

Supporting Information for
Global competition in the lithium-ion battery supply chain: A novel perspective
for criticality analysis

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1. Underlying data and relevant sources

Table S1 Domestic production and import of lithium minerals by country

Lithium mineral/ton lithium metallic equivalent		
Country	Domestic production	Import
Argentina	6,300	0
Australia	45,000	0
Brazil	2,400	0
Canada	200	0
Chile	19,300	0
China	10,800	48,023
Portugal	900	0
USA	1,380	295

The production data is extracted from USGS's report¹. The import data is extracted from the report of China nonferrous metals industry association².

Table S2 Domestic production and import of cobalt ores by country

Cobalt ore/ton cobalt metallic equivalent		
Country	Domestic production	Import
Australia	5,740	0
Belgium	0	6,600
Botswana	400	0
Brazil	1,200	49
Canada	3,340	3,160
China	2,500	75,860
Cuba	3,800	0
Czechia	0	14
Democratic Republic of the Congo	100,000	0
El Salvador	0	3
Finland	440	12,360
France	0	3
Germany	0	14
India	0	100
Indonesia	400	2
Ireland	0	27
Israel	0	4
Italy	0	13

Japan	0	4,000
Madagascar	3,400	0
Malaysia	0	1,293
Morocco	2,300	1,245
New Caledonia	1,600	0
Norway	0	3,500
Papua New Guinea	2,910	0
Philippines	5,100	23
Qatar	0	7
Rep. of Korea	0	1,725
Singapore	0	1
South Africa	2,100	40
Spain	0	1,429
Switzerland	0	1
Thailand	0	5
Turkey	0	27
United Kingdom	0	94
USA	500	174
Viet Nam	0	82
Zambia	1,000	1,000
Zimbabwe	800	0

The production data is extracted from USGS's report¹. The import data is extracted from UN Comtrade database³. HS code of relevant commodity is 260500. Estimation of cobalt content in relevant commodity is adopted from our previous studies⁴.

Table S3 Domestic production and import of nickel ores by country

Nickel ore/ton nickel metallic equivalent		
Country	Domestic production	Import
Albania	5,520	0
Australia	159,000	0
Austria	0	1
Belgium	0	31
Botswana	15,195	0
Brazil	60,600	7
Canada	181,000	0
China	120,000	841,743
Colombia	36,564	0
Cuba	49,200	0

Cyprus	0	35
Finland	8,779	0
France	0	2
Germany	0	61
Greece	17,748	898
Guatemala	47,425	0
Indonesia	853,000	2,538
Italy	0	1
Japan	0	57,660
Lao People's Dem. Rep.	0	19
Madagascar	41,700	0
Malaysia	0	6
Morocco	250	0
New Caledonia	208,000	0
Norway	350	0
Papua New Guinea	25,582	0
Philippines	323,000	0
Rep. of Korea	0	47,386
Serbia	7,418	0
Singapore	0	9
South Africa	33,400	1
Spain	7,213	0
Thailand	0	1
Turkey	9,600	0
USA	13,500	1
Venezuela	3,700	0
Viet Nam	0	1
Zimbabwe	14,579	0

The production data is extracted from USGS's report¹. The import data is extracted from UN Comtrade database³. HS code of relevant commodity is 260400. Estimation of nickel content in relevant commodity is adopted from previous literatures⁵.

Table S4 Domestic production and import of manganese ores by country

Manganese ore/kiloton manganese metallic equivalent					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	0	6	Mexico	202	57
Australia	3,180	21	Namibia	0	15

Belgium	0	24	Netherlands	0	8
Brazil	1,740	27	Norway	0	550
China	1,300	11,832	Poland	0	53
Colombia	0	11	Rep. of Korea	0	455
Czechia	0	12	Russian Federation	0	488
France	0	217	Saudi Arabia	0	85
Gabon	2,510	0	Serbia	0	9
Georgia	116	41	Singapore	0	5
Germany	0	9	Slovakia	0	18
Ghana	1,550	0	South Africa	5,800	11
Greece	0	18	Spain	0	134
Guatemala	0	1	Thailand	0	19
Hungary	0	10	Turkey	0	1
India	801	1,292	Ukraine	500	0
Indonesia	0	161	United Kingdom	0	2
Italy	0	2	USA	0	196
Japan	0	469	Uzbekistan	0	7
Kazakhstan	140	0	Viet Nam	0	37
Malaysia	390	544			

The production data is extracted from USGS's report¹. The import data is extracted from UN Comtrade database³. HS code of relevant commodity is 260200. Estimation of cobalt content in relevant commodity is adopted from our previous studies⁶.

Table S5 Domestic production and import of natural graphite by country

Natural graphite/ton					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	0	1,109	Luxembourg	0	2
Armenia	0	6	Madagascar	48,000	940
Australia	0	437	Malawi	0	6
Austria	1,000	16,837	Malaysia	0	27,506
Azerbaijan	0	54	Mauritania	0	90
Belarus	0	597	Mauritius	0	9
Belgium	0	9,077	Mongolia	0	117
Belize	0	1	Morocco	0	56
Bermuda	0	59	Myanmar	0	1,263
Bosnia Herzegovina	0	4	Netherlands	0	11,955

Botswana	0	51	New Zealand	0	18
Bulgaria	0	18	Nigeria	0	82
Burkina Faso	0	1	Norway	16,000	49
Burundi	0	207	Pakistan	14,000	3,952
Cambodia	0	5	Paraguay	0	208
Chile	0	118	Philippines	0	1,354
China	700,000	196,991	Poland	0	11,884
Colombia	0	756	Portugal	0	16
Congo	0	189	Qatar	0	135
Costa Rica	0	2	Rep. of Moldova	0	5
Croatia	0	27	Romania	0	230
Czechia	0	5,647	Russian Federation	0	3,825
Denmark	0	223	Rwanda	0	4
Ecuador	0	67	Saudi Arabia	0	127
Egypt	0	309	Senegal	0	28
El Salvador	0	1	Serbia	0	92
Estonia	0	3	Singapore	0	274
Finland	0	257	Slovenia	0	209
France	0	8,148	South Africa	0	769
Germany	800	48,608	Spain	0	6,229
Guatemala	0	221	State of Palestine	0	9
Guyana	0	137	Sweden	0	1,564
Iceland	0	25	Switzerland	0	548
India	35,000	45,003	Tunisia	0	14
Indonesia	0	2,124	Turkey	2,000	10,584
Ireland	0	21	United Arab Emirates	0	197
Italy	0	5,909	United Kingdom	0	5,925
Japan	0	58,996	Uruguay	0	236
Kazakhstan	0	247	USA	0	50,209
Kenya	0	2	Uzbekistan	100	155
Kuwait	0	239	Viet Nam	0	1,443
Kyrgyzstan	0	143	Yemen	0	19
Lao People's Dem. Rep.	0	6	Zambia	0	46
Latvia	0	10			

The production data is extracted from USGS's report¹. The import data is extracted from UN Comtrade database³. HS code of relevant commodities are 250410 and

250490⁷. The natural graphite content in relevant commodities is assumed to be 100%.

