Appendix

Appendix 1: Regional, Sectoral, and Environmental Classifications

Country Grouping on the Global scale

Appendix Table 1.1:
Global Country Grouping

China
n=4
China Taiwan Macao Hong Kong

Group 1	
Core	**High-income**
n=3	n=41
Europe	Austria (AUT) Germany (DEU) Belgium (BEL) Cyprus (CYP) Czech Republic (CZE) Denmark (DNK) Estonia (EST) Finland (FIN) France (FRA) Iceland (ISL) Ireland (IRL) Israel (ISR) Italy (ITA) Latvia (LVA) Luxembourg (LUX) Malta (MLT) Netherlands (NLD) Norway (NOR) Portugal (PRT) Slovakia (SVK) Slovenia (SVN) Spain (ESP) Sweden (SWE) Switzerland (CHE) United Kingdom (GBR)
North America	Trinidad and Tobago (TTO) British Virgin Islands (VGB) United States of America (USA) Canada (CAN)
Asia & Pacific	Bahrain (BHR) Brunei (BRN) Oman (OMN) Qatar (QAT) Saudi Arabia (SAU) United Arab Emirates (ARE) Australia (AUS) New Zealand (NZL) Japan (JPN) South Korea (KOR) Singapore (SGP) Israel (ISR) Kuwait (KWT)

Group 2	
Semi-Periphery	**Upper-middle income**
n=5	n=41
East Europe	Serbia (SRB) Montenegro (MNE) Romania (ROU) Croatia (HRV) Greece (GRC) Hungary (HUN) Latvia (LVA) Poland (POL)
Latin America & the Carribbean	Costa Rica (CRI) Barbados (BRB) Mexico (MEX) Antigua and Barbuda (ATG) Argentina (ARG) Bahamas (BHS) Barbados (BRB) Brazil (BRA) Chile (CHL) Colombia (COL) Cuba (CUB) Dominican Republic (DOM) Uruguay (URY) Panama (PAN) Suriname (SUR) Venezuela (VEN)
Africa	Algeria (DZA) Botswana (BWA) Gabon (GAB) Libya (LBY) Mauritius (MUS) South Africa (ZAF) Seychelles (SYC)
Asia & Middle East	Iran (IRN) Lebanon (LBN) Iraq (IRQ) Malaysia (MYS) North Macedonia (MKD) Thailand (THA) Turkey (TUR) Kazakhstan (KAZ) Azerbaijan (AZE)
Russia	Russia (RUS)

Group 3			
Periphery	**India**	**Lower-middle income**	**Low-Income**
n=4	n=1	n=36	n=50
India	India		
Latin America & the Carribean		Belize (BLZ) Bolivia (BOL) Ecuador (ECU) El Salvador (SLV) Guatemala (GTM) Jamaica (JAM) Paraguay (PRY) Peru (PER)	Haiti (HTI) Honduras (HND) Nicaragua (NIC)
Africa		Cape Verde (CPV) Republic of the Congo (COG) Angola (AGO) Namibia (NAM) Nigeria (NGA) Morocco (MAR) Tunisia (TUN) Egypt (EGY) Svaziland (SWZ)	Burkina Faso (BFA) Burundi (BDI) Cameroon (CMR) Central African Republic (CAF) Chad (TCD) Côte d'Ivoire (CIV) Djibouti (DJI) Equatorial Guinea (GNQ) Eritrea (ERI) Ethiopia (ETH) Gambia (GMB) Ghana (GHA) Guinea (GIN) Kenya (KEN) Lesotho (LSO) Liberia (LBR) Madagascar (MDG) Malawi (MWI) Mali (MLI) Mauritania (MRT) Mozambique (MOZ) Niger (NER) Rwanda (RWA) São Tomé and Príncipe (STP) Senegal (SEN) Sierra Leone (SLE) Somalia (SOM) South Sudan (SSD) Sudan (SDN) Tanzania (TZA) Togo (TGO) Uganda (UGA) Zambia (ZMB) Zimbabwe (ZWE)
Asia & Middle East		Armenia (ARM) Bhutan (BTN) Fiji (FJI) Georgia (GEO) Indonesia (IDN) Jordan (JOR) Maldives (MDV) Mongolia (MNG) Pakistan (PAK) Philippines (PHL) Sri Lanka (LKA) Turkmenistan (TKM) Uzbekistan (UZB) Vietnam (VNM) Samao (WSM)	Bangladesh (BGD) Afghanistan (AFG) Cambodia (KHM) Kyrgyzstan (KGZ) Laos (LAO) Myanmar (MMR) Nepal (NPL) North Korea (PRK) Syria (SYR) Tajikistan (TJK) Timor-Leste (TLS) Yemen (YEM) Vanuatu (VUT)
discarded		Albania (ALB) Ukraine (UKR) Bosnia and Herzegovina (BIH) Moldovia (MDA)	

Do we discuss the case of India her?

Regional Classification

For the purpose of this study and given the scope of the work, we choose to classify China's provinces into its four main economic zones - North zone (NZ), East Coast zone (ECZ), Western zone (WZ), Central zone (CZ) and measure the value-added and energy trade between these zones. While China officially names three economic zones, namely the East Coast zone (ECZ), Central zone (CZ) and the Western zone (WZ), the classifications do change over time, and China has run regional development programs corresponding closely to the four regions that we identify.[1] In order to provide the time-series from 1987-2017, we are bound by the regional classification

[1] We further tested ecologically unequal exchange using the seven main regions of China and five different income groups. For the results, see Appendix 3.

of the 1987 table. Moreover, regions had to be adjusted in order to achieve even population sizes, which, as noted above, is fundamental when analysing material flows between regions. Hence, there are minor differences between the official economic zones of China and the ones presented in this paper (State Council of China, 1986). In our analysis, the ECZ entails South China and East China, the WZ entails Southwest and Northwest, while the NZ entails Northeast China. We choose to separate Central China from the three economic zones classified as Central Zone to achieve even (aggregated) population sizes. In comparison, in the official classification, the East Coast region contains South China, East China and North China, plus Lianoning province from Northeast China and Guangxi province from Southwest China. The Central region contains Central China and Northeast China except for Lianoning province. The Western region entails Southwest China and Northwest China with the exception of Guangxi province (see Appendix Table 1.4: for a detailed overview of our regional grouping). Therefore, our economic zones diverge from the official Chinese state classification. However, with North China, including Beijing as its political and financial centre, we are taking away a powerful region from the East Coast zone and adding it to the North zone. Hence it is argued that, among all the limitation that may have been produced by this regional shift, it is very likely that the patterns observed are even stronger when respecting the official regional classification. This intuition is also confirmed by the fact that ecologically unequal exchange was the most apparent when considering five different income groups (see below).

Appendix Table 1.2:
Regional Grouping by Economic Zone

China's 3 Economic Zones			Official Classifiation	Provinces 1987 MRIO Table	Provinces 1997, 2002, 2007 MRIO Table	Provinces 2012, 2015, 2017 MRIO Table
1	A	Central Zone	Jilin, Heilongjiang, Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi	Northeast, North China	Liaoning, Jilin, Heilongjiang, Beijing, Tianjin, Hebei, Shandong	Liaoning, Jilin, Heilongjiang, Beijing, Tianjin, Hebei, Shandong
2	B	Western Zone	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, Sichuan, Guizhou, Yunnan, Tibet	Southwest, Northwest	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, ***Inner Mongolia*** , Sichuan, ***Chongqing,*** Guizhou, Yunnan, Guangxi	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, ***Inner Mongolia*** , Sichuan ***Chongqing,*** Guizhou, Yunnan, Guangxi, ***Tibet***
3	C	East Coast Zone	Guangdong, Fujian, Hainan, Beijing, Tianjin, Hebei, Shandong, Inner Mongolia, Shanghai, Jiangsu, Zhejiang, Liaoning, Guangxi	East China, South China	Guangdong, Fujian, Hainan, Shanghai, Jiangsu, Zhejiang	Guangdong, Fujian, Hainan, Shanghai, Jiangsu, Zhejiang
5	D	Central China	-	Central China	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi

Appendix Table 1.3:
Regional Grouping by Geographical Region

China's 7 Regions			Provinces 1987 MRIO Table	Provinces 1997, 2002, 2007 MRIO Table	Provinces 2012, 2015, 2017 MRIO Table
1	A	Northeast	Liaoning, Jilin, Heilongjiang	Liaoning, Jilin, Heilongjiang	Liaoning, Jilin, Heilongjiang
2	B	North China	Beijing, Tianjin, Hebei, Shandong, ***Inner Mongolia***	Beijing, Tianjin, Hebei, Shandong	Beijing, Tianjin, Hebei, Shandong
3	C	East Coast	Shanghai, Jiangsu, Zhejiang	Shanghai, Jiangsu, Zhejiang	Shanghai, Jiangsu, Zhejiang
4	D	South Coast	Guangdong, Fujian, Hainan	Guangdong, Fujian, Hainan	Guangdong, Fujian, Hainan
5	E	Central China	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi	Shanxi, Henan, Anhui, Hubei, Hunan, Jiangxi
6	F	Northwest	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, ***Inner Mongolia***	Shaanxi, Gansu, Ningxia, Qinghai, Xinjiang, ***Inner Mongolia,***
7	G	Southwest	Sichuan, Guizhou, Yunnan, Guangxi, ***Tibet***	Sichuan, Guizhou, Yunnan, Guangxi	Sichuan, Guizhou, Yunnan, Guangxi, ***Tibet***

