Supplementary Information for

Technological Diffusion and Cooperation in Emission Reduction Alliances: Reshaping Regional Paths to Low-Carbon Development

CGE Model structure

1.1 Production block

In the CGE model, the production function is calculated using nested constant-elasticity-of substitution (CES) functions that reflect substitution possibilities between inputs. At the first level, we nest the nonenergy intermediate input ($QINTA_{R,A}$) and value-added ($QVA_{R,A}$) into departmental output ($QA_{R,A}$) through the Leontief production function. At the second level, $QINTA_{R,A}$ is a combination of nonenergy intermediate input; $QVA_{R,A}$ is nested by the capital energy bundle ($QKE_{R,A}$), knowledge input ($QHD_{R,A}$)and labor input ($QLD_{R,A}$). At the third level, we combine the capital input ($QKD_{R,A}$), and energy input ($QEE_{R,A}$) into $QKE_{R,A}$ with the help of the CES function. At the last level, fossil fuels input ($QFOSI_{R,A}$) and electricity power input ($ELE_{R,A}$) are the foundation of $QEE_{R,A}$. The production function is shown below. **Fig.S1** describes the production structure in the CGE model.

$$QA_{R,A} = LEO_1\left\{QINTA_{R,A}, CES_2\left[QLD_{R,A}, QHD_{R,A}, CES_3\left(QKD_{R,A}, CES_4\left\langle QELE_{R,A}, QFOSI_{R,A}\right\rangle\right)\right]\right\} \quad P1$$

$$q = f(K,H,L) = A[\delta^k K^\rho + \delta^h H^\rho + \delta^l L^\rho]^{\frac{1}{\rho}}, \quad \delta^k + \delta^h + \delta^l = 1 \quad P2$$

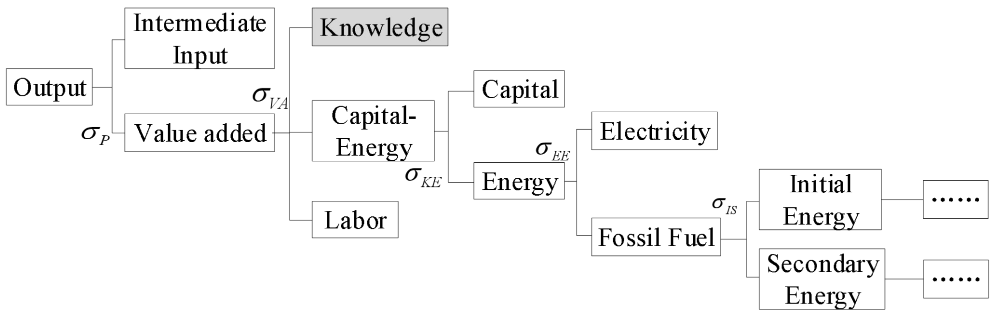

Fig. S1. The production structure in the ITC-CGE model (Based on Hu et al. 2019 and Garau et al. 2015).

1.2 Trade block

We use the Armington assumption to describe the substitute between local ($QD_{R,C}$), imports from other regions of the country ($QMR_{R,C}$), and imported goods ($QM_{R,C}$). And locally produced goods ($QX_{R,C}$) are divided into local markets ($QD_{R,C}$), exported to other regions of the country ($QDR_{R,C}$), and exported abroad ($QE_{R,C}$) through the CET function (see **Fig. S2**).

$$QX_{R,C} = \Big\{ \quad {}_{R,C}, \quad {}_1\Big[\quad {}_{R,C}, \quad {}_2\Big(D \quad {}_{R,C,R1}, \cdots\cdots, \quad S_{R,C,R30}\Big)\Big]\Big\} \quad T1$$

$$QQ_{R,C} = \Big\{ \quad {}_{R,C}, \quad {}_1\Big[\quad {}_{R,C}, \quad {}_2\Big(M \quad {}_{R,C,R1}, \cdots\cdots, \quad S_{R,C,R30}\Big)\Big]\Big\} \quad T2$$

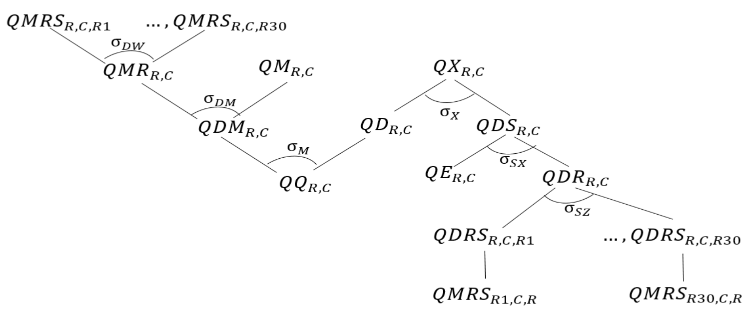

Fig. S2. Commodity flows in the market.

