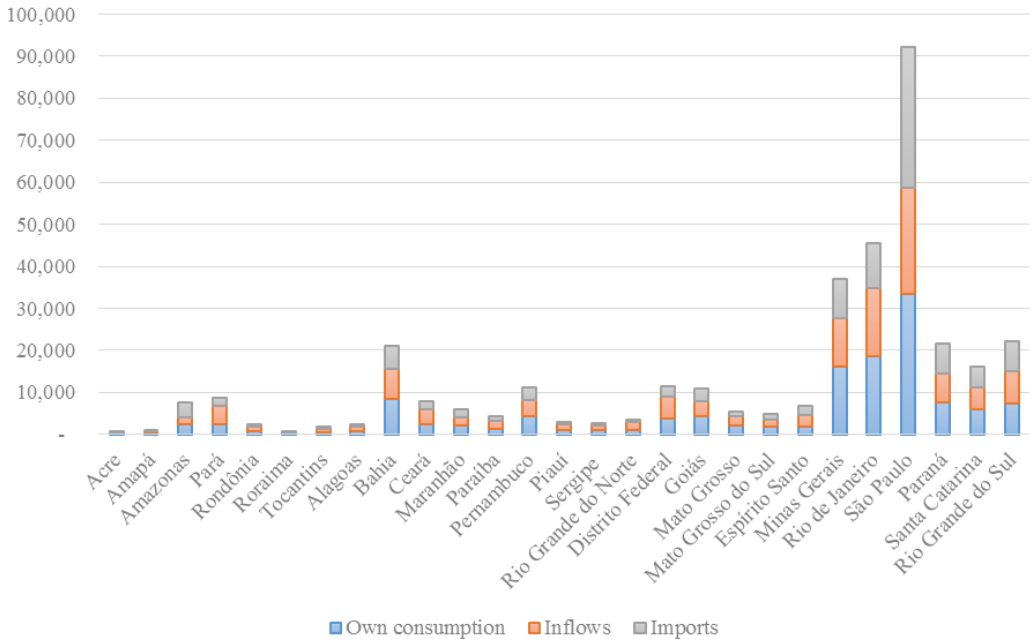
Figures 2 and 3 break down the CO2 emissions embodied in the production and in the final demand respectively, by internal, domestic, and foreign components. In Figure 2, it is noticeable that large shares of Pará's and Espírito Santo's CO2 emissions are exported. In Espírito Santo, only 10% of the emissions are due to its own final demand. Concerning the embodied CO2 emissions in states' final demand, São Paulo stands out by presenting the largest share that is supplied by foreign countries (about 36%).

Figure 2. Embodied CO2 emissions (Gg) in Brazilian states' production, by destination



Source: Research data.

Figure 3. Embodied CO2 emissions (Gg) in Brazilian states' final demand, by source



Source: Research data.

Tables 4 to 7 present in detail the inter-regional trade in CO2 emissions.

From Table 6, we can apprehend that there is great variation on CO2 emissions intensity in the inter-regional trade flows. The highest intensity of CO2 (in relation to value added content of trade flows) corresponds to Espírito Santo: on average, for each US$ one million of value added due other states' final demand, 0.77 Gg of CO2 was produced there (in the whole inter-regional system, the average was 0.28 Gg of CO2 / US$ one million of value added). Concerning the inflows, São Paulo presents the highest intensity of CO2 emissions.

Table 7 presents the bilateral balances of trade in CO2 emissions. Amazonas presents surpluses of trade in CO2 emission with every state. With this exception, such surpluses are also verified for Espírito Santo (with exception of Amazonas). In the case of São Paulo, differently for what was observed considering trade in value-added (Dietzenbacher et al., 2013), when the state presented surpluses with all other states (except Amazonas), here the sum of its deficits almost cancel its surpluses in inter-regional trade in CO2 emissions. São Paulo presents large deficits in CO2 emissions in the trade relations with Espírito Santo and Minas Gerais.

Table 4. Inter-regional trade in CO2 emissions (Gg)

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
AC	-	0	2	4	2	0	1	1	7	3	2	4	5	1	1	2	7	3	2	2	3	12	14	30	7	6	12	135
AP	0	-	1	2	0	0	0	0	4	2	1	1	2	0	1	1	4	2	1	1	2	8	8	17	4	3	7	72
AM	17	20	-	197	66	13	33	46	213	123	103	79	184	57	50	64	268	132	102	56	135	572	683	2,000	273	230	270	5,985
PA	5	7	34	-	15	3	11	16	87	51	61	26	58	23	13	30	121	45	26	25	45	166	243	490	107	87	178	1,974
RO	6	2	36	17	-	1	2	5	31	13	15	8	17	6	5	7	53	14	10	11	22	64	77	161	43	22	69	716
RR	0	0	1	3	1	-	0	0	5	2	1	1	2	1	0	1	3	2	1	1	1	7	23	15	3	4	5	83
TO	1	2	7	25	3	1	-	3	25	17	22	8	15	7	4	5	32	18	5	6	11	59	52	96	18	15	36	490
AL	1	2	5	16	6	1	2	-	47	18	6	16	57	7	10	7	15	10	6	5	7	37	110	91	21	20	26	547
BA	18	20	85	177	54	10	37	80	-	189	107	102	285	77	103	98	272	166	100	86	165	588	692	1,778	323	293	389	6,296
CE	3	5	16	44	8	2	5	10	77	-	31	38	68	47	9	67	31	30	11	10	16	78	94	210	37	45	53	1,044
MA	12	10	36	182	30	6	43	26	204	87	-	40	91	95	17	44	116	88	60	23	41	368	250	491	106	87	143	2,697
PB	5	3	10	26	7	1	4	18	75	69	18	-	85	13	11	86	53	14	8	9	19	68	81	204	37	49	60	1,036
PE	8	10	41	88	23	5	15	87	403	213	83	222	-	55	48	110	171	58	37	38	75	246	309	697	135	108	229	3,515
PI	1	2	5	18	3	1	3	3	24	34	51	5	14	-	3	4	15	8	5	4	7	27	38	81	19	16	27	418
SE	3	4	16	28	10	2	6	24	148	37	25	15	43	14	-	17	88	37	15	17	32	111	148	318	58	46	121	1,381
RN	3	3	15	26	7	1	5	7	70	53	15	25	37	11	9	-	37	21	13	9	19	93	71	247	56	43	62	960
DF	4	7	15	44	18	2	13	7	80	25	12	21	25	17	6	14	-	127	11	12	18	209	387	205	34	39	51	1,402
GO	8	10	38	107	21	4	37	23	141	73	48	45	83	32	22	46	161	-	49	34	48	376	296	702	157	90	133	2,785
MT	12	16	64	143	56	6	19	28	224	95	67	63	105	50	31	45	128	83	-	70	66	306	637	786	302	172	199	3,772
MS	8	9	48	79	23	4	13	17	125	52	37	30	57	25	18	25	90	55	52	-	38	183	306	694	200	161	121	2,470
ES	18	18	116	185	52	10	36	55	439	154	100	83	222	59	57	82	247	218	115	82	-	813	1,009	2,540	427	271	394	7,802
MG	39	42	223	390	109	23	79	113	827	449	224	172	424	123	118	160	534	573	220	171	533	-	2,199	4,495	766	515	737	14,257
RJ	41	41	206	450	119	24	80	112	700	326	218	170	430	131	116	174	550	431	236	165	489	1,393	-	3,577	675	659	815	12,328
SP	91	112	484	1,044	297	51	174	252	1,877	737	420	419	925	321	220	387	1,253	990	527	416	598	3,551	5,409	-	1,764	1,235	2,073	25,628
PR	36	36	103	396	94	19	66	75	520	173	122	120	205	95	58	110	329	261	187	119	135	986	1,208	2,274	-	517	571	8,817
SC	24	27	99	273	63	14	45	64	388	174	138	92	198	75	58	86	299	183	107	100	152	696	841	1,681	723	-	722	7,322
RS	22	24	77	253	68	10	44	53	343	173	130	97	168	84	49	82	203	176	97	67	115	570	963	1,367	330	333	-	5,899
Total	385	432	1,786	4,217	1,155	214	776	1,122	7,084	3,342	2,056	1,902	3,804	1,427	1,037	1,754	5,078	3,749	2,005	1,538	2,793	11,587	16,148	25,247	6,626	5,065	7,501	119,832

Source: Research data.

Table 5. Share of bilateral trade in CO2 emissions in total inter-regional trade (%)

