

Supplementary Material

Supply chain structural leverage for synergetic reduction of food-related greenhouse gas and phosphorus emissions

Jiajing Pan^a, Qiumeng Zhong^a, Haifeng Zhou^a, Yumeng Li^a, Zhenying Tan^a, Sai Liang^{a,*}

^a Guangdong Basic Research Center of Excellence for Ecological Security and Green Development, Key Laboratory for City Cluster Environmental Safety and Green Development of the Ministry of Education, School of Ecology, Environment and Ocean, Guangdong University of Technology, Guangzhou, Guangdong 510006, P. R. China

* Correspondence to: liangsai@gdut.edu.cn (Sai Liang).

Sensitivity analysis

A sensitivity analysis was conducted to quantify the influence of parameters on the results of food-related GHG and P emissions. Specifically, we evaluated the sensitivity of total food-related emissions to variations in three parameter groups: (1) GHG/P emission intensity, (2) the intermediate transaction matrix, and (3) the final demand for food products. The sensitivity was assessed using both sensitivity coefficients and elasticities, which were calculated according to Equations (S1)–(S6).

$$\frac{\partial C}{\partial f} = \mathbf{L} \times y_i \quad (\text{S1})$$

$$\frac{\frac{\partial C}{\partial f}}{\frac{C}{f}} = (\mathbf{L} \times y)_i \times \frac{f}{C} \quad (\text{S2})$$

$$\frac{\partial C}{\partial T_{ij}} = \frac{(f \times \mathbf{L})_i \times (\mathbf{L} \times y)_j}{x_j} \quad (\text{S3})$$

