Supporting Information for

Direct and indirect consumption activities drive distinct urban-rural inequalities in air pollution-related mortality in China

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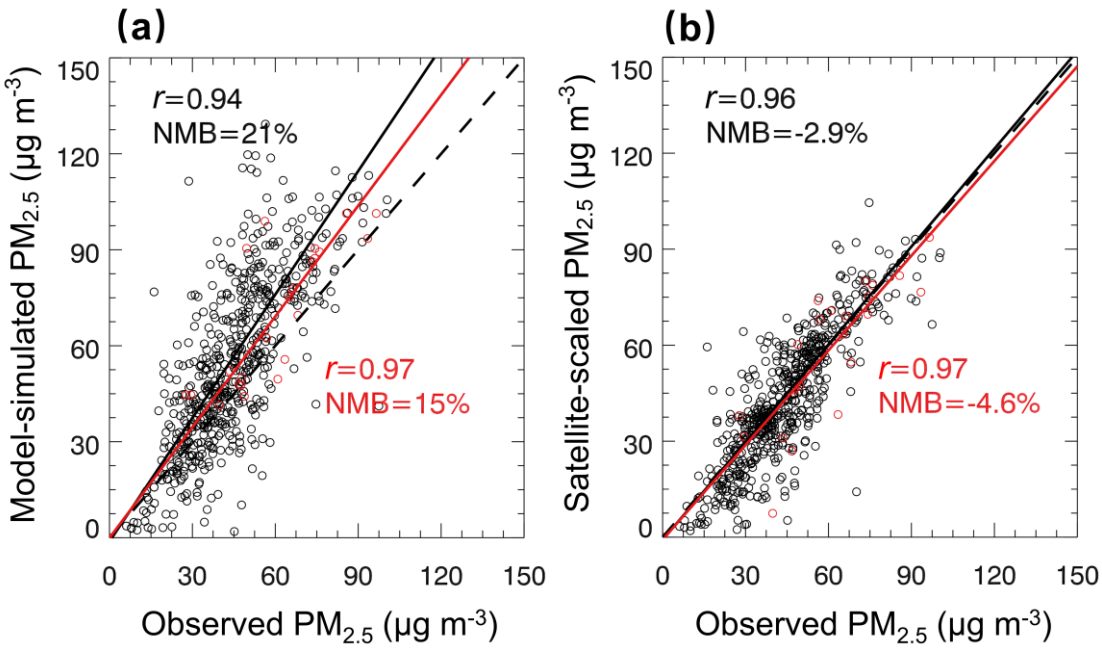


Fig. S1. Comparison of model-simulated (a) and satellite-scaled (b) with observed annual mean $PM_{2.5}$ concentrations at selected stations in China. Each circle represents the result of each station. Details for the air quality monitoring stations are shown in Fig. S2. The red circles represent areas with a population density of more than 2,000 people/km^2. We select 55 densely-populated stations (red) and 1425 other stations (black) in this study. R represents the correlation coefficient and NMB refers to normalized mean bias.

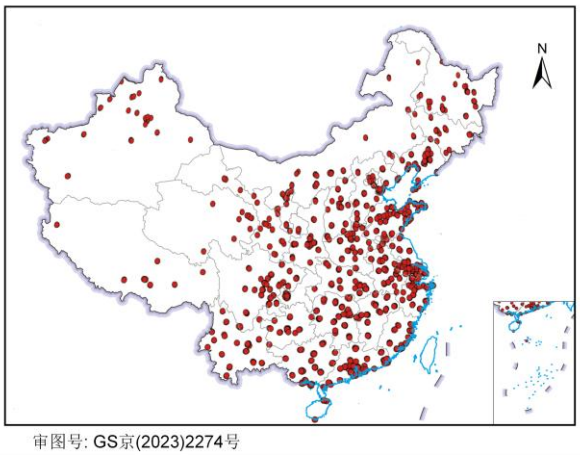


Fig. S2. Locations of air quality monitoring stations. The air quality data of the stations are gotten from the China National Environmental Monitoring Center (CNEMC) (http://www.cnemc.cn/), belonging to the Ministry of Ecology and Environment of the People's Republic of China (MEE). The value of Taiwan Province is blank due to lack of data.