1.3 Institution block

1.3.1 Household

Households obtain income by providing labor and capital, while enterprises, government, and foreigners also transfer payments to residents. Then household pays taxes and saves, and the remaining disposable income ($EH_{R,H}$). We use Lluch's Extended Liner Expenditure System (ELES) to describe residents' consumption behavior derived from the Stone-Geary utility function.

$$PQ_{R,C} \times QH_{R,C,H} = PQ_{R,C} \times LESsub_{R,C,H} + LESbeta_{R,C,H} \times \left(EH_{R,H} - \sum_{C} LESsub_{R,C,H} \times PQ_{R,C}\right) \quad \text{I1}$$

Where $QH_{R,C,H}$ is the consumption of commodities, $LESsub_{R,C,HO}$ is a basic survival requirement, $LESbeta_{R,C,HO}$ is LES margin consumption, $PQ_{R,C}$ is the price of the commodity, $PQ0_{R,C}$ is the initial price of the commodity.

1.3.2 Government

The government revenue (YG_R) comes from value-added tax collected from production activities, income tax levied on households and enterprises, and tariffs. Government expenditure consists of transfer payments to other institutions and commodity demand. Besides, we use the Cobb-Douglas utility function to describe government consumption behavior.

$$EG_R = \sum_{C}\left(PQ_{R,C} \times QG_{R,C}\right) + \sum_{H}\left(ah_{R,h,gov} \times YG_R\right) + aent_{R,ent,gov} \times YG_R + (1-\alpha_A) \times GCR_R \quad \text{I2}$$

$$GCR_t = p \times (1-\beta_t) TA_t \quad \text{I3}$$

$$PQ_{R,C} \times QG_{R,C} = igc_{R,C} \times EG_R \quad \text{I4}$$

Where EG_R is government goods consumption and transfers to other institutions, $QG_{R,C}$ is government demand for goods, $ah_{R,h,gov}$ is the proportion of government transfer payments to households, $aent_{R,ent,gov}$ is the proportion of government transfer payments to enterprises, $igc_{R,C}$ is share parameters. α_A is the proportion of carbon revenue allocated to R&D subsidies; $(1-\alpha_A) \times GCR_R$ is the remaining government carbon revenue after spending on R&D subsidies, and it only exists when there is a quota auction.

If ETS revenues are distributed according to the HIP rule, $\alpha_{A,t}$ is calculated as follows:

$$\alpha_{A,t} = \omega \times \frac{CI_{R,A,t}}{\sum_{i} CI_{R,A,t}} \times \frac{CI_{R,t}}{\sum_{R} CI_{R,t}} \quad \text{I5}$$

While ETS revenues are distributed according to the LIP rule, $\alpha_{A,t}$ is calculated as follows:

$$\alpha_{A,t} = \omega \times \frac{(\sum_A CI_{R,A,t} \times \sum_R CI_{R,t}) - (CI_{R,A,t} \times CI_{R,t})}{(m \times n - 1) \times (\sum_A CI_{R,A,t} \times \sum_R CI_{R,t})} \quad \text{I6}$$

where $CI_{R,A,t}$ and $CI_{R,t}$ are the carbon intensity of sector *A* in region *R* and the overall carbon intensity of region *R*, respectively. *m* and *n* represent the total number of regions and sectors, respectively.

1.3.3 Enterprise

The total income of the enterprise ($YENT_R$) is the remuneration obtained by its capital factor production input. These earnings are distributed to savings, income tax, and transfers to other institutions.

$$ENTSAV_R = (1 - tent_R) \times YENT_R - \sum_H ratehue_{R,H} \times YENT_R - \sum_A CC_{R,A} + (1-\omega)\sum_A CR_{R,A} \quad I5$$

Where $ENTSAV_R$ is enterprise savings, $tent_R$ is enterprise income tax rate, $ratehue_{R,H}$ is the proportion of enterprise transfer payments to the household. ω is the proportion of carbon revenue allocated to R&D subsidies. The setting of ω is described in the scenario design section.