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
AC	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.03	0.01	0.01	0.01	0.11
AP	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.06
AM	0.01	0.02	-	0.16	0.06	0.01	0.03	0.04	0.18	0.10	0.09	0.07	0.15	0.05	0.04	0.05	0.22	0.11	0.09	0.05	0.11	0.48	0.57	1.67	0.23	0.19	0.22	4.99
PA	0.00	0.01	0.03	-	0.01	0.00	0.01	0.01	0.07	0.04	0.05	0.02	0.05	0.02	0.01	0.03	0.10	0.04	0.02	0.02	0.04	0.14	0.20	0.41	0.09	0.07	0.15	1.65
RO	0.00	0.00	0.03	0.01	-	0.00	0.00	0.00	0.03	0.01	0.01	0.01	0.01	0.01	0.00	0.01	0.04	0.01	0.01	0.01	0.02	0.05	0.06	0.13	0.04	0.02	0.06	0.60
RR	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.00	0.07
TO	0.00	0.00	0.01	0.02	0.00	0.00	-	0.00	0.02	0.01	0.02	0.01	0.01	0.01	0.00	0.00	0.03	0.02	0.00	0.00	0.01	0.05	0.04	0.08	0.02	0.01	0.03	0.41
AL	0.00	0.00	0.00	0.01	0.00	0.00	0.00	-	0.04	0.02	0.00	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.03	0.09	0.08	0.02	0.02	0.02	0.46
BA	0.01	0.02	0.07	0.15	0.05	0.01	0.03	0.07	-	0.16	0.09	0.09	0.24	0.06	0.09	0.08	0.23	0.14	0.08	0.07	0.14	0.49	0.58	1.48	0.27	0.24	0.32	5.25
CE	0.00	0.00	0.01	0.04	0.01	0.00	0.00	0.01	0.06	-	0.03	0.03	0.06	0.04	0.01	0.06	0.03	0.02	0.01	0.01	0.01	0.06	0.08	0.18	0.03	0.04	0.04	0.87
MA	0.01	0.01	0.03	0.15	0.03	0.01	0.04	0.02	0.17	0.07	-	0.03	0.08	0.08	0.01	0.04	0.10	0.07	0.05	0.02	0.03	0.31	0.21	0.41	0.09	0.07	0.12	2.25
PB	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.01	0.06	0.06	0.01	-	0.07	0.01	0.01	0.07	0.04	0.01	0.01	0.01	0.02	0.06	0.07	0.17	0.03	0.04	0.05	0.86
PE	0.01	0.01	0.03	0.07	0.02	0.00	0.01	0.07	0.34	0.18	0.07	0.19	-	0.05	0.04	0.09	0.14	0.05	0.03	0.03	0.06	0.21	0.26	0.58	0.11	0.09	0.19	2.93
PI	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.03	0.04	0.00	0.01	-	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.02	0.03	0.07	0.02	0.01	0.02	0.35
SE	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.02	0.12	0.03	0.02	0.01	0.04	0.01	-	0.01	0.07	0.03	0.01	0.01	0.03	0.09	0.12	0.27	0.05	0.04	0.10	1.15
RN	0.00	0.00	0.01	0.02	0.01	0.00	0.00	0.01	0.06	0.04	0.01	0.02	0.03	0.01	0.01	-	0.03	0.02	0.01	0.01	0.02	0.08	0.06	0.21	0.05	0.04	0.05	0.80
DF	0.00	0.01	0.01	0.04	0.02	0.00	0.01	0.01	0.07	0.02	0.01	0.02	0.02	0.01	0.00	0.01	-	0.11	0.01	0.01	0.01	0.17	0.32	0.17	0.03	0.03	0.04	1.17
GO	0.01	0.01	0.03	0.09	0.02	0.00	0.03	0.02	0.12	0.06	0.04	0.04	0.07	0.03	0.02	0.04	0.13	-	0.04	0.03	0.04	0.31	0.25	0.59	0.13	0.08	0.11	2.32
MT	0.01	0.01	0.05	0.12	0.05	0.00	0.02	0.02	0.19	0.08	0.06	0.05	0.09	0.04	0.03	0.04	0.11	0.07	-	0.06	0.06	0.26	0.53	0.66	0.25	0.14	0.17	3.15
MS	0.01	0.01	0.04	0.07	0.02	0.00	0.01	0.01	0.10	0.04	0.03	0.03	0.05	0.02	0.02	0.02	0.08	0.05	0.04	-	0.03	0.15	0.26	0.58	0.17	0.13	0.10	2.06
ES	0.01	0.02	0.10	0.15	0.04	0.01	0.03	0.05	0.37	0.13	0.08	0.07	0.18	0.05	0.05	0.07	0.21	0.18	0.10	0.07	-	0.68	0.84	2.12	0.36	0.23	0.33	6.51
MG	0.03	0.04	0.19	0.33	0.09	0.02	0.07	0.09	0.69	0.37	0.19	0.14	0.35	0.10	0.10	0.13	0.45	0.48	0.18	0.14	0.44	-	1.84	3.75	0.64	0.43	0.61	11.90
RJ	0.03	0.03	0.17	0.38	0.10	0.02	0.07	0.09	0.58	0.27	0.18	0.14	0.36	0.11	0.10	0.15	0.46	0.36	0.20	0.14	0.41	1.16	-	2.98	0.56	0.55	0.68	10.29
SP	0.08	0.09	0.40	0.87	0.25	0.04	0.15	0.21	1.57	0.61	0.35	0.35	0.77	0.27	0.18	0.32	1.05	0.83	0.44	0.35	0.50	2.96	4.51	-	1.47	1.03	1.73	21.39
PR	0.03	0.03	0.09	0.33	0.08	0.02	0.06	0.06	0.43	0.14	0.10	0.10	0.17	0.08	0.05	0.09	0.27	0.22	0.16	0.10	0.11	0.82	1.01	1.90	-	0.43	0.48	7.36
SC	0.02	0.02	0.08	0.23	0.05	0.01	0.04	0.05	0.32	0.15	0.12	0.08	0.17	0.06	0.05	0.07	0.25	0.15	0.09	0.08	0.13	0.58	0.70	1.40	0.60	-	0.60	6.11
RS	0.02	0.02	0.06	0.21	0.06	0.01	0.04	0.04	0.29	0.14	0.11	0.08	0.14	0.07	0.04	0.07	0.17	0.15	0.08	0.06	0.10	0.48	0.80	1.14	0.28	0.28	-	4.92
Total	0.32	0.36	1.49	3.52	0.96	0.18	0.65	0.94	5.91	2.79	1.72	1.59	3.17	1.19	0.87	1.46	4.24	3.13	1.67	1.28	2.33	9.67	13.48	21.07	5.53	4.23	6.26	100.00

Source: Research data.

Table 6. Inter-regional trade in CO2 emissions / inter-regional trade in value added (Gg / 2008 US$ million)

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
AC	-	0.17	0.13	0.16	0.22	0.22	0.18	0.21	0.14	0.19	0.22	0.19	0.17	0.17	0.19	0.23	0.14	0.20	0.24	0.23	0.20	0.15	0.17	0.20	0.18	0.14	0.21	0.18
AP	0.29	-	0.08	0.12	0.29	0.20	0.17	0.26	0.11	0.30	0.22	0.16	0.17	0.27	0.15	0.24	0.19	0.21	0.30	0.22	0.17	0.12	0.17	0.21	0.15	0.10	0.23	0.16
AM	0.41	0.50	-	0.41	0.50	0.50	0.50	0.50	0.38	0.46	0.49	0.52	0.45	0.43	0.40	0.43	0.56	0.37	0.49	0.36	0.40	0.50	0.37	0.42	0.51	0.53	0.37	0.43
PA	0.57	0.35	0.36	-	0.41	0.51	0.42	0.43	0.47	0.39	0.42	0.30	0.32	0.35	0.45	0.47	0.28	0.45	0.54	0.48	0.39	0.33	0.35	0.43	0.42	0.29	0.46	0.38
RO	0.33	0.29	0.24	0.26	-	0.30	0.27	0.29	0.24	0.29	0.38	0.28	0.28	0.28	0.26	0.34	0.51	0.28	0.33	0.41	0.42	0.30	0.35	0.31	0.26	0.27	0.46	0.32
RR	0.27	0.23	0.14	0.23	0.30	-	0.21	0.18	0.20	0.24	0.21	0.24	0.15	0.20	0.15	0.35	0.12	0.20	0.26	0.25	0.26	0.19	0.46	0.20	0.19	0.20	0.22	0.23
TO	0.35	0.15	0.26	0.31	0.16	0.38	-	0.23	0.29	0.22	0.37	0.18	0.18	0.19	0.28	0.34	0.15	0.33	0.34	0.36	0.39	0.23	0.22	0.28	0.28	0.22	0.30	0.25
AL	0.18	0.29	0.22	0.26	0.29	0.22	0.20	-	0.22	0.32	0.18	0.33	0.23	0.21	0.14	0.30	0.15	0.22	0.20	0.17	0.19	0.25	0.59	0.19	0.21	0.22	0.18	0.24
BA	0.53	0.49	0.53	0.55	0.53	0.57	0.56	0.51	-	0.56	0.52	0.53	0.49	0.50	0.40	0.57	0.44	0.60	0.57	0.52	0.52	0.56	0.53	0.43	0.55	0.54	0.51	0.49
CE	0.11	0.14	0.10	0.12	0.12	0.15	0.13	0.15	0.14	-	0.12	0.18	0.15	0.16	0.11	0.22	0.10	0.14	0.14	0.10	0.10	0.11	0.12	0.12	0.13	0.13	0.11	0.13
MA	0.93	0.49	0.37	0.60	0.62	0.81	0.70	0.55	0.57	0.50	-	0.52	0.40	0.55	0.43	0.56	0.44	0.69	0.68	0.40	0.49	0.63	0.47	0.41	0.42	0.45	0.41	0.50
PB	0.48	0.48	0.44	0.42	0.52	0.58	0.51	0.53	0.57	0.47	0.43	-	0.37	0.48	0.39	0.61	0.56	0.44	0.44	0.41	0.50	0.36	0.48	0.42	0.52	0.63	0.54	0.47
PE	0.50	0.48	0.48	0.49	0.50	0.53	0.49	0.43	0.51	0.52	0.49	0.40	-	0.49	0.35	0.47	0.56	0.50	0.50	0.50	0.56	0.56	0.55	0.45	0.53	0.56	0.51	0.49
PI	0.40	0.35	0.24	0.31	0.42	0.42	0.37	0.38	0.33	0.43	0.41	0.31	0.37	-	0.34	0.36	0.34	0.34	0.40	0.32	0.30	0.27	0.31	0.33	0.30	0.27	0.30	0.33
SE	0.50	0.44	0.42	0.44	0.46	0.48	0.44	0.47	0.49	0.46	0.44	0.41	0.39	0.41	-	0.50	0.41	0.46	0.48	0.47	0.45	0.41	0.50	0.47	0.43	0.39	0.46	0.45
RN	0.26	0.30	0.30	0.28	0.32	0.37	0.33	0.36	0.33	0.39	0.35	0.34	0.29	0.27	0.26	-	0.40	0.35	0.36	0.32	0.39	0.39	0.37	0.32	0.39	0.41	0.35	0.34
DF	0.19	0.31	0.14	0.19	0.25	0.28	0.18	0.20	0.18	0.44	0.12	0.27	0.16	0.21	0.12	0.34	-	0.20	0.25	0.14	0.16	0.16	0.39	0.32	0.21	0.13	0.20	0.23
GO	0.29	0.27	0.26	0.28	0.28	0.28	0.28	0.26	0.27	0.28	0.24	0.27	0.26	0.27	0.27	0.29	0.22	-	0.28	0.26	0.25	0.26	0.31	0.25	0.25	0.28	0.25	0.26
MT	0.42	0.46	0.33	0.39	0.49	0.43	0.43	0.36	0.41	0.43	0.33	0.39	0.34	0.38	0.35	0.45	0.36	0.37	-	0.40	0.40	0.36	0.58	0.39	0.38	0.39	0.39	0.41
MS	0.55	0.49	0.36	0.48	0.64	0.55	0.51	0.42	0.46	0.48	0.36	0.43	0.45	0.41	0.45	0.50	0.60	0.46	0.51	-	0.49	0.50	0.55	0.43	0.44	0.70	0.47	0.48
ES	0.86	0.59	1.05	0.92	0.75	0.92	0.93	0.85	0.89	0.79	0.92	0.72	0.74	0.60	0.89	0.94	0.53	1.00	1.12	1.01	-	0.55	0.62	0.87	0.99	0.89	0.86	0.77
MG	0.40	0.37	0.45	0.39	0.40	0.46	0.39	0.42	0.43	0.44	0.40	0.39	0.40	0.36	0.42	0.43	0.41	0.45	0.44	0.41	0.35	-	0.43	0.41	0.51	0.46	0.45	0.42
RJ	0.30	0.26	0.30	0.32	0.27	0.33	0.28	0.33	0.30	0.36	0.30	0.30	0.32	0.25	0.30	0.33	0.28	0.32	0.30	0.27	0.35	0.28	-	0.32	0.28	0.30	0.25	0.30
SP	0.18	0.17	0.14	0.19	0.17	0.19	0.16	0.18	0.16	0.21	0.14	0.18	0.17	0.16	0.16	0.20	0.14	0.16	0.17	0.15	0.13	0.14	0.20	-	0.15	0.14	0.15	0.16
PR	0.35	0.29	0.25	0.34	0.35	0.40	0.36	0.30	0.32	0.32	0.22	0.31	0.26	0.27	0.23	0.35	0.36	0.32	0.35	0.25	0.22	0.31	0.30	0.27	-	0.28	0.26	0.29
SC	0.40	0.36	0.37	0.39	0.39	0.42	0.41	0.37	0.39	0.40	0.35	0.38	0.34	0.37	0.36	0.44	0.44	0.41	0.42	0.39	0.38	0.42	0.38	0.35	0.31	-	0.35	0.37
RS	0.24	0.25	0.20	0.24	0.25	0.24	0.24	0.21	0.25	0.23	0.18	0.24	0.19	0.21	0.19	0.25	0.24	0.22	0.24	0.19	0.21	0.23	0.29	0.19	0.19	0.22	-	0.22
Total	0.30	0.27	0.24	0.29	0.28	0.32	0.28	0.30	0.27	0.34	0.26	0.29	0.27	0.26	0.26	0.33	0.26	0.27	0.29	0.25	0.25	0.24	0.30	0.36	0.26	0.26	0.26	0.28

