Assessment of issues related to international trade and environmental impacts (Emissions): a computable general equilibrium modeling

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Main Aim

Evaluate the impacts of the Brazilian trade structure on the amount of emissions

Identify the main trade links of Brazil in terms of CO_2 emissions

Deal with the impacts of changes in trade not only from the economic point of view, but also from the perspective of deterioration in welfare, as measured by emissions

Simulations

I) Specifies an incentive in the form of subsidies to Brazil's world exports to all sectors and regions in 10%

II) Specifies a reduction in import tariffs for all sectors and regions of Brazil by 10%

Results

Incentives to exports and incentives to imports would *increase* the emissions in Brazil and in most other regions

In the first case, *due to* the increase in the economic activity level of those sectors that use energy products more intensely as intermediate inputs, such as the transport sector

In the second, *due to* the relative cheapness of foreign products, which would facilitate the purchase of energy inputs by Brazil. The emissions of most of the regions would increase due to the production stimulation promoted by the Brazilian market
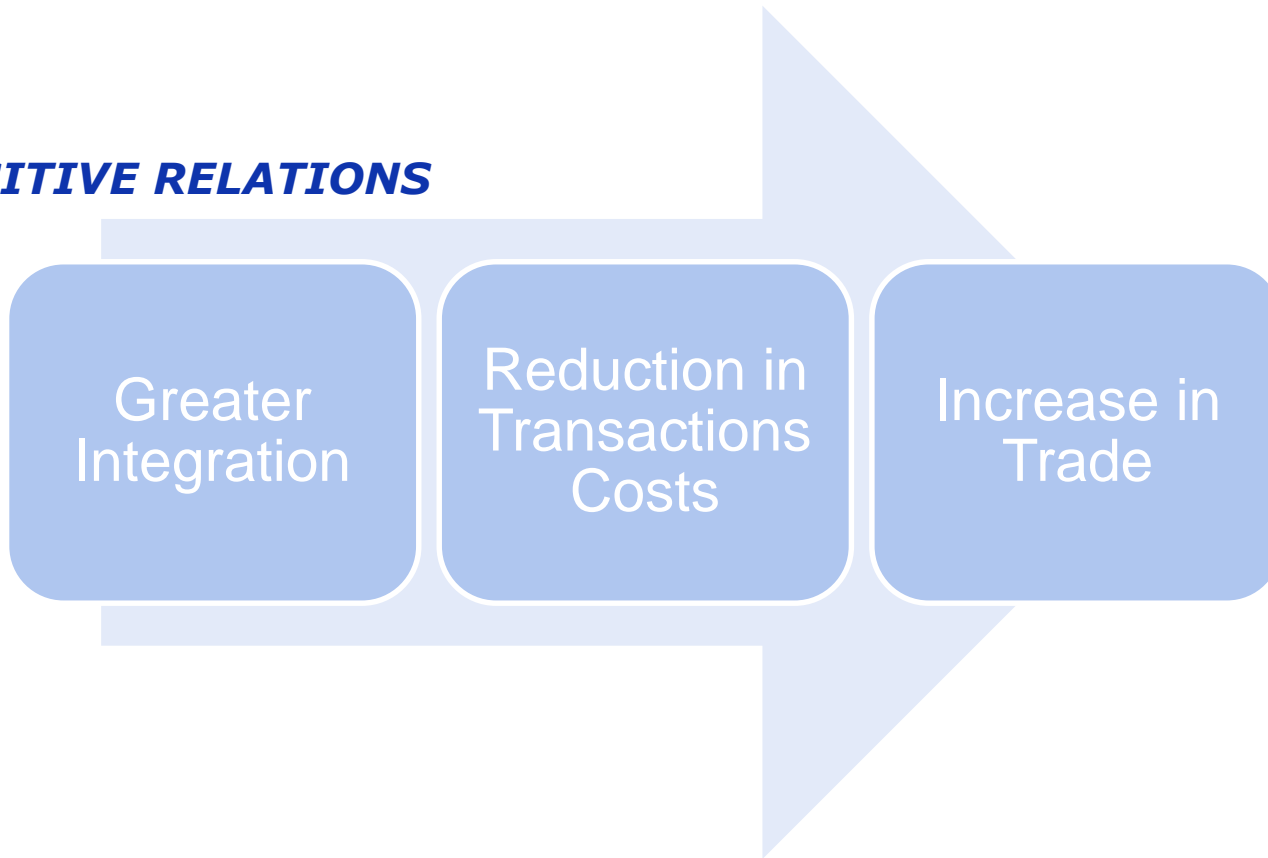
The world economy has been undergoing continuous changes over the years….

<u>Changes</u> in:

- Economic activity

- Population

- Income per capita

- Degree of economic integration → technological advances in the fields of communication and information, the reduction of trade barriers, and foreign investments

The world economy has been undergoing continuous changes over the years….

POSITIVE RELATIONS

Greater Integration

Reduction in Transactions Costs

Increase in Trade

The world economy has been undergoing continuous changes over the years….

Gains from growth of the world economy → Negative Externalities → Environment Degradation, Deforestation, Pollution

Discussions on the environmental consequences of trade liberalization have increased in intensity and amount…

Establishment of the World Trade Organization (WTO)

Proposals for future rounds of trade negotiations

The debate involves the possibility that some countries may have environmental gains by engaging in international trade and others might stand losses, according to their own choices

A vast literature on the environmental consequences of economic growth and international trade…

The papers deal with:

- The relationship between international trade, economic growth and effects on the environment

- Per capita income and pollution

- Environmental regulations and trade flows

- Reducing trade barriers and shifting the pollution-intensive industry from countries with stringent standards to countries with weaker standards

A vast literature on the environmental consequences of economic growth and international trade…

These approaches are mainly summarized in the hypotheses and discussions behind:

- The environmental Kuznets (CKA)
- Pollution haven effect
- Pollution-haven-hypothesis
- Pollution-haven-driven trade assumptions and competitive advantages
- Differences in technology, property rights for environmental resources and trade patterns, "free riders"
- Carbon leakages

Model and database analysis...

GTAP-E version 9a

Originally covers 57 commodities and 140 regions, including Brazil

Five production factors (land, skilled labor, unskilled labor, natural resources and capital)

GTAP-E incorporates emissions from the combustion of fossil fuels

In terms of theoretical structure, the model presents the same standard structure as the GTAP model, incorporating the possibility of substitution of use among the different energy sources

Database analysis…

The choice of the regional and sectoral structure of the model had as a parameter the observation of the main trading partners of Brazil, as well as the main emitting sectors

The idea was to capture the emissions of the main links of exports and imports from Brazil from the trade sectoral structure

The model used in this work recognizes 22 sectors and 16 regions

Main destinations of exports and origins of imports from Brazil (%)

Regions		Exports			Imports		
		1995	*2004*	*2011*	*1995*	*2004*	*2011*
1	China	1.08	5.47	14.84	2.61	6.98	20.31
2	Japan	5.06	4.08	3.10	7.10	3.18	4.57
3	South Korea	2.70	3.00	4.25	2.01	1.78	2.03
4	Rest of Asia	9.82	8.74	10.32	10.36	9.89	11.48
5	United States	22.68	20.47	15.86	18.67	21.27	12.40
6	Rest of North America and the Caribbean	4.66	2.73	4.18	4.17	8.40	5.60
7	Argentina	10.78	8.68	7.81	8.68	7.20	8.55
8	Chile	2.15	2.18	2.08	2.55	2.63	2.06
9	Venezuela	1.54	0.34	0.55	1.00	1.34	1.86
10	Rest of South America	3.68	3.32	3.70	7.67	4.06	4.84
11	Germany	9.73	8.66	7.25	5.30	5.84	4.38
12	France	2.93	3.55	2.54	3.05	2.65	2.23
13	Italy	5.88	3.30	2.86	4.26	3.25	2.30
14	Rest of Europe	13.26	14.93	12.54	17.84	16.68	12.13
15	Rest of the World	4.03	10.56	8.11	4.73	4.86	5.28
	Total	100	100	100	100	100	100

Source: Own elaboration based on the GTAP 9a database.

Percentage share (%) of Brazilian exports by region of origin (2011)

Sectors		China	Japan	South Korea	Rest of Asia	United States	Rest of North America and the Caribbean	Argentina	Chile	Venezuela	Rest of South America	Germany	France	Italy	Rest of Europe	Rest of the World	Total
S1	Agriculture and products of plant origin	39.07	3.40	1.76	5.87	6.81	0.77	0.41	0.11	0.41	1.37	5.96	1.25	2.39	19.13	11.28	13.42
S2	Livestock and animal products	2.76	9.59	0.50	7.20	1.67	0.36	1.25	1.89	9.39	1.21	2.51	0.55	1.50	22.98	36.65	5.58
S3	Mineral extractive	46.69	11.22	4.60	4.26	0.58	0.26	2.37	0.00	0.06	0.10	8.26	2.16	3.67	6.91	8.88	21.27
S4	Food and beverages	7.12	2.57	2.29	12.27	6.63	2.06	1.42	0.59	2.53	3.24	2.35	5.00	0.75	17.56	33.62	10.68
S5	Textiles and clothing	2.08	1.75	0.41	3.68	10.69	3.65	28.44	3.82	5.57	19.85	1.89	1.63	1.62	4.52	9.89	0.58
S6	Other light industry	8.67	1.29	1.33	3.06	13.15	4.56	28.34	2.43	1.79	7.20	3.92	2.70	3.98	8.76	8.81	13.48
S7	Coal	3.72	0.36	1.78	14.54	7.50	1.49	8.79	0.07	0.00	1.52	4.57	0.84	3.45	7.68	43.70	0.00
S8	Petroleum	15.69	0.01	0.01	6.47	30.96	1.05	0.00	9.11	0.00	0.79	0.01	1.43	0.00	6.32	28.14	4.12
S9	Gas	0.24	0.08	0.34	25.56	4.28	0.20	10.83	0.05	1.18	0.02	2.35	0.76	0.84	7.71	45.57	0.00
S10	Petroleum products	0.39	0.06	0.89	5.15	43.72	0.62	25.24	0.17	0.04	14.09	0.21	0.21	0.45	4.23	4.53	2.27
S11	Electricity	5.35	0.00	0.02	16.66	9.95	1.65	5.63	0.18	0.05	5.45	2.04	1.25	11.65	16.05	24.06	0.06
S12	Chemicals	3.70	1.80	0.46	2.94	14.86	4.45	19.15	4.03	4.39	15.21	4.94	1.84	1.62	12.92	7.69	6.09
S13	Mineral products	0.53	0.37	0.12	1.11	40.47	8.01	9.63	2.57	2.23	14.76	2.40	1.04	0.99	5.95	9.82	0.82
S14	Ferrous metal products	5.94	3.50	6.75	12.15	22.31	4.65	8.67	1.38	0.50	7.32	3.58	1.93	1.84	5.30	4.20	3.86
S15	Metals	2.73	8.82	0.41	2.48	13.57	13.87	6.68	0.43	0.57	3.07	2.44	1.79	3.56	33.62	5.96	2.53
S16	Other heavy industry	2.12	0.46	0.40	3.14	16.92	6.83	17.02	4.08	4.30	17.46	5.11	1.55	1.46	6.40	12.75	5.74
S17	Construction and utilities	2.08	0.26	0.95	19.18	5.67	0.33	0.14	0.10	0.08	0.18	9.87	4.67	2.52	8.03	45.96	0.06
S18	Road transport	8.11	0.73	3.78	13.97	22.21	0.94	0.40	0.18	0.18	0.40	3.15	2.40	7.88	14.79	20.88	0.78
S19	Water transport	0.49	5.45	9.52	15.38	1.01	0.99	0.03	2.46	0.14	0.23	17.17	8.45	1.63	28.78	8.26	0.98
S20	Air Transport	4.01	1.32	3.26	14.21	10.56	0.79	0.41	0.20	0.25	0.52	9.40	5.67	6.62	15.97	26.80	0.34
S21	Trade and communication	10.90	2.33	4.22	19.89	11.19	1.20	0.28	0.26	0.12	0.41	3.28	2.68	8.23	16.77	18.24	0.81
S22	Other services	3.94	1.74	2.66	16.78	23.50	2.84	0.18	0.13	0.20	0.32	3.85	1.85	2.72	22.92	16.37	6.54

Percentage share (%) of imports from the Brazilian sectors by region of origin (2011)

| Sectors		China	Japan	South Korea	Rest of Asia	United States	Rest of North America and the Caribbean	Argentina	Chile	Venezuela	Rest of South America	Germany	France	Italy	Rest of Europe	Rest of the World	Total
S1	Agriculture and products of plant origin	3.71	0.10	0.00	1.57	9.45	1.04	54.37	3.70	0.00	15.32	0.35	0.22	0.74	3.61	5.82	1.81
S2	Livestock and animal products	7.82	0.10	0.01	1.27	11.14	1.34	20.10	1.97	0.02	31.53	7.84	1.60	1.64	8.33	5.30	0.24
S3	Mineral extractive	0.80	0.07	0.01	0.53	6.23	2.38	2.05	58.21	0.73	9.49	1.10	0.34	0.43	8.03	9.59	1.35
S4	Food and beverages	6.14	0.10	0.10	10.23	14.90	0.96	23.82	1.60	0.00	11.88	1.91	3.19	2.19	19.15	1.83	2.77
S5	Textiles and clothing	50.23	0.25	2.85	23.79	3.33	0.58	3.04	0.29	0.00	4.00	1.38	0.81	1.68	4.63	3.14	2.71
S6	Other light industry	12.83	5.54	6.55	4.17	13.48	7.46	18.77	0.71	0.05	0.69	9.40	4.22	3.42	11.06	1.64	15.81
S7	Coal	0.01	0.00	0.00	0.10	36.02	11.59	0.01	0.00	0.93	16.82	0.00	0.00	0.00	7.77	26.73	1.05
S8	Petroleum	0.00	0.00	0.00	0.55	0.92	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.06	98.44	3.60
S9	Gas	0.00	0.00	0.00	0.63	5.73	0.07	0.00	0.00	0.00	60.36	0.03	0.01	0.00	5.13	27.97	0.37
S10	Petroleum products	5.55	0.33	4.75	21.08	34.79	0.07	8.35	0.04	4.65	0.82	0.18	0.46	0.29	4.90	13.75	8.90
S11	Electricity	2.13	0.00	0.00	3.89	1.80	2.32	0.12	0.00	0.01	14.03	6.86	11.97	1.73	36.88	18.26	1.07
S12	Chemicals	8.98	2.21	1.96	7.31	20.54	5.79	4.69	1.29	0.19	2.60	9.00	3.66	2.13	23.59	6.06	18.55
S13	Mineral products	34.63	1.61	0.46	3.89	11.51	6.97	2.22	0.18	0.66	2.57	5.79	2.82	4.73	16.24	5.74	0.87
S14	Ferrous metal products	21.91	5.30	7.22	5.12	8.57	1.87	2.51	1.68	3.41	2.06	5.75	3.69	3.56	17.24	10.10	1.50
S15	Metals	6.78	0.52	0.42	0.73	3.78	6.75	6.71	35.07	3.70	14.42	9.02	1.26	0.63	6.44	3.86	2.02
S16	Other heavy industry	28.37	5.24	6.58	7.84	16.19	2.15	1.21	0.05	0.00	0.15	11.15	2.53	5.53	11.93	1.09	22.09
S17	Construction and utilities	1.12	0.10	0.05	18.08	1.34	0.09	0.13	0.10	0.03	0.18	2.83	14.73	3.44	19.07	38.42	0.09
S18	Road transport	2.48	0.84	0.28	12.45	3.33	0.75	0.51	0.26	0.10	0.93	5.11	10.89	5.85	32.82	23.40	1.14
S19	Water transport	0.33	1.80	0.78	8.89	1.66	1.51	0.55	1.53	0.20	0.44	4.90	15.50	1.52	52.22	8.18	1.32
S20	Air Transport	0.36	0.44	0.22	9.58	12.90	0.30	0.38	0.38	0.06	0.54	14.04	10.47	5.33	32.98	12.02	1.52
S21	Trade and communication	9.05	4.78	0.94	17.50	3.28	0.75	0.28	0.18	0.06	0.29	4.80	5.93	5.96	33.98	12.21	1.55
S22	Other services	1.35	1.92	1.35	15.32	15.73	1.79	0.36	0.20	0.03	0.20	5.72	2.91	3.22	39.99	9.93	9.68

GTAP-E CO_2 Emissions…

GTAP-E considers CO2 emissions from the use of energy products from the coal (S7), oil (S8), gas (S9) and petroleum products (S10) sectors

Such products can be used as inputs in the production process and as final goods for consumption by households and government

Energy products both produced domestically and imported are considered

The model does not take into account other types of emissions (e.g. CO), nor does it consider other forms of emission generation (e.g. land use)

Participation (%) of regions in emissions according to use – 2011

Legend: Intermediate Use ■ Household consumption ■ Total
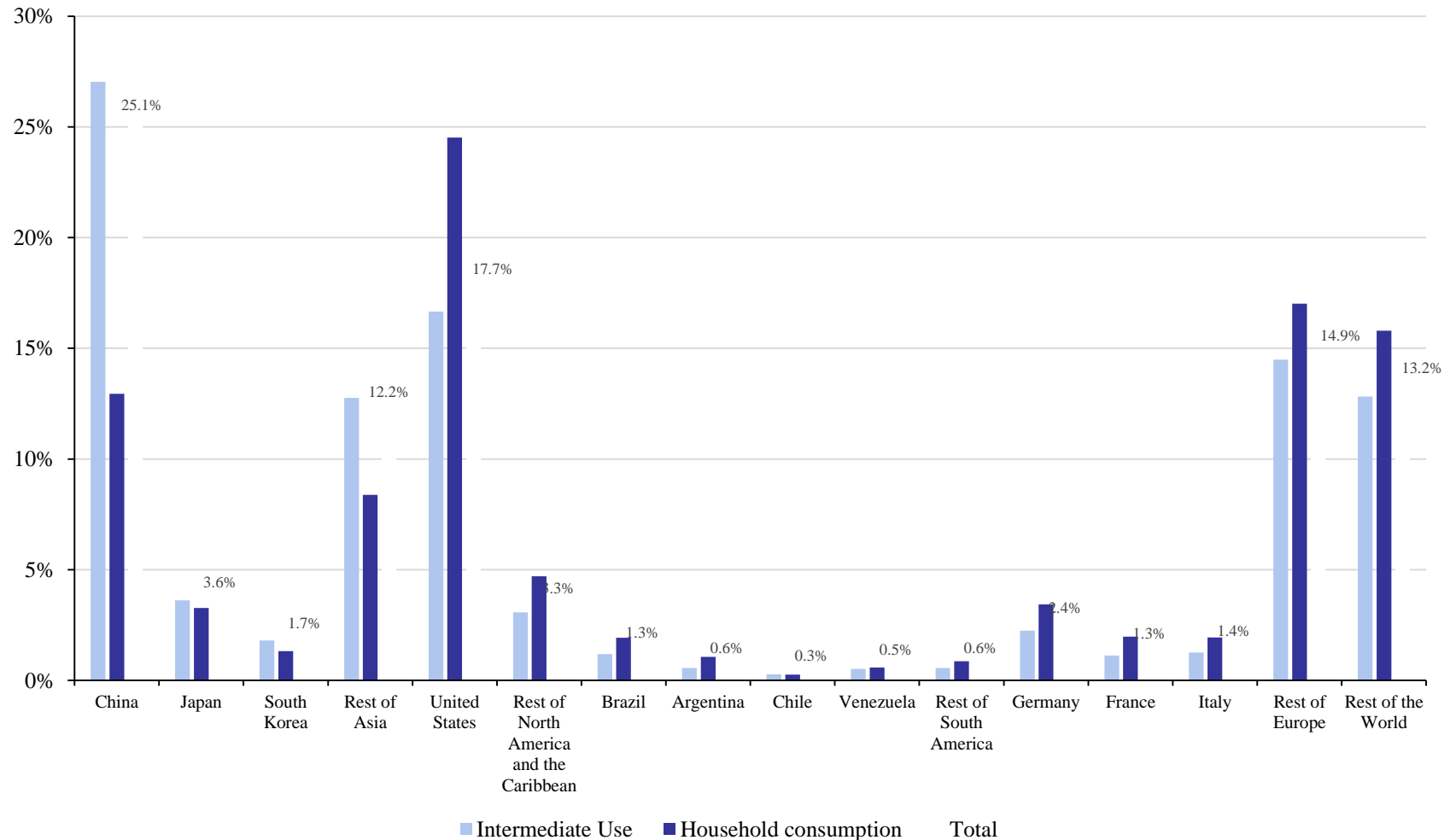
Sectoral emissions according to the uses of domestic energy products in participation (%) - Brazil and the World (2011)

	Sectors	Brazil					World				
		Coal	Petroleum	Gas	Petr. prod.	Total	Coal	Petroleum	Gas	Petr. prod.	Total
S1	Agriculture and products of plant origin	0.04	0.00	0.17	5.50	4.49	0.23	0.03	0.25	2.84	1.03
S2	Livestock and animal products	0.32	0.04	0.67	2.52	2.16	0.20	0.36	0.36	0.68	0.38
S3	Mineral extractive	33.87	0.00	3.50	2.46	3.56	0.30	0.03	1.25	2.02	1.00
S4	Food and beverages	3.06	0.21	2.66	0.87	1.22	0.88	2.62	1.94	0.70	1.03
S5	Textiles and clothing	0.03	0.01	1.44	0.14	0.34	0.43	1.28	0.25	0.20	0.33
S6	Other light industry	10.81	0.07	3.33	0.99	1.65	1.40	0.90	3.04	1.52	1.73
S7	Coal	0.03	0.00	0.00	0.00	0.00	1.56	0.01	0.01	0.24	0.86
S8	Petroleum	0.00	9.07	9.81	1.21	2.54	0.00	7.10	3.93	0.27	0.85
S9	Gas	0.00	61.43	6.83	0.11	1.22	0.01	3.92	8.74	0.20	1.70
S10	Petroleum products	0.00	0.00	12.71	3.27	4.66	0.31	2.71	3.77	7.70	3.22
S11	Electricity	14.36	27.26	23.01	5.27	8.36	78.77	70.31	49.32	9.35	52.05
S12	Chemicals	8.82	0.20	9.15	2.23	3.52	2.32	2.56	5.71	3.54	3.32
S13	Mineral products	9.41	0.06	5.11	6.15	6.08	6.84	2.14	2.96	2.36	4.72
S14	Ferrous metal products	0.34	0.09	4.79	1.34	1.85	3.88	1.01	3.00	4.87	4.00
S15	Metals	18.51	0.00	3.14	2.93	3.43	0.51	0.00	0.83	0.60	0.59
S16	Other heavy industry	0.04	0.08	0.61	0.15	0.22	0.32	1.76	1.35	0.85	0.68
S17	Construction and utilities	0.08	1.06	0.48	0.15	0.20	0.36	2.95	1.02	1.43	0.83
S18	Road transport	0.00	0.00	10.66	51.23	43.23	0.17	0.00	4.55	38.52	12.72
S19	Water transport	0.00	0.00	0.04	3.19	2.59	0.01	0.00	0.19	6.13	1.92
S20	Air Transport	0.00	0.00	0.18	8.96	7.29	0.00	0.00	0.19	11.38	3.52
S21	Trade and communication	0.14	0.04	0.44	0.54	0.51	0.42	0.19	2.36	1.50	1.10
S22	Other services	0.13	0.37	1.28	0.83	0.88	1.09	0.13	4.99	3.12	2.42
Total		100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Analysis strategy

Objective → identify the main CO_2 emitting links in international trade in Brazil

Two simulations were performed:

- The first specified an incentive in the form of subsidy to Brazil's world exports for all sectors and regions by 10%

- Such intervention functioned in the model as a reduction to existing barriers to entry for all Brazilian products, for all regions

Analysis strategy

The second specified a reduction in Brazilian import tariffs for all sectors and regions by 10%

This intervention, therefore, functioned as a facilitator for the entry of foreign goods into the Brazilian market

These simulations aimed to expand Brazil's international trade capacity to expose and highlight the main emitting relationships related to the transaction of goods with the outside world

Analysis strategy

Hypothesis: the variation of Brazilian CO_2 emissions depends on the productive structure of the country's economy, as well as its main commercial partners and types of products commercialized

If the Brazilian production structure depends heavily on energy inputs, then higher emissions are expected with increasing sector production

The magnitude of the emission variation still depends on the types of products that are most commercialized

If the most traded goods are intensive in the use of energy inputs, emissions tend to increase more with exports and imports

Analysis strategy

The trade profile with the different regions may also be important on the level of emissions

If Brazil commercializes a specific product with a certain region, the level of emissions of this commercial link depends on how much emission is generated in the production of this product

Analysis strategy

The trade profile with the different regions may also be important on the level of emissions

If Brazil commercializes a specific product with a certain region, the level of emissions of this commercial link depends on how much emission is generated in the production of this product

In the model language, the export shock was attributed to the exogenous parameter that captures changes in bilateral rates/subsidies on region j product exports

Analysis strategy

This variable, specified as σ, composes the equation that determines the world FOB prices of the product already offered from region **r** to region **s**:

$$p_{j,r,s}^{fob} = p_{j,r}^{m} - \sigma_{j,r}^{X}$$

For the second simulation, shock was attributed to the exogenous term capturing changes in bilateral rates/subsidies on imports of product *j* from region **r**:

$$p_{j,r,s}^{m} = p_{j,r,s}^{cif} + \sigma_{j,r}^{M}$$

The main mechanisms of propagation of the isolated effects caused by the application of exogenous policies in the system, due to the effects of an applied subsidy on Brazilian exports.
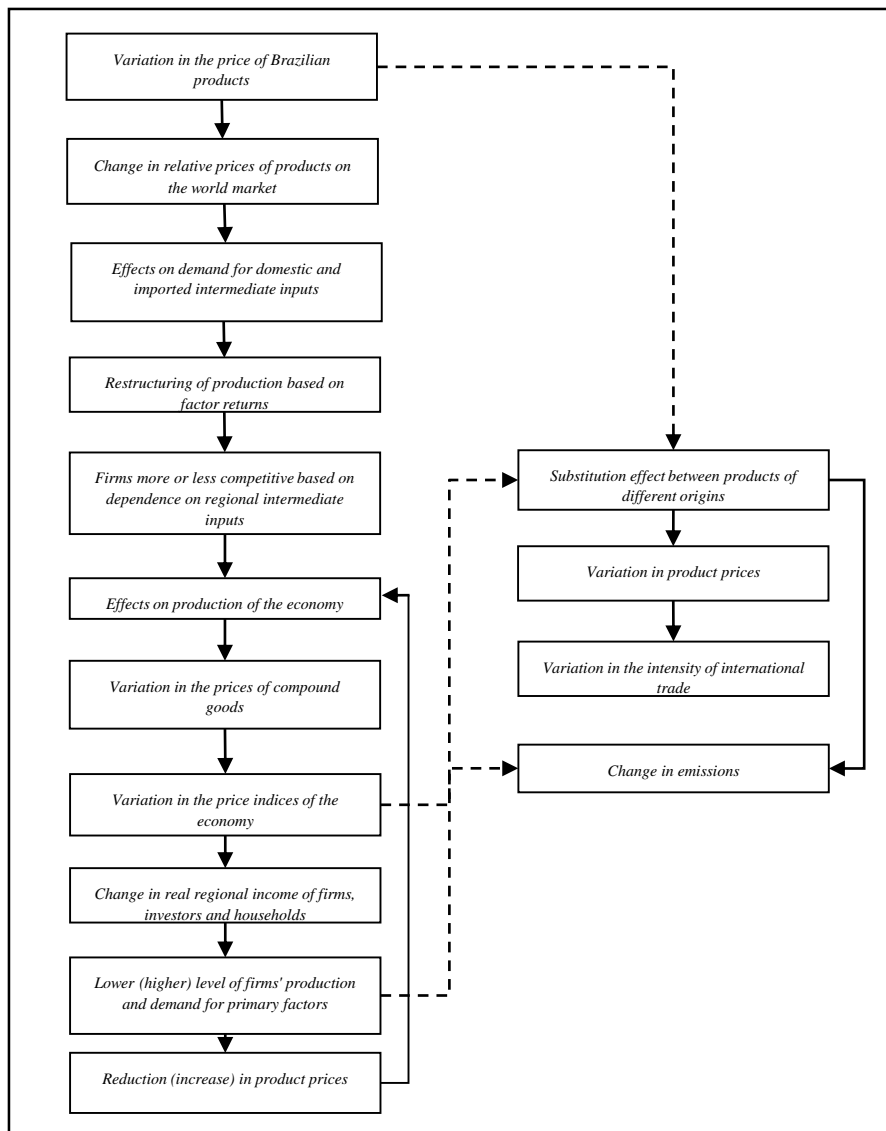
Causal relations of the mechanism of operation of the model to the subsidy to exports of Brazilian products

The main mechanisms of propagation of the isolated effects caused by the application of exogenous policies in the system, due to the effects of an applied subsidy on Brazilian exports.

The subsidy tends to reduce the prices of Brazilian products

The outcome of this measure depends to a large extent on Brazil's production structure, its main trading partners, exportable products, national demand for exportable products, demand for intermediate inputs and regional competition

Thus, the impact on emissions due to the stimulus of exports occurs as a result of systemic effects that may or may not contribute to the positive variation of emissions

Effects of increased Brazilian exports

Effects on emissions (% change)

Regions		Coal	Petroleum	Gas	Petroleum products	Total
1	China	0.015	0.042	-0.001	-0.013	0.010
2	Japan	-0.012	-0.074	-0.026	-0.067	-0.045
3	South Korea	0.011	-0.049	0.018	0.038	0.022
4	Rest of Asia	-0.015	0.067	0.019	-0.014	-0.010
5	United States	0.005	0.075	0.011	-0.018	-0.003
6	Rest of North America and the Caribbean	0.020	-0.125	0.028	-0.025	-0.002
7	Brazil	4.170	-8.699	3.180	2.564	2.747
8	Argentina	0.487	-1.094	-1.205	0.268	-0.483
9	Chile	0.015	0.301	0.052	0.161	0.112
10	Venezuela	-0.048	-0.025	0.016	0.022	0.019
11	Rest of South America	0.025	0.096	0.142	0.184	0.158
12	Germany	0.044	-0.074	0.020	0.031	0.033
13	France	0.083	-0.084	0.024	0.033	0.034
14	Italy	0.024	-0.096	0.013	-0.006	0.004
15	Rest of Europe	0.033	-0.005	0.025	0.023	0.026
16	Rest of the World	0.002	-0.055	0.017	-0.017	-0.003

Results on the level of sectoral activity (% change)

Sectors		China	Japan	South Korea	Rest of Asia	United States	Rest of North America and the Caribbean	Brazil	Argentina	Chile	Venezuela	Rest of South America	Germany	France	Italy	Rest of Europe	Rest of the World
S1	Agriculture and products of plant origin	-0.020	0.010	-0.037	-0.006	-0.002	-0.009	0.360	-0.703	0.088	0.007	0.086	-0.097	-0.023	-0.015	-0.046	-0.010
S2	Livestock and animal products	-0.009	-0.024	-0.003	-0.027	-0.010	-0.024	1.607	-0.572	-0.167	-0.156	0.071	-0.057	-0.010	0.009	-0.051	-0.076
S3	Mineral extractive	-0.043	-0.048	-0.047	-0.058	-0.028	-0.066	0.833	-0.080	0.036	-0.040	-0.090	-0.119	-0.048	-0.102	-0.085	-0.097
S4	Food and beverages	0.005	-0.001	0.003	0.008	0.031	0.002	0.360	-1.224	0.027	-0.001	0.155	-0.013	0.031	0.041	0.011	-0.025
S5	Textiles and clothing	0.164	0.138	0.075	0.119	0.056	0.052	-3.215	-0.542	0.026	-0.046	0.078	-0.004	0.102	0.092	0.032	0.021
S6	Other light industry	-0.021	0.098	0.060	-0.056	-0.002	0.066	0.140	0.808	-0.168	-0.120	-0.193	-0.039	0.078	0.059	-0.035	-0.075
S7	Coal	0.015	0.238	-0.011	0.006	0.080	0.190	-7.453	-2.302	-0.063	0.312	-0.122	0.028	0.147	0.041	0.049	0.038
S8	Petroleum	0.050	0.138	0.050	0.075	0.072	0.061	-0.208	-0.741	-0.275	0.034	-0.068	0.054	0.092	0.092	0.060	0.091
S9	Gas	-0.015	0.187	-0.197	0.069	0.081	0.079	-11.441	-2.304	-0.153	0.031	0.490	0.022	0.130	0.115	0.065	0.066
S10	Petroleum products	0.020	-0.063	0.039	0.048	0.060	-0.034	1.527	0.257	0.355	0.170	-0.032	0.028	0.029	-0.014	0.018	0.039
S11	Electricity	0.024	0.007	0.009	-0.001	0.005	0.024	-0.784	0.286	-0.007	0.166	0.511	0.047	0.145	0.035	0.037	0.006
S12	Chemicals	0.062	0.175	-0.027	0.060	0.201	0.249	-2.989	-1.086	0.300	-0.114	0.141	0.127	0.207	0.157	0.143	0.057
S13	Mineral products	-0.054	-0.072	-0.110	-0.111	-0.066	-0.066	2.785	0.782	-0.053	-0.052	-0.058	-0.080	-0.054	-0.089	-0.095	-0.087
S14	Ferrous metal products	-0.014	0.092	-0.072	-0.153	-0.068	-0.174	0.517	-2.279	-0.102	0.423	-0.359	-0.065	0.068	0.050	-0.090	-0.103
S15	Metals	0.048	0.214	0.000	-0.110	-0.040	-0.046	2.680	-3.828	-0.100	1.176	-0.295	-0.071	0.031	-0.019	-0.125	-0.169
S16	Other heavy industry	0.067	0.232	0.077	-0.004	0.063	0.024	-2.684	-1.938	-0.580	-0.389	-0.590	0.042	0.128	0.163	-0.006	-0.101
S17	Construction and utilities	-0.115	-0.340	-0.157	-0.141	-0.168	-0.183	5.719	2.413	-0.041	-0.112	-0.007	-0.183	-0.270	-0.362	-0.193	-0.146
S18	Road transport	-0.019	-0.017	0.039	0.009	0.008	0.009	0.107	-0.186	0.029	-0.007	0.032	0.057	0.059	0.035	0.042	0.010
S19	Water transport	0.125	0.414	0.449	0.224	0.078	0.178	-0.138	-2.414	0.364	0.194	0.183	0.439	0.414	0.266	0.313	0.149
S20	Air Transport	0.027	0.111	0.081	0.062	0.050	0.018	-0.719	-1.589	0.069	0.062	0.059	0.099	0.164	0.093	0.079	0.058
S21	Trade and communication	0.000	-0.026	0.001	-0.006	-0.012	-0.007	0.243	0.214	0.019	0.012	0.021	0.007	0.020	0.011	0.011	-0.009
S22	Other services	-0.004	-0.008	-0.014	0.022	0.004	0.003	-0.466	0.076	0.022	0.015	0.021	0.000	-0.007	0.002	0.013	0.013

Effect on emissions from individual relationships of Brazilian exports (% change)

	Regions	China	Japan	South Korea	Rest of Asia	United States	Rest of North America and the Caribbean	Argentina	Chile	Venezuela	Rest of South America	Germany	France	Italy	Rest of Europe	Rest of the World
1	China	0.0512	-0.0045	-0.0028	-0.0025	-0.0067	-0.0022	-0.0036	-0.0009	-0.0007	-0.0034	-0.0026	-0.0010	-0.0013	-0.0065	-0.0056
2	Japan	-0.0110	0.0510	-0.0078	-0.0129	-0.0163	-0.0071	-0.0185	-0.0018	-0.0014	-0.0105	-0.0048	-0.0015	-0.0032	-0.0153	0.0051
3	South Korea	-0.0037	-0.0092	0.0710	-0.0101	-0.0103	-0.0042	-0.0093	-0.0022	0.0003	-0.0064	-0.0003	0.0005	-0.0007	-0.0024	0.0062
4	Rest of Asia	-0.0024	-0.0054	-0.0033	0.0144	-0.0065	-0.0011	-0.0034	-0.0004	-0.0001	-0.0018	-0.0012	-0.0001	-0.0007	-0.0029	0.0050
5	United States	-0.0053	-0.0025	-0.0011	-0.0029	0.0405	-0.0084	-0.0058	0.0003	-0.0005	-0.0042	-0.0012	-0.0006	-0.0008	-0.0066	-0.0039
6	Rest of North America and the Caribbean	-0.0014	-0.0027	-0.0019	0.0018	-0.0069	0.0101	0.0033	0.0013	0.0005	0.0007	-0.0025	0.0000	0.0004	-0.0037	0.0056
7	Brazil	0.0165	0.2394	0.1128	0.1551	0.2167	0.3164	0.3370	-0.0521	0.0745	0.2673	0.2168	0.0903	0.1535	0.7613	0.0193
8	Argentina	0.0164	0.0036	0.0020	0.0053	-0.0195	-0.0095	-0.6625	0.0628	0.0135	0.0118	0.0027	-0.0006	0.0012	0.0037	0.0085
9	Chile	-0.0509	-0.0381	-0.0085	-0.0181	-0.0307	0.0007	-0.0388	0.4394	-0.0005	-0.0190	-0.0039	-0.0016	0.0011	-0.0069	-0.0349
10	Venezuela	-0.0010	-0.0024	-0.0012	-0.0006	0.0374	-0.0055	-0.0057	-0.0003	0.0152	-0.0123	-0.0039	-0.0011	-0.0020	-0.0066	0.0042
11	Rest of South America	-0.0006	0.0041	0.0011	0.0031	0.0119	0.0048	0.0078	0.0277	-0.0048	0.0812	0.0056	0.0024	0.0033	0.0138	0.0104
12	Germany	0.0014	-0.0017	-0.0012	0.0006	0.0039	-0.0007	-0.0040	0.0012	0.0004	-0.0011	0.0436	-0.0017	-0.0027	-0.0092	0.0070
13	France	0.0119	0.0003	-0.0006	0.0026	0.0149	0.0009	0.0010	0.0012	0.0020	0.0017	-0.0067	0.0296	-0.0047	-0.0155	0.0103
14	Italy	0.0039	-0.0004	-0.0006	0.0008	0.0017	-0.0014	-0.0034	0.0001	0.0007	-0.0011	-0.0074	-0.0021	0.0260	-0.0173	0.0069
15	Rest of Europe	0.0077	-0.0011	-0.0013	0.0012	0.0051	0.0004	0.0019	0.0010	0.0014	0.0024	-0.0058	-0.0008	-0.0018	0.0153	0.0081
16	Rest of the World	-0.0014	-0.0065	-0.0023	-0.0025	-0.0071	-0.0038	-0.0060	-0.0009	-0.0006	-0.0035	-0.0032	-0.0009	-0.0020	-0.0128	0.0504