1.4 Factors Market

In the CGE model, labor and capital are factor inputs. Factor market clearing requires the demand for these two factors to equal the supply. We assume that the labor force is fully mobile between sectors but immobile among regions, which is the same as the setting used in Hu et al. (2019). Meanwhile, we assume that the capital flows incompletely between sectors and regions, which is inferred from the setting in Yang et al. (2021)(Yang et al., 2021).

$$nksup_R \times ptotk^{omeganksup} = anksup_R \times totnksup \times pk_R^{omeganksup} \quad (nksup0_R \neq 0 \;\&\; omeganksup \neq inf) \quad F1$$

$$nhsup_R \times ptoth^{omeganhsup} = anhsup_R \times totnhsup \times ph_R^{omeganhsup} \quad (nhsup0_R \neq 0 \;\&\; omeganhsup \neq inf) \quad F2$$

$$ptotk = pk_R \quad (nksup0_R \neq 0 \;\&\; omeganksup = inf) \quad F3$$

$$ptoth = ph_R \quad (nhsup0_R \neq 0 \;\&\; omeganhsup = inf) \quad F4$$

$$ptotk^{1+omeganksup} = \sum_R anksup_R \times pk_R^{1+omeganksup} \quad (omeganksup \neq inf) \quad F5$$

$$ptoth^{1+omeganhsup} = \sum_R anhsup_R \times ph_R^{1+omeganhsup} \quad (omeganhsup \neq inf) \quad F6$$

$$totnk\sup = \sum_R nksup_R \quad (omeganksup = inf) \quad F7$$

$$totnh\sup = \sum_R nhsup_R \quad (omeganhsup = inf) \quad F8$$

$$nks_{R,A} \times pk_R^{omegak_R} = aks_{R,A} \times nk\sup_R \times WK_{R,A}^{omegak_R} \quad (nks0_{R,A} \neq 0 \;\&\; omegak \neq inf) \quad F9$$

$$nhs_{R,A} \times ph_R^{omegah_R} = ahs_{R,A} \times nhsup_R \times WH_{R,A}^{omegah_R} \quad (nhs0_{R,A} \neq 0 \;\&\; omegah \neq inf) \quad F10$$

$$WK_{R,A} = PK_R \qquad (nks0_{R,A} \neq 0 \;\&\; omegak = inf) \qquad F11$$

$$WH_{R,A} = PH_R \qquad (nhs0_{R,A} \neq 0 \;\&\; omegah = inf) \qquad F12$$

$$nks_{R,A} = 0 \qquad (nks0_{R,A} = 0) \qquad F13$$

$$nhs_{R,A} = 0 \qquad (nhs0_{R,A} = 0) \qquad F14$$

$$pk_R^{1+omegak_R} = \sum_A aks_{R,A} \times WK_{R,A}^{1+omegak_R} \qquad (nksup0_R \neq 0 \;\&\; omegak \neq inf) \qquad F15$$

$$ph_R^{1+omegah_R} = \sum_A ahs_{R,A} \times WH_{R,A}^{1+omegah_R} \qquad (nhsup0_R \neq 0 \;\&\; omegah \neq inf) \qquad F16$$

$$nksup_R = \sum_A nks_{R,A} \qquad (nksup0_R \neq 0 \;\&\; omegak = inf) \qquad F17$$

$$nhsup_R = \sum_A nhs_{R,A} \qquad (nhsup0_R \neq 0 \;\&\; omegah = inf) \qquad F18$$

$$PK_R = 0 \qquad (nksup0_R = 0) \qquad F19$$

$$PH_R = 0 \qquad (nhsup0_R = 0) \qquad F20$$

$$QKD_{R,A} = kslag_{R,A} + nks_{R,A} \qquad F21$$

$$QHD_{R,A} = hslag_{R,A} + nhs_{R,A} \qquad F22$$

$$QHD_{R,A} = (1-\delta_H)H(t) + RD_H(t) + \varphi_{i,t}\sum_i CR_{i,t-1} + \alpha_{i,t} GCR_R \qquad F23$$

$$ls_R = \sum_A QLD_{R,A} \qquad (ls0_R \neq 0 \;\&\; omegam2_R = inf) \qquad F24$$

$$ewage_R^{1+omegam2_R} = \sum_A aqld_{R,A} \times WL_{R,A}^{1+omegam2_R} \qquad (ls0_R \neq 0 \;\&\; omegam2_R \neq inf) \qquad F25$$