Table S6 Domestic production and import of lithium carbonates by country

Lithium carbonate/ton					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	34,904	87	Kazakhstan	0	1
Australia	0	164	Latvia	0	1
Austria	0	259	Lithuania	0	1
Belarus	0	2	Malaysia	0	59
Belgium	0	6,874	Mauritius	0	1
Belize	0	1	Netherlands	0	6,855
Bulgaria	0	1	New Zealand	0	2
Canada	0	1,978	Nigeria	0	7
Chile	102,692	12	Norway	0	43
China	154,000	29,316	Pakistan	0	49
Colombia	0	9	Peru	0	2
Costa Rica	0	4	Philippines	0	2
Croatia	0	6	Poland	0	137
Czechia	0	84	Portugal	0	33
Denmark	0	79	Rep. of Korea	0	38,578
Ecuador	0	1	Romania	0	8
Egypt	0	10	Russian Federation	0	7,414
Estonia	0	1	Saudi Arabia	0	5
Finland	0	52	Serbia	0	1
France	0	1,694	Singapore	0	33
Germany	0	2,270	Slovakia	0	20
Greece	0	43	Slovenia	0	54
Honduras	0	1	South Africa	0	72
Hungary	0	79	Spain	0	1,288
Iceland	0	4	Sweden	0	193
India	0	1,298	Switzerland	0	80
Indonesia	0	11	Thailand	0	90
Ireland	0	1	United Arab Emirates	0	26
Israel	0	1	United Kingdom	0	1,667
Italy	0	579	Uruguay	0	1

Japan	0	23,571	USA	0	12,707
Jordan	0	2	Viet Nam	0	321

The production data is extracted from USGS's and China nonferrous metals industry association's report^{1, 2}. The import data is extracted from UN Comtrade database³. HS code of relevant commodities is 283691. Estimation of lithium carbonate content in relevant commodity is assumed to be 100%.

Table S7 Domestic production and import of lithium hydroxides by country

Lithium hydroxide/ton					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	0	291	Mexico	0	18
Australia	0	139	Morocco	0	30
Austria	0	26	Myanmar	0	1
Azerbaijan	0	4	Netherlands	0	1,463
Belarus	0	26	New Zealand	0	2
Belgium	0	1,763	Nigeria	0	2
Bulgaria	0	8	Pakistan	0	61
Canada	0	1,824	Peru	0	48
Chile	9,120	20	Philippines	0	54
China	76,000	545	Poland	0	206
Colombia	0	33	Portugal	0	11
Croatia	0	6	Qatar	0	7
Czechia	0	147	Rep. of Korea	0	23,469
Denmark	0	5	Romania	0	35
Ecuador	0	4	Russian Federation	0	238
Egypt	0	118	Saudi Arabia	0	182
Estonia	0	200	Serbia	0	8
Finland	0	13	Singapore	0	313
France	0	6,927	Slovenia	0	244
Ghana	0	840	South Africa	0	428
Greece	0	27	Spain	0	2,444
Hungary	0	20	Sweden	0	202
India	0	1,928	Switzerland	0	76
Indonesia	0	126	Thailand	0	297
Ireland	0	7	Tunisia	0	21

Israel	0	18	Turkey	0	300
Italy	0	282	United Arab Emirates	0	550
Japan	0	37,339	United Kingdom	0	559
Kazakhstan	0	6	USA	13,173	1,252
Kenya	0	2	Uzbekistan	0	17
Kuwait	0	7	Viet Nam	0	25
Malaysia	0	12	Zambia	0	1

The production data is extracted from USGS's and China nonferrous metals industry association's report^{1,2}. The import data is extracted from UN Comtrade database³. HS code of relevant commodities is 282520. Estimation of lithium hydroxide content in relevant commodity is assumed to be 100%.

Table S8 Domestic production and import of refined cobalt by country

Refined cobalt/ton cobalt metallic equivalent					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	0	7	Malaysia	0	1,752
Australia	3,200	31	Mexico	0	76
Austria	0	51	Morocco	1,600	0
Belarus	0	1	Netherlands	0	189
Belgium	6,600	757	New Zealand	0	1
Brazil	0	330	Nigeria	0	5
Canada	6,500	2	Norway	3,500	78
Chile	0	1	Pakistan	0	31
China	78,360	23,013	Philippines	0	3
Colombia	0	3	Poland	0	6
Costa Rica	0	5	Portugal	0	4
Croatia	0	1	Rep. of Korea	0	1,465
Czechia	0	13	Romania	0	2
Democratic Republic of the Congo	400	0	Russian Federation	0	13
Egypt	0	2	Saudi Arabia	0	38
Finland	12,800	15	Singapore	0	332
France	0	255	Slovakia	0	4
Germany	0	393	Slovenia	0	11

Ghana	0	1	South Africa	1,000	13
Greece	0	2	Spain	0	194
Hungary	0	74	Sweden	0	30
India	100	118	Switzerland	0	25
Indonesia	0	53	Thailand	0	31
Ireland	0	72	Tunisia	0	15
Israel	0	6	Turkey	0	50
Italy	0	78	United Arab Emirates	0	9
Japan	4,000	774	United Kingdom	0	425
Lao People's Dem. Rep.	0	1	USA	0	1,241
Lithuania	0	8	Uzbekistan	0	1
Luxembourg	0	5	Viet Nam	0	9
Madagascar	2,800	0	Zambia	2,000	597

The production data is extracted from Cobalt Institute's report⁸. The import data is extracted from UN Comtrade database³. HS codes of relevant commodities are 282200, 282734, 810520, 810530 and 810590. Estimation of cobalt content in relevant commodities is adopted from our previous studies⁴.