Source: Research data.

Table 7. Balance of inter-regional trade in CO2 emissions (Gg)

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
AC	-	0	-15	-1	-4	0	-0	-0	-11	0	-10	-2	-3	0	-2	-1	3	-5	-10	-6	-15	-26	-26	-60	-29	-18	-10	-251
AP	-0	-	-19	-4	-1	-0	-1	-2	-16	-3	-8	-2	-8	-2	-4	-2	-2	-8	-15	-8	-16	-35	-33	-95	-33	-24	-17	-360
AM	15	19	-	163	30	12	26	40	128	107	68	69	143	52	34	49	252	94	38	7	18	349	477	1,515	170	132	193	4,200
PA	1	4	-163	-	-3	0	-13	-0	-90	7	-121	1	-30	6	-15	4	77	-62	-117	-54	-140	-225	-207	-554	-289	-186	-75	-2,243
RO	4	1	-30	3	-	0	-0	-1	-23	5	-15	1	-6	3	-5	-0	35	-7	-46	-13	-30	-45	-42	-136	-51	-41	2	-439
RR	-0	0	-12	-0	-0	-	-0	-0	-6	0	-5	-0	-4	0	-1	-1	2	-3	-5	-3	-9	-16	-1	-36	-16	-10	-6	-131
TO	0	1	-26	13	0	0	-	1	-12	12	-21	4	-1	4	-2	0	19	-19	-14	-7	-25	-21	-28	-78	-48	-30	-9	-286
AL	0	2	-40	0	1	0	-1	-	-33	8	-20	-2	-30	5	-13	-1	8	-13	-22	-12	-48	-76	-2	-161	-54	-44	-26	-575
BA	11	16	-128	90	23	6	12	33	-	112	-98	27	-118	53	-45	28	191	25	-124	-39	-274	-239	-8	-99	-197	-95	46	-788
CE	-0	3	-107	-7	-5	-0	-12	-8	-112	-	-56	-31	-145	12	-28	14	6	-44	-83	-42	-138	-371	-231	-527	-136	-129	-120	-2,298
MA	10	8	-68	121	15	5	21	20	98	56	-	22	8	44	-7	29	104	41	-7	-14	-59	144	32	71	-16	-51	13	641
PB	2	2	-69	-1	-1	0	-4	2	-27	31	-22	-	-137	8	-4	61	32	-31	-54	-21	-64	-103	-89	-215	-82	-43	-36	-866
PE	3	8	-143	30	6	4	1	30	118	145	-8	137	-	41	5	73	147	-25	-68	-19	-146	-177	-122	-228	-70	-90	62	-288
PI	-0	2	-52	-6	-3	-0	-4	-5	-53	-12	-44	-8	-41	-	-11	-7	-2	-24	-45	-21	-52	-95	-92	-240	-76	-59	-57	-1,009
SE	2	4	-34	15	5	1	2	13	45	28	7	4	-5	11	-	8	82	16	-16	-1	-25	-7	32	98	-1	-12	72	344
RN	1	2	-49	-4	0	1	-0	1	-28	-14	-29	-61	-73	7	-8	-	23	-25	-32	-16	-63	-67	-103	-140	-54	-43	-20	-795
DF	-3	2	-252	-77	-35	-2	-19	-8	-191	-6	-104	-32	-147	2	-82	-23	-	-34	-117	-78	-229	-325	-163	-1,048	-295	-261	-153	-3,676
GO	5	8	-94	62	7	3	19	13	-25	44	-41	31	25	24	-16	25	34	-	-34	-21	-171	-196	-135	-289	-104	-93	-43	-963
MT	10	15	-38	117	46	5	14	22	124	83	7	54	68	45	16	32	117	34	-	17	-49	86	400	259	115	66	102	1,767
MS	6	8	-7	54	13	3	7	12	39	42	14	21	19	21	1	16	78	21	-17	-	-44	12	141	278	80	62	54	933
ES	15	16	-18	140	30	9	25	48	274	138	59	64	146	52	25	63	229	171	49	44	-	280	520	1,941	292	118	279	5,009
MG	26	35	-349	225	45	16	21	76	239	371	-144	103	177	95	7	67	325	196	-86	-12	-280	-	806	944	-220	-181	167	2,670
RJ	26	33	-477	207	42	1	28	2	8	231	-32	89	122	92	-32	103	163	135	-400	-141	-520	-806	-	-1,832	-534	-182	-148	-3,820
SP	60	95	-1,515	554	136	36	78	161	99	527	-71	215	228	240	-98	140	1,048	289	-259	-278	-1,941	-944	1,832	-	-510	-446	705	381
PR	29	33	-170	289	51	16	48	54	197	136	16	82	70	76	1	54	295	104	-115	-80	-292	220	534	510	-	-207	241	2,191
SC	18	24	-132	186	41	10	30	44	95	129	51	43	90	59	12	43	261	93	-66	-62	-118	181	182	446	207	-	388	2,257
RS	10	17	-193	75	-2	6	9	26	-46	120	-13	36	-62	57	-72	20	153	43	-102	-54	-279	-167	148	-705	-241	-388	-	-1,603
Total	251	360	-4,200	2,243	439	131	286	575	788	2,298	-641	866	288	1,009	-344	795	3,676	963	-1,767	-933	-5,009	-2,670	3,820	-381	-2,191	-2,257	1,603	0.00

Source: Research data.

The states' exports in CO2 emissions are detailed, by trade partner, in Tables 8 to 10.[6]

According to Table 9, the main exporter of CO2 emissions was Minas Gerais (almost 19% of the national exports), which surpassed São Paulo (about 17% of national exports). Corresponding to approximately 12.5%, Espírito Santo also stands out. Concerning the exports by trade partners, the largest share (34%) corresponded to the group of countries "Other + ROW", being followed by USA (18.4%) and China (8.7%).

Table 10 presents the ratio between exports in CO2 emissions (in Gg) and exports in value added (in US$ million), as an indicator of CO2 intensity. As was observed for the outflows, also for exports the highest intensity corresponded to Espírito Santo. It is interesting that the average CO2 intensity varies with the trade partner. So, in Brazil as whole, USA's final demand generates a higher CO2 / value added ratio than China's.

In their turn, Tables 11 to 13 detail, by trade partner, Brazilian states' imports in CO2 emissions.

São Paulo was largely dominant in the imports in CO2 emissions (31% of national imports). In relation to the trade partners, the group "Other + ROW" and China produced the largest amounts of CO2 emissions in foreign countries due to Brazilian states' final demand (34.5% and 28%, respectively). Concerning the CO2 intensities of Brazilian states' imports, it is noticeable from Table 13 that the BRICs exports to Brazil presented quite high CO2 / value added ratio.

Finally, Table 14 detail the foreign trade balances for the Brazilian states. São Paulo turns out to be a large net importer of CO2 emissions (in total and considering each trade partner), while Pará, Espírito Santo and Minas Gerais are important net exporters. Considering the foreign trade partners, the BRICs are net exporters of CO2 emissions to almost every state in Brazil. On the other hand, the countries from UE27 and the USA are net importers of Brazilian CO2 emissions.

[6] In the next Tables, for better presentation, the countries in our model are classified as follows: CHN: China; IND: India, RUS: Russia; MEX: Mexico; CAN: Canada; DEU: Germany; ESP: Spain; FRA: France; GBR: United Kingdom; ITA: Italy; Other EU27: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hungary, Ireland, Lithuania, Luxembourg, Latvia, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, and Sweden; JPN: Japan; KOR: Korea; USA: United States; TWN: Taiwan; Other + ROW: Australia, Indonesia, Turkey, and ROW.