$$ewage_R = 1 \qquad (ls0_R = 0 \;\&\; omegam2_R = inf) \qquad F26$$

$$QLD_{R,A} = aqld_{R,A}\left(\frac{WL_{R,A}}{ewage_R}\right)^{omegam2_R} \times ls_R \qquad (QLD0_{R,A} \neq 0 \;\&\; omegam2_R \neq inf) \qquad F27$$

$$WL_{R,A} = phil_{R,A} \times ewage_R \qquad (QLD0_{R,A} \neq 0 \;\&\; omegam2_R = inf) \qquad F28$$

$$WL_{R,A} = 1 \qquad (QLD0_{R,A} = 0) \qquad F29$$

Where $totnksup$ and $totnhsup$ are the total quantity of new capital and new knowledge capital, $nksup_R$ and $nhsup_R$ are the new capital and new knowledge capital flowing to region R, $nks_{R,A}$ $nhs_{R,A}$ are the new capital and new knowledge capital flowing into region R and sector A, p$totk$ and p$toth$ are the national average return on capital and knowledge capital, pk_R and ph_R are the return on capital and knowledge capital on region R, $WK_{R,A}$ and $WH_{R,A}$ are the return on capital and knowledge capital on region R and sector A, $anksup_R$, $anhsup_R$, $aks_{R,A}$ and $ahs_{R,A}$ are scale parameters. Besides, $wnksup$ and $wnhsup$ are the elasticity of new capital and new knowledge capital flow among regions, and wk_R and wh_R are the elasticity of new capital and new knowledge capital flow among sectors in each region. In addition, ls_R is the total labor supply in region R, $QLD_{R,A}$ is the labor supply in region R and industry A, $WL_{R,A}$ is wage of $QLD_{R,A}$, $ewage_R$ is the average wage in region R, $plev_R$ is the regional average price, als_R and $phil_{R,A}$ are share parameters, $omega1_R$ is the elasticity of labor flow among regions.

1.5 Knowledge capital accounting and dynamics

First, the intermediate input matrix is derived from the basic Social Accounting Matrix (SAM). The R&D capital investment for each province and sector can be obtained from various statistical yearbooks (Levy and Terleckyj 1983; Wang, Wang, and Chen 2009; Wolff and Ishaq Nadiri 1993), thus forming the knowledge input matrix as **Eq. F30**. Subsequently, the original intermediate input matrix is adjusted by subtracting the knowledge input, resulting in the modified intermediate input matrix (**Eq. F31**). The row and column sums of the R&D matrix represent the R&D investment and knowledge capital for each sector, respectively. This approach ensures the GDP calculations remain unchanged. Additionally, the main sources of R&D funding in China are government funding, corporate funding, foreign funding. Given that the proportion of foreign funding is minimal, it is out of consideration in this paper.

$$W_{i,j} = \frac{VL_{i,j}}{\sum_j VL_{i,j}} INV_i^{R\&D} \qquad F30$$

$$VL_{i,j}^{adj} = VL_{i,j} - W_{i,j} \qquad F31$$

where $VL_{i,j}$ denotes the intermediate input matrix from the SAM table, $W_{i,j}$ represents the knowledge component of the intermediate input matrix, $INV_i^{R\&D}$ is the R&D investment for each sector, and $VL_{i,j}^{adj}$ is the adjusted intermediate input matrix.

Capital change is the key dynamic feature in a recursive dynamic CGE model. This study assumes that knowledge capital follows the same dynamic mechanism as general capital. Specifically, the knowledge factor is determined by the "knowledge capital stock". The next period's "knowledge capital stock" (*H(t+1)*) is influenced by the current year's R&D investment ($RD_H(t)$), the previous year's knowledge capital stock (*H(t)*), and the depreciation rate (δ_H), as shown in **Eq. F32**.

$$H(t+1) = RD_H(t) + (1-\delta_H)H(t) \qquad F32$$

Based on existing studies (Wang, Wang, and Chen 2009), we set the depreciation rate for physical capital at 3% (Jin 2012; Křístková 2012). Given that knowledge capital is updated more rapidly and does not involve residual machinery and equipment upon obsolescence, its depreciation rate is relatively higher, generally above 10% (Buonanno, Carraro, and Galeotti 2003; Bye and Jacobsen 2011; Wang, Wang, and Chen 2009). In this study, we use a depreciation rate of 15%.