Table S9 Domestic production and import of nickel chemicals by country

Nickel chemicals/kilo ton		
Country	Domestic production	Import
Australia	0	2
Belgium	0	4
Canada	0	3
China	167	1
Finland	8	0
France	1	0
Germany	0	1
Italy	0	1
Japan	17	22
Malaysia	0	1
Norway	8	0
Philippines	0	1

Rep. of Korea	12	3
South Africa	6	0
Thailand	0	1
United Kingdom	8	2

The production data is extracted from China bulk commodity metal database⁹. The import data is extracted from UN Comtrade database³. HS codes of relevant commodity is 283324. Estimation of nickel content in relevant commodities is adopted from previous literatures⁵.

Table S10 Domestic production and import of electrolytic manganese dioxides by country

Electrolytic manganese dioxide/ton					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	0	9	Madagascar	0	1
Australia	0	11,216	Malawi	0	1
Austria	0	150	Malaysia	0	4,074
Belarus	0	13	Mexico	0	1,039
Belgium	0	18,929	Morocco	0	165
Bosnia Herzegovina	0	1	Myanmar	0	597
Brazil	0	1,724	Namibia	0	4,552
Cambodia	0	2	Netherlands	0	102
Canada	0	3,399	New Zealand	0	41
Chile	0	26	Nigeria	0	1
China	300,400	3,934	Norway	0	6
Colombia	5,143	108	Pakistan	0	193
Costa Rica	0	1,243	Peru	0	874
Croatia	0	19	Philippines	0	98
Czechia	0	8	Poland	0	4,987
Denmark	0	51	Portugal	0	51
Ecuador	0	74	Rep. of Korea	0	3,258
Egypt	0	991	Romania	0	7
El Salvador	0	11	Russian	0	4,496

			Federation		
Estonia	0	119	Rwanda	0	1
Finland	0	11	Saudi Arabia	0	787
France	0	190	Serbia	0	77
Germany	0	14,586	Singapore	0	15,131
Greece	22,286	43	Slovakia	0	34
Guatemala	0	349	Slovenia	0	128
Hungary	0	305	South Africa	0	361
India	857	11,066	Spain	12,857	626
Indonesia	0	17,769	Sweden	0	51
Ireland	0	6	Switzerland	0	67
Israel	0	217	Thailand	0	7,335
Italy	0	355	Turkey	0	71
Japan	28,286	1,220	United Arab Emirates	0	58
Jordan	0	2	United Kingdom	0	1,244
Kazakhstan	0	19	Uruguay	0	1
Kenya	0	2,901	USA	50,143	4,996
Kuwait	0	34	Uzbekistan	0	9
Lao People's Dem. Rep.	0	66	Viet Nam	0	2,037
Latvia	0	189	Zimbabwe	0	6
Lithuania	0	96	Madagascar	0	1

The production data estimated based on the production statistics of EMD by country in 2017 by Li et al. and total production amount of EMD in 2019 which is extracted from GGII's report^{10, 11}. The import data is extracted from UN Comtrade database³. HS code of relevant commodities is 282010. Estimation of manganese dioxide content in relevant commodity is assumed to be 100%.

Table S11 Domestic production and import of lithium nickel cobalt manganese oxide & lithium nickel cobalt aluminium oxide (NCM & NCA) by country

NCM & NCA/ton		
Country	Domestic production	Import
China	197,000	38,200

Hungary	0	1,150
Japan	56,481	2,491
Poland	0	2,491
Rep. of Korea	94,135	12,645
United Kingdom	0	771
USA	0	9,483

The production data is extracted from China nonferrous metals industry association's report and China bulk commodity website^{2, 12}. The import data is extracted from custom database of China, Japan and Korea¹³⁻¹⁵. HS code of relevant commodities is 2842903000. Estimation of NCM & NCA content in relevant commodity is adopted from our previous studies¹⁶.

Table S12 Domestic production and import of lithium iron phosphate (LFP) by

country		
	LFP/ton	
Country	Domestic production	Import
Canada	5,000	29
China	80,000	552
France	0	45
Rep. of Korea	0	154
USA	4,000	3

The production data is extracted from China nonferrous metals industry association's report and China bulk commodity website^{2, 12}. The import data is extracted from custom database of China, Japan and Korea¹³⁻¹⁵. HS code of relevant commodities is 2842904000. Estimation of LFP content in relevant commodity is adopted from our previous studies¹⁶.

Table S13 Domestic production and import of lithium manganese oxide (LMO)

by country

LMO/ton		
Country	Domestic production	Import
China	76,400	81
Japan	10,629	0
Malaysia	0	588
Rep. of Korea	0	18

The production data is extracted from China nonferrous metals industry association's report and China bulk commodity website^{2, 12}. The import data is extracted from custom database of China, Japan and Korea¹³⁻¹⁵. HS code of relevant commodities is 2841691000. Estimation of LMO content in relevant commodity is adopted from our previous studies¹⁶.

Table S14 Domestic production and import of lithium cobalt oxide (LCO) by

country

LCO/ton		
Country	Domestic production	Import
China	54,800	8,491
Japan	5,509	1,740
Rep. of Korea	23,413	7,070
USA	0	1,059

The production data is extracted from China nonferrous metals industry association's report and China bulk commodity website^{2, 12}. The import data is extracted from custom database of China, Japan and Korea¹³⁻¹⁵. HS code of relevant commodities is 2841900010. Estimation of cobalt content in relevant commodity is adopted from our previous studies¹⁶.

Table S15 Domestic production and import of lithium-ion battery (LIB) by

country

The production data of China is extracted from China's National Bureau of Statistics¹⁷. The production data of Japan is extracted from National Bureau of Statistics¹⁸. The production of other countries was extracted from Global Information's report¹⁹. The import data in weight unit is extracted from UN Comtrade database³. HS code of relevant commodities is 850760. Estimation of LIB specific energy density is adopted from our previous studies¹⁶. Countries such as Russia, Vietnam and Malaysia also have LIB production facilities, of which total capacity are less 1000 MWh²⁰. Owing to unreachable information and limited impact, the LIB production data of these countries are ignored.