Table 8. Exports in CO2 emissions (Gg), Brazilian states

	CHN	IND	RUS	MEX	CAN	DEU	ESP	FRA	GBR	ITA	Other EU27	JPN	KOR	USA	TWN	Other + RoW	Total
AC	3	0	1	0	0	2	1	1	2	1	3	1	0	3	0	12	31
AP	12	1	1	2	3	4	1	2	3	2	8	3	1	44	1	32	123
AM	76	10	18	35	21	67	20	32	31	30	95	28	11	191	6	491	1,163
PA	544	61	57	110	290	270	93	188	102	127	411	443	86	1,251	27	1,274	5,332
RO	14	1	23	2	3	11	6	6	11	8	21	6	2	21	1	86	224
RR	1	0	0	0	0	1	0	1	1	1	2	2	0	2	0	6	17
TO	25	1	6	1	2	7	12	5	4	3	15	4	1	12	0	44	143
AL	11	3	10	3	6	12	3	6	5	5	23	4	3	24	1	77	196
BA	406	50	66	168	89	422	101	166	137	220	537	134	48	911	25	1,465	4,946
CE	17	2	7	7	7	26	8	13	15	15	43	7	2	56	1	85	312
MA	210	26	27	58	48	91	57	57	44	49	167	75	25	465	10	647	2,057
PB	11	1	3	4	4	10	4	5	5	6	17	5	2	34	1	53	164
PE	57	9	17	19	21	52	18	26	31	25	102	22	9	182	4	351	947
PI	13	1	2	2	2	7	3	5	4	3	10	5	1	15	1	35	109
SE	21	3	5	6	5	16	6	8	8	8	37	8	3	52	1	129	317
RN	15	2	4	4	6	16	9	9	12	9	40	7	3	100	1	99	337
DF	14	1	5	3	3	19	5	7	8	9	33	9	2	25	1	67	211
GO	158	34	49	19	17	105	87	58	48	41	162	52	18	132	5	449	1,433
MT	383	15	53	14	24	111	109	83	82	74	261	62	40	178	10	776	2,274
MS	100	8	30	11	15	48	15	34	24	24	80	31	14	152	4	348	936
ES	721	93	114	279	176	392	192	216	164	230	589	436	383	2,482	138	2,617	9,222
MG	1,170	158	205	355	270	929	242	404	331	424	1,186	630	364	2,779	213	4,342	14,003
RJ	874	95	98	177	118	354	151	206	173	195	601	189	82	1,091	40	2,860	7,302
SP	816	112	250	321	231	806	240	390	336	352	1,209	320	130	2,033	67	4,968	12,581
PR	325	29	72	59	63	276	70	130	97	105	360	112	47	417	15	1,329	3,504
SC	185	25	60	62	58	176	53	86	90	80	264	127	31	426	12	1,229	2,965
RS	286	28	82	67	46	195	55	91	83	85	301	91	36	580	13	1,329	3,369
Total	6,464	770	1,267	1,790	1,531	4,425	1,560	2,235	1,850	2,130	6,576	2,814	1,344	13,657	598	25,204	74,216

Source: Research data.

Table 9. Share of bilateral trade in CO2 emissions in total exports (%), Brazilian states

	CHN	IND	RUS	MEX	CAN	DEU	ESP	FRA	GBR	ITA	Other EU27	JPN	KOR	USA	TWN	Other + RoW	Total
AC	3	0	1	0	0	2	1	1	2	1	3	1	0	3	0	12	31
AP	12	1	1	2	3	4	1	2	3	2	8	3	1	44	1	32	123
AM	76	10	18	35	21	67	20	32	31	30	95	28	11	191	6	491	1,163
PA	544	61	57	110	290	270	93	188	102	127	411	443	86	1,251	27	1,274	5,332
RO	14	1	23	2	3	11	6	6	11	8	21	6	2	21	1	86	224
RR	1	0	0	0	0	1	0	1	1	1	2	2	0	2	0	6	17
TO	25	1	6	1	2	7	12	5	4	3	15	4	1	12	0	44	143
AL	11	3	10	3	6	12	3	6	5	5	23	4	3	24	1	77	196
BA	406	50	66	168	89	422	101	166	137	220	537	134	48	911	25	1,465	4,946
CE	17	2	7	7	7	26	8	13	15	15	43	7	2	56	1	85	312
MA	210	26	27	58	48	91	57	57	44	49	167	75	25	465	10	647	2,057
PB	11	1	3	4	4	10	4	5	5	6	17	5	2	34	1	53	164
PE	57	9	17	19	21	52	18	26	31	25	102	22	9	182	4	351	947
PI	13	1	2	2	2	7	3	5	4	3	10	5	1	15	1	35	109
SE	21	3	5	6	5	16	6	8	8	8	37	8	3	52	1	129	317
RN	15	2	4	4	6	16	9	9	12	9	40	7	3	100	1	99	337
DF	14	1	5	3	3	19	5	7	8	9	33	9	2	25	1	67	211
GO	158	34	49	19	17	105	87	58	48	41	162	52	18	132	5	449	1,433
MT	383	15	53	14	24	111	109	83	82	74	261	62	40	178	10	776	2,274
MS	100	8	30	11	15	48	15	34	24	24	80	31	14	152	4	348	936
ES	721	93	114	279	176	392	192	216	164	230	589	436	383	2,482	138	2,617	9,222
MG	1,170	158	205	355	270	929	242	404	331	424	1,186	630	364	2,779	213	4,342	14,003
RJ	874	95	98	177	118	354	151	206	173	195	601	189	82	1,091	40	2,860	7,302
SP	816	112	250	321	231	806	240	390	336	352	1,209	320	130	2,033	67	4,968	12,581
PR	325	29	72	59	63	276	70	130	97	105	360	112	47	417	15	1,329	3,504
SC	185	25	60	62	58	176	53	86	90	80	264	127	31	426	12	1,229	2,965
RS	286	28	82	67	46	195	55	91	83	85	301	91	36	580	13	1,329	3,369
Total	6,464	770	1,267	1,790	1,531	4,425	1,560	2,235	1,850	2,130	6,576	2,814	1,344	13,657	598	25,204	74,216

Source: Research data.

Table 10. Exports in CO2 emissions / exports in value added (Gg / 2008 US$ million), Brazilian states

	CHN	IND	RUS	MEX	CAN	DEU	ESP	FRA	GBR	ITA	Other EU27	JPN	KOR	USA	TWN	Other + RoW	Total
AC	0.23	0.22	0.23	0.23	0.21	0.21	0.22	0.24	0.17	0.18	0.22	0.23	0.24	0.23	0.24	0.23	0.22
AP	0.52	0.69	0.47	0.72	0.75	0.49	0.44	0.54	0.38	0.40	0.34	0.54	0.59	0.88	0.64	0.45	0.56
AM	0.64	0.68	0.59	0.48	0.52	0.57	0.59	0.62	0.45	0.49	0.57	0.66	0.71	0.61	0.63	0.52	0.55
PA	0.55	0.76	0.65	0.82	0.72	0.74	0.61	0.59	0.58	0.62	0.68	0.81	0.64	0.59	0.71	0.69	0.65
RO	0.32	0.35	0.26	0.43	0.36	0.32	0.29	0.31	0.27	0.28	0.30	0.32	0.36	0.39	0.37	0.30	0.31
RR	0.28	0.24	0.28	0.26	0.24	0.22	0.25	0.30	0.19	0.19	0.24	0.55	0.29	0.27	0.28	0.26	0.27
TO	0.30	0.35	0.26	0.39	0.32	0.31	0.29	0.33	0.27	0.26	0.30	0.33	0.35	0.38	0.38	0.30	0.31
AL	0.33	0.34	0.16	0.32	0.16	0.32	0.30	0.39	0.18	0.26	0.25	0.26	0.36	0.19	0.29	0.20	0.22
BA	0.71	0.81	0.66	0.65	0.62	0.62	0.67	0.66	0.51	0.70	0.72	0.68	0.75	0.72	0.74	0.67	0.68
CE	0.20	0.20	0.16	0.15	0.17	0.21	0.17	0.28	0.12	0.15	0.23	0.16	0.19	0.18	0.18	0.17	0.18
MA	0.52	0.87	0.61	0.98	0.83	0.69	0.58	0.64	0.55	0.63	0.65	0.67	0.74	0.92	0.83	0.77	0.73
PB	0.57	0.54	0.37	0.54	0.36	0.35	0.37	0.46	0.26	0.29	0.41	0.45	0.52	0.32	0.47	0.46	0.40
PE	0.64	0.70	0.48	0.69	0.51	0.42	0.50	0.54	0.34	0.39	0.53	0.59	0.66	0.71	0.67	0.56	0.55
PI	0.34	0.40	0.32	0.57	0.33	0.32	0.34	0.32	0.24	0.27	0.32	0.33	0.41	0.47	0.39	0.35	0.35
SE	0.54	0.52	0.46	0.51	0.46	0.40	0.45	0.49	0.36	0.39	0.42	0.50	0.52	0.50	0.52	0.52	0.48
RN	0.42	0.42	0.36	0.42	0.34	0.30	0.32	0.36	0.27	0.28	0.40	0.41	0.43	0.62	0.43	0.38	0.42
DF	0.27	0.25	0.24	0.23	0.19	0.13	0.24	0.30	0.15	0.16	0.26	0.26	0.24	0.24	0.24	0.24	0.22
GO	0.30	0.70	0.27	0.57	0.35	0.44	0.64	0.42	0.30	0.34	0.39	0.34	0.40	0.46	0.44	0.31	0.36
MT	0.36	0.37	0.36	0.47	0.41	0.43	0.36	0.37	0.36	0.37	0.39	0.37	0.37	0.47	0.38	0.35	0.37
MS	0.40	0.49	0.34	0.67	0.46	0.46	0.48	0.44	0.38	0.40	0.46	0.40	0.40	0.63	0.50	0.41	0.44
ES	0.86	1.19	1.20	1.55	1.13	0.97	1.09	0.97	0.89	0.77	0.96	1.15	1.72	0.91	1.64	1.15	1.03
MG	0.80	0.88	0.57	0.68	0.61	0.49	0.60	0.64	0.52	0.49	0.60	0.54	0.86	0.61	1.02	0.67	0.63
RJ	0.18	0.36	0.36	0.50	0.34	0.29	0.33	0.33	0.25	0.34	0.29	0.30	0.29	0.37	0.38	0.39	0.32
SP	0.21	0.22	0.19	0.18	0.19	0.16	0.20	0.18	0.17	0.17	0.17	0.22	0.24	0.20	0.21	0.20	0.19
PR	0.25	0.28	0.26	0.31	0.28	0.27	0.28	0.31	0.26	0.28	0.32	0.28	0.25	0.36	0.31	0.26	0.28
SC	0.46	0.48	0.37	0.40	0.41	0.37	0.36	0.38	0.32	0.36	0.40	0.37	0.45	0.43	0.51	0.42	0.41
RS	0.18	0.22	0.19	0.26	0.21	0.24	0.22	0.28	0.18	0.21	0.26	0.23	0.18	0.27	0.21	0.22	0.23
Total	0.35	0.47	0.32	0.43	0.41	0.33	0.39	0.37	0.30	0.35	0.35	0.45	0.55	0.44	0.58	0.37	0.38

Source: Research data.