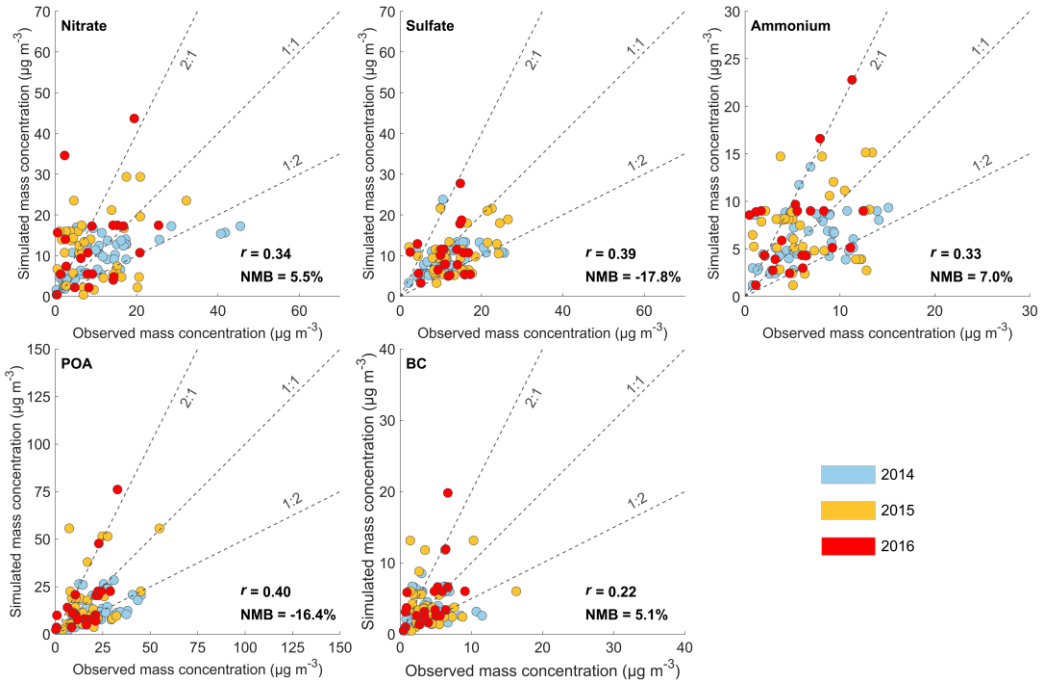


Fig. S3. Comparison of model-simulated with observed $PM_{2.5}$ composition concentrations in 2015. Here, we compare both annual and seasonal mean concentrations of the observed and the coincident simulated concentrations according to the availability of observations from the literature for 2014–2016. To be comparable with the modeled primary organic aerosol (POA), observational organic carbon (OC) is converted to POA with an POA/OC ratio of 1.4 (https://clipc-services.ceda.ac.uk/dreq/u/79433cf8854f00ee833d6c2979fa5eb1.html). R represents the correlation coefficient and NMB refers to normalized mean bias. Details for the observed composition concentrations data collected from the literature are shown in Table S5.