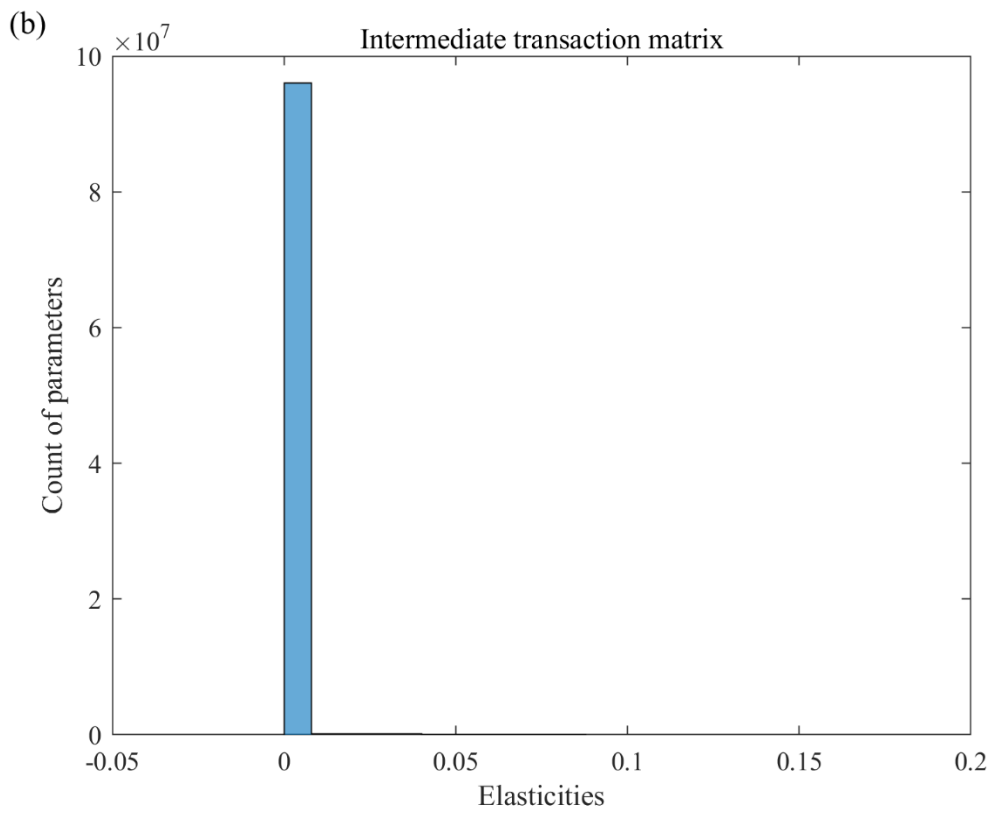
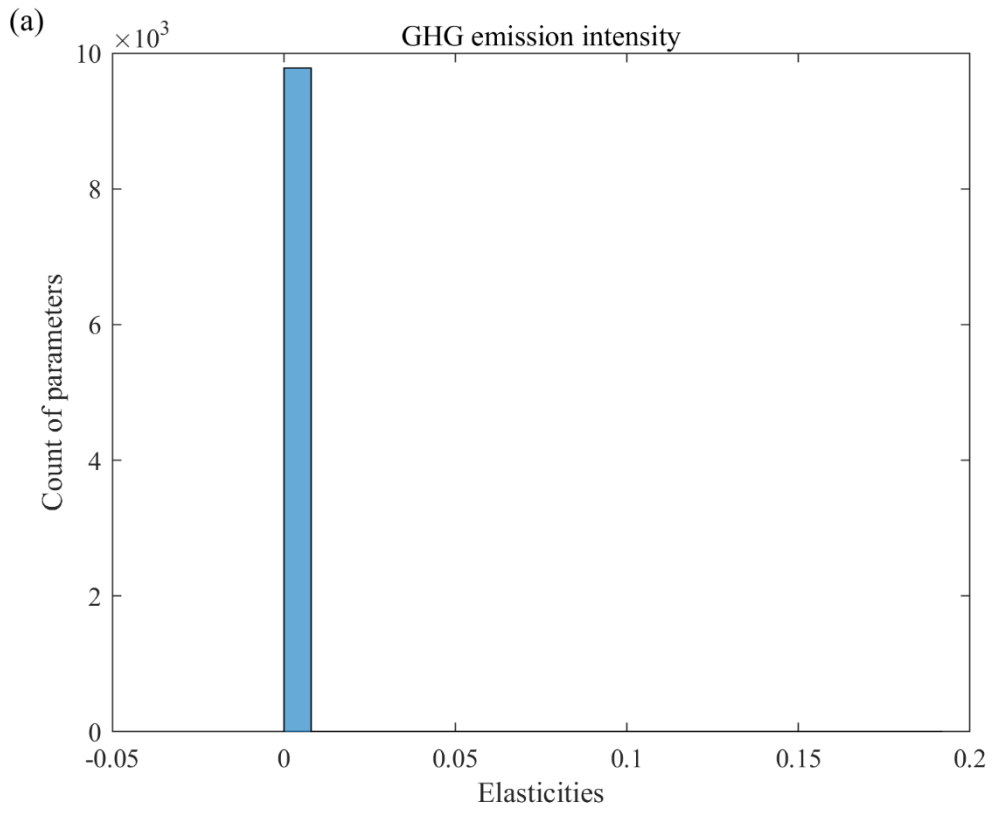
$$\frac{\frac{\partial C}{\partial T_{ij}}}{\frac{C}{T_{ij}}} = \frac{(f \times \mathbf{L})_i \times (\mathbf{L} \times y)_j}{x_j} \times \frac{T_{ij}}{C} \quad (\text{S4})$$

$$\frac{\partial C}{\partial y_i} = f \times \mathbf{L} \quad (\text{S5})$$

$$\frac{\frac{\partial C}{\partial y_i}}{\frac{C}{y_i}} = (f \times \mathbf{L})_i \times \frac{y_i}{C} \quad (\text{S6})$$

The notation f denotes the GHG/P emission intensity of sectors; \mathbf{L} indicates the Leontief inverse matrix; and y_i denotes China's household demand for the product from food sector i . The terms $\frac{\partial C}{\partial f}$, $\frac{\partial C}{\partial T_{ij}}$, and $\frac{\partial C}{\partial y_i}$ represent the sensitivity coefficients of total food-related emissions for GHG/P emission intensity, the intermediate transaction matrix, and the final demand for food products, respectively. Correspondingly, the elasticities of total food-related emissions for these parameters

are given by $\frac{\frac{\partial C}{\partial f}}{\frac{C}{f}}$, $\frac{\frac{\partial C}{\partial T_{ij}}}{\frac{C}{T_{ij}}}$, and $\frac{\frac{\partial C}{\partial y_i}}{\frac{C}{y_i}}$.