Appendix Table 1.4:
Region Grouping by Income Group
Source: Own Illustration based on own calculations

China's 5 Income Regions			Provinces 1997, 2002, 2007 MRIO Table	Provinces 2012, 2015, 2017 MRIO Table
1	A	High income	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Guangdong	Beijing, Tianjin, Shanghai, Jiangsu, Zhejiang, Guangdong
2	B	Upper-middle income	Inner Mongolia, Liaoning, Fujian, Shandong, Hubei, Chongqing	Inner Mongolia, Liaoning, Fujian, Shandong, Hubei, Chongqing
3	C	Middle income	Jilin, Henan, Sichuan, Shaanxi, Ningxia	Jilin, Henan, Sichuan, Shaanxi, Ningxia
4	D	Lower-middle income	Hebei, Heilongjiang, Jiangxi, Hunan, Hainan, Qinghai	Hebei, Heilongjiang, Jiangxi, Hunan, Hainan, Tibet, Qinghai
5	E	Low income	Shanxi, Anhui, Guangxi, Guizhou, Yunnan, Gansu, Xinjiang	Shanxi, Anhui, Guangxi, Guizhou, Yunnan, Gansu, Xinjiang

Sectoral Classification and Differences between Chinese MRIO tables

The 1987 MRIO table consists of a joint work of the International Center for the Study of East Asia of Japan and the Development Research Center of China (Ichimura & Wang, 2003). The aggregated version entails 9 sectors and 7 regions. The 1997, 2002 and 2007 table were also compiled by the Development Research Center of the State Council, P.R.C. and include 28 sectors and 30 regions.The 2012, 2015 and 2017 MRIO tables were sourced from the CEADS49 website and include 42 sectors and 31 regions (Y. Guan et al., 2021; Shan et al., 2018, 2020; H. Zheng et al., 2020). Since, the 1997, 2002, and 2007 MRIO tables were published in 1997 prices, and the 1987, 2012, 2015 and 2017 tables in current prices, we use the RAS method to adjust them into constant 2017 prices.

Note that the compilation methods used to produce the 1987, the 1997, 2002, 2007 and the 2012, 2015 and 2017 table differ significantly. [2] The main differences can be summarized in two basic points. First, the tables entail three different methods of compiling interregional intermediate demand. This difference is important as it prevents us from using the 1987 table for the detailed SDA. A further difference refers to the regional and industrial classification across the MRIO tables. To start, there exist important differences across regions. The political separation of Chongqing represents no further problem as the subsequent MRIO tables entail higher regional detail, which allow for (Meng & Qu, 2007; Yang & Lahr, 2008) because of the economic scale of Inner Mongolia, this bias is likely to be fairly small.[3] A last important difference concerns the fact that the 1987 MRIO table is divided into 7 regions, while the others entail 30 and 31 regions respectively. This forces us to adapt the same regional aggregation for the 30 -year time-series analysis for all the six other MRIO tables. Moreover, there are significant differences with respect to industrial classifications, as the number of sectors included differs significantly. Nevertheless, for the purpose of this study all sectors were aggregated, rendering the industrial classification differences redundant.

Since, the 1997, 2002, and 2007 MRIO tables were published in 1997 prices, and the 1987, 2012, 2015 and 2017 tables in current prices, we use the RAS method to adjust them into constant 2017 prices.[4] The RAS approach is widely used and recognized as a technique of updating coefficients and often used to update MRIO tables into constant prices (see e.g., Yang & Lahr, 2008; Zhang & Lahr, 2014).[5] As we opt to aggregate all sectors, we use the Chinese CPI from 1987 to 2017 to inflate the data.

[2] As described above, for the analysis of net trade of embodied energy, these differences represented only minor and acceptable limitations, however as will be seen they may overstate the total final demand effect.
[3] For our analysis, we decide to accept the negligible limitations and classify Inner Mongolia according to its most recent political affiliation in Northwest China.
[4] See Allen & Gossling (1975), Lahr (1993), and Miller & Blair (2009) for a detailed theoretical and critical review of the RAS method.
[5] I want to express my gratitude for the theoretical support, the provision of materials, as well as the provision of the RAS-Algorithm to Michael Lahr during the work on this study.

Data for the CPI was gathered from the Chinese Statistical Yearbooks from the respective years (CSY, 1999-2018).

Appendix Table 1.5:
Sector Classification of Chinese MRIO Tables

1987 MRIO		1997, 2002, 2007 MRIO		2012, 2015, 2017 MRIO	
N° Sector	**Sector**	**N° Sector**	**Sector**	**N° Sector**	**Sector**
1	Agriculture	1	Agriculture	1	Agriculture, Forestry, Animal Husbandry and Fishery
2	Mining and Processing	2	Coal mining	2	Mining and washing of coal
		3	Petroleum and gas	3	Extraction of petroleum and natural gas
		4	Metal mining	4	Mining and processing of metal ores
		5	Nonmetal mining	5	Mining and processing of nonmetal and other ores
		6	Food processing and tobacco	6	Food and tobacco processing
3	Light Industry	7	Textiles	7	Textile industry
		8	Clothing, leather, fur, etc.	8	Manufacture of leather, fur, feather and related products
		9	Wood processing and furnishing	9	Processing of timber and furniture
		10	Paper making, printing, stationery, etc	10	Manufacture of paper, printing and articles for culture, education and sport activity
		11	Petroleum refining, coking, etc.	11	Processing of petroleum, coking, processing of nuclear fuel
4	Heavy Industry	12	Chemical industry	12	Manufacture of chemical products
		13	Nonmetal products	13	Manuf. of non -metallic mineral products
		14	Metallurgy	14	Smelting and processing of metals
		15	Metal products	15	Manufacture of metal products
		16	General and specialist machinery	16	Manufacture of general purpose machinery
		17	Electrical equipment	17	Manufacture of special purpose machinery
		18	Transport Equipement	18	Manufacture of transport equipment
		19	Electronic equipment	19	Manufacture of electrical machinery and equipment
		20	Instrument and meter	20	Manufacture of communication equipment, computers and other electronic equipment
		21	Other manufacturing	21	Manufacture of measuring instruments
				22	Other manufacturing
				23	Comprehensive use of waste resources
				24	Repair of metal products, machinery and equipment
5	Energy Industry	22	Electricity and hot water production and supply	25	Production and distribution of electric power and heat power
		23	Gas production and supply	26	Production and distribution of gas
		24	Water production and supply	27	Production and distribution of tap water
6	Construction	25	Construction	28	Construction
7	Trade and Transport	26	Transportation, storage	29	Transport, storage, and postal services
8	Wholesale, retailing, and catering	27	Wholesale, retailing, and catering	30	Wholesale and retail trades
				31	Accomodation and catering
9	Services	28	Other Services	32	Information transfer, software and information technology services
				33	Finance
				34	Real estate
				35	Leasing and commercial services
				36	Scientific research and polytechnic services
				37	Administration of water, environment, and public facilities
				38	Resident, repair and other services
				39	Education
				40	Health care and social work
				41	Culture, sports, and entertainment
				42	Public administration, social insurance, and social organizations

Compilation of Energy Data

We further choose to assess intra-country ecologically unequal exchange using embodied energy. Energy data was sourced from the CEADS website and available for each year from 1997 to 2017 and each province separately (Guan et al., 2021; Shan et al., 2018, 2020; Zheng et al., 2020). Each dataset entailed the energy consumption of 45 sectors divided into 16 different types of energy, measured in their physical units.[6] For the purpose of this study, we aggregate the different types of energy to one total energy consumption vector and convert all energy types into one common unit (e.g., Joule). Conversion factors were sourced from the Chinese Energy Statistical Yearbook (CESY, 2007) and the United Nations Energy Statistical Yearbook (United Nations, 2020) and available for most of the energy types.[7] Note that energy consumption was available for 45 sectors, which diverged from the sectoral classifications used in the 1997-2017 tables. To achieve coherence with the different sectoral classification of the MRIO tables, energy consumption was aggregated and

[6] Note that energy consumption was not available for Tibet but was artificially set to 0. As Tibet is excluded in the 1987, 1997, 2002 and 2007 MRIO table, this modification represents no further limitation.
[7] For those not available, we chose the conversion factors for similar energy types (for details see Table 1.7)

disaggregated by sector for each year and each province. Due to the different sectoral classification of the MRIO tables, different aggregation and disaggregation methods were used for the 1997, 2002, 2007 MRIO tables and the 2012, 2015, 2017 table.[8] For the year 1987, energy data was provided along with the table and available for 9 sectors.