1.6 Macro Closure

Macro closure reflects the economic theories, structures, and choices of exogenous variables in the model.

Neoclassical closure is employed in this CGE model, that is, investment is savings driven, and all savings are turned into fixed assets investment. The model has no financial assets, so overall consistency requires equating total domestic investment to national savings plus net foreign savings. The investment amounts by region and sector are endogenously determined by total investments, share parameters, and the price of capital, while the transport-related investment variables are exogenous. We nest the regional sectoral investment ($QINV_{R,C}$) into the fixed capital investment in region R (xf_R) through the CES function. And we do not specify the source of increased transport investment, like Jin (2019). It is determined endogenously by the model's saving investment equations (M1, M2, and M3).

$$xf_R \times pf_R + \sum_c PQ_{R,C} \times qinvt_{R,C} = \begin{pmatrix} \sum_h MPS_{R,H} \times (1-ty_{R,H}) YH_{R,h} + (YG_R - EG_R) \\ +EXR \times FSAV_R + ENTSAV_R \\ +\sum_{ROMC} SAVR_{R,ROMC} \times plev_{ROMC} \end{pmatrix} \qquad \text{M1}$$

$$\begin{aligned} &\sum_C pwe_{R,C} \times EXR \times QE_{R,C} + \sum_I tr_{R,I,row} \times EXR + FSAV_R \times EXR \\ &= \sum_C pwm_{R,C} \times EXR \times QM_{R,C} \end{aligned} \qquad \text{M2}$$

$$SAVR_{R,ROMC} \times plev_R = \begin{pmatrix} \sum_C (QMRS_{ROMC,C,R} \times PMRS_{ROMC,C,R} \\ -QDRS_{R,C,ROMC} \times PDRS_{R,C,ROMC}) \end{pmatrix} \qquad \text{M3}$$

Where pf_R is the price of capital goods, $af_{R,C}$ is the scale parameter, σf_R is the substitution elasticity of different regional investments, $qinvt_{R,C}$ is inventory investment, $ty_{R,H}$ is the household income tax rate, $MPS_{R,H}$ is household marginal saving rate, $YH_{R,h}$ is household income, YG_R is government revenue, EG_R is government goods consumption and transfers to other institutions, EXR is the exchange rate, $FSAV0_R$ is foreign savings, $ENTSAV_R$ is enterprise savings, and $SAVR0_{R,ROMC}$ is savings in other regions of the country.

1.7 Energy and Emission block

In our model, the emissions of 8 kinds of atmospheric emissions (e.g., CO_2, CH_4, N_2O, SO_2, NO_x, $PM_{2.5}$, PM_{10}, CO) are calculated by multiplying energy consumption by energy emission factors, and the various energy emission factors are referred to IPCC and and other institutions(EPA, 2006; NAEI, 2006). Our model includes 13 energy sources such as raw coal, washed coal, coke, gasoline, kerosene, diesel, fuel oil, natural gas, and electricity. The above multi-sectoral and multi-regional energy inventory data were obtained from CEADs(Guan et al., 2021; Shan et al., 2020; Shan et al., 2016). Then, the 13 energy sources in our model are divided into five types, including coal ($QCOAL_{R,A}$), crude oil and natural gas ($QOAG_{R,A}$), processed petroleum products and coking products ($QOIL_{R,A}$), gas ($QGAS_{R,A}$) and electricity ($QELE_{R,A}$).

$$QCOAL_{R,A} = CES\left\{QENERGY_{R,A,RAWCOAL}, QENERGY_{R,A,WASHCOAL}\right\} \qquad E1$$

$$QOAG_{R,A} = CES\left\{QENERGY_{R,A,CRUDE-OIL}, QENERGY_{R,A,NATURAL-GAS}\right\} \qquad E2$$

$$QOIL_{R,A} = CES\left\{QENERGY_{R,A,GASOLINE},.......,QENERGY_{R,A,DIESEL}\right\} \quad E3$$

$$QOIL_{R,A} = CES\left\{QENERGY_{R,A,GAS},.......,QENERGY_{R,A,OTHERGAS}\right\} \quad E4$$

$$EM_{R,A,EN} = EF_{EN} \times QENERGY_{R,A,EN} \quad E5$$

1.8 Dynamic block

This model adopts recursive dynamics, and the dynamic process is driven by labor, capital, and total factor technological progress. Labor growth ($gpop_R$) is an exogenous variable determined by a previous study (Liu, 2014). Capital is accumulated by current investment ($nks_{R,A}$, $nhs_{R,A}$) and capital after last year's depreciation ($kslag_{R,A}$, $hslag_{R,A}$). Different sectors have different growth rates for total factor productivity, which are used to calibrate the different growth paths of agriculture, industry and services.