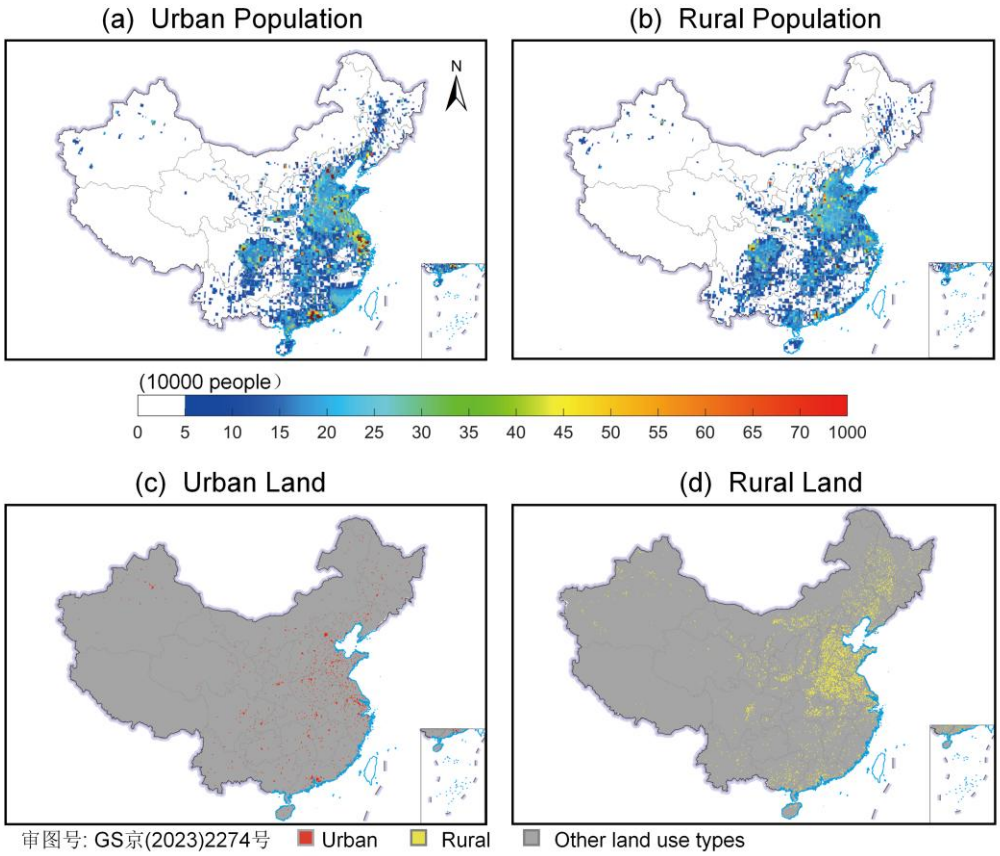


Fig. S4. Spatial distributions of urban and rural population densities (a-b) and land use types (c-d) in 2015. c) and d) show the geographical distribution of different land use types. The land use dataset is obtained from the Geographical Information Monitoring Cloud Platform (http://www.dsac.cn/). The value of Taiwan Province is blank due to lack of data.

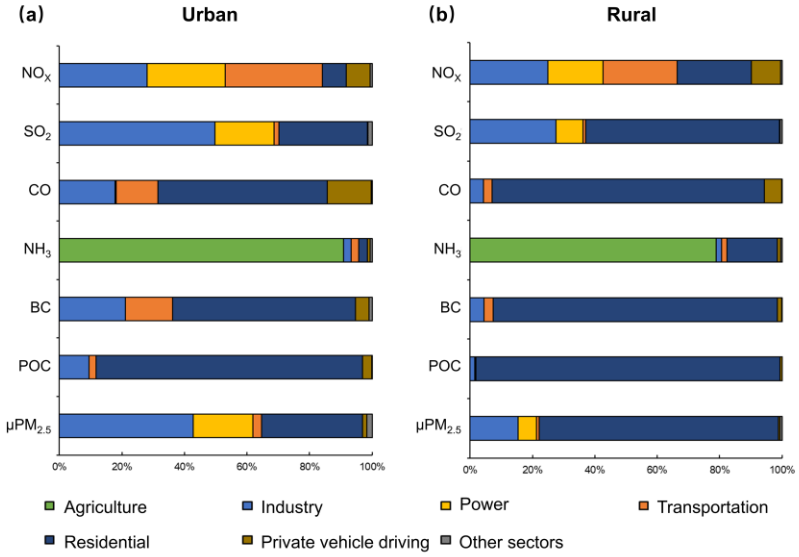


Fig. S5. Urban (a) and rural (b) household consumption activities' contribution to each production-based sector emissions in 2015. Residential emissions here represent those from household fuel use for heating and cooking. $\mu PM_{2.5}$ presents other primary $PM_{2.5}$ except BC and POC.