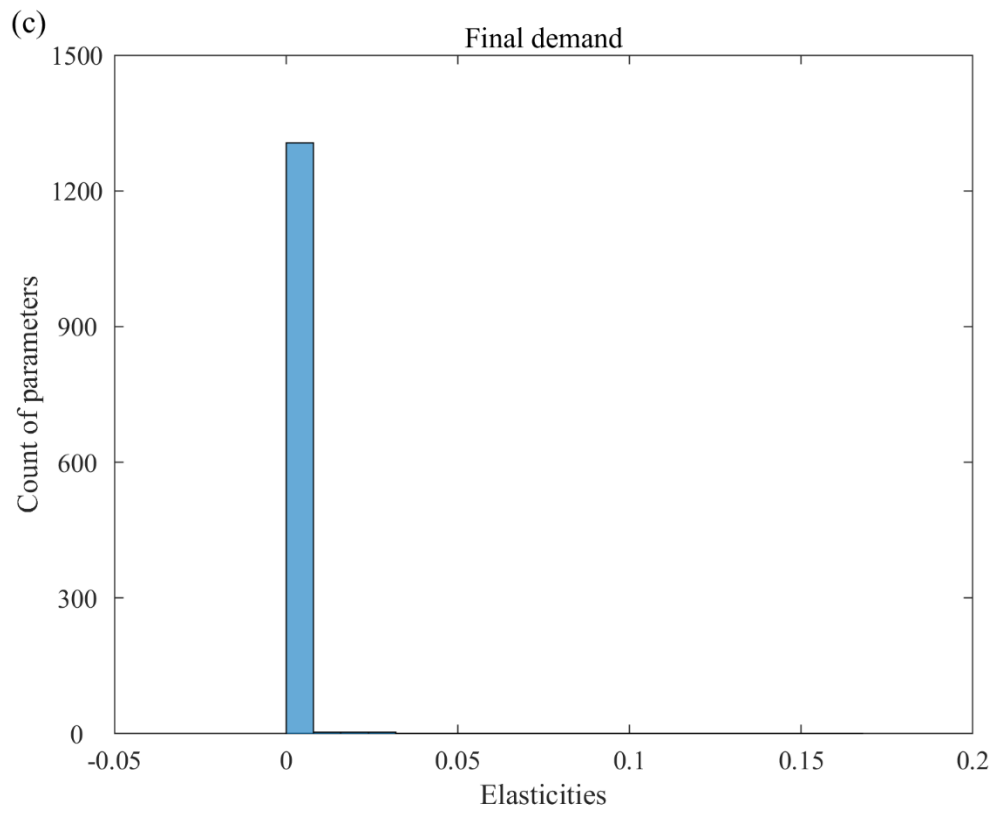
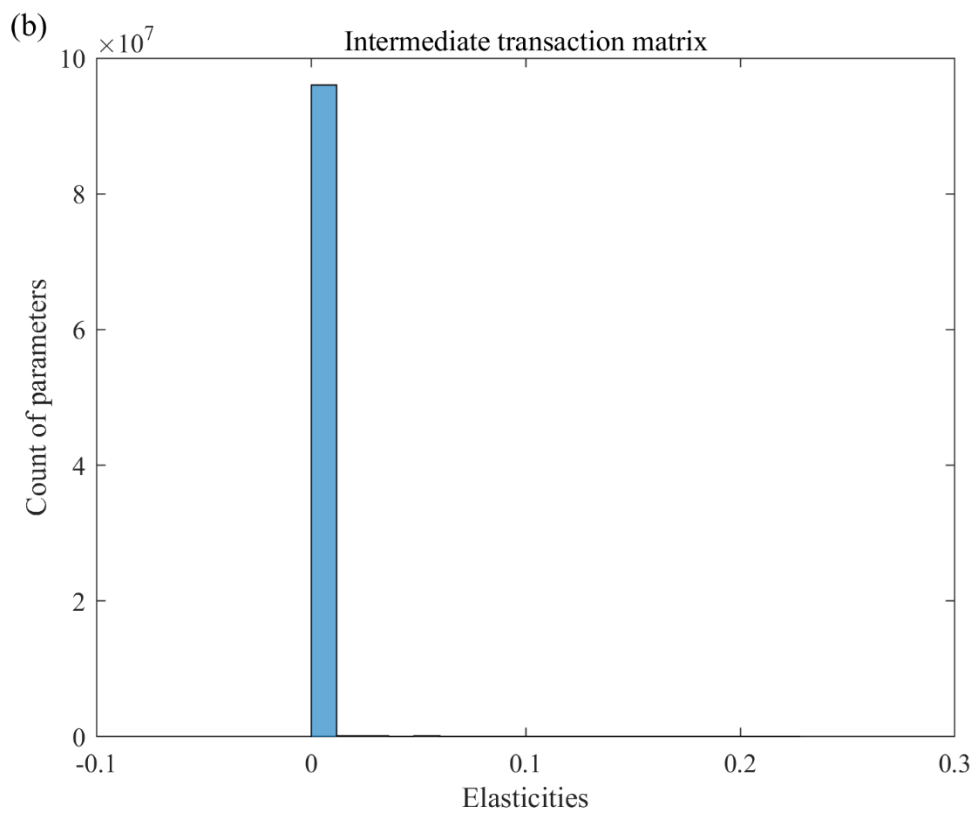