$$ls_R = gpop_R \times ls0_R \quad D1$$

$$QKD_{t+1} = \left(1 - dep_K\right)QKD_t + nsk_t \quad D2$$

$$QHD_{t+1} = \left(1 - dep_H\right)QHD_t + nsh_t \quad D3$$

2 Calibration and projection of socioeconomic and carbon emissions

2.1 Simulation of economy development

The initial version of the model was presented in the work of Hu et al. (2019), and this study has been updated to incorporate data from 2017. Additionally, the model now includes an energy module and an end-of-pipe treatment module. The economic model encompasses 18 sectors and 14 energy-related sectors, which are detailed in Table S2 and Table S3, respectively. The dynamic nature of the model is driven by factors such as capital accumulation, labor growth, and total factor productivity (TFP) growth. The growth of provincial GDP from 2017 to 2021 has been calibrated based on data from the China Statistical Yearbook, while the growth rates from 2021 to 2030 are influenced by regional labor growth rates, saving rates, and TFP growth rates. The provincial GDP and industrial structure can be observed in Figure S4 and Figure S5, respectively.

Table S2. Definition of sectors in the model

Sector	Sub-sector	Abbreviations
Agriculture, Forestry, etc.	Agriculture, Forestry, Animal Husbandry and Fishery	A01AGR
Production of Coal and Mining Industry	Mining and washing of coal, Mining and processing of metal ores, Mining and processing of nonmetal and other ores	A02COAL
Petroleum and Natural Gas	Extraction of petroleum and natural gas	A03NGS
Processing of Food	Food and tobacco processing	A04FOOD
Textile Industry	Textile industry Manufacture of leather, fur, feather and related products	

Timber, Paper, etc.	Processing of timber and furniture Manufacture of paper, printing and articles for culture, education and sport activity	
Petroleum, Coking, etc.	Processing of petroleum, coking, processing of nuclear fuel	A05OIL
Chemical Products	Manufacture of chemical products	A06NMET
Non-Metallic Product	Manuf. of non -metallic mineral products	
Metallic Product	Smelting and processing of metals Manufacture of metal products	
Machinery and Equipment	Manufacture of general-purpose machinery Manufacture of special purpose machinery Manufacture of transport equipment Manufacture of electrical machinery and equipment Manufacture of communication equipment, computers and other electronic equipment Manufacture of measuring instruments Other manufacturing Comprehensive use of waste resources Repair of metal products, machinery and equipment	
Power Industry	Production and distribution of electric power and heat power	A07-POW-T and A07-POW-NT
Production of Gas	Production and distribution of gas	A08GAS
Production of Water	Production and distribution of tap water	
Construction	Construction	A09CON
Transport, Storage, etc.	Transport, storage, and postal services	A10TRAN
Other Service	Wholesale and retail trades Accommodation and catering Information transfer, software and information technology services Finance Real estate Leasing and commercial services Scientific research and polytechnic services Administration of water, environment, and public facilities Resident, repair and other services Education Health care and social work Culture, sports, and entertainment Public administration, social insurance, and social organizations	A11SERV

Table S3. Definition of energy-related sectors in the model

Sector	Description
Rawcoal	Raw coal
washedcoal	washed coal
curdeoil	Crude oil
Naturalgas	Natural Gas
coke	Coke
gasoline	gasoline
kerosene	kerosene
dieseloil	Diesel oil
fueloil	Fuel oil
otheroil	Other oil
cokegas	Coke gas
LPG	LPG
refinerygas	Refinery gas
othergas	Other gas