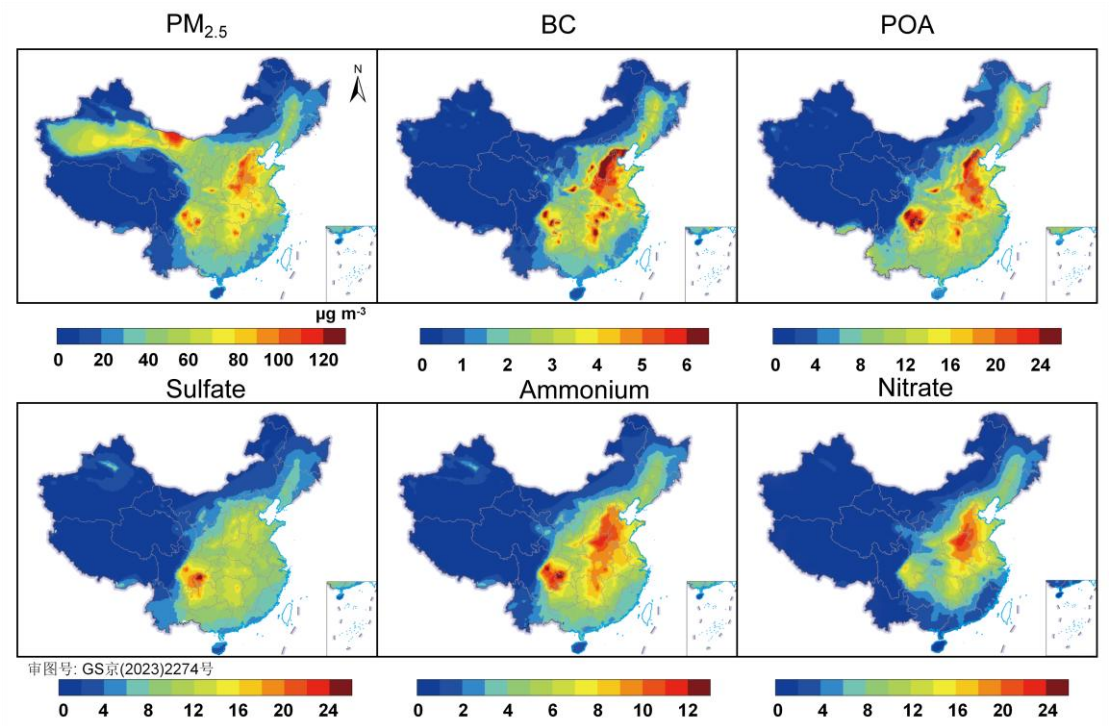


Fig. S6. Spatial distributions of surface $PM_{2.5}$ and its main composition in China in 2015. The value of Taiwan Province is blank due to lack of data.

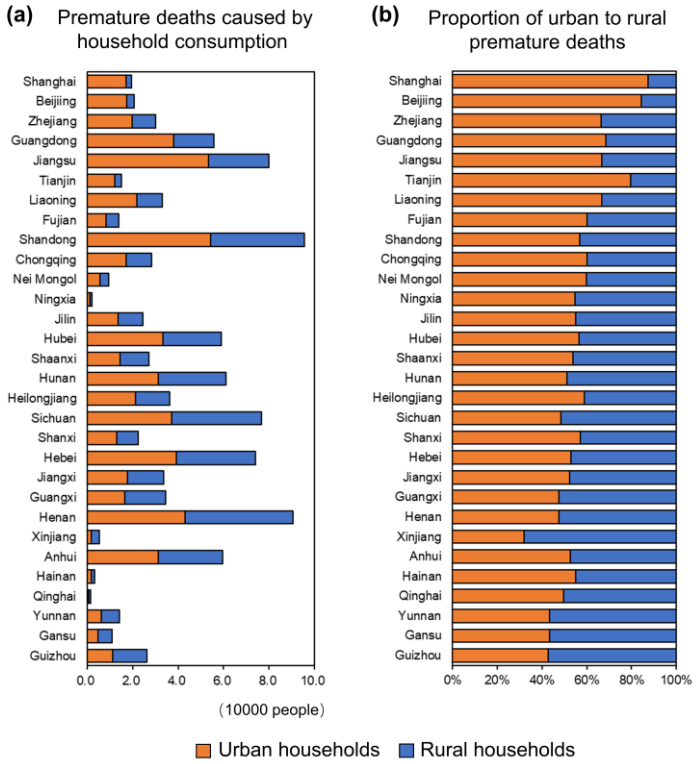


Fig. S7. Urban and rural premature deaths caused by household consumption-associated $PM_{2.5}$ (a) and their proportion (b) of each province in 2015. Here the pollution over each province is derived from locally formed as well as atmospherically transported pollution associated with consumption in all provinces. Provinces are ranked according to their per capita consumption expenditure shown in Fig. S9.