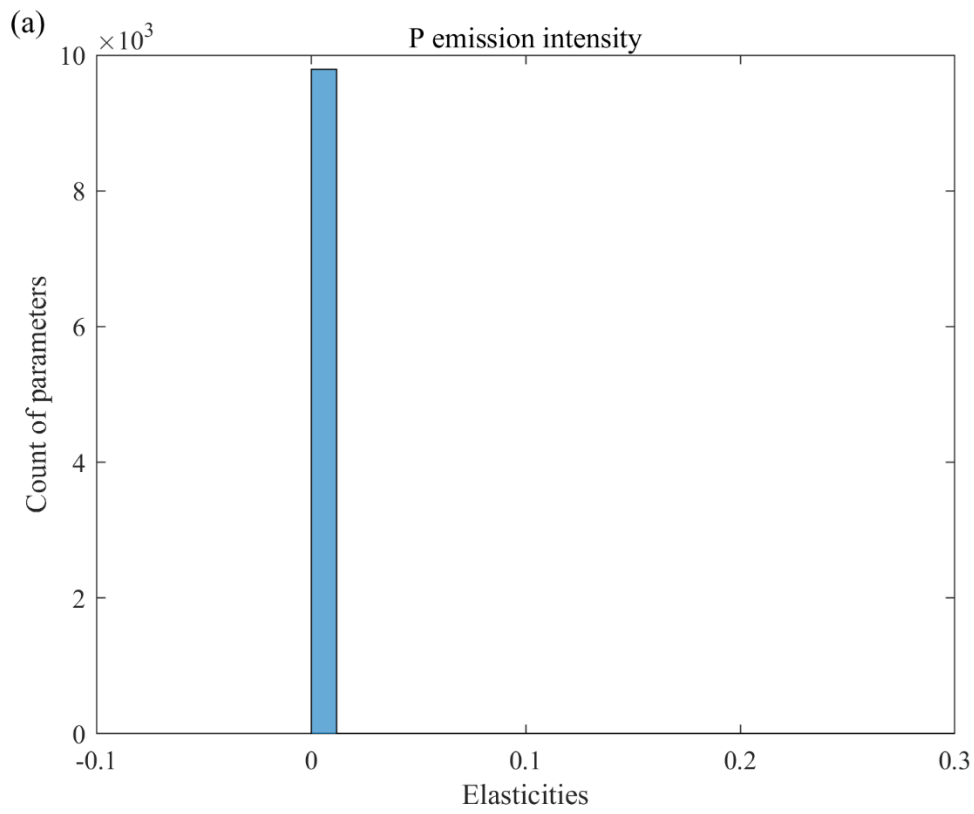