Appendix Table 1.6:
Energy Inventory and MRIO Classification
Source: Own Illustration based on own calculations

Energy Inventory		1997, 2002, 2007 MRIO		2012, 2015, 2017 MRIO	
N° Sector	Sector	N° Sector	Sector	N° Sector	Sector
1	Farming, Forestry, Animal Husbandry, Fishery & Water Conservancy	1	Agriculture	1	Agriculture, Forestry, Animal Husbandry and Fishery
2	Coal Mining and Dressing	2	Coal mining	2	Mining and washing of coal
3	Petroleum and Naturl Gas Extraction	3	Petroleum and gas	3	Extraction of petroleum and natural gas
4	Ferrous Metals Mining and Dressing	4	Metal mining	4	Mining and processing of metal ores
5	Nonferrous Metals Mining and Dressing				
6	Nonmetal Minerals Mining and Dressing				
7	Other Minerals Mining and Dressing	5	Nonmetal mining	5	Mining and processing of nonmetal and other ores
8	Food Processing	6	Food processing and tobacco	6	Food and tobacco processing
9	Food Production				
10	Beverage Production				
11	Tobacco Processing				
12	Textile Industry	7	Textiles	7	Textile industry
13	Garments and Other Fiber Products				
14	Leather, Furs, Down and Related Products	8	Clothing, leather, fur, etc.	8	Manufacture of leather, fur, feather and related products
15	Logging and Transport of Wood and Bamboo	9	Wood processing and furnishing	9	Processing of timber and furniture
16	Timber Processing, Bamboo, Cane, Palm & Straw Products				
17	Furniture Manufacturing				
18	Papermaking and Paper Products	10	Paper making, printing, stationery, etc	10	Manufacture of paper, printing and articles for culture, education and sport activity
19	Printing and Record Medium Reproduction				
20	Cultural, Educational and Sports Articles				
21	Petroleum Processing and Coking	11	Petroleum refining, coking, etc.	11	Processing of petroleum, coking, processing of nuclear fuel
22	Raw Chemical Materials and Chemical Products	12	Chemical industry	12	Manufacture of chemical products
23	Medical and Pharmaceutical Products				
24	Chemical Fiber				
25	Rubber Products				
26	Plastic Products				
27	Nonmetal Mineral Products	13	Nonmetal products	13	Manuf. of non -metallic mineral products
28	Smelting and Pressing of Ferrous Metals	14	Metallurgy	14	Smelting and processing of metals
29	Smelting and Pressing of Nonferrous Metals				
30	Metal Products	15	Metal products	15	Manufacture of metal products
31	Ordinary Machinery	16	General and specialist machinery	16	Manufacture of general purpose machinery
32	Equipment for Special Purpose			17	Manufacture of special purpose machinery
33	Transportation Equipment	17	Transport Equipement	18	Manufacture of transport equipment
34	Electric Equipment and Machinery	18	Electrical equipment	19	Manufacture of electrical machinery and equipment
35	Electronic and Telecommunications Equipment	19	Electronic equipment	20	Manufacture of communication equipment, computers and other electronic equipment
36	Instruments, Meters Cultural and Office Machinery	20	Instrument and meter	21	Manufacture of measuring instruments
37	Other Manufacturing Industry	21	Other manufacturing	22	Other manufacturing
				23	Repair of metal products, machinery and equipment
38	Scrap and waste			24	Comprehensive use of waste resources
39	Electric Power, Steam and Hot Water Production and Supply	22	Electricity and hot water production and supply	25	Production and distribution of electric power and heat power
40	Gas Production and Supply	23	Gas production and supply	26	Production and distribution of gas
41	Tap Water Production and Supply	24	Water production and supply	27	Production and distribution of tap water
42	Construction	25	Construction	28	Construction
43	Transport, Storage, Postal & Telecommunications Services	26	Transportation, storage	29	Transport, storage, and postal services
44	Wholesale, Retail Trade and Catering Service	27	Wholesale, retailing, and catering	30	Wholesale and retail trades
				31	Accomodation and catering
45	Other	28	Other Services	32	Information transfer, software and information technology services
				33	Finance
				34	Real estate
				35	Leasing and commercial services
				36	Scientific research and polytechnic services
				37	Administration of water, environment, and public facilities
				38	Resident, repair and other services
				39	Education
				40	Health care and social work
				41	Culture, sports, and entertainment
				42	Public administration, social insurance, and social organizations

[8] See Table 1.7 for a detailed overview of the energy aggregation.

Appendix Table 1.7:
Conversion Factors from Physical units to Coal Equivalent
Source: Provided by Yuli Shan based on Chinese Energy Statistical Yearbook (CESY, 2007)

Energy	Average Low Calorific Value	Conversion Factor
Raw Coal	20 908 kjoule/(5 000 kcal)/ kg	0.7143 kgce/kg
Cleaned Coal	26 344 kjoule/(6 300 kcal)/kg	0.9000 kgce/kg
Other Washed Coal		
Middlings	8 363 kjoule/(2 000 kcal)/kg	0.2857 kgce/kg
Slimes	8 363～12 545 kjoule/(2 000～3 000kcal)/kg	0.2857～0.4286 kgce/kg
Coke	28 435 kjoule/(6 800 kcal)/kg	0.9714 kgce/kg
Crude Oil	41 816 kjoule/(10 000 kcal)/kg	1.4286 kgce/kg
Fuel Oil	41 816 kjoule/(10 000 kcal)/kg	1.4286 kgce/kg
Gasoline	43 070 kjoule/(10 300 kcal)/kg	1.4714 kgce/kg
Kerosene	43 070 kjoule/(10 300 kcal)/kg	1.4714 kgce/kg
Diesel	42 652 kjoule/(10 200 kcal)/kg	1.4571 kgce/kg
Liquefied Petroleum Gas	50 179 kjoule/(12 000 kcal)/kg	1.7143 kgce/kg
Refinery Gas	45 998 kjoule/(11 000 kcal)/kg	1.5714 kgce/kg
Natural Gas	32 238～38 931kjoule/(7 700～9 310 kcal)/ cu.m	1.1000～1.3300 kgce/cu.m
Coke Oven Gas	16 726～17 981kjoule/(4 000～ 4 300kca1)/cu.m	0.5714～0.6143 kgce/cu.m
Other Coal Gas		
By Gas Furnace	5 227 kjoule/(1 250 kcal)/cu.m	0.1786 kgce/cu.m
By Heavy Oil Catalytic Cracking	19 235 kjoule/(4 600 kcal)/ cu.m	0.6571 kgce/cu.m
By Heavy Oil Thermal Cracking	35 544 kjoule/(8 500 kcal)/cu.m1.2143 kgce/cu.m	
Coke Gas	16 308 kjoule/(3 900 kcal)/cu.m	0.5571 kgce/cu.m
By Pressure Gasification	15 054 kjoule/(3 600 kcal)/cu.m	0.5143 kgce/cu.m
Water Coal Gas	10 454 kjoule/(2 500 kcal)/cu.m	0.3571 kgce/cu.m
Coal Tar	33 453 kjoule/(8 000 kcal)/kg	1.1429 kgce/kg
Benzene	41 816 kjoule/(10 000 kcal)/kg	1.4286 kgce/kg
Heat (in calorific value)	0.03412 kgce/Mjoule	(0.14286 kgce/1000 kcal)
Electricity (in calorific value)	3 600 kjoule/(860 kcal)/kW-h	0.1229 kgce/kW-h
(in coal equivalent)	calculated by average coal input for thermal power generation in the year	
Biomass Energy		
Night Soill	8 817 kjoule/(4 500 kcal)/kg	0.643 kgce/kg
Cow Dung	13 799 kjoule/ (3 300 kcal)l kg	0.471 kgce/kg
Pig Dung	12 545 kjoule/(3 000 kcal)/kg	0.429 kgce/kg
Sheep/Donkey/Horse/Mule Dung	15 472 kjoule/(3 700 kcal)/kg	0.529 kgce/kg
Poultry Manure	18 817 kjoule/(4 500 kcal)/kg	0.643 kgce/kg
Soybean Stalk,Cotton Stalk	15 890 kjoule/(3 800 kcal) / kg	0.543 kgce/kg
Paddy Stalk	12 545 kjoule/(3 000 kcal)/kg	0.429 kgce/kg
Wheat stalk	14 635 kjoule/(3 500 kcal)/kg	0.500 kgce/kg
Maize Stalk	15 472 kjoule/(3 700 kcal)/kg	0.529 kgce/kg
Fireweed	13 799 kjoule/(3 300 kcal)/kg	0.471 kgce/kg
Leaves	14 635 kjoule/(3 500 kcal)/kg	0.500 kgce/kg
Firewood	16 726 kjoule/(4 000 kcal)/ kg	0.571 kgce/kg
Biogas	20 908 kjoule/(5 000 kcal)/cu.m	0.714 kgce/cu.m

Appendix 2: Methodology

Final Demand Composition

Following H. Zhang & Lahr (2014), we expect that changes in final demand are an important driver of regional energy consumption. As final demand is made up of various components, including government expenditure, exports or capital investment, we opt to further decompose the total contribution of final demand to the change in energy consumption. This allows us to assess in more detail, what parts of final demand (e.g., exports or government expenditure) have been driving regional energy consumption and thus the intra-country ecologically unequal exchange. It provides yet another, more granulated assessment of the driving forces of EUE on a regional level, allowing us to move substantially beyond what is common within the literature on EUE. In this context, we decide to employ an additive decomposition method.