LIB/MWh					
Country	Domestic production	Import	Country	Domestic production	Import
Argentina	0	125	Lithuania	0	46
Armenia	0	5	Luxembourg	0	6
Aruba	0	1	Madagascar	0	5
Australia	0	1,043	Malawi	0	25
Austria	0	1,460	Malaysia	0	170
Azerbaijan	0	12	Malta	0	4
Belarus	0	50	Mauritania	0	1
Belgium	0	3,937	Mauritius	0	7
Benin	0	8	Mexico	0	1,242
Bosnia Herzegovina	0	5	Mongolia	0	4
Botswana	0	18	Morocco	0	29
Brazil	0	790	Myanmar	0	27
Brunei Darussalam	0	1	Namibia	0	7
Bulgaria	0	153	Netherlands	0	2,284
Burkina Faso	0	3	New Zealand	0	89
Burundi	0	2	Nicaragua	0	20
Cambodia	0	21	Nigeria	0	181
Canada	0	670	Norway	0	525

Chile	0	85	Pakistan	0	55
China	131,600	9,162	Paraguay	0	12
Colombia	0	67	Peru	0	115
Congo	0	1	Philippines	0	209
Costa Rica	0	28	Poland	6,000	3,752
Croatia	0	28	Portugal	0	102
Cyprus	0	3	Qatar	0	14
Czechia	0	810	Rep. of Korea	12,640	5,348
Denmark	0	210	Rep. of Moldova	0	5
Ecuador	0	17	Romania	0	400
Egypt	0	119	Russian Federation	0	432
El Salvador	0	12	Rwanda	0	8
Estonia	0	39	Saint Lucia	0	1
Fiji	0	6	Saudi Arabia	0	256
Finland	0	6	Senegal	0	5
France	0	2,649	Serbia	0	15
Georgia	0	2	Seychelles	0	7
Germany	0	13,077	Singapore	0	472
Ghana	0	65	Slovakia	0	1,380
Greece	0	71	Slovenia	0	225
Guatemala	0	45	South Africa	0	226
Guyana	0	2	Spain	0	583
Honduras	0	18	State of Palestine	0	1
Hungary	7,500	2,474	Sweden	0	2,330
Iceland	0	4	Switzerland	0	410
India	0	3,405	Thailand	0	322
Indonesia	0	1,086	Togo	0	7
Ireland	0	77	Tunisia	0	6
Israel	0	84	Turkey	0	553
Italy	0	1,071	United Arab Emirates	0	601
Jamaica	0	23	United Kingdom	2,500	2,712
Japan	12,860	3,553	Uruguay	0	8
Jordan	0	40	USA	15,000	9,689
Kazakhstan	0	111	Uzbekistan	0	11
Kenya	0	67	Viet Nam	0	4,367
Kuwait	0	22	Yemen	0	23
Kyrgyzstan	0	4	Zambia	0	15
Latvia	0	15	Zimbabwe	0	20

2. Model assumptions and data treatment

The data utilized in this study is mainly the production and trade data of 215 countries and regions. It should be noticed that national output is not the same as the output of a country's local firms. In the context of economic globalization, a considerable part of output is often contributed by foreign enterprises. Many developed countries tend to locate their production bases in less developed regions, such as China, due to their high human resource costs, stringent environmental regulations, etc. Here we take some representative companies in the lithium battery supply chain for example as following.

- **Umicore:** It is a Belgium's company, which is the largest supplier of cathode material. Its production plants of cathode material locate in the China (Jiangmen) and South Korea (Cheonan)²¹. There is mainly its research and development base in Europe.
- **Livent:** It is a subsidiary of American FMC, which is one of the largest suppliers of lithium basic chemicals. Its production plants locate in the USA and China²².
- **Panasonic:** It is a Japan's lithium battery manufacturer. Its production plants locate in the China (Dalian and Suzhou) and the USA²³.
- **LG chem:** It is a Korea's lithium battery manufacturer. Its production plants locate in Korea, China, Poland (production begins in 2019), and the USA.

As mentioned in the methods section of the text, not all the commodities covered in this study are related to the lithium battery industry chain. Therefore, we propose vulnerability factor as an indicator to describe the degree of correlation. However, it is important to note that vulnerability indicators are developed based on global aggregate data. And the basic data for this study is at the national level. For the same kind of goods, the attributes of goods produced and traded in different countries are generally different. For example, although many countries also import a large amount of lithium carbonate, they import almost all industrial grade lithium carbonate, which is used in non-battery application fields of materials (see Table S16). Thus the value of the vulnerability factor should be much smaller for those countries' imports. However, the specific types of imported goods and the proportion of trade volume cannot be obtained. Therefore, this factor is not taken into account in our model.

Table S16 Information about lithium carbonate buyers of India, Belgium, and Germany for the year of 2019

Country	Buyer	Weight/kg	Business scope
Belgium	Acros Organics BVBA	NA	Non battery-related
Belgium	Belpol International SPRL	NA	Non battery-related
Belgium	Chemacid SA	NA	Non battery-related
Belgium	Cobby's NV	NA	Non battery-related
Belgium	Dechimex SA	NA	Non battery-related
Belgium	Harco Group SA	NA	Non battery-related
Belgium	IMCD Benelux NV	NA	Non battery-related
Belgium	Kaneka Belgium NV	NA	Non battery-related
Belgium	Kaneka Belgium SA-NV	NA	Non battery-related
Belgium	Keyser & Mackay VBR	NA	Non battery-related
Belgium	Limaru NV	NA	Non battery-related
Belgium	Mitsui & Co Benelux SA	NA	Non battery-related
Belgium	Norgine NV	NA	Non battery-related

Belgium	Roam Technology NV	NA	Non battery-related
Belgium	Societe De Financement Importation Et Exporta SA	NA	Non battery-related
Belgium	Solventis BVBA	NA	Non battery-related
Belgium	Specialty Metals Company SA	NA	Non battery-related
Belgium	Stockmeier Chemicals Belux SA	NA	Non battery-related
Belgium	Sumitomo Benelux SA	NA	Non battery-related
Belgium	Toyota Tsusho Europe NV	NA	Battery-related
Belgium	Unifert Group SA	NA	Non battery-related
India	MYLAN LABORATORIES LIMITED	4,500	Non battery-related
India	ALEMBIC PHARMACEUTICALS LTD	1,800	Non battery-related
India	J.B. CHEMICALS & PHARMACEUTICALS LIMITED	1,100	Non battery-related
India	J B CHEMICALS PHARMACEUTICALS LIMITED	1,000	Non battery-related
India	INTAS PHARMACEUTICALS LTD	700	Non battery-related
India	ESAB INDIA LTD.	500	Non battery-related
India	INTAS PHARMACEUTICALS LTD.	400	Non battery-related
India	EMCURE PHARMACEUTICALS LTD.	300	Non battery-related
India	THERMO FISHER SCIENTIFIC INDIA PRIVATE LIMITED	50	Non battery-related
India	DOLPHIN CHEMICAL TRADERS INDIA PVT LTD	48	Non battery-related
India	CHROMACHEMIE LABORATORY PRIVATE LIMITED	16	Non battery-related
India	TATA INSTITUTE OF FUNDAMENTAL RESEARCH	10	Non battery-related
India	GMM PFAUDLER LIMITED	7	Non battery-related
India	MERCK LIFE SCIENCE PVT LTD	6	Non battery-related
India	MERCK LIFE SCIENCE PVT LTD	6	Non battery-related
India	PACIFIC ORGANICS PVT LTD	5	Non battery-related
India	LAURUS LABS LTD	5	Non battery-related
India	EMCURE PHARMACEUTICALS LTD	2	Non battery-related
India	SIGMA ALDRICH CHEMICALS P LTD	1	Non battery-related
Germany	K.D. Feddersen Holding GmbH	NA	Non battery-related
Germany	DINOX Handels GmbH	NA	Non battery-related
Germany	Galvachem Chemiehandelsgesellschaft mbH	NA	Non battery-related
Germany	Mitsui & Co. Deutschland GmbH	NA	Non battery-related
Germany	A. + E. Fischer-Chemie GmbH & Co.KG	NA	Non battery-related
Germany	Azelis Deutschland GmbH	NA	Non battery-related
Germany	Behn Meyer Europe GmbH	NA	Non battery-related
Germany	C.H. Erbslöh GmbH & Co. KG	NA	Non battery-related
Germany	Carl Spaeter GmbH	NA	Non battery-related
Germany	FOX-CHEMICALS	NA	Non battery-related
Germany	GTS German Trading Service GmbH for Raw Materials	NA	Non battery-related