Table 11. Imports in CO2 emissions (Gg), Brazilian states

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
CHN	33	69	1,976	499	187	19	117	138	1,341	544	263	356	610	197	130	184	544	625	230	341	769	2,579	2,589	10,044	2,226	1,718	1,499	29,829
IND	4	5	55	51	19	2	12	14	145	203	127	31	69	20	21	26	103	87	31	44	58	277	305	955	223	183	209	3,279
RUS	9	11	95	113	29	5	21	28	331	96	182	52	152	34	33	41	144	162	68	66	89	539	531	1,500	385	220	441	5,378
MEX	1	1	24	10	3	1	2	2	40	9	7	5	26	3	3	4	15	11	5	5	13	53	55	208	62	25	37	630
CAN	6	7	44	62	17	3	12	19	129	58	41	29	86	20	17	25	89	114	42	39	54	363	304	777	215	105	184	2,861
DEU	9	10	77	88	27	6	18	19	160	77	48	35	107	24	25	33	115	88	34	53	61	348	463	1,209	240	147	215	3,737
ESP	1	1	10	13	4	1	5	3	58	16	8	6	17	4	4	5	19	15	7	8	13	56	94	229	54	32	44	726
FRA	1	2	13	15	4	1	3	4	30	13	9	6	20	4	4	5	28	18	7	9	15	71	119	269	65	30	44	809
GBR	2	2	21	21	6	1	4	5	55	21	25	10	37	7	6	9	42	26	10	15	19	94	177	380	76	45	68	1,184
ITA	2	2	18	22	6	1	5	6	49	20	12	10	25	7	6	9	35	26	10	14	23	156	141	394	81	51	78	1,206
Other EU27	9	11	91	101	28	5	19	24	201	87	71	41	123	28	27	37	141	111	47	65	76	402	551	1,434	325	190	282	4,528
JPN	3	4	118	41	10	2	7	10	94	35	23	18	43	11	11	15	47	85	20	20	49	201	222	791	145	89	128	2,243
KOR	2	3	128	33	9	1	6	9	90	30	29	16	41	9	9	13	41	189	17	19	70	156	192	674	127	90	112	2,116
USA	15	20	193	249	48	9	35	51	405	158	163	81	262	53	62	76	264	242	91	102	165	792	1,159	3,043	534	352	519	9,141
TWN	2	3	87	30	10	1	6	8	76	30	40	16	33	9	8	11	36	36	15	17	40	148	154	639	123	82	96	1,757
Other + RoW	60	74	630	764	203	36	146	183	2,290	696	770	363	1,174	227	215	283	1,005	951	410	485	617	3,065	3,778	10,709	2,426	1,758	3,239	36,558
Total	160	226	3,580	2,111	611	95	419	521	5,493	2,093	1,819	1,074	2,827	656	579	777	2,669	2,786	1,043	1,302	2,134	9,301	10,833	33,255	7,308	5,116	7,194	105,982

Source: Research data.

Table 12. Share of bilateral trade in CO2 emissions in total imports (%), Brazilian states

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
CHN	0.03	0.07	1.86	0.47	0.18	0.02	0.11	0.13	1.27	0.51	0.25	0.34	0.58	0.19	0.12	0.17	0.51	0.59	0.22	0.32	0.73	2.43	2.44	9.48	2.10	1.62	1.41	28.15
IND	0.00	0.01	0.05	0.05	0.02	0.00	0.01	0.01	0.14	0.19	0.12	0.03	0.06	0.02	0.02	0.02	0.10	0.08	0.03	0.04	0.06	0.26	0.29	0.90	0.21	0.17	0.20	3.09
RUS	0.01	0.01	0.09	0.11	0.03	0.00	0.02	0.03	0.31	0.09	0.17	0.05	0.14	0.03	0.03	0.04	0.14	0.15	0.06	0.06	0.08	0.51	0.50	1.42	0.36	0.21	0.42	5.07
MEX	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.04	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.05	0.05	0.20	0.06	0.02	0.03	0.59
CAN	0.01	0.01	0.04	0.06	0.02	0.00	0.01	0.02	0.12	0.05	0.04	0.03	0.08	0.02	0.02	0.02	0.08	0.11	0.04	0.04	0.05	0.34	0.29	0.73	0.20	0.10	0.17	2.70
DEU	0.01	0.01	0.07	0.08	0.03	0.01	0.02	0.02	0.15	0.07	0.05	0.03	0.10	0.02	0.02	0.03	0.11	0.08	0.03	0.05	0.06	0.33	0.44	1.14	0.23	0.14	0.20	3.53
ESP	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.05	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.02	0.01	0.01	0.01	0.01	0.05	0.09	0.22	0.05	0.03	0.04	0.69
FRA	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.03	0.01	0.01	0.01	0.02	0.00	0.00	0.01	0.03	0.02	0.01	0.01	0.01	0.07	0.11	0.25	0.06	0.03	0.04	0.76
GBR	0.00	0.00	0.02	0.02	0.01	0.00	0.00	0.01	0.05	0.02	0.02	0.01	0.03	0.01	0.01	0.01	0.04	0.02	0.01	0.01	0.02	0.09	0.17	0.36	0.07	0.04	0.06	1.12
ITA	0.00	0.00	0.02	0.02	0.01	0.00	0.00	0.01	0.05	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.03	0.02	0.01	0.01	0.02	0.15	0.13	0.37	0.08	0.05	0.07	1.14
Other EU27	0.01	0.01	0.09	0.10	0.03	0.01	0.02	0.02	0.19	0.08	0.07	0.04	0.12	0.03	0.03	0.04	0.13	0.11	0.04	0.06	0.07	0.38	0.52	1.35	0.31	0.18	0.27	4.27
JPN	0.00	0.00	0.11	0.04	0.01	0.00	0.01	0.01	0.09	0.03	0.02	0.02	0.04	0.01	0.01	0.01	0.04	0.08	0.02	0.02	0.05	0.19	0.21	0.75	0.14	0.08	0.12	2.12
KOR	0.00	0.00	0.12	0.03	0.01	0.00	0.01	0.01	0.08	0.03	0.03	0.02	0.04	0.01	0.01	0.01	0.04	0.18	0.02	0.02	0.07	0.15	0.18	0.64	0.12	0.08	0.11	2.00
USA	0.01	0.02	0.18	0.23	0.05	0.01	0.03	0.05	0.38	0.15	0.15	0.08	0.25	0.05	0.06	0.07	0.25	0.23	0.09	0.10	0.16	0.75	1.09	2.87	0.50	0.33	0.49	8.63
TWN	0.00	0.00	0.08	0.03	0.01	0.00	0.01	0.01	0.07	0.03	0.04	0.01	0.03	0.01	0.01	0.01	0.03	0.03	0.01	0.02	0.04	0.14	0.15	0.60	0.12	0.08	0.09	1.66
Other + RoW	0.06	0.07	0.59	0.72	0.19	0.03	0.14	0.17	2.16	0.66	0.73	0.34	1.11	0.21	0.20	0.27	0.95	0.90	0.39	0.46	0.58	2.89	3.56	10.10	2.29	1.66	3.06	34.49
Total	0.15	0.21	3.38	1.99	0.58	0.09	0.40	0.49	5.18	1.97	1.72	1.01	2.67	0.62	0.55	0.73	2.52	2.63	0.98	1.23	2.01	8.78	10.22	31.38	6.90	4.83	6.79	100.00

Source: Research data.