F: aggregated final demand (scalar).

cu: vector of urban consumption with $\mathbf{cu}_i^r$ representing the total final demand of urban consumption for industry i in region r ($nm \times 1$ vector), constructed by aggregating the rows of the final demand matrix **F** with respect to urban consumption.

$\mathbf{cr}$: vector of rural consumption with $\mathbf{cr}_i^r$ representing the total final demand of rural consumption for industry i in region r ($nm \times 1$ vector), constructed by aggregating the rows of the final demand matrix **F** with respect to rural consumption.

$\mathbf{g}$: vector of government expenditure with $\mathbf{g}_i^r$ representing the total government expenditure for industry i in region r ($nm \times 1$ vector), constructed by aggregating the rows of the final demand matrix **F** with respect to government expenditure.

i: vector of capital investment with $\mathbf{i}_i^r$ representing the total capital investment for industry i in region r ($nm \times 1$ vector), constructed by aggregating the rows of the final demand matrix **F** with respect to capital investment.

ex: vector of international exports with $\mathbf{ex}_i^r$ representing the total exports for industry i in region r ($nm \times 1$ vector), constructed by aggregating the rows of the final demand matrix **F** with respect to exports.

Thus, knowing that $F = \mathbf{cu} + \mathbf{cr} + \mathbf{g} + \mathbf{i} + \mathbf{ex}$, we can denote its change, with indices as time indicators, where 0 represents 1997 and 1 represents 2015, as

$$\frac{F_1}{F_0} = \frac{\mathbf{cr}_1 + \mathbf{cu}_1 + \mathbf{g}_1 + \mathbf{i}_1 + \mathbf{ex}_1}{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_0 + \mathbf{i}_0 + \mathbf{ex}_0} \tag{1}$$

Where the first factor represents the change in urban consumption, the second represents the change in rural consumption, the third and fourth denoting government expenditure and capital investment changes respectively, while the last factor denotes the changes in international exports.[9]

Consequently, the final decomposition of aggregated final demand change can be written as

$$\frac{F_1}{F_0} = (9) + (10) + (11) + (12) + (13)$$

$$= \frac{\mathbf{cr}_1 + \mathbf{cu}_1 + \mathbf{g}_1 + \mathbf{i}_1 + \mathbf{ex}_1}{\mathbf{cr}_0 + \mathbf{cu}_1 + \mathbf{g}_1 + \mathbf{i}_1 + \mathbf{ex}_1} \tag{2}$$

$$= \frac{\mathbf{cr}_0 + \mathbf{cu}_1 + \mathbf{g}_1 + \mathbf{i}_1 + \mathbf{ex}_1}{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_1 + \mathbf{i}_1 + \mathbf{ex}_1} \tag{3}$$

$$= \frac{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_1 + \mathbf{i}_1 + \mathbf{ex}_1}{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_0 + \mathbf{i}_1 + \mathbf{ex}_1} \tag{4}$$

$$= \frac{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_0 + \mathbf{i}_1 + \mathbf{ex}_1}{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_0 + \mathbf{i}_0 + \mathbf{ex}_1} \tag{5}$$

$$= \frac{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_0 + \mathbf{i}_0 + \mathbf{ex}_1}{\mathbf{cr}_0 + \mathbf{cu}_0 + \mathbf{g}_0 + \mathbf{i}_0 + \mathbf{ex}_0} \tag{6}$$

Total final demand change is thus decomposed into five partial effects.

$\Delta\mathbf{cu}$: effect of changes in urban consumption (Eq. 9)

[9] Note that similar to the analysis above, we only represent one side of the polar decomposition. In our study, we conduct both polar decompositions and take the geometric average of the two methods to obtain Fisher's indices to analyse the results.

$\Delta\mathbf{cr}$: effect of changes in rural consumption (Eq. 10)

$\Delta\mathbf{g}$: effect of changes in government expenditure (Eq. 11)

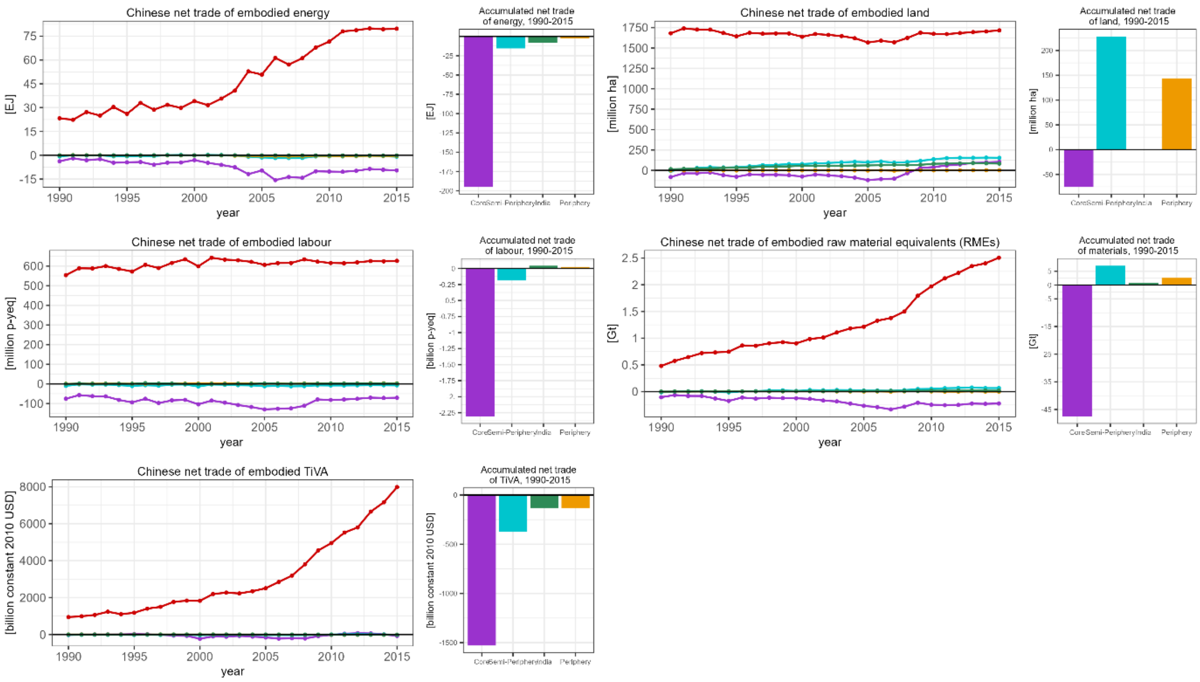
$\Delta\mathbf{i}$: effect of changes in capital investment (Eq. 12)

$\Delta\mathbf{ex}$: effect of changes in international exports (Eq. 13)

Appendix 3: Graphs and Figures

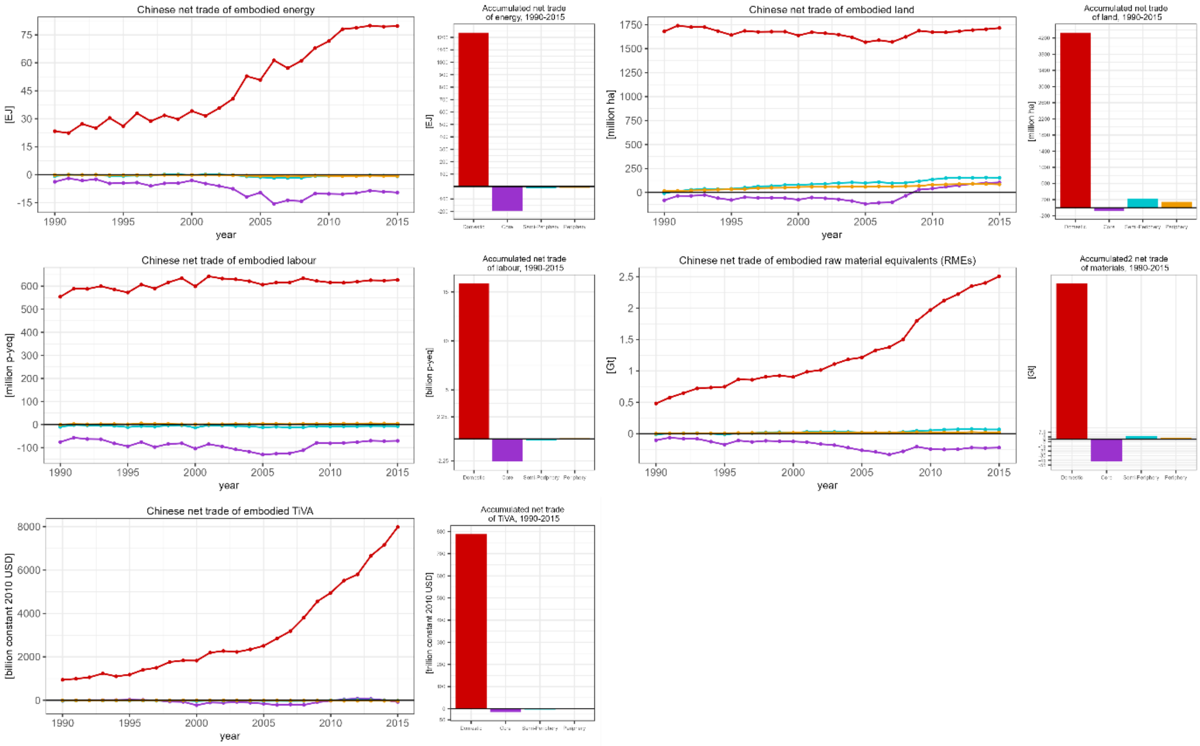
A) Global Analysis

Appendix Figure 3.1: China's Involvement in Inter-Country EUE with the Income Groups (including India)