Germany	HARKE Chemicals GmbH	NA	Non battery-related
Germany	Häffner International GmbH	NA	Non battery-related
Germany	Jebsen & Jessen (GmbH & Co.) KG	NA	Non battery-related
Germany	K.D. Feddersen Ueberseegesellschaft mbH	NA	Non battery-related
Germany	KRAHN CHEMIE GMBH	NA	Non battery-related
Germany	Klose Chemie Handelsgegesellschaft mbH	NA	Non battery-related
Germany	Lehmann&Voss&Co. KG	NA	Non battery-related
Germany	Liebau Chemie Handelsgesellschaft mbH	NA	Non battery-related
Germany	Mitsubishi International GmbH	NA	Non battery-related
Germany	NAGASE (EUROPA) GmbH	NA	Non battery-related
Germany	Ortex GmbH	NA	Non battery-related
Germany	PICCADILLY Internationaler Handel GmbH	NA	Non battery-related
Germany	Penta Chemikalien GmbH & Co. KG	NA	Non battery-related
Germany	REMY GmbH & Co. KG	NA	Non battery-related
Germany	SHOWA DENKO EUROPE GmbH	NA	Non battery-related
Germany	Sumitomo Deutschland GmbH	NA	Non battery-related
Germany	TER HELL & CO. GMBH	NA	Non battery-related
Germany	Ulrich Friederich	NA	Non battery-related
Germany	Vopelius Chemie AG	NA	Non battery-related
Germany	WKI Kunststoffe GmbH Berlin	NA	Non battery-related
Germany	Willers Engel & Co. GmbH & Co.	NA	Non battery-related
Germany	Worlée-Chemie GmbH	NA	Non battery-related
Germany	Zbigniew Bak Bak Handelsbetrieb	NA	Non battery-related
Germany	A&L Simonyan Company	NA	Non battery-related
Germany	ACTEGA DS GmbH	NA	Non battery-related
Germany	AD STEIN	NA	Non battery-related
Germany	AKO GmbH AKO The Spice Company!	NA	Non battery-related
Germany	Andenex - Chemie Engelhard + Partner GmbH	NA	Non battery-related
Germany	Aqua-Concept Gesellschaft für Wasserbehandlung mbH	NA	Non battery-related
Germany	Astellas Pharma GmbH	NA	Non battery-related
Germany	Atriplex GmbH	NA	Non battery-related
Germany	BCD Chemie GmbH Niederlassung Hildesheim	NA	Non battery-related
Germany	CBC Europe GmbH	NA	Non battery-related
Germany	CEBE Reinigungschemie GmbH	NA	Non battery-related
Germany	CJ Europe GmbH	NA	Non battery-related
Germany	CareFusion Germany 234 GmbH	NA	Non battery-related
Germany	Carl Jäger Tonindustriebedarf GmbH	NA	Non battery-related
Germany	Christian Oswald Import - Export GmbH	NA	Non battery-related
Germany	Colux GmbH	NA	Non battery-related
Germany	DBH Osthandelsgesellschaft mbH	NA	Non battery-related
Germany	Denka Chemicals GmbH	NA	Non battery-related
Germany	Deutsche ICI GmbH	NA	Non battery-related

Germany	EMRA-MED Arzneimittel GmbH	NA	Non battery-related
Germany	Europe-Asia Import Export GmbH	NA	Non battery-related
Germany	F. Wilhelm Sengewald GmbH	NA	Non battery-related
Germany	Floragard Vertriebs GmbH für Gartenbau	NA	Non battery-related
Germany	Frey + Lau GmbH	NA	Non battery-related
Germany	GE Healthcare Europe GmbH	NA	Non battery-related
Germany	Gustav C. Meht GmbH & Co. KG	NA	Non battery-related
Germany	Gustav Grolman GmbH & Co. KG	NA	Non battery-related
Germany	H.U. Scheulen GmbH & Co. KG	NA	Non battery-related
Germany	HANWHA EUROPE GmbH	NA	Non battery-related
Germany	HYUNDAI CORPORATION EUROPE GMBH	NA	Non battery-related
Germany	Hans Seemann GmbH	NA	Non battery-related
Germany	Heinrich Brand GmbH & Co. KG	NA	Non battery-related
Germany	Herbert Kolloge KG	NA	Non battery-related
Germany	ITOCHU Deutschland GmbH	NA	Non battery-related
Germany	Intatrade Chemicals GmbH	NA	Non battery-related
Germany	Intra. Chem. Trading. GmbH	NA	Non battery-related
Germany	JFE Shoji Trade Corporation	NA	Non battery-related
Germany	JOTUN Deutschland GmbH	NA	Non battery-related
Germany	Julius Hoesch GmbH & Co. KG	NA	Non battery-related
Germany	KENT Deutschland GmbH	NA	Non battery-related
Germany	Kanematsu GmbH	NA	Non battery-related
Germany	LGC Standards GmbH	NA	Non battery-related
Germany	LUCIEN ORTSCHKEIT GmbH	NA	Non battery-related
Germany	MCC-Menssing Chemiehandel & Consultants GmbH	NA	Non battery-related
Germany	MEDICEM Siegfried R. Moser e.K.	NA	Non battery-related
Germany	MTK-Pharma Vertriebs-GmbH	NA	Non battery-related
Germany	Medline International Germany GmbH	NA	Non battery-related
Germany	Mitsubishi Chemical Europe GmbH	NA	Non battery-related
Germany	Mitsui Chemicals Europe GmbH	NA	Non battery-related
Germany	N+P NIEBERGALL + PARTNER	NA	Non battery-related
Germany	Noweda eG Apothekergenossenschaft	NA	Non battery-related
Germany	Oskar Berg GmbH	NA	Non battery-related
Germany	Otto Brandes GmbH	NA	Non battery-related
Germany	PHOENIX Pharma-Einkauf GmbH	NA	Non battery-related
Germany	PHOENIX Pharmahandel GmbH & Co KG	NA	Non battery-related
Germany	PKV Pappenheimer Kunststoffmaschinenvertrieb	NA	Non battery-related
Germany	Rudolf Ostermann GmbH	NA	Non battery-related
Germany	Seitz + Kerler GmbH & Co. KG	NA	Non battery-related
Germany	Simon, Evers & Co GmbH	NA	Non battery-related
Germany	Sojitz Europe plc	NA	Non battery-related
Germany	TROPAG Oscar H. Ritter Nachf. GmbH	NA	Non battery-related
Germany	Tennants GmbH	NA	Non battery-related