Table 13. Imports in CO2 emissions / imports in value added (Gg / 2008 US$ million), Brazilian states

	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Total
CHN	1.54	1.46	1.36	1.55	1.45	1.58	1.48	1.48	1.45	1.54	1.53	1.22	1.52	1.63	1.54	1.54	1.53	1.60	1.64	1.42	1.43	1.53	1.50	1.43	1.48	1.48	1.52	1.46
IND	1.55	1.53	1.45	1.54	1.53	1.55	1.45	1.53	1.56	1.32	1.70	1.58	1.49	1.65	1.50	1.51	1.52	1.55	1.58	1.46	1.58	1.56	1.56	1.52	1.49	1.51	1.50	1.52
RUS	1.37	1.36	1.34	1.34	1.36	1.37	1.37	1.37	1.25	1.36	1.27	1.33	1.25	1.37	1.39	1.36	1.32	1.41	1.40	1.38	1.36	1.41	1.33	1.30	1.39	1.35	1.27	1.32
MEX	0.35	0.34	0.31	0.34	0.38	0.39	0.35	0.35	0.26	0.37	0.33	0.37	0.36	0.35	0.34	0.37	0.35	0.34	0.34	0.35	0.33	0.30	0.35	0.32	0.24	0.33	0.29	0.31
CAN	0.43	0.43	0.40	0.42	0.45	0.43	0.44	0.45	0.42	0.42	0.42	0.43	0.43	0.44	0.44	0.43	0.41	0.46	0.46	0.42	0.42	0.45	0.39	0.41	0.44	0.43	0.44	0.42
DEU	0.41	0.33	0.29	0.29	0.41	0.42	0.34	0.29	0.28	0.29	0.30	0.29	0.32	0.31	0.31	0.29	0.24	0.28	0.27	0.31	0.23	0.24	0.27	0.22	0.23	0.25	0.25	0.25
ESP	0.26	0.32	0.29	0.30	0.31	0.33	0.27	0.31	0.47	0.25	0.33	0.30	0.32	0.31	0.32	0.31	0.33	0.30	0.31	0.31	0.29	0.29	0.32	0.28	0.27	0.29	0.29	0.30
FRA	0.15	0.14	0.14	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.14	0.12	0.13	0.15	0.13	0.14	0.13	0.12	0.14	0.13	0.14	0.14	0.14
GBR	0.17	0.18	0.20	0.20	0.20	0.18	0.20	0.20	0.20	0.18	0.25	0.19	0.21	0.18	0.20	0.18	0.16	0.20	0.21	0.16	0.21	0.20	0.21	0.19	0.19	0.20	0.19	0.19
ITA	0.17	0.17	0.18	0.19	0.18	0.16	0.19	0.19	0.21	0.18	0.18	0.20	0.19	0.18	0.19	0.18	0.16	0.19	0.19	0.16	0.20	0.18	0.19	0.18	0.19	0.19	0.19	0.19
Other EU27	0.31	0.27	0.28	0.28	0.32	0.30	0.29	0.30	0.30	0.29	0.31	0.30	0.29	0.30	0.32	0.29	0.23	0.30	0.31	0.26	0.28	0.29	0.27	0.25	0.28	0.28	0.30	0.27
JPN	0.35	0.33	0.27	0.33	0.34	0.34	0.34	0.34	0.32	0.33	0.35	0.33	0.33	0.34	0.34	0.33	0.34	0.30	0.34	0.34	0.31	0.33	0.34	0.31	0.31	0.33	0.32	0.32
KOR	0.70	0.68	0.50	0.67	0.69	0.70	0.69	0.68	0.64	0.69	0.85	0.67	0.68	0.69	0.67	0.67	0.66	0.50	0.69	0.71	0.55	0.67	0.64	0.59	0.67	0.68	0.68	0.61
USA	0.51	0.46	0.41	0.47	0.49	0.51	0.51	0.50	0.47	0.48	0.52	0.49	0.50	0.49	0.49	0.42	0.45	0.46	0.47	0.47	0.40	0.43	0.43	0.40	0.43	0.44	0.43	0.43
TWN	1.02	0.92	0.66	0.94	1.03	1.03	1.03	1.00	0.87	0.99	1.80	1.00	0.99	1.05	0.94	0.95	1.01	1.00	1.06	1.06	0.81	0.88	0.90	0.86	0.83	0.93	0.98	0.89
Other + RoW	0.57	0.56	0.64	0.65	0.63	0.59	0.62	0.66	0.71	0.61	0.73	0.67	0.68	0.63	0.65	0.62	0.61	0.68	0.71	0.56	0.67	0.63	0.59	0.64	0.65	0.67	0.72	0.65
Total	0.57	0.59	0.72	0.60	0.65	0.57	0.62	0.62	0.65	0.63	0.69	0.65	0.62	0.64	0.62	0.58	0.52	0.60	0.64	0.57	0.63	0.59	0.54	0.57	0.60	0.66	0.63	0.59

Source: Research data.

Table 14. Balance of international trade in CO2 emissions (Gg), Brazilian states

	CHN	IND	RUS	MEX	CAN	DEU	ESP	FRA	GBR	ITA	Other EU27	JPN	KOR	USA	TWN	Other + RoW	Total
AC	-31	-4	-8	-0	-5	-8	-1	-0	-0	-1	-6	-2	-2	-12	-2	-47	-129
AP	-58	-4	-10	1	-3	-5	0	1	0	-0	-2	-1	-2	25	-3	-41	-103
AM	-1,900	-45	-77	11	-23	-10	10	19	9	12	5	-89	-117	-2	-81	-139	-2,418
PA	45	9	-56	100	227	182	80	173	81	105	310	401	53	1,002	-3	510	3,221
RO	-174	-18	-5	-1	-13	-16	3	2	6	3	-7	-5	-7	-27	-9	-118	-387
RR	-18	-2	-5	-0	-3	-5	-0	-0	-1	-0	-4	0	-1	-7	-1	-30	-78
TO	-92	-12	-15	-1	-10	-11	7	2	-0	-1	-5	-3	-5	-23	-6	-102	-277
AL	-127	-10	-18	0	-13	-7	0	3	-0	-0	-1	-5	-6	-26	-7	-106	-324
BA	-935	-95	-264	129	-40	262	43	136	82	171	336	40	-42	506	-51	-825	-547
CE	-527	-201	-89	-2	-51	-50	-8	-0	-6	-5	-44	-28	-27	-102	-29	-611	-1,781
MA	-54	-101	-155	51	7	43	49	47	19	37	96	52	-4	303	-30	-123	237
PB	-346	-29	-49	-2	-25	-25	-2	-2	-5	-4	-24	-13	-14	-47	-15	-310	-911
PE	-554	-59	-135	-7	-65	-54	0	6	-6	0	-21	-21	-33	-80	-29	-822	-1,879
PI	-184	-19	-32	-1	-19	-17	-1	1	-3	-3	-18	-6	-8	-38	-9	-191	-547
SE	-109	-18	-28	3	-12	-9	2	4	2	3	9	-2	-6	-9	-7	-85	-262
RN	-169	-24	-37	0	-20	-17	4	4	4	0	2	-8	-10	24	-10	-183	-440
DF	-530	-101	-140	-12	-86	-96	-14	-20	-33	-27	-108	-39	-39	-239	-35	-938	-2,459
GO	-467	-53	-113	8	-96	16	71	40	22	15	51	-33	-171	-110	-30	-502	-1,352
MT	153	-16	-15	9	-17	76	102	76	71	64	214	42	24	87	-5	366	1,230
MS	-241	-36	-36	6	-24	-5	7	25	9	10	14	10	-5	50	-14	-137	-367
ES	-48	34	25	266	122	332	179	201	145	207	513	386	312	2,317	98	1,999	7,088
MG	-1,409	-119	-333	302	-93	582	186	333	236	268	783	429	207	1,987	65	1,277	4,702
RJ	-1,715	-211	-433	123	-186	-109	57	86	-4	54	50	-33	-110	-68	-114	-918	-3,531
SP	-9,229	-843	-1,251	112	-546	-404	11	122	-44	-42	-225	-471	-543	-1,010	-571	-5,741	-20,674
PR	-1,901	-194	-313	-4	-153	36	16	66	21	23	35	-34	-79	-117	-108	-1,097	-3,804
SC	-1,533	-158	-160	38	-47	29	21	55	45	30	74	38	-59	75	-70	-529	-2,151
RS	-1,213	-181	-359	30	-138	-20	11	47	15	7	19	-36	-76	61	-83	-1,910	-3,825
Total	-23,365	-2,509	-4,111	1,161	-1,330	689	833	1,426	666	924	2,048	570	-772	4,516	-1,159	-11,354	-31,766

Source: Research data.

3.3. Decomposition of Brazilian states' outflows and exports in CO2 emissions

In this subsection, in order to analyze the participation and the position of states in domestic and global value chains, in terms of CO2 emissions, we apply the decomposition from subsection 2.4.

Table 15 presents the results. By analyzing the decomposition of outflows, we can observe that the states present different positions in the domestic value chains, in terms of CO2 emissions. The largest share of São Paulo's CO2 emissions embodied in outflows corresponds to final products. The same applies to Amazonas, Roraima, Ceará, the states from the Central-West region, and Rio Grande do Sul. However, for the other states, the CO2 emissions embodied in outflows of intermediate products are prevalent. In Espírito Santo, the CO2 emissions embodied in indirect outflows also stand out.

In the global value chains, as can be apprehended examining the last four columns of Table 15, the exports of CO2 emissions are largely generated by Brazilian states as sources of intermediate products.

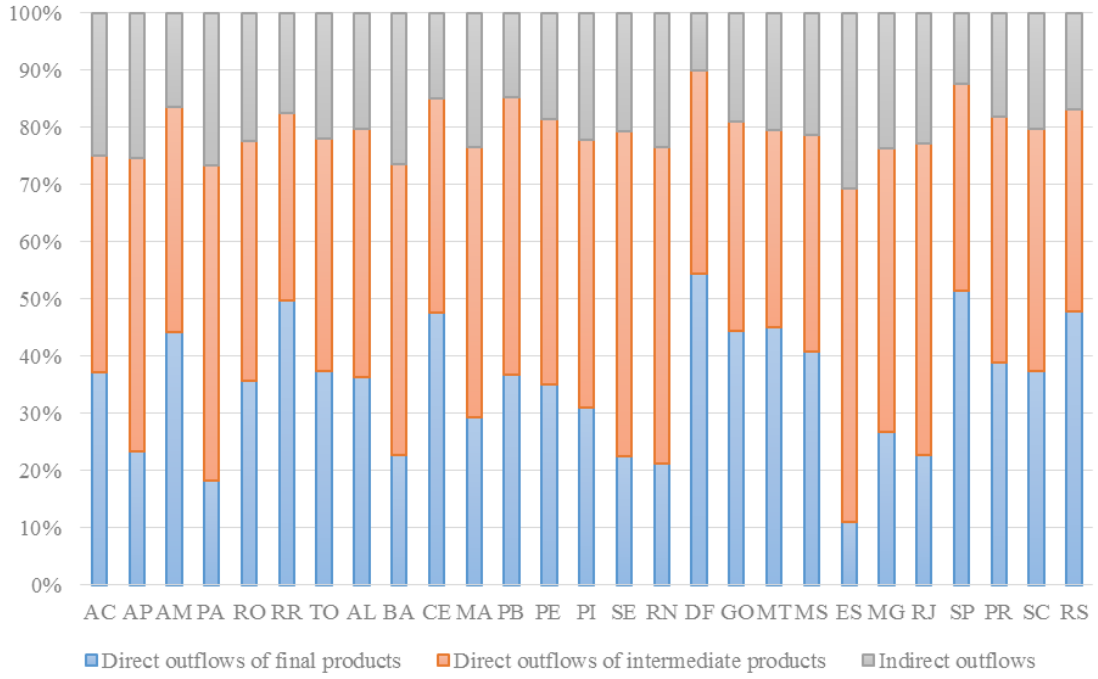
Table 15. Decomposition of outflows and exports in CO2 emissions (Gg)