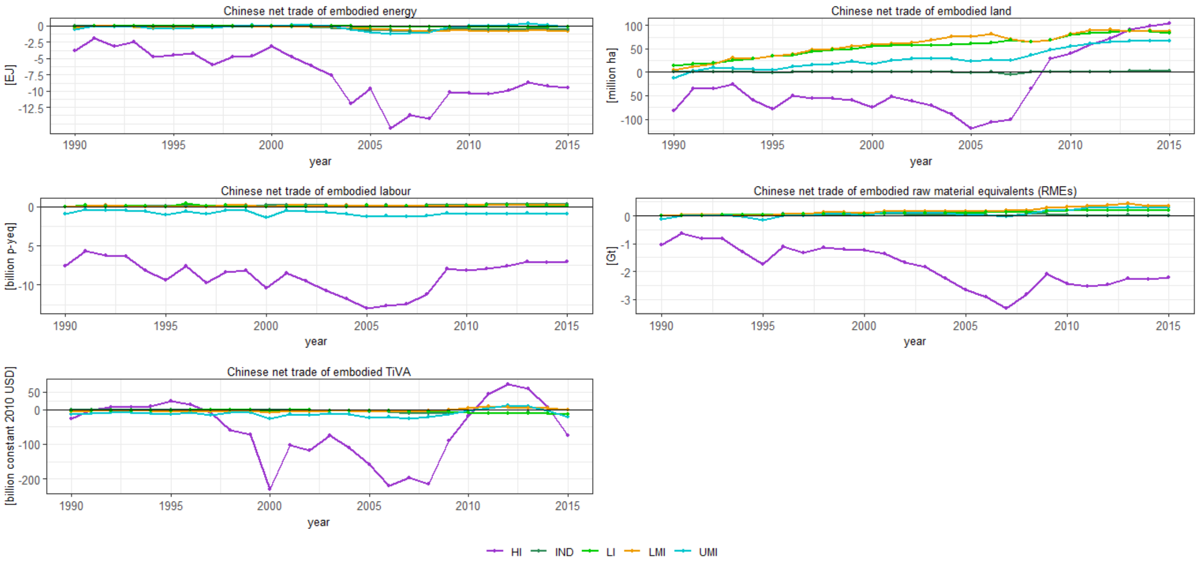
Description: China's net trade of resources with the core grouped country classification over time with India separated, 1990–2015. Top left: embodied energy [EJ]; top right: embodied land [billion ha]; middle left: embodied labour [million p-y_{eq}]; middle right: raw material equivalents (RMEs) [Gt]; and bottom left: trade in value added (TiVA) [bn constant 2010 USD]. Positive values represent a net appropriation of resources.

Appendix Figure 3.2: China's Involvement in Inter-Country EUE with the Income Groups (including China in accumulated graph)



Description: China's net trade of resources with the core grouped country classification over time, 1990–2015. Top left: embodied energy [EJ]; top right: embodied land [billion ha]; middle left: embodied labour [million p-y_{eq}]; middle right: raw material equivalents (RMEs) [Gt]; and bottom left: trade in value added (TiVA) [bn constant 2010 USD]. Positive values represent a net appropriation of resources.

Appendix Figure 3.3: China's Involvement in Inter-Country EUE with Income Groups (no HI)

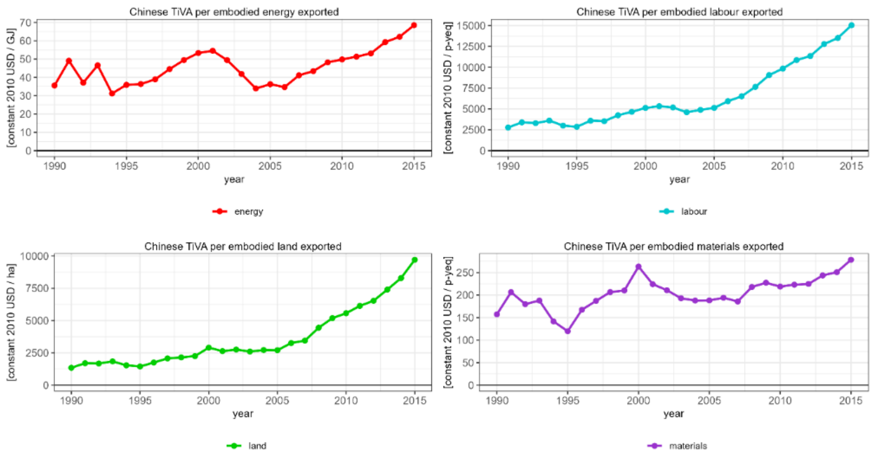


Description: China's net trade of resources with the income-grouped countries over time without domestic, 1990–2015. Top left: embodied energy [EJ]; top right: embodied land [billion ha]; middle left: embodied labour [million p-y_{eq}]; middle right: raw material equivalents (RMEs) [Gt]; and bottom left: trade in value added (TiVA) [bn constant 2010 USD]. Positive values represent a net appropriation of resources.

Appendix Figure 3.4: China's Involvement in Inter-Country EUE with Income Groups (no HI)

Description: China's net trade of resources with the income-grouped countries over time without domestic and no high-income countries, 1990–2015. Top left: embodied energy [EJ]; top right: embodied land [billion ha]; middle left: embodied labour [million p-$\mathbf{y_{eq}}$]; middle right: raw material equivalents (RMEs) [Gt]; and bottom left: trade in value added (TiVA) [bn constant 2010 USD]. Positive values represent a net appropriation of resources.

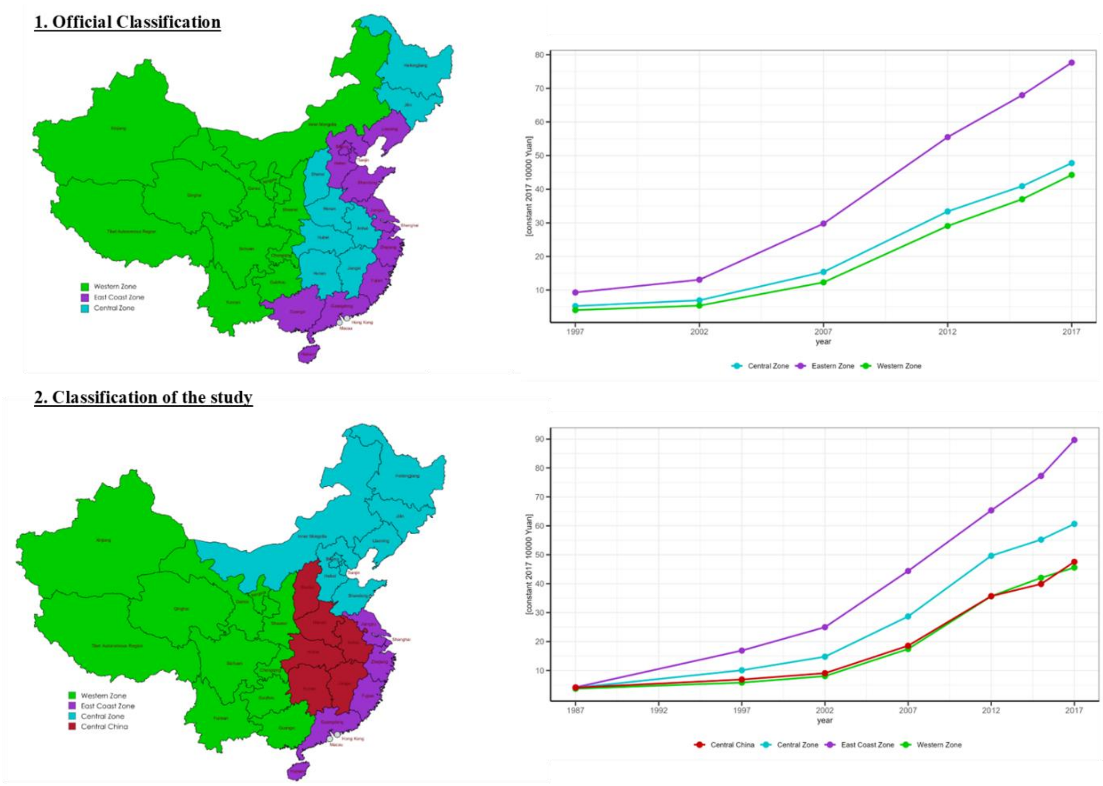
Appendix Figure 3.5: TiVA per Embodied Resource



Description: Trade in value added (TiVA) of resources embodied in exports, 1990–2015, in constant international 2010 USD. Top left: value added per unit of embodied energy exported [USD per GJ]; top right: value added per hectare embodied in exports [USD per ha]; bottom left: value added per labour equivalent embodied in exports [USD per p-$\mathbf{y_{eq}}$]; bottom right: value added per raw material equivalent (RME) exported [USD per t].