Fig. S1. Distributions of the elasticities for global GHG emissions driven by food consumption in China.



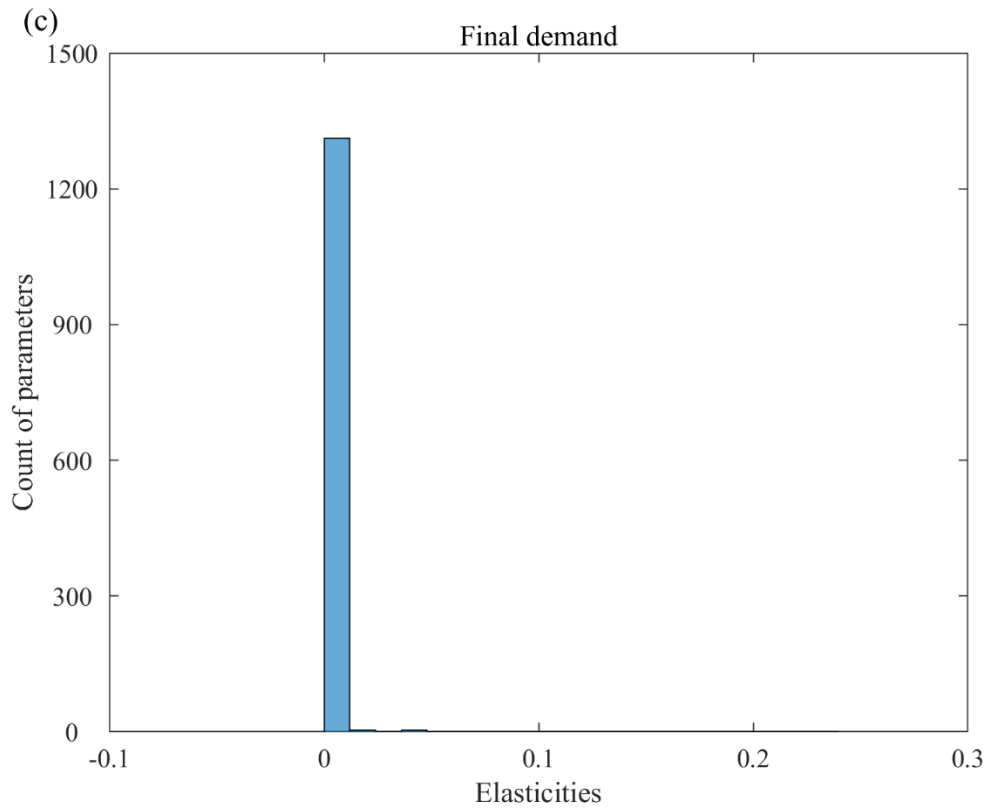


Fig. S2. Distributions of the elasticities for global P emissions driven by food consumption in China.

Table S1 Full names of sectoral and regional abbreviations.

Number	Abbreviations	Full names
1	POWD	Distribution and trade services of electricity
2	POWT	Transmission services of electricity
3	RUBP	Rubber and plastic products
4	TLND	Other land transportation services
5	FISH	Fish and other fishing products; services incidental of fishing
6	TDWH	Wholesale trade and commission trade services, except of motor vehicles and motorcycles
7	TDRT	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods
8	FABM	Fabricated metal products, except machinery and equipment
9	VOIL	Products of vegetable oils and fats
10	COIL	Crude petroleum and services related to crude oil extraction, excluding surveying
11	GASE	Natural gas and services related to natural gas extraction, excluding surveying
12	GASD	Distribution services of gaseous fuels through mains
13	WA	RoW Asia and Pacific

Table S2 Classifications of sectors.