Germany	The Graymor Chemical Hamburg GmbH	NA	Non battery-related
Germany	Univar GmbH	NA	Non battery-related
Germany	VF Import-Export	NA	Non battery-related
Germany	VINK CHEMICALS GmbH & Co.KG	NA	Non battery-related
Germany	Verschleißschutz und Gummitechnik GmbH	NA	Non battery-related
Germany	Vink + Co GmbH Handelsgesellschaft und Co.KG	NA	Non battery-related
Germany	WEISSMEER BALTISCHE Import - Export GmbH	NA	Non battery-related
Germany	WELDING GMBH & CO. KG	NA	Non battery-related
Germany	WTH Walter Thieme Handel GmbH	NA	Non battery-related
Germany	euronopa GmbH	NA	Non battery-related
Germany	ilapo Internationale Ludwigs- Arzneimittel GmbH & Co. KG	NA	Non battery-related
Germany	kohlpharma GmbH	NA	Non battery-related

The data is adopted from the custom database Operated by Tradesns Science & Technology (DaLian) Co.,LTD²⁴. It includes the international trade data on the enterprise level for over 80 countries (Some of the information has to be paid to be accessible). NA: Information is not available in the database.

3. Detail results

Table S17 Competition index of various commodities

Commodity	Competition index
LH	438
LIB	401
LC	352
CO	203
NC	83
EMD	58
RC	55
NCM/NCA	43
NG	11
NO	7
LCO	5
MO	4
LMO	4
LFE	2
LM	1

Table S18 HHI values of various commodities

Commodity	HHI
LM	3350
CO	4901
NO	1532
MO	1536
NG	4264
LC	4173
LH	5884
RC	4149
NC	5100
EMD	5343
NCM/NCA	4209
LFP	8132
LMO	7856
LCO	5110
LIB	5078

Table S19 Top 10 trade partners with highest competition index

Trade partners		Competition index
Japan	Rep. of Korea	219
China	Finland	61
Japan	France	49
Rep. of Korea	USA	41
Belgium	China	37
France	Rep. of Korea	36
Belgium	Japan	36
China	Rep. of Korea	35
China	Japan	34
Belgium	Rep. of Korea	28

Table S20 Regional competition index

Country	LM	CO	NO	MO	NG	LC	LH	RC	NC	EMD	NCM /NCA	LFP	LMO	LCO	LIB
Afghanistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Albania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Algeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

American Samoa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Andorra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Angola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anguilla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antarctica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antigua and Barbuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Argentina	0	0	0	0	0	0	4	0	0	0	0	0	0	0	2
Armenia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aruba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Australia	0	0	0	0	0	1	2	0	14	9	0	0	0	0	14
Austria	0	0	0	0	1	2	0	1	0	0	0	0	0	0	20
Azerbaijan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bahamas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bahrain	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bangladesh	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Barbados	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belarus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Belgium	0	46	0	0	1	49	25	1	23	15	0	0	0	0	52
Belize	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bermuda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bhutan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bolivia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bonaire, Saint Eustatius and Saba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bosnia and Herzegovina	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Botswana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	0	3	2	2	0	0	0	0	11
British Antarctic Territories	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
British Indian Ocean Territories	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
British Virgin Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Brunei Darussalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Bunkers	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burkina Faso	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burundi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cabo Verde	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cambodia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cameroon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Canada	0	11	0	0	0	15	26	0	17	3	0	0	0	0	9
Cayman Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Central African Republic	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chile	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
China	1	172	7	3	3	34	0	34	0	0	25	0	0	3	8
China, Hong Kong	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
China, Macao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Christmas Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocos Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Colombia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Comoros	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Congo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cook Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Costa Rica	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Côte d'Ivoire	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Croatia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Curaçao	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czechia	0	0	0	0	0	1	2	0	2	0	0	0	0	0	11
Democratic People's Republic of Korea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Democratic Republic of the Congo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Denmark	0	0	0	0	0	1	0	0	0	0	0	0	0	0	3
Djibouti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dominica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dominican Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ecuador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Egypt	0	0	0	0	0	0	2	0	0	1	0	0	0	0	2
El Salvador	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equatorial Guinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eritrea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	0	0	0	0	0	0	3	0	0	0	0	0	0	0	1