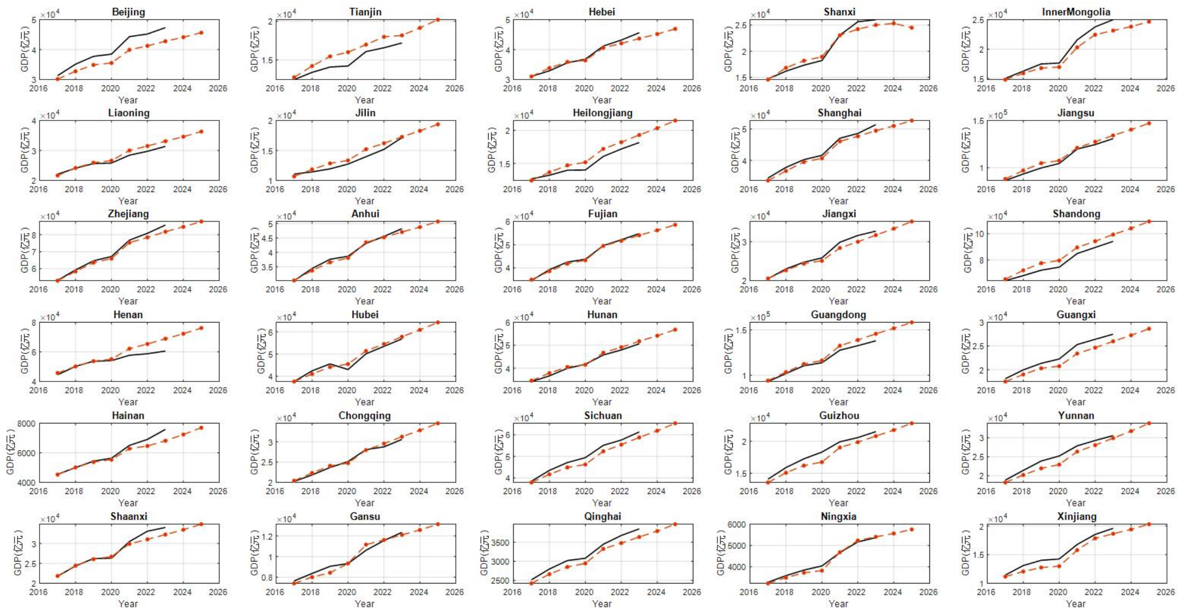

Fig. S3. Provincial GDP simulation of the Base scenario from 2017 to 2030.

Note: the red dots are from model simulation and the black dots are from the China Statistical Yearbook.

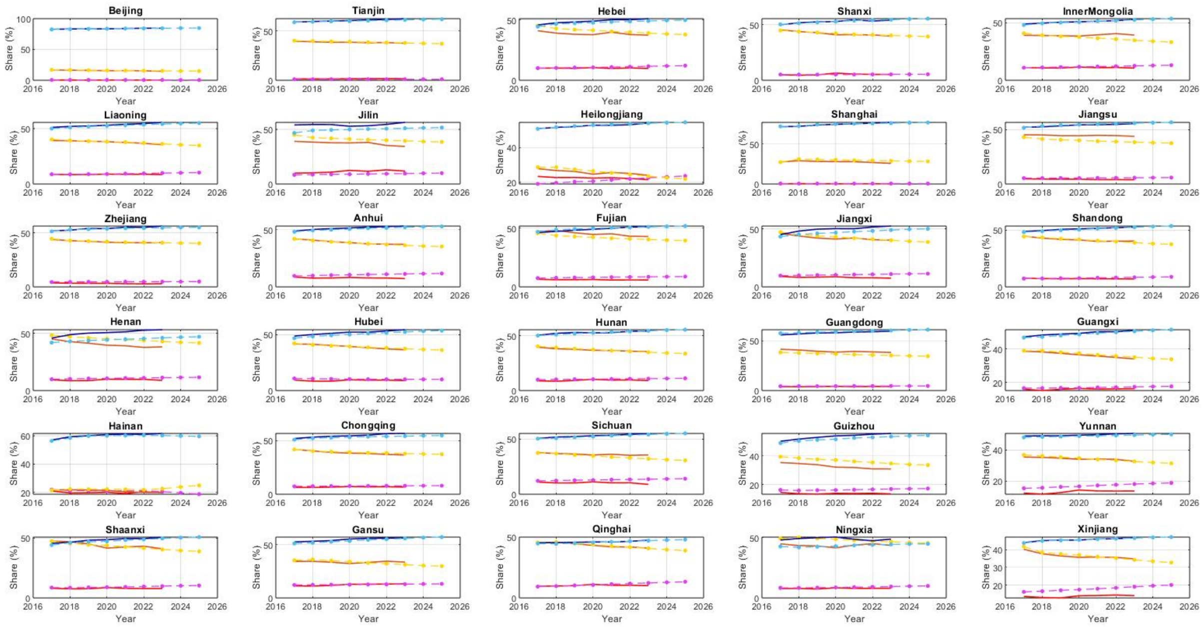

Figure S4. Provincial industrial structure simulation from 2017 to 2030.