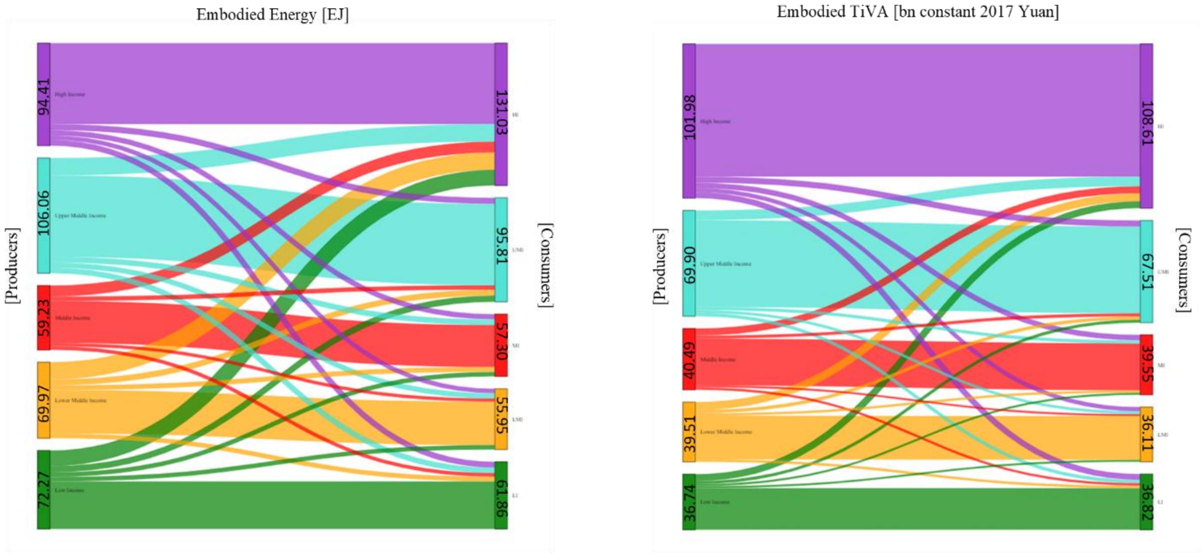
B) Domestic

Appendix Figure 3.6: Comparing GDP Growth Rates between official and our classification



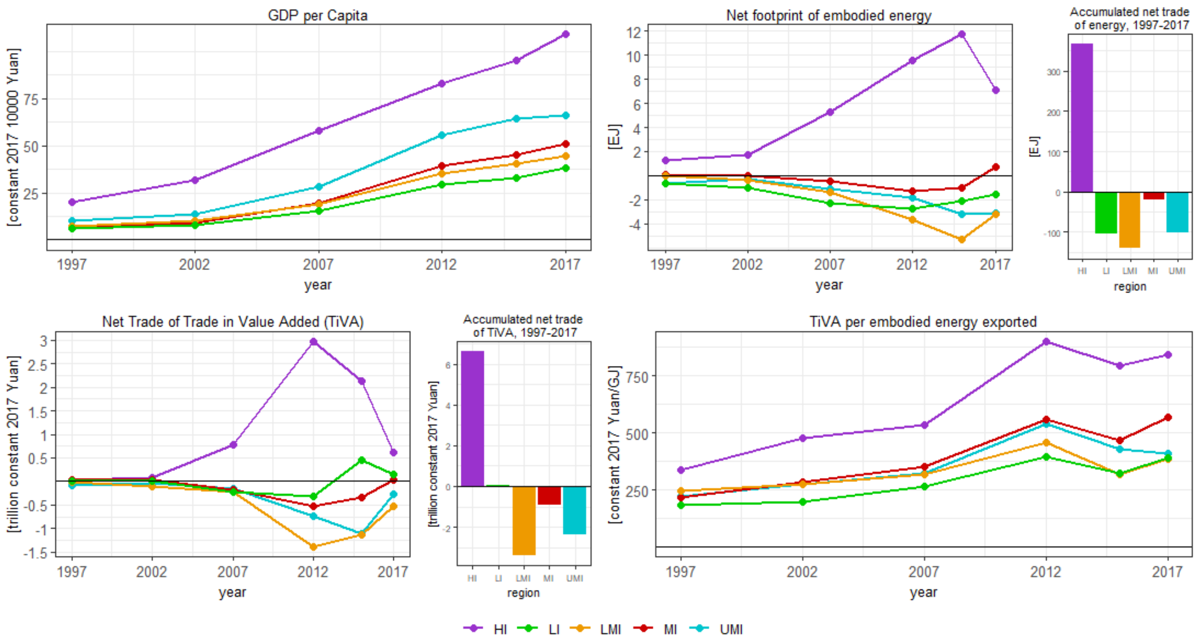
D-EUE analysis using 5 different income regions

Appendix Figure 3.7: China's Involvement in D-EUE: Sankey Diagram (Income Groups)



Description: Sankey diagrams exhibiting accumulated production and consumption of embodied energy and TiVA in each income group (high income (HI), upper-middle income (UMI), middle income (MI), lower-middle income (LMI), low income (LI)) from 1987-2017. Flows represent the redistribution of resources through trade. Note that money (as consumer expenditures) and resources flow in opposite directions in trade relations, i.e., money flows from consumers to producers. However, embodied value added (TiVA) is aligned in the same direction as embodied resources (q).

Appendix Figure 3.8: China's Involvement in D-EUE: Time-Series Analysis (Income Gr.)

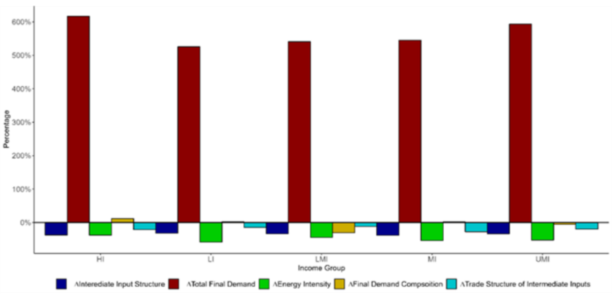


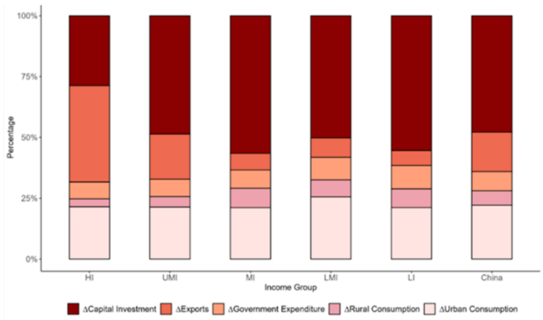
Description: Top left: GDP per capita [in constant 2017 10 000 Yuan]; Top right: Net trade of embodied energy over time, accumulated appropriation and supply as bar plots [in EJ]; bottom left: Net trade of embodied TiVA over time, accumulated appropriation and supply as bar plots [in million constant 2017 Yuan]; bottom right: TiVA per energy exported over time [constant 2017 Yuan/GJ]. Positive values represent net appropriation.

Appendix Figure 3.9: Results of the Structural Decomposition Analysis (Income Gr.)

Income Group	Energy Consumption						Final Demand					
	Δe (%)	ΔA* (%)	ΔT^A (%)	ΔF (%)	Δf (%)	Total (%)	Δrc (%)	Δuc (%)	Δg (%)	Δi (%)	Δex (%)	Total (%)
HI	-38	-37	-21	6	600	510	9	59	19	79	109	275
UMI	-53	-34	-20	-3	588	479	11	54	18	123	47	253
MI	-54	-38	-28	1	565	447	21	56	20	150	18	264
LMI	-44	-33	-12	-14	564	462	15	55	20	108	17	216
LI	-58	-32	-14	1	560	457	20	55	25	144	16	261
China	-49	-35	-19	-2	575	471	15	56	20	121	41	254

Income Group	rc (%)	uc (%)	g (%)	i (%)	ex (%)
HI	3	21	7	29	40
UMI	4	21	7	49	19
MI	8	21	8	57	7
LMI	7	26	9	50	8
LI	8	21	10	55	6
China	6	22	8	48	16