Ethiopia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Faeroe Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falkland Islands (Malvinas)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Federated State of Micronesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fiji	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Finland	0	79	0	0	0	0	0	0	0	0	0	0	0	0	0
France	0	0	0	0	1	13	94	3	0	0	0	2	0	0	36
Free Zones	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
French Polynesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
French South Antarctic Territories	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gabon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gambia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Georgia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	3	17	0	4	7	12	0	0	0	0	143
Ghana	0	0	0	0	0	0	12	0	0	0	0	0	0	0	1
Gibraltar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Greece	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Greenland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Grenada	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guatemala	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Guinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guinea-Bissau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Guyana	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haiti	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heard Island and McDonald Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Holy See (Vatican City State)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Honduras	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	0	0	1	0	1	0	0	6	0	0	0	9
Iceland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ile Bouvet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
India	0	1	0	1	2	10	28	1	3	9	0	0	0	0	45
Indonesia	0	0	0	0	0	0	2	1	1	14	0	0	0	0	15
Iran	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iraq	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Ireland	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Israel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Italy	0	0	0	0	0	4	4	1	4	0	0	0	0	0	15
Jamaica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Japan	0	29	4	1	3	142	304	1	50	0	1	0	0	1	11
Jordan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Kazakhstan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Kenya	0	0	0	0	0	0	0	0	0	3	0	0	0	0	1
Kiribati	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kuwait	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kyrgyzstan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lao People's Dem. Rep.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lebanon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lesotho	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Liberia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Libya	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Luxembourg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macedonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Madagascar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malawi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malaysia	0	10	0	0	2	0	0	16	7	4	0	0	4	0	2
Maldives	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mali	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Marshall Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mauritania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mauritius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mayotte	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mexico	0	0	0	0	0	0	0	1	2	1	0	0	0	0	17
Mongolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Montenegro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Montserrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Morocco	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Mozambique	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myanmar	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Namibia	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0
Nauru	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nepal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	0	0	0	1	49	21	2	2	0	0	0	0	0	31
Neutral Zone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

New Caledonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
New Zealand	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Nicaragua	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Niger	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nigeria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Niue	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norfolk Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Northern Mariana Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norway	0	25	0	1	0	0	0	0	0	0	0	0	0	0	7
Oman	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pakistan	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Palau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Panama	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Papua New Guinea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paraguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Peru	0	0	0	0	0	0	1	0	0	1	0	0	0	0	2
Philippines	0	0	0	0	0	0	1	0	7	0	0	0	0	0	3
Pitcairn	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	1	1	3	0	1	4	13	0	0	0	20
Portugal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Qatar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rep. of Korea	0	13	3	1	0	194	249	14	4	3	8	2	4	4	22
Rep. of Moldova	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Romania	0	0	0	0	0	0	1	0	0	0	0	0	0	0	6
Russian Federation	0	0	0	1	0	53	3	0	0	4	0	0	0	0	6
Rwanda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Barthélemy	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Helena	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Kitts and Nevis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Lucia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Maarten (Dutch part)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Pierre and Miquelon	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Saint Vincent and the Grenadines	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Samoa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Marino	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sao Tome and Principe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Principe																
Saudi Arabia	0	0	0	0	0	0	3	0	0	1	0	0	0	0	0	4
Senegal	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Serbia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Seychelles	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sierra Leone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Singapore	0	0	0	0	0	0	5	3	3	12	0	0	0	0	0	7
Slovakia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
Slovenia	0	0	0	0	0	0	4	0	1	0	0	0	0	0	0	3
Solomon Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somalia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Africa	0	0	0	0	0	1	6	0	0	0	0	0	0	0	0	3
South Georgia and the South Sandwich Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
South Sudan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Spain	0	11	0	0	0	10	35	2	1	0	0	0	0	0	0	8
Special Categories	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sri Lanka	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
State of Palestine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sudan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Suriname	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Swaziland	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sweden	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	32
Switzerland	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	6
Syria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tajikistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thailand	0	0	0	0	0	1	4	0	3	6	0	0	0	0	0	5
Timor-Leste	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Togo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tokelau	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tonga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trinidad and Tobago	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tunisia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turkey	0	0	0	0	1	0	4	1	1	0	0	0	0	0	0	8
Turkmenistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turks and Caicos Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tuvalu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uganda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ukraine	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

United Arab Emirates	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	8
United Kingdom	0	1	0	0	0	12	8	4	2	1	4	0	0	0	0	19
United Rep. of Tanzania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Uruguay	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
USA	1	0	0	0	3	86	2	12	2	0	30	0	0	3	29	
Uzbekistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vanuatu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Venezuela	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Viet Nam	0	1	0	0	0	2	0	0	3	2	0	0	0	0	0	57
Wallis and Futuna Islands	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Western Sahara	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yemen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yugoslavia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yugoslavia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zambia	0	4	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Zimbabwe	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table S21 Global supply chain of LIB produced by Tesla’s Gigafactory 1 in Nevada

LIB/GWh			NCA/ton			LH/ton		
Destination	Supply source	Volume	Destination	Supply source	Volume	Destination	Supply source	Volume
USA	USA	70	USA	Japan	97,300	Japan	Chile	737
						Japan	China	19,200
						Japan	USA	4,451
LM/ton lithium metallic equivalent			RC/ton cobalt metallic equivalent			CO/ton cobalt metallic equivalent		
Destination	Supply source	Volume	Destination	Supply source	Volume	Destination	Supply source	Volume
Chile	Chile	214	Japan	Japan	7,488	Japan	DRC	7,488
China	China	1,022	Japan	Australia	25	Australia	Australia	25
China	Australia	4,544	Japan	Belgium	38	Belgium	DRC	38
USA	Chile	1,290	Japan	Canada	215	Canada	Canada	215
			Japan	China	98	China	China	3
			Japan	Finland	769	China	DRC	95
			Japan	France	4	Finland	Finland	26
			Japan	Madagascar	58	Finland	DRC	742
			Japan	Morocco	55	France	France	4

			Japan	Norway	59	Madagascar	Madagascar	58
			Japan	Russia	24	Morocco	Morocco	55
			Japan	South Africa	7	Norway	DRC	59
			Japan	Zambia	99	Russia	Russia	24
						South Africa	South Africa	7
						Africa		
						Zambia	Zambia	50
						Zambia	DRC	50
NC/ ton nickel metallic equivalent			NO/ ton nickel metallic equivalent					
Destination	Supply source	Volume	Destination	Supply source	Volume			
Japan	Japan	53,779	Japan	Indonesia	711			
Japan	Finland	9,800	Japan	New Caledonia	29,221			
Japan	Korea	12,513	Japan	Philippines	23,847			
Japan	China (Taiwan)	49,553	Finland	Finland	9,800			
			China	China	6,183			
			Rep. of Korea	Australia	0			
			Rep. of Korea	China	1			
			Rep. of Korea	Netherlands	0			
			Rep. of Korea	New Caledonia	43,369			
			Rep. of Korea	Papua New Guinea	0			
			Rep. of Korea	South Africa	1			
			Rep. of Korea	Turkey	0			
			Rep. of Korea	USA	0			

This global supply chain is artificially assumed based on the 2019 supply network of Tesla, which is not completely consistent with the actual situation. In 2019, the LIB used by Tesla' electric vehicle mainly comes from Panasonic²⁵. We assume that the batteries produced in Gigafactory 1 are all supported by Panasonic. Referring to Panasonic's product technical manual, the cathode material of their batteries is NCA. The mass of cathode materials required for per kWh NCA battery is 1.39 kg²⁶. Thus, the cathode materials required for the 70 GWh battery is 97000 ton NCA. Further, the

raw materials needed for these cathode materials are: 24388 ton LH, 8938 ton RC (cobalt content), 125645 ton nickel sulfate, 7070 ton LM (lithium content), 8938 ton CO (cobalt content), and 47670 ton NO (nickel content). Japan Sumitomo Metal Industries is the only cathode materials supplier of Panasonic²⁵. Thus we assume all the cathode materials come from Japan. Information about supply relationships of other raw materials is not available. Here we use the 2019 global international trade network of each type of commodity to allocate the supply of needed commodities.