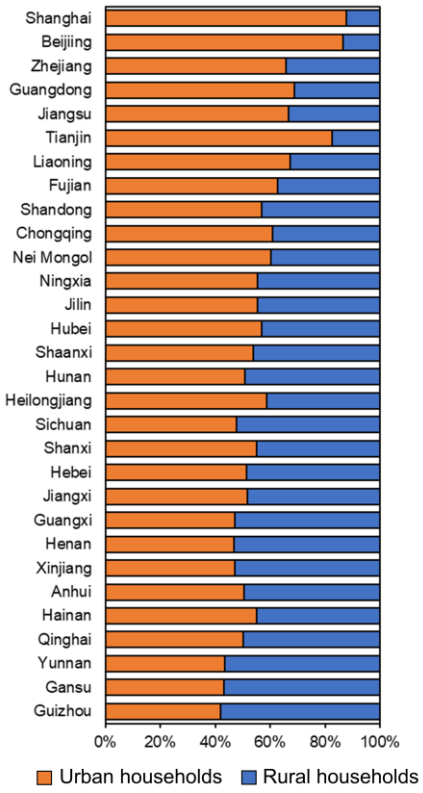


Fig. S8. Proportion of urban and rural population of each province in 2015. Provinces are ranked according to their per capita consumption expenditure shown in Fig. S9.

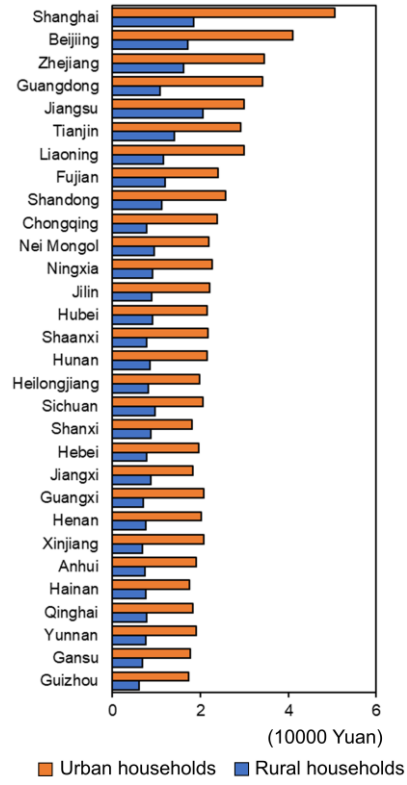


Fig. S9. Urban and rural household per capita consumption expenditure of each province in 2015. Household per capita consumption expenditure is calculated based on national statistical population data [1] and final demand obtained from Chinese provincial MRIO table [2] used in this study.

Table S1. Sectors of China's MRIO table used in this study

Code	Sectors	Code	Sectors
1	Farming, Forestry, Animal Husbandry, and Fishery Conservancy	16	Equipment for Ordinary and Special Purposes
2	Coal Mining and Dressing	17	Transportation Equipment
3	Petroleum and Natural Gas Extraction	18	Electric, Machinery and Instrument
4	Metals Mining and Dressing	19	Telecommunications Equipment, Computer and Other Electric Equipment
5	Other Minerals Mining and Dressing	20	Instruments, Meters, Cultural and Office Machinery
6	Food Processing and Tobacco Processing	21	Other Products
7	Textile Industry	22	Production and Supply of Electric Power and Steam
8	Textile ,Leather, Furs, Down, Garments and Other related Products	23	Production and Supply of Gas and Water
9	Timber Processing and Straw Products	24	Construction
10	Papermaking, Printing and Cultural, Educational and Sports Products	25	Transportation and Storage Service
11	Petroleum Processing, Coking and fission fuel	26	Wholesale and Retail Trade Service
12	Chemical industry	27	Accommodation and Catering Service
13	Nonmetal Mineral Products	28	Commerical Leasing Service
14	Smelting and Pressing of Metals	29	Industrial Research and Experimental Development
15	Metal Products	30	Other Service