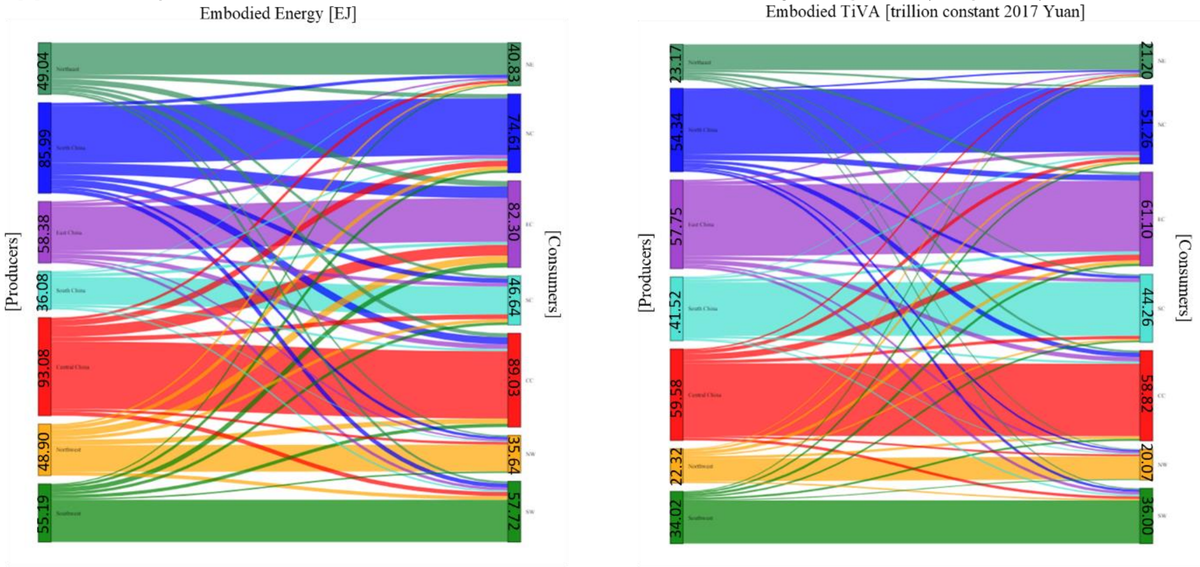




Description: Top left: Driving forces of energy consumption for each income group; top right: driving forces of final demand for energy consumption for each income group; bottom left: Driving forces of energy consumption for each income group by category; bottom right: driving forces of energy consumption by final demand category for each income group.

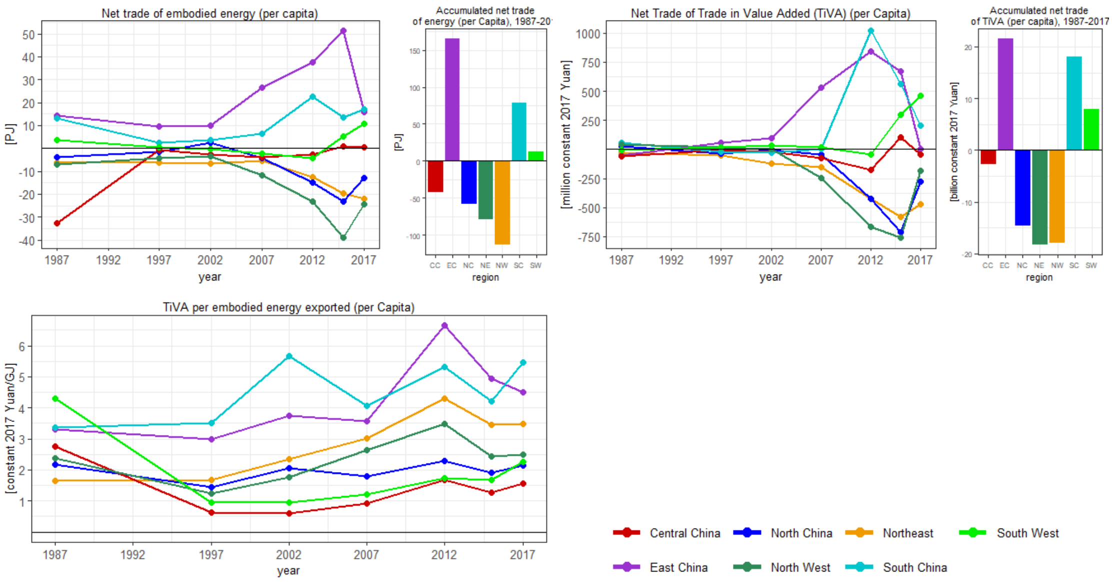
D-EUE Analysis using 7 Regions of China

Appendix Figure 3.10: China's Involvement in D-EUE: Sankey Diagram (Regions)



Description: Sankey diagrams exhibiting accumulated production and consumption of embodied energy and TiVA in each economic zone (Northeast (NE), North China (NC), East China (EC), South China (SC), Central China (CC), Northwest (NW), Southwest (SW) from 1987-2017. Flows represent the redistribution of resources through trade. Note that money (as consumer expenditures) and resources flow in opposite directions in trade relations, i.e., money flows from consumers to producers. However, embodied value added (TiVA) is aligned in the same direction as embodied resources (q).

Appendix Figure 3.11: China's Involvement in Intra-Country EUE: Time-Series Analysis.



Description: Top left: Net trade of embodied energy over time, accumulated appropriation and supply as bar plots [in EJ]; top right: Net trade of embodied TiVA over time, accumulated appropriation and supply as bar plots [in million constant 2017 Yuan]; bottom left: TiVA per energy exported over time [constant 2017 Yuan/GJ]. Positive values represent net appropriation.

Appendix 4: Details on Limitations and Future Research

The present study has potential limitations not only related to the operationalisation of the theory, but also with respect to the methods and the data used and the scope of the work. In the following we provide a more extensive overview of the most important limitations of this study and draw important and necessary implications for future research from those limitations.

Data & Methodology

Global Analysis

It is first important to note that, given our methodology, there are uncertainties with respect to the global EEMRIO databases. Global databases are often constructed with different sectoral and spatial aggregation which can have significant impacts on the footprints results (de Koning et al., 2015; Piñero et al., 2015). While we rely on the full Eora database for our global analysis, it must be noted that environmental footprints can differ substantially across databases, leading to different results and conclusions (Dorninger et al., 2021; Majeau-Bettez et al., 2014). Note for example that the environmental footprints of GLORIA suggest that China is one of the largest consumers of land, raw materials, and energy. On the contrary, our study shows that China's production-based accounts are substantially larger than its net imports. Unfortunately, our study was not able to confirm whether such differences are the result of definitions, computational errors, or differences in the databases. Generally speaking, it has been noted that these differences in environmental extensions can have substantial effects on the production-based and consumption-based accounts of countries (Tukker et al., 2018), which suggest that the latter rather the former is the result of the differences between our study and the GLORIA results. It has been shown that after harmonizing the effects of environmental extensions between different EEMRIO databases, carbon and material footprints results for the largest economies disagree by less than 10-15% (Giljum et al., 2019; Moran & Wood, 2014).

Regional Analysis

Given these data limitations on the global level, we argue that these limitations are even bigger for our national analysis. We rely on MRIO tables compiled by four different institutions, using four different computational methods, which is likely to have led to some bias with respect to our regional and sectoral aggregation (Yang & Lahr, 2008; H. Zhang & Lahr, 2014). In light of the inconsistencies in computational methods, we had to modify some of the MRIO tables (see Appendix 1), which is likely to have produced some uncertainty and bias. Given the fact that we rely on aggregated environmental extensions, as well as regional and sectoral aggregation for our final method, it is argued that this may have produced some additional uncertainties (Dorninger et al., 2021). As noted in Appendix 1, due to the complex process of aggregating the energy consumption to fit the MRIO table and its subsequent conversion process from physical to energy units, it is likely that this process has further resulted in some bias of our results. Morever, we use the RAS method to adjust the MRIO tables in constant prices. To adjust prices, we rely on a price vector based on the CPI of China's region. In a more detailed sectoral analysis, this is likely to result in some bias, as relative price changes between industries are disregarded, however for the purpose of this study and the scope of this work, it is argued that the loss of relative price changes represents only a minor limitation. A final methodological limitation may result from the fact that our regional aggregation was bound by the regional aggregation of the 1987 MRIO table. Hence, in order to achieve even population sizes, the economic zones had to be adjusted and slightly modified.[10] Therefore, as noted in section Appendix 1 our economic zones diverge from the official Chinese state classification. However, with North China, including Beijing as its political and financial centre, we are taking away a powerful region from the East Coast zone and adding it to the Central zone. Hence it is argued that, among all the limitation that may have been produced by this regional shift, it is very likely that the patterns observed are even stronger when respecting the official regional classification.[11]

Scope

First of all, we were only able to test the hypotheses derived from EUE that could be tested given the available data. Hypotheses that attempted to explain the emergence of EUE as a product of military power, technological progress, or as a result of

[10] See Appendix for a detailed representation of our regional grouping.

[11] This intuition is also confirmed by the fact that ecologically unequal exchange was the most apparent when considering five different income groups (see Appendix Figure 3.7, 3.8, 3.9)

historical processes could not be tested. In this context, due to data availability, we were unable to conduct a structural decomposition analysis on the global level to determine the driving forces of EUE on the global level. It is argued that a more granulated assessment of potential drivers on the global level could substantially enhance the predictions made by this study (Hickel et al., 2022). However, applying SPA or SDA on the global level, including 173 countries demands substantial amounts of additional computational resources and time, which would be beyond the scope of this work. Moreover, while we were able to assess EUE in four different biophysical indicators on a global level, we were only able to test one indicator on the regional level, which limits potential conclusions of this study. Moreover, our study was able to confirm the first hypothesis of EUE, namely that there exists an asymmetric transfer of material resources between regions, however we were unable to provide clear evidence for the second hypothesis, namely that there is a further asymmetry in the environmental impacts. It is argued that a more detailed analysis of for example CO2 emissions could have enhanced the present study.