4. Uncertainty analysis

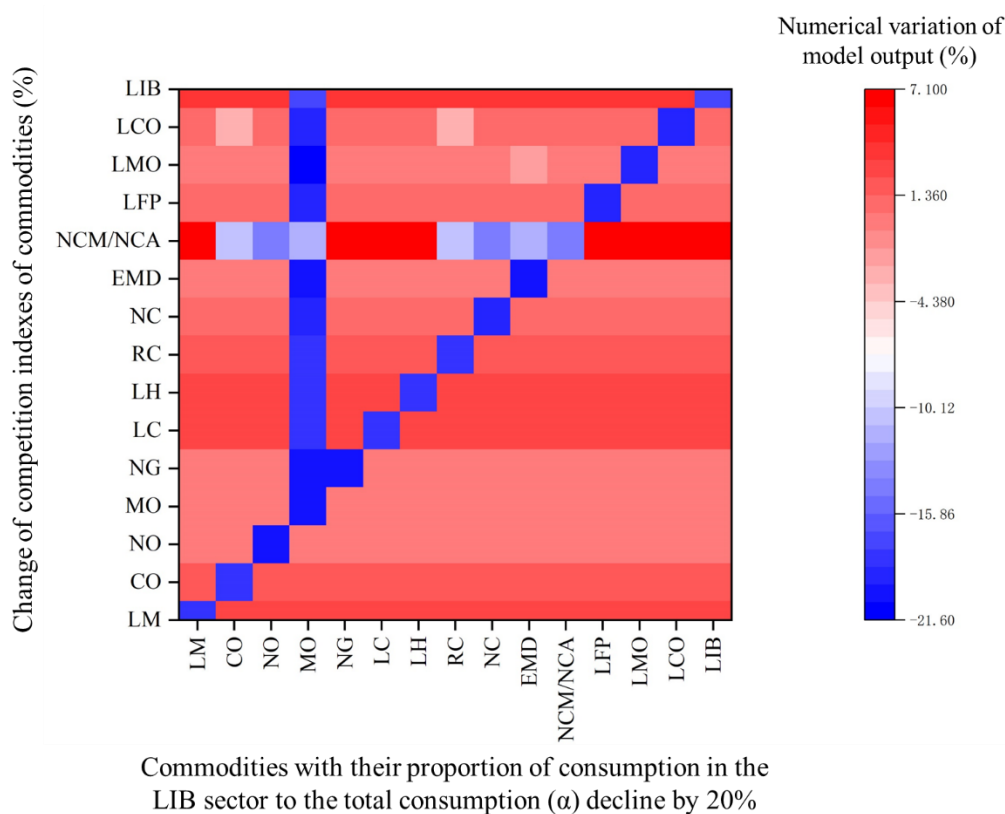


Figure S1 Uncertainty analysis of proportion of consumption in the LIB sector to the total consumption (α)

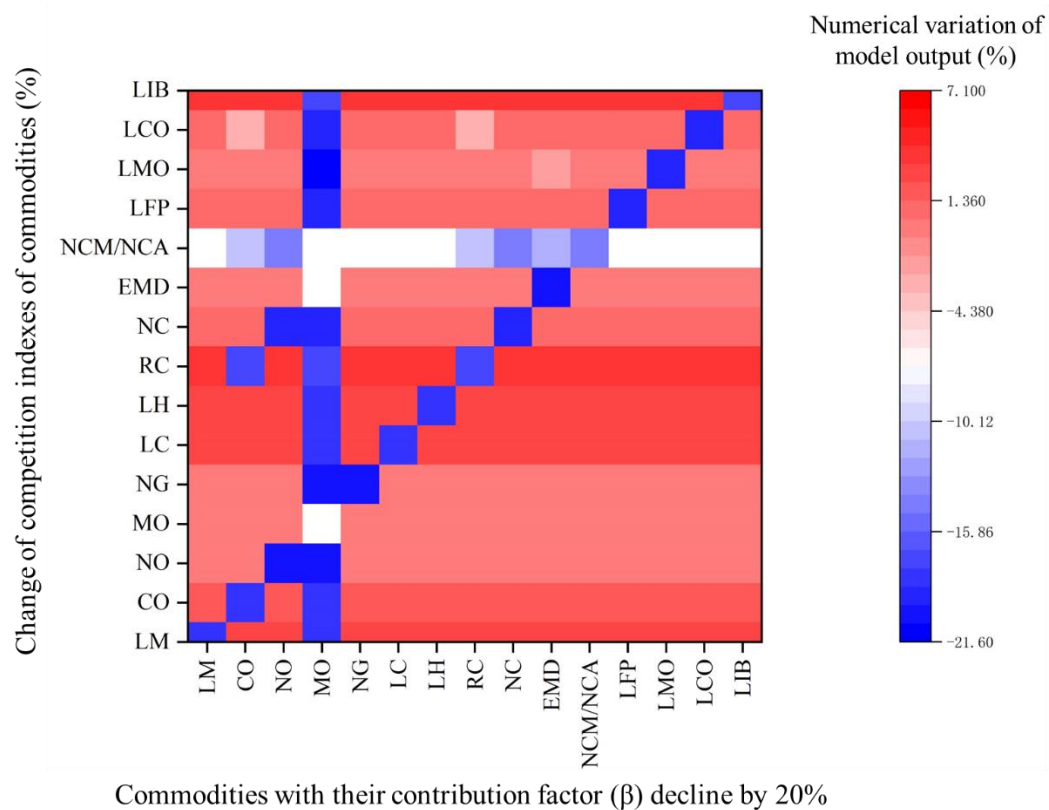


Figure S2 Uncertainty analysis of contribution factor (β)

Figure S1 and S2 show the change of the competition index of each commodity as the α and β value of each commodity drops by 20%. The color of the mesh corresponds to the percentage change. The mapping between colors and changes is shown in the legend on the right in the figure.

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