Table S2. Sector mapping among GAINS, MRIO and MEIC

Code	GAINS（56）	MRIO（30）[a]	MEIC（4）
1	Public electricity and heat production	22	Power
2	Petroleum refining	11	Industry
3	Manufacture of solid fuels and other energy industries	2, 3, 11	Industry
4	Stationary combustion in industry Iron and steel	14	Industry
5	Stationary combustion in industry: Non-ferrous metals	14	Industry
6	Stationary combustion in industry: Chemicals	12	Industry
7	Stationary combustion in industry: Pulp, Paper and Print	10	Industry
8	Stationary combustion in industry: Food processing, beverages and tobacco and Other	6	Industry
9	Stationary combustion in industry: Nonmetallic minerals	13	Industry
10	Mobile Combustion in industry	2–21, 24	Industry
11	Civil aviation	25	Transportation
12	Road transport: Passenger cars	Private car[b]	Transportation
13	Road transport: Light duty vehicles	25	Transportation
14	Road transport: Heavy duty vehicles and buses	25	Transportation
15	Road transport: Mopeds and motorcycles	Private car[b]	Transportation
16	Railways	25	Transportation
17	Commercial / institutional: stationary	26–30	Industry
18	Residential stationary	Residential	Residential
19	Agriculture / Forestry / Fishing: Stationary	1	Agriculture
20	Agriculture / Forestry / Fishing: Off_road vehicles and other machinery	25	Transportation
21	Other / mobile (including military / land based and recreational boats)	25, 30	Transportation
22	Solid fuel transformation	11	Industry
23	Oil: Refining / storage	11	Industry
24	Fugitive emissions from natural gas	NAN[c]	NAN[c]
25	Chemical industry: Other	12	Industry
26	Nitric acid production	12	Industry

27	Iron and steel production	14, 15	Industry
28	Other metal production	14, 15	Industry
29	Pulp and paper industry	10	Industry
30	Field burning of agricultural residues	NAN[c]	NAN[c]
31	Open burning of waste	NAN[c]	NAN[c]
32	Other (included in national total)	1–30	Industry
33	Aluminium production	14, 15	Industry
34	Other solvent use	12	Industry
35	Dairy cattle_Manure management	1	Agriculture
36	Non_dairy cattle_ Manure management	1	Agriculture
37	Sheep_Manure management	1	Agriculture
38	Swine_Manure management	1	Agriculture
39	Horses_Manure management	1	Agriculture
40	Laying hens_Manure management	1	Agriculture
41	Other poultry_Manure management	1	Agriculture
42	N-fertilizer	1	Agriculture
43	Road transport: Automobile tyre and brake wear	25	Transportation
44	Road transport: Automobile road abrasion	25	Transportation
45	Coal mining and handling	2	Industry
46	Construction and demolition	24	Industry
47	Storage, handling and transport of mineral products	25	Transportation
48	Storage, handling and transport of chemical products	25	Transportation
49	Wood processing	9	Industry
50	Storage, handling and transport of agricultural products	25	Transportation
51	National navigation incl. Int. inland waterways; Fishing	25	Transportation
52	Quarrying and mining of minerals other than coal	4, 5	Industry
53	Venting and flaring	3, 11, 23	Industry
54	Buffalo_Manure management	1	Agriculture
55	Household and gardening (mobile)	NAN[c]	NAN[c]
56	Other animals_Manure management	1	Agriculture

a. MRIO's 30 sectors are listed in Table S1.

b. Emissions from private car driving do not participate in economic supply chains.

c. “NAN” indicates that emissions from these sectors are included in GAINS but not in MEIC, so these emissions are not considered in our study.

Table S3. Pollution equivalent coefficient for each pollutant[a]

Air pollutant	Pollution equivalent coefficient
SO_2	0.95
NO_x	0.95
CO	16.7
NH_3	9.09
BC, POC and other primary $PM_{2.5}$[b]	2.18

a. Data are from the National People’s Congress of the People’s Republic of China: http://www.npc.gov.cn/npc/.

b. Pollutant equivalent coefficients for BC, POC, and other primary $PM_{2.5}$ are assumed to be the same as that for soot.

Table S4. The setting of emissions in all simulations

Code	Simulations	Setting of Emissions
1	CTL	Including all the emissions
2	xANTH	Excluding all anthropogenic emissions
3	xURBAN_DI	Excluding urban direct consumption-related emissions
4	xURBAN_IN	Excluding urban indirect consumption-related emissions
5	xRURAL_DI	Excluding rural direct consumption-related emissions
6	xRURAL_IN	Excluding rural indirect consumption-related emissions

References

[1] National Bureau of Statistics of the People's Republic of China, National Statistics Yearbook 2021. Beijing: China Statistics Press; 2022 (in Chinese).

[2] Zhang Y, Liu Y, Li J. Research of China’s multi-regional input-output model design method. Statistical Research 2012; 5: 3-9 (in Chinese).