	Inter-regional Trade - Outflows				International Trade - Exports			
	Final products	Interm. products	Indirect	Total Outflows	Final products	Interm. products	Indirect	Total Exports
Acre	50	51	34	135	0	16	14	31
Amapá	17	37	18	72	3	94	25	123
Amazonas	2,639	2,364	983	5,985	87	652	424	1,163
Pará	358	1,090	525	1,974	115	4,072	1,145	5,332
Rondônia	256	300	160	716	38	115	71	224
Roraima	41	27	15	83	2	9	6	17
Tocantins	183	199	108	490	8	82	53	143
Alagoas	199	237	111	547	38	106	52	196
Bahia	1,421	3,213	1,662	6,296	439	3,215	1,292	4,946
Ceará	496	392	155	1,044	53	171	89	312
Maranhão	788	1,274	635	2,697	41	1,497	519	2,057
Paraíba	381	502	152	1,036	14	94	55	164
Pernambuco	1,233	1,629	653	3,515	90	564	293	947
Piauí	130	196	93	418	5	63	41	109
Sergipe	310	784	287	1,381	9	193	114	317
Rio Grande do Norte	203	532	225	960	39	196	101	337
Distrito Federal	762	498	142	1,402	21	130	60	211
Goiás	1,238	1,018	529	2,785	181	855	397	1,433
Mato Grosso	1,700	1,299	772	3,772	344	1,338	592	2,274
Mato Grosso do Sul	1,008	934	528	2,470	112	540	284	936
Espírito Santo	855	4,545	2,402	7,802	147	6,594	2,481	9,222
Minas Gerais	3,821	7,061	3,376	14,257	737	9,621	3,645	14,003
Rio de Janeiro	2,795	6,714	2,819	12,328	431	4,651	2,220	7,302
São Paulo	13,150	9,290	3,189	25,628	2,608	7,242	2,731	12,581
Paraná	3,419	3,788	1,610	8,817	626	1,966	912	3,504
Santa Catarina	2,736	3,105	1,481	7,322	497	1,630	839	2,965
Rio Grande do Sul	2,817	2,090	992	5,899	996	1,679	693	3,369
Total	43,006	53,171	23,655	119,832	7,682	47,387	19,147	74,216

Source: Research data.

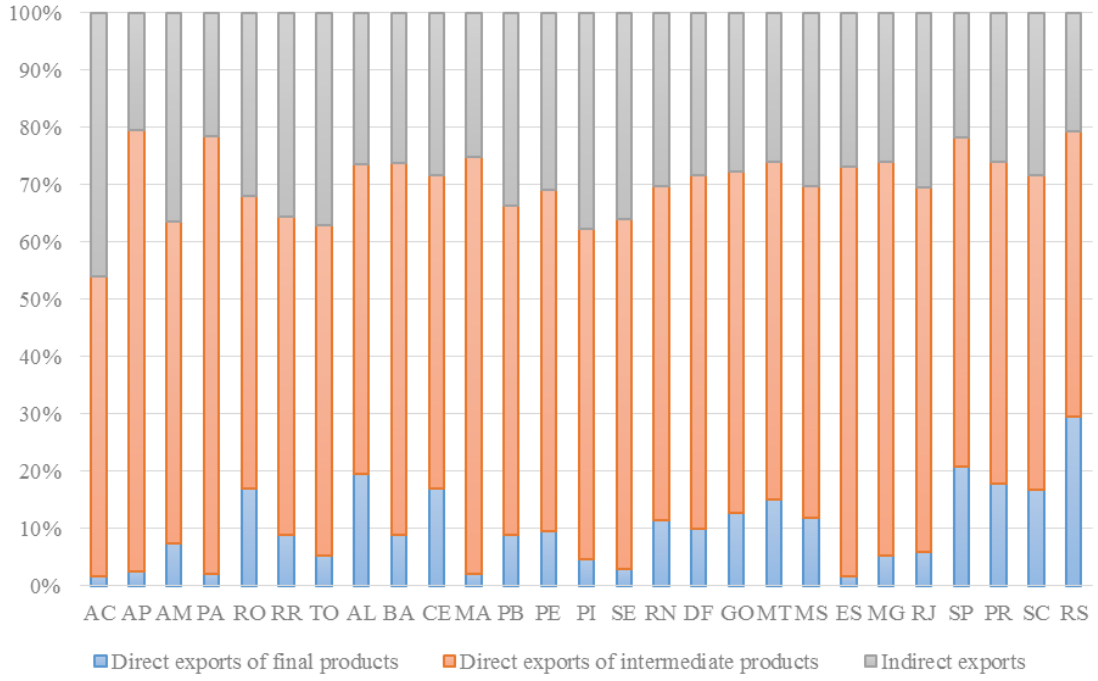
Figures 4 and 5 illustrate the participation of these components in Brazilian states' outflows and exports respectively.

Figure 4. Decomposition of outflows in CO2 emissions (%)



Source: Research data.

Figure 5. Decomposition of exports in CO2 emissions (%)



Source: Research data.

3.4. Assessing the relevance of trade in CO2 emissions for Brazilian states

It is also possible to assess the relevance of trade in CO2 emission for the Brazilian states. In this subsection, we do this by comparing its figures with those from trade in value added (Dietzenbacher et al, 2013).

First, we consider all the states together. The first block of Table 16, "Production", presents the participation of the own state, outflows and exports in the total CO2 emissions or value added of the state. The internal component ("own state") is 22.21 pp lower in the case of CO2 emissions, indicating that trade flows are more intense in terms of emissions (than in terms of value added). Both outflows and exports correspond to larger shares in trade in CO2 emissions. This higher intensity of trade in CO2 emissions can also be understood from the demand perspective, as from the second block of Table 16. In CO2 terms, the imports of Brazilian states are considerably more relevant than in value added terms.

Table 16. Comparing trade in CO2 emissions (TiCE) and trade in value added (TiVA)

Production			
	TiCE	TiVA	Difference (pp)
Own state	41%	63%	-22.21
Outflows	37%	25%	11.30
Exports	23%	12%	10.91

Final demand			
	TiCE	TiVA	Difference (pp)
Own state	37%	64%	-26.48
Inflows	33%	26%	7.79
Imports	30%	11%	18.68

Source: Research data.

The higher intensity of trade in terms of CO2 emissions also holds for every Brazilian state, as can be understood from Tables 17 and 18. From the production perspective, the trade in CO2 emissions becomes especially more relevant for Espírito Santo. From the demand perspective, it applies to São Paulo the most.

Table 17. Comparing trade in CO2 emissions (TiCE) and trade in value added (TiVA), Brazilian states' production

	Trade in CO2 emissions			Trade in value added			Difference (pp)		
	Own state	Inflows	Imports	Own state	Inflows	Imports	Own state	Inflows	Imports
Acre	59%	34%	8%	74%	22%	4%	-15.06	11.42	3.64
Amapá	55%	17%	28%	81%	13%	6%	-26.06	4.05	22.00
Amazonas	25%	63%	12%	39%	53%	8%	-14.02	9.84	4.17
Pará	25%	20%	55%	56%	17%	27%	-31.17	3.35	27.82
Rondônia	44%	42%	13%	67%	25%	8%	-22.61	17.51	5.10
Roraima	59%	34%	7%	84%	14%	2%	-24.27	19.83	4.44
Tocantins	46%	42%	12%	64%	29%	7%	-17.35	12.16	5.19
Alagoas	51%	36%	13%	69%	23%	9%	-17.88	13.78	4.10
Bahia	43%	32%	25%	67%	21%	12%	-24.35	11.18	13.17
Ceará	65%	27%	8%	67%	27%	6%	-2.64	0.24	2.39
Maranhão	30%	40%	30%	61%	26%	13%	-30.66	13.87	16.78
Paraíba	54%	39%	6%	80%	17%	3%	-25.47	22.41	3.06
Pernambuco	50%	39%	11%	75%	20%	5%	-24.98	19.18	5.80
Piauí	64%	28%	7%	81%	15%	4%	-17.07	13.38	3.69
Sergipe	36%	52%	12%	63%	31%	7%	-26.53	21.21	5.32
Rio Grande do Norte	45%	41%	14%	72%	22%	6%	-26.73	18.81	7.92
Distrito Federal	70%	26%	4%	88%	10%	2%	-17.76	15.51	2.25
Goiás	50%	33%	17%	62%	28%	10%	-11.70	5.14	6.55
Mato Grosso	27%	45%	27%	43%	34%	23%	-16.33	11.47	4.86
Mato Grosso do Sul	37%	46%	17%	58%	30%	12%	-21.86	16.47	5.39
Espírito Santo	10%	41%	49%	44%	30%	26%	-34.00	11.57	22.43
Minas Gerais	36%	32%	32%	60%	24%	16%	-23.93	8.10	15.83
Rio de Janeiro	49%	32%	19%	64%	23%	13%	-14.90	8.90	6.01
São Paulo	47%	36%	18%	56%	31%	13%	-9.51	4.77	4.74
Paraná	39%	44%	17%	54%	33%	14%	-15.02	11.10	3.91
Santa Catarina	37%	45%	18%	57%	32%	12%	-19.76	13.21	6.55
Rio Grande do Sul	44%	35%	20%	60%	26%	14%	-15.25	9.38	5.87

Source: Research data.