Furthermore, our study allowed us to determine the importance of certain regions in the world for China's resource consumption, but not the importance of China for each of the other regions. In light of previous research that has highlighted how China has transitioned to one of the most important trading partners of Africa (Githaiga et al., 2019; Okeowo, 2013) or Brazil (Gouvea et al., 2020; Gusarova, 2019; Sawhney & Kiran, 2019) , it is argued that such considerations could substantially enhance the predictions and conclusions resulting from this study. Therefore, it is argued that future research should not only focus more extensively on individual countries' trade position against the rest of the world (as done in our study), but also consider more fine-grained approaches that determine the relative asymmetries of ecologically unequal exchange in bilateral trade. This could reveal that there is not only an asymmetric transfer of embodied biophysical resources from the periphery to the core, but this asymmetric transfer is disproportionally felt by the periphery, given the structural dependency on resource exports to the core.

Lastly, given the case study design, we are able to make predictions only about the analysed case. While we are able to make some generalisations, we are unable to provide clear evidence for the extent to which these mechanisms operate for different countries, including countries within different hierarchical positions in the world-system. In relation to that, we were unable to test whether the intra-country EUE mechanisms that we observed are particular to semi-peripheral countries, to countries characterized by the mode of extraction or in fact only to countries with sufficient population sizes. In this context, we argue that future research should aim to test, theoretically and empirically, the robustness and applicability of our multi-tiered hierarchical framework, incorporating both inter-country and intra-country EUE., as well as the important role of the semi-periphery in the context of ecologically unequal exchange.

The Ecological Transition

Considering the backward-looking design of the present study and the data availability, we are unable to make precise predictions about potential developments of ecologically unequal exchange in the future. This substantially limits potential policy conclusions that can be drawn from this work. In particular in context of the ecological transition, future research should aim at developing potential scenarios within the following two areas to improve predictions about the future pathways of EUE.

First, given the green growth policies promoted by current governments in the core, we may observe a surge in demand for critical raw materials, including metals, minerals and rare earth elements (REEs) (Boer et al., 2021; H. Miller et al., 2023). These transition-critical minerals are located predominately in the periphery or semi-periphery, including large reserves in China (Chang, 2022; Yin & Song, 2022; T. Zhang et al., 2022). Consequently, future research should develop scenarios to investigate how the increased demand for critical minerals under a supposed 'green capitalism' will reproduce similar forms of resource appropriation and ecologically unequal exchange that have occurred under fossil-led capitalism, and/or produce new forms of environmental conflicts between (Church & Crawford, 2018; Gulley et al., 2019) and within countries (Martinez-Alier et al., 2016).

Second, an increasingly large body of research is investigating potential pathways to a post-growth regime (Hickel, 2020; Mastini et al., 2021). Some authors have argued that degrowth in the core may free peripheral countries from their dependencies on extractive activities and resource exportation and provide 'ecological space' for the periphery to develop (Hickel, 2021; Kallis, 2015). However, this has been objected by predominately structuralists and dependency scholars, who argue that given the periphery's dependence on the exportation and exploitation of nature to the core, an immediate degrowth trajectory may lead to negative effects on employment, taxation and foreign reserves, plumbing the periphery into a potential balance-of-payment crisis (Espagne et al., 2021, 2023; Magacho et al., 2023). Consequently, future research should closely examine the role of post-growth in the context of EUE, namely to what extent degrowth will lead to an intensification of underdevelopment and EUE or to more global sustainability and ecological and economic equity.

FDI and Monetary Hierarchies

Our study shows that intra-country ecologically unequal exchange is largely driven by foreign capital inflows, and the subsequent expansion of foreign-held enterprises in those export-oriented capitalist centres. In reverse, there has been an increasing literature that has provided important insights into China's accelerating economic and ecological presence in the periphery, largely driven by its acceleration in FDI outflows (Gong et al., 2021; Shinwari et al., 2022; Tawiah et al., 2021). Moreover, FDI has been linked to ecologically unequal exchange in particular with respect to CO_2 emissions and deforestation (Doytch & Ashraf, 2022; Jorgenson, 2016). The fact that this study was unable to provide a detailed account of China's FDI outflows in relation to ecologically unequal exchange represents a potential limitation of this study. Therefore, it is argued that future research should aim at examining the importance of FDI in- and outflows as a perpetuating mechanism of EUE on the regional and global level. In particular, it should closely examine the role of foreign-held enterprises and multi-national enterprises in the context of ecologically unequal exchange (Duan & Jiang, 2021; Z. Zhang et al., 2020).

As repeatedly shown throughout this work, increasing attention is being devoted to the relationship between monetary hierarchies and ecologically unequal exchange especially among a few prominent scholars within the field of ecological macroeconomics (Althouse & Svartzman, 2022; Svartzman & Althouse, 2020). Despite our contributions to this branch of research, we argue that future research should focus on the development of methods to operationalize monetary hierarchies and potentially link them to EEMRIO analysis, providing a more empirical assessment of the relationship between ecologically unequal exchange and monetary hierarchies. In particular, future research may examine to what extent the implementation of a resource currency can provide a potential pathway to limit ecologically unequal exchange in a multi-tiered hierarchical framework (Aglietta & Coudert, 2019).

Epistemology

The epistemological framework for this study has essentially relied on the assessment of a complex phenomenon from an exclusively empirical and positivist perspective.[12] By relying on a positivist epistemological approach and prioritizing the empirical assessment of the complex dynamics of ecologically unequal exchange, we render important aspects of reality invisible. The sole focus on quantitative variables in this study fundamentally ignores crucial factors that are said to reproduce some of the phenomenon studied in this study. It seems evident that capitalism and resource exploitation is not only dependent on class relations, but also that cultural, ethnic, racial and gender related aspects exert substantial influence on the studied phenomenon (Crenshaw, 1989; Grosfoguel, 2002; Harding, 2002; Hill-Collins, 1991). However, our studies misses that the hierarchy of environmental transformation includes the structural exploitation based on religious, ethnic, gender, and racial grounds. Our empirical study is unable to capture these socio-cultural and metaphysical dynamics. In light of these shortcomings, we argue that future research within the field of EUE must take into account not only the epistemological limitations of assessing complex social phenomena based on solely quantitative testing, but also the variety of social, cultural, racial, gender, and colonial factors in perpetuating and

[12] In essence, positivist economics sets out empirical testing, statistical methods and arbitrary thresholds that constitute the 'necessary and sufficient conditions' that must hold for a model to be meaningful, and to be *(footnote continued)* understood as the contender for the next best 'approximation of reality' (Dorninger et al., 2021). While logical positivism has set out its principles to produce a more objective, commensurable determination to assess what is meaningful and what is not, it would be absurd to belief that statistical models and empirical testing 'approximate' reality. However, as Kuhn (2012) argues, science does not move toward an approximation of truth, but rather produces the reality it aims to create. On the contrary, it has led to what Kuhn calls the immensurable thesis, according to which no neutral observation language between paradigms exist, but rather that "each group uses its own paradigm to argue in that paradigm" (quoted in Ojong (2008, p. 81)). Each study consists within and only within its epistemological paradigm. Consequently, any production of knowledge is ultimately socially constructed and influenced by the existing power relations (Gouws, 1996; Grosfoguel, 2011).

enabling the observed dynamics. In this regard, it is argued that concepts such as 'internal colonialism' may provide a coherent framework that is able to provide a more metaphysical explanation to the phenomenon studied in this work (Drakakis-Smith, 1983; Gonzalez Casanova, 1965). In particular, it may provide a more adequate explanation for the structural exploitation of the Uighurs in China, which did not find any consideration in the scope of this project. In any case this study would greatly benefit by aligning its propositions with those of decolonial and cultural perspectives.

However, I further posit that the epistemological limitation of this study can be extended to the epistemology of EUE, political ecology and world-systems in general. In fact, there is an increasing need to align culturalist and decolonialist perspectives, which focus on the consequences of colonial structures within nations, as well as in the production of knowledge, with those focusing on ecologically unequal exchange or the political economy (Grosfoguel, 2011; Piñero et al., 2020). The epistemology of ecologically unequal exchange is dominated by white, cis-male scholars from the core who reproduce a western and patriarchal canon of political economy, capitalism, and the world-system. Despite the attempts of EUE to produce radical, alternative, and anti-colonial knowledge, apart from a few exceptions, studies are produced about the periphery, rather than with and from a perspective of the periphery. EUE must acknowledge that its product of knowledge is ultimately epistemically located in the dominant, post-structuralist western domain of thought. So far, EUE has largely failed to do so. In fact, I argue that EUE has essentially structurally under-acknowledged the role of LA structuralism and dependency theory as fundamental and important pre-requisites for the development of EUE. For example, while EUE tends to acknowledge Prebisch's important role in the development of dependency school, it often fails to acknowledge his important contributions on the structural dynamics of resource exploitation, monetary hierarchies and even intra-country dependencies between extractive and export-oriented regions. Hence, there arises an eminent need within EUE to engage in a critical dialogue with decolonial and cultural perspectives and ultimately incorporate and acknowledge the epistemic perspective from critical, post-colonial and anti-capitalist thinkers from the periphery and with peripheral perspectives. Or as Paolo Freire said: "True solidarity with the oppressed means fighting at their side to transform the objective reality which has made them these ‘beings for another’” (2000, p. 49).

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