Note: the dots are from this study, and the lines are from the China Statistical Yearbook. Reds, yellows, and blues are for the primary industry, the secondary industry, and the tertiary industry, respectively.

2.2 CO2 emission inventory for 2017

In this study, we calibrate the provincial carbon emission factors as shown in table S4.

Table S4. The provincial emissions of CO_2 for 2017 (Gg).

Province	CO_2	Province	CO_2
China	**935752.0**		
Beijing	7871.6	Henan	46170.7
Tianjin	13247.2	Hubei	30508.4
Hebei	72894.0	Hunan	29711.9
Shanxi	46790.1	Guangdong	51231.0
Inner Mongolia	60429.9	Guangxi	20966.0
Liaoning	45708.6	Hainan	3878.4
Jilin	18798.9	Chongqing	14770.6
Heilongjiang	25475.8	Sichuan	29333.4
Shanghai	18046.1	Guizhou	23704.5
Jiangsu	69725.0	Yunnan	18308.8
Zhejiang	35379.9	Shaanxi	25210.7
Anhui	35163.9	Gansu	13980.2
Fujian	21617.2	Qinghai	4920.7
Jiangxi	21066.1	Ningxia	16433.4
Shandong	76895.4	Xinjiang	37513.6

3 Parameters in the model

Table S5. Elasticities of production functions

	σ_P	σ_{VA}	σ_{tr}	σ_{KE}	σ_{EE}	σ_{IS}	σ_{CO}	σ_{OG}
Agriculture, Forestry, etc.	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Production of Coal	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Petroleum and Natural Gas	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Mining Industry	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Processing of Food	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Textile Industry	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Timber, Paper, etc.	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Petroleum, Coking, etc.	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Chemical Products	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Non Metallic Product	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Metallic Product	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Machinery and Equipment	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Power Industry	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Production of gas	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Production of water	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Construction	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Transport, Storage, etc.	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8
Other Service	0.05	0.01	0.8	0.8	2	1.2	1.4	1.8

Table S6. Elasticities in the commodities market

	σ_{SZ}	σ_{SX}	σ_X	σ_{DW}	σ_{DM}	σ_M
Agriculture, Forestry, etc.	4.0	4.0	4.0	2.2	2.2	2.2
Production of Coal	4.4	4.4	4.4	3.0	3.0	3.0
Petroleum and Natural Gas	4.4	4.4	4.4	3.0	3.0	3.0
Mining Industry	4.4	4.4	4.4	3.0	3.0	3.0
Processing of Food	4.6	4.6	4.6	3.2	3.2	3.2
Textile Industry	4.6	4.6	4.6	3.2	3.2	3.2
Timber, Paper, etc.	4.6	4.6	4.6	3.2	3.2	3.2
Petroleum, Coking, etc.	4.6	4.6	4.6	3.2	3.2	3.2
Chemical Products	4.6	4.6	4.6	3.2	3.2	3.2
Non Metallic Product	4.6	4.6	4.6	3.2	3.2	3.2
Metallic Product	4.6	4.6	4.6	3.2	3.2	3.2
Machinery and Equipment	4.6	4.6	4.6	3.2	3.2	3.2
Power Industry	3.0	3.0	0.5	2.0	2.0	0.9
Production of gas	3.0	3.0	0.5	2.0	2.0	0.9
Production of water	3.0	3.0	0.5	2.0	2.0	0.9
Construction	4.0	4.0	4.0	2.0	2.0	2.0
Transport, Storage, etc.	2.8	2.8	2.8	1.9	1.9	1.9
Other Service	2.8	2.8	2.8	1.9	1.9	1.9

Reference

EPA U, (2006). Emissions Factors & AP42[EB/0L]. US EPA

Guan Y R, Shan Y L, Huang Q, Chen H L, Wang D, Hubacek K, (2021). Assessment to China's Recent Emission Pattern Shifts. Earth Future, 9: 13

NAEI U, (2006). The Methodology of the National Atmospheric Emissions Inventory Appendix[OL]

Shan Y L, Huang Q, Guan, D B, Hubacek K (2020). China CO2 emission accounts 2016-2017. Scientific. Data, 7: 9

Shan Y L, Liu J H, Liu Z, Xu X W H , Shao S, Wang P, Guan