Table 18. Comparing trade in CO2 emissions (TiCE) and trade in value added (TiVA), Brazilian states' final demand

	Trade in CO2 emissions			Trade in value added			Difference (pp)		
	Own state	Inflows	Imports	Own state	Inflows	Imports	Own state	Inflows	Imports
Acre	30%	49%	20%	62%	31%	7%	-31.50	17.89	13.61
Amapá	27%	48%	25%	59%	33%	8%	-32.26	15.03	17.24
Amazonas	31%	23%	46%	45%	33%	22%	-14.67	-9.57	24.24
Pará	28%	48%	24%	49%	41%	10%	-20.97	7.02	13.95
Rondônia	30%	46%	24%	54%	37%	9%	-24.79	8.98	15.81
Roraima	32%	47%	21%	72%	23%	6%	-39.81	24.55	15.25
Tocantins	31%	45%	24%	56%	35%	9%	-24.37	9.14	15.23
Alagoas	32%	47%	22%	60%	33%	7%	-28.27	13.97	14.31
Bahia	40%	34%	26%	55%	34%	11%	-14.41	-0.53	14.94
Ceará	32%	42%	26%	61%	29%	10%	-29.19	12.70	16.48
Maranhão	35%	35%	31%	55%	34%	11%	-19.90	0.53	19.37
Paraíba	32%	43%	24%	56%	35%	9%	-23.49	8.02	15.47
Pernambuco	40%	34%	26%	58%	31%	10%	-18.35	2.95	15.41
Piauí	31%	47%	22%	52%	41%	8%	-20.38	6.41	13.97
Sergipe	38%	40%	22%	56%	35%	8%	-18.81	4.84	13.97
Rio Grande do Norte	30%	49%	22%	58%	34%	8%	-28.25	15.09	13.16
Distrito Federal	33%	44%	23%	68%	25%	7%	-35.01	18.54	16.46
Goiás	40%	35%	26%	57%	33%	11%	-17.01	2.13	14.88
Mato Grosso	43%	38%	20%	58%	34%	8%	-15.84	4.20	11.64
Mato Grosso do Sul	41%	32%	27%	55%	33%	12%	-13.80	-1.08	14.88
Espírito Santo	28%	41%	31%	51%	37%	11%	-23.10	3.42	19.68
Minas Gerais	44%	31%	25%	57%	32%	11%	-13.46	-1.03	14.49
Rio de Janeiro	41%	35%	24%	60%	29%	11%	-18.97	6.03	12.94
São Paulo	36%	27%	36%	69%	17%	14%	-32.51	10.36	22.15
Paraná	36%	31%	34%	57%	29%	14%	-21.20	1.50	19.70
Santa Catarina	37%	31%	32%	56%	31%	12%	-19.25	-0.05	19.30
Rio Grande do Sul	33%	34%	33%	60%	29%	11%	-26.72	5.36	21.36

Source: Research data.

4. Concluding Remarks

Our results from the empirical application can be summarized as follows: (1) the CO2 emissions due to fossil fuels are largely concentrated in the states of Southeast and South region, and Bahia in the Northeast region (75% of the national total in 2008); (2) there is great variation among states concerning the industry profile of their emissions, but in most of them the Transport sector is prevalent; (3) São Paulo's dominance in inter-regional trade is less intense in terms of emissions than in terms of value added; (4) Espírito Santo and Minas Gerais are also main sources of trade in CO2 emissions due to mining and metallurgical activities. Trade flows from these states present high intensity of CO2 (in relation to its value added content); (5) São Paulo is a large net importer of CO2 emissions (in total and considering each trade parner), while Pará, Espírito Santo and Minas Gerais are important net exporters; (6) the BRICs countries are net exporters of CO2 emissions to almost every state; (7) on the other hand, the countries from UE27 and the USA are net importers of Brazilian CO2 emissions; (8) in the global value chains, the exports of CO2 emissions are largely generated by Brazilian states as sources of intermediate products; (9) for the Brazilian states, trade in CO2 emissions is considerably more relevant than trade in gross terms or trade in value added, considering both inter-regional and international markets.

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Annex

Table A1. CO2 emissions (Gg) by industry in 2008, Brazilian states

Industry	AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI
Agriculture	138	31	255	567	465	48	388	0	844	57	967	192	506	245
Mining and Quarrying	2	48	252	1,339	23	2	10	0	410	0	177	34	11	10
Food, Beverages and Tobacco	5	1	93	86	48	2	21	5	223	61	29	24	150	40
Textiles and Textile Products	0	0	2	3	0	0	0	0	16	40	2	22	21	3
Leather, Leather and Footwear	1	0	0	7	4	0	1	0	4	14	1	40	5	1
Wood and Products of Wood	3	4	3	77	14	1	0	0	48	8	3	0	1	0
Pulp, Paper,	2	6	395	76	5	1	4	0	405	4	10	55	147	16
Refined Petroleum	0	0	2,827	73	4	0	19	1	1,399	1	323	480	460	85
Chemicals and Chemical Products	2	0	219	162	6	1	23	220	3,652	21	209	23	1,188	37
Rubber and Plastics	2	0	172	11	2	0	4	47	777	4	4	24	92	5
Other Non-Metallic Mineral	18	8	119	594	26	2	53	0	171	116	105	318	525	94
Basic Metals and Fabricated Metal	3	8	1,009	3,072	61	1	7	0	2,452	36	1,386	45	779	67
Machinery, Nec	0	0	18	1	4	0	0	1	47	9	1	0	7	1
Electrical and Optical Equipment	0	0	172	0	0	0	0	1	49	12	0	1	9	0
Transport Equipment	0	0	325	2	4	0	0	2	108	22	1	0	16	3
Manufacturing, Nec; Recycling	0	0	16	3	0	0	0	0	18	3	1	2	7	2
Electricity, Gas and Water Supply	64	69	636	857	425	48	216	29	1,029	16	234	388	1,345	177
Construction	2	1	8	14	2	1	5	2	33	16	9	4	12	3
Wholesale and retail trade	4	5	24	34	13	2	9	1	68	11	27	18	47	13
Hotels and Restaurants	3	3	28	25	5	2	4	0	64	5	18	14	46	8
Transport	121	175	2,797	2,574	500	102	360	1,194	7,381	3,343	3,105	826	3,194	578
Other Business Activities	4	4	25	41	11	4	7	1	38	5	22	16	67	10
Financial Intermediation	1	0	3	5	1	1	1	1	16	2	3	3	12	2
Real Estate Activities	0	0	1	2	0	0	0	0	2	0	1	1	2	0
Public Admin and Defence	17	23	56	80	36	19	26	1	324	33	53	48	129	35
Education	6	7	22	25	10	5	8	0	54	6	23	23	43	10
Health and Social Work	3	4	16	17	7	3	6	0	44	6	15	14	37	11
Other Services	2	3	15	25	8	2	6	0	56	6	18	14	45	10
Households	75	83	316	763	222	36	148	325	2,174	803	508	396	973	292
Total	**476**	**483**	**9,825**	**10,537**	**1,906**	**281**	**1,328**	**1,833**	**21,904**	**4,660**	**7,253**	**3,024**	**9,875**	**1,762**

Table A1 (continued)

Industry	SE	RN	DF	GO	MT	MS	ES	MG	RJ	SP	PR	SC	RS	Brazil
Agriculture	127	165	109	687	2,662	1,061	117	1,866	415	3,463	1,174	2,032	620	19,203
Mining and Quarrying	398	528	4	359	25	101	2,519	1,635	227	219	9	141	52	8,534
Food, Beverages and Tobacco	27	25	31	199	323	146	46	607	393	1,436	209	383	531	5,143
Textiles and Textile Products	16	35	1	0	9	12	7	244	40	368	9	264	34	1,150
Leather, Leather and Footwear	6	1	0	0	8	10	2	43	11	118	2	20	6	305
Wood and Products of Wood	0	0	0	17	37	3	16	115	56	270	39	68	105	891
Pulp, Paper,	11	12	41	0	16	24	383	186	119	1,240	378	454	429	4,418
Refined Petroleum	55	145	1	2	998	1,125	161	54	771	2,225	829	92	148	12,279
Chemicals and Chemical Products	121	38	97	61	538	106	170	425	893	2,762	424	684	774	12,855
Rubber and Plastics	10	11	5	13	43	7	36	90	190	587	90	343	164	2,734
Other Non-Metallic Mineral	287	82	419	246	216	120	107	2,952	1,158	4,706	2,701	1,150	179	16,471
Basic Metals and Fabricated Metal	15	29	139	614	195	282	9,858	17,903	11,332	7,987	102	2,336	524	60,241
Machinery, Nec	3	1	1	4	1	9	19	74	114	704	40	159	124	1,342
Electrical and Optical Equipment	0	0	1	6	1	1	23	61	139	1,049	43	58	136	1,764
Transport Equipment	1	0	0	10	1	2	44	176	254	1,208	92	91	1,057	3,419
Manufacturing, Nec; Recycling	1	2	2	1	2	1	6	31	42	210	14	39	50	456
Electricity, Gas and Water Supply	461	231	326	17	519	275	1,081	6	5,314	183	677	1,820	255	16,698
Construction	4	5	13	12	8	7	29	33	83	814	48	20	41	1,229
Wholesale and retail trade	10	17	41	12	45	24	52	41	493	182	20	93	169	1,479
Hotels and Restaurants	10	19	55	12	19	14	17	264	152	698	96	58	107	1,747
Transport	1,027	885	3,001	6,151	2,471	1,909	3,198	17,283	13,492	40,055	12,927	5,664	10,277	144,588
Other Business Activities	12	17	116	17	29	27	26	55	304	149	20	103	103	1,232
Financial Intermediation	2	3	38	1	6	5	10	10	125	52	4	17	37	361
Real Estate Activities	0	1	2	0	1	1	2	1	19	9	1	3	6	56
Public Admin and Defence	34	45	867	41	55	46	79	113	1,133	532	60	85	385	4,352
Education	12	20	24	5	20	17	30	69	329	191	26	48	122	1,155
Health and Social Work	8	13	42	6	17	13	25	75	246	218	29	35	97	1,005
Other Services	9	14	72	2	22	19	33	34	396	104	13	63	132	1,121
Households	212	310	641	1,093	384	381	792	3,855	5,071	7,358	2,157	1,437	2,819	33,623
Total	**2,881**	**2,654**	**6,091**	**9,589**	**8,670**	**5,745**	**18,888**	**48,302**	**43,312**	**79,097**	**22,233**	**17,761**	**19,482**	**359,853**

Source: Research data.