Sector categories	Number	Sectors
Agriculture	1	Paddy rice
	2	Wheat
	3	Cereal grains nec
	4	Vegetables, fruit, nuts
	5	Oil seeds
	6	Sugar cane, sugar beet
	7	Plant-based fibers
	8	Crops nec
	9	Cattle
	10	Pigs
	11	Poultry
	12	Meat animals nec
	13	Animal products nec
	14	Raw milk
	15	Wool, silk-worm cocoons
	16	Manure (conventional treatment)
	17	Manure (biogas treatment)
	Mining and quarrying	18
19		Fish and other fishing products; services incidental of fishing
20		Anthracite
21		Coking Coal
22		Other Bituminous Coal
23		Sub-Bituminous Coal
24		Patent Fuel
25		Lignite/Brown Coal
26		BKB/Peat Briquettes
27		Peat
28	Crude petroleum and services related to crude oil extraction, excluding surveying	
29	Natural gas and services related to natural gas extraction, excluding surveying	
30	Natural Gas Liquids	
31	Other Hydrocarbons	
32	Uranium and thorium ores	
33	Iron ores	
34	Copper ores and concentrates	
35	Nickel ores and concentrates	
36	Aluminium ores and concentrates	
37	Precious metal ores and concentrates	

	38	Lead, zinc and tin ores and concentrates
	39	Other non-ferrous metal ores and concentrates
	40	Stone
	41	Sand and clay
	42	Chemical and fertilizer minerals, salt and other mining and quarrying products nec
	43	Products of meat cattle
	44	Products of meat pigs
	45	Products of meat poultry
	46	Meat products nec
	47	products of Vegetable oils and fats
Food processing	48	Dairy products
	49	Processed rice
	50	Sugar
	51	Food products nec
	52	Beverages
	53	Fish products
	54	Tobacco products
Textiles and leather products	55	Textiles
	56	Wearing apparel; furs
	57	Leather and leather products
	58	Wood and products of wood and cork (except furniture); articles of straw and plaiting materials
	59	Wood material for treatment, Re-processing of secondary wood material into new wood material
Wood and paper	60	Pulp
		Secondary paper for treatment,
	61	Re-processing of secondary paper into new pulp
	62	Paper and paper products
	63	Printed matter and recorded media
	64	Coke Oven Coke
	65	Gas Coke
	66	Coal Tar
Petroleum, chemical and non-metallic mineral products	67	Motor Gasoline
	68	Aviation Gasoline
	69	Gasoline Type Jet Fuel
	70	Kerosene Type Jet Fuel
	71	Kerosene
	72	Gas/Diesel Oil
	73	Heavy Fuel Oil

	74	Refinery Gas
	75	Liquefied Petroleum Gases
	76	Refinery Feedstocks
	77	Ethane
	78	Naphtha
	79	White Spirit & SBP
	80	Lubricants
	81	Bitumen
	82	Paraffin Waxes
	83	Petroleum Coke
	84	Non-specified Petroleum Products
	85	Nuclear fuel
	86	Plastics, basic
		Secondary plastic for treatment,
	87	Re-processing of secondary plastic into new plastic
	88	N-fertiliser
	89	P- and other fertiliser
	90	Chemicals nec
	91	Charcoal
	92	Additives/Blending Components
	93	Biogasoline
	94	Biodiesels
	95	Other Liquid Biofuels
	96	Rubber and plastic products
	97	Glass and glass products
		Secondary glass for treatment,
	98	Re-processing of secondary glass into new glass
	99	Ceramic goods
	100	Bricks, tiles and construction products, in baked clay
	101	Cement, lime and plaster
	102	Ash for treatment, Re-processing of ash into clinker
	103	Other non-metallic mineral products
	104	Basic iron and steel and of ferro-alloys and first products thereof
Basic metals and fabricated metal	105	Secondary steel for treatment, Re-processing of secondary steel into new steel
	106	Precious metals
		Secondary precious metals for treatment,
	107	Re-processing of secondary precious metals into new precious metals

	108	Aluminium and aluminium products
		Secondary aluminium for treatment,
	109	Re-processing of secondary aluminium into new aluminium
	110	Lead, zinc and tin and products thereof
	111	Secondary lead for treatment, Re-processing of secondary lead into new lead
	112	Copper products
		Secondary copper for treatment,
	113	Re-processing of secondary copper into new copper
	114	Other non-ferrous metal products
		Secondary other non-ferrous metals for treatment, Re-processing of secondary other non-ferrous metals into new other non-ferrous metals
	115	
	116	Foundry work services
	117	Fabricated metal products, except machinery and equipment
	118	Machinery and equipment nec
	119	Office machinery and computers
	120	Electrical machinery and apparatus nec
	121	Radio, television and communication equipment and apparatus
	122	Medical, precision and optical instruments, watches and clocks
Manufacturing	123	Motor vehicles, trailers and semi-trailers
	124	Other transport equipment
	125	Furniture; other manufactured goods nec
	126	Secondary raw materials
	127	Bottles for treatment, Recycling of bottles by direct reuse
	128	Electricity by coal
	129	Electricity by gas
	130	Electricity by nuclear
	131	Electricity by hydro
	132	Electricity by wind
Electricity, gas, and water	133	Electricity by petroleum and other oil derivatives
	134	Electricity by biomass and waste
	135	Electricity by solar photovoltaic
	136	Electricity by solar thermal
	137	Electricity by tide, wave, ocean
	138	Electricity by Geothermal