Effects of increased Brazilian imports

Effects on CO$_2$ emissions (% change)

Regions		Coal	Petroleum	Gas	Petroleum products	Total
1	China	0.016	0.040	0.002	-0.010	0.011
2	Japan	-0.008	-0.077	-0.024	-0.069	-0.044
3	South Korea	0.017	-0.063	0.022	0.041	0.026
4	Rest of Asia	-0.021	0.072	0.018	-0.014	-0.013
5	United States	0.004	0.078	0.010	-0.016	-0.002
6	Rest of North America and the Caribbean	0.016	-0.128	0.026	-0.027	-0.004
7	Brazil	4.914	-9.260	3.656	2.808	3.055
8	Argentina	0.530	-1.224	-1.350	0.295	-0.544
9	Chile	0.018	0.346	0.056	0.183	0.127
10	Venezuela	-0.047	-0.017	0.016	0.024	0.021
11	Rest of South America	0.013	0.096	0.145	0.204	0.172
12	Germany	0.047	-0.077	0.021	0.031	0.035
13	France	0.089	-0.087	0.024	0.035	0.036
14	Italy	0.027	-0.098	0.014	-0.007	0.005
15	Rest of Europe	0.034	-0.006	0.026	0.023	0.027
16	Rest of the World	0.000	-0.060	0.017	-0.017	-0.004

Results on the level of sectoral activity (% change)

Sectors		China	Japan	South Korea	Rest of Asia	United States	Rest of North America and the Caribbean	Brazil	Argentina	Chile	Venezuela	Rest of South America	Germany	France	Italy	Rest of Europe	Rest of the World
S1	Agriculture and products of plant origin	-0.038	-0.003	-0.049	-0.013	-0.022	-0.029	0.671	-0.804	0.088	0.001	0.086	-0.137	-0.058	-0.049	-0.073	-0.023
S2	Livestock and animal products	-0.009	-0.047	-0.001	-0.035	-0.020	-0.038	1.927	-0.645	-0.215	-0.217	0.065	-0.089	-0.034	-0.006	-0.077	-0.106
S3	Mineral extractive	-0.058	-0.058	-0.055	-0.069	-0.038	-0.081	1.147	-0.087	0.048	-0.049	-0.099	-0.151	-0.064	-0.126	-0.103	-0.117
S4	Food and beverages	0.004	-0.002	0.006	0.002	0.030	-0.002	0.501	-1.371	0.022	-0.011	0.160	-0.020	0.021	0.036	0.004	-0.039
S5	Textiles and clothing	0.176	0.139	0.079	0.132	0.055	0.055	-3.476	-0.636	0.026	-0.059	0.073	-0.004	0.107	0.094	0.034	0.028
S6	Other light industry	-0.023	0.097	0.056	-0.057	-0.004	0.071	0.387	0.771	-0.196	-0.136	-0.227	-0.044	0.080	0.057	-0.037	-0.078
S7	Coal	0.014	0.228	-0.023	0.007	0.088	0.211	-7.705	-2.560	-0.073	0.366	-0.113	0.025	0.146	0.032	0.053	0.053
S8	Petroleum	0.049	0.142	0.049	0.078	0.075	0.063	-0.034	-0.829	-0.317	0.036	-0.076	0.055	0.096	0.095	0.064	0.099
S9	Gas	-0.018	0.186	-0.226	0.071	0.084	0.084	-12.220	-2.569	-0.160	0.034	0.543	0.022	0.139	0.118	0.068	0.075
S10	Petroleum products	0.025	-0.066	0.045	0.056	0.070	-0.041	1.698	0.278	0.411	0.189	-0.039	0.028	0.029	-0.017	0.017	0.043
S11	Electricity	0.026	0.008	0.012	-0.001	0.005	0.022	-0.694	0.307	-0.007	0.180	0.547	0.050	0.154	0.035	0.039	0.005
S12	Chemicals	0.061	0.176	-0.030	0.065	0.209	0.264	-2.980	-1.265	0.305	-0.144	0.114	0.131	0.216	0.159	0.149	0.063
S13	Mineral products	-0.049	-0.074	-0.113	-0.110	-0.074	-0.071	3.121	0.903	-0.055	-0.052	-0.055	-0.076	-0.055	-0.089	-0.096	-0.089
S14	Ferrous metal products	-0.014	0.087	-0.084	-0.174	-0.095	-0.214	1.057	-2.587	-0.145	0.449	-0.436	-0.074	0.063	0.040	-0.104	-0.116
S15	Metals	0.050	0.244	0.014	-0.137	-0.077	-0.080	4.215	-4.213	-0.128	1.273	-0.349	-0.090	0.006	-0.056	-0.156	-0.203
S16	Other heavy industry	0.072	0.241	0.081	0.006	0.068	0.033	-2.571	-2.206	-0.663	-0.443	-0.686	0.053	0.140	0.178	0.002	-0.103
S17	Construction and utilities	-0.111	-0.346	-0.156	-0.141	-0.170	-0.186	6.169	2.787	-0.026	-0.095	0.025	-0.186	-0.278	-0.368	-0.196	-0.146
S18	Road transport	-0.018	-0.018	0.042	0.011	0.008	0.010	0.138	-0.207	0.034	-0.006	0.037	0.057	0.064	0.037	0.046	0.012
S19	Water transport	0.125	0.417	0.455	0.223	0.078	0.175	1.637	-2.691	0.377	0.199	0.193	0.444	0.436	0.265	0.316	0.150
S20	Air Transport	0.024	0.107	0.068	0.060	0.050	0.021	-0.530	-1.761	0.068	0.074	0.069	0.100	0.170	0.096	0.081	0.061
S21	Trade and communication	0.002	-0.026	0.003	-0.005	-0.012	-0.007	0.182	0.246	0.025	0.019	0.025	0.007	0.022	0.013	0.013	-0.008
S22	Other services	-0.002	-0.008	-0.013	0.023	0.004	0.004	-0.651	0.092	0.027	0.019	0.025	0.001	-0.007	0.002	0.015	0.015

Effect on CO$_2$ emissions from individual relationships of Brazilian imports (% change)

	Regions	China	Japan	South Korea	Rest of Asia	United States	Rest of North America and the Caribbean	Argentina	Chile	Venezuela	Rest of South America	Germany	France	Italy	Rest of Europe	Rest of the World
1	China	0.0739	-0.0061	-0.0037	-0.0049	-0.0097	-0.0031	-0.0049	-0.0019	-0.0008	-0.0056	-0.0040	-0.0016	-0.0020	-0.0098	-0.0094
2	Japan	-0.0254	0.0423	-0.0113	-0.0174	-0.0244	-0.0097	-0.0205	-0.0029	-0.0003	-0.0114	-0.0083	-0.0027	-0.0046	-0.0193	0.0142
3	South Korea	-0.0097	-0.0138	0.0794	-0.0113	-0.0144	-0.0049	-0.0092	-0.0028	0.0013	-0.0059	-0.0016	0.0000	-0.0014	-0.0020	0.0160
4	Rest of Asia	-0.0030	-0.0077	-0.0044	0.0177	-0.0073	-0.0012	-0.0030	-0.0009	0.0003	-0.0023	-0.0017	-0.0003	-0.0008	-0.0023	0.0052
5	United States	-0.0081	-0.0035	-0.0017	-0.0035	0.0322	-0.0100	-0.0072	-0.0001	0.0016	-0.0041	-0.0019	-0.0009	-0.0011	-0.0073	-0.0013
6	Rest of North America and the Caribbean	0.0030	-0.0024	-0.0019	0.0037	-0.0060	0.0087	0.0041	0.0012	0.0018	-0.0004	-0.0029	0.0003	0.0007	-0.0014	0.0106
7	Brazil	0.2218	0.3320	0.1600	0.2689	0.4122	0.4189	0.4737	-0.0405	0.1115	0.3833	0.3119	0.1337	0.2118	1.0382	0.2071
8	Argentina	0.0267	0.0030	0.0029	0.0085	-0.0282	-0.0108	-0.0452	0.0758	0.0184	0.0120	0.0038	-0.0009	0.0010	0.0018	0.0097
9	Chile	-0.0572	-0.0458	-0.0104	-0.0207	-0.0300	0.0014	-0.0257	0.4268	0.0008	-0.0057	-0.0057	-0.0019	0.0015	-0.0059	-0.0338
10	Venezuela	-0.0045	-0.0041	-0.0022	-0.0019	0.0419	-0.0065	-0.0084	-0.0024	0.0542	-0.0157	-0.0062	-0.0019	-0.0031	-0.0133	0.0058
11	Rest of South America	0.0119	0.0079	0.0028	0.0091	0.0262	0.0083	-0.0057	0.0336	-0.0018	-0.0377	0.0099	0.0044	0.0058	0.0266	0.0269
12	Germany	0.0028	-0.0027	-0.0016	0.0015	0.0064	-0.0006	-0.0039	0.0012	0.0020	-0.0009	0.0464	-0.0031	-0.0039	-0.0077	0.0144
13	France	0.0179	0.0007	-0.0005	0.0047	0.0206	0.0020	0.0014	0.0017	0.0054	0.0060	-0.0082	0.0156	-0.0066	-0.0161	0.0240
14	Italy	0.0047	-0.0011	-0.0010	0.0018	0.0028	-0.0013	-0.0039	0.0002	0.0026	0.0009	-0.0100	-0.0040	0.0088	-0.0166	0.0162
15	Rest of Europe	0.0127	-0.0013	-0.0014	0.0030	0.0082	0.0012	0.0031	0.0011	0.0032	0.0036	-0.0071	-0.0014	-0.0023	0.0123	0.0157
16	Rest of the World	-0.0035	-0.0086	-0.0032	-0.0027	-0.0090	-0.0049	-0.0068	-0.0020	0.0005	-0.0065	-0.0048	-0.0014	-0.0027	-0.0147	0.0360

Conclusion

The study considers only emissions from the use of energy products. Brazil's energy emissions accounted for 1.3% of total global emissions

However, mitigation policies and efforts to reduce emissions correspond to global demand

Brazil has the advantage of having an energy matrix that is less intensive in fossil fuels, in relative terms

Thus, emissions from energy use can be better controlled if directed at the main causes

Conclusion

Transport sector is the one that emits the most due to the intensive use of petroleum products

An alternative would be to focus on the reduction of emissions related to this sector, with incentives to improve engine technology (e.g., hybrid motors with electric power components), use of biofuels, use of public transportation and greater diversification of the matrix, with a view to other modalities

The international trade of Brazil tends to stimulate the emissions of the country itself and of several other regions

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Conclusion

This is because the Brazilian structure of use of energy inputs is distinct from the ones found elsewhere

Part of the emissions from the Brazilian trade structure also comes from the transportation sector, since products are heavily used in road and rail transportation

Therefore, policies for the transport sector would have an effect on emissions from the international trade

Conclusion

Extensions of this study could assess the effects of reducing the use of fuels (petroleum products) on Brazilian emissions from exports and imports.

Such policies could be implemented with the target of substituting the type of energy input, adopting low-emitting choices or implementing technologies adapted to the sector.

The modification of the model to include a module of emissions from land use.