	139	Electricity nec
	140	Transmission services of electricity
	141	Distribution and trade services of electricity
	142	Coke oven gas
	143	Blast Furnace Gas
	144	Oxygen Steel Furnace Gas
	145	Gas Works Gas
	146	Biogas
	147	Distribution services of gaseous fuels through mains
	148	Steam and hot water supply services
	149	Collected and purified water, distribution services of water
	150	Construction work
Construction		Secondary construction material for treatment, Re-processing of secondary construction material into aggregates
	151	
	152	Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessoires
	153	Retail trade services of motor fuel
	154	Wholesale trade and commission trade services, except of motor vehicles and motorcycles
	155	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods
	156	Hotel and restaurant services
	157	Railway transportation services
	158	Other land transportation services
Trade and service	159	Transportation services via pipelines
	160	Sea and coastal water transportation services
	161	Inland water transportation services
	162	Air transport services
	163	Supporting and auxiliary transport services; travel agency services
	164	Post and telecommunication services
	165	Financial intermediation services, except insurance and pension funding services
	166	Insurance and pension funding services, except compulsory social security services
	167	Services auxiliary to financial intermediation
	168	Real estate services
	169	Renting services of machinery and

	equipment without operator and of personal and household goods
170	Computer and related services
171	Research and development services
172	Other business services
173	Public administration and defence services; compulsory social security services
174	Education services
175	Health and social work services
176	Food waste for treatment: incineration
177	Paper waste for treatment: incineration
178	Plastic waste for treatment: incineration
179	Inert/metal waste for treatment: incineration
180	Textiles waste for treatment: incineration
181	Wood waste for treatment: incineration
182	Oil/hazardous waste for treatment: incineration
183	Food waste for treatment: biogasification and land application
184	Paper waste for treatment: biogasification and land application
185	Sewage sludge for treatment: biogasification and land application
186	Food waste for treatment: composting and land application
187	Paper and wood waste for treatment: composting and land application
188	Food waste for treatment: waste water treatment
189	Other waste for treatment: waste water treatment
190	Food waste for treatment: landfill
191	Paper for treatment: landfill
192	Plastic waste for treatment: landfill
193	Inert/metal/hazardous waste for treatment: landfill
194	Textiles waste for treatment: landfill
195	Wood waste for treatment: landfill
196	Membership organisation services nec
197	Recreational, cultural and sporting services
198	Other services
199	Private households with employed persons
200	Extra-territorial organizations and bodies

Table S3 List of nations/regions in the EXIOBASE database.

Number	Nation/Region	Number	Nation/Region
1	Austria	26	Slovenia
2	Belgium	27	Slovakia
3	Bulgaria	28	United Kingdom
4	Cyprus	29	United States
5	Czech Republic	30	Japan
6	Germany	31	China
7	Denmark	32	Canada
8	Estonia	33	South Korea
9	Spain	34	Brazil
10	Finland	35	India
11	France	36	Mexico
12	Greece	37	Russia
13	Croatia	38	Australia
14	Hungary	39	Switzerland
15	Ireland	40	Turkey
16	Italy	41	Taiwan, China
17	Lithuania	42	Norway
18	Luxembourg	43	Indonesia
19	Latvia	44	South Africa
20	Malta	45	RoW Asia and Pacific
21	Netherlands	46	RoW America
22	Poland	47	RoW Europe
23	Portugal	48	RoW Africa
24	Romania	49	RoW Middle East
25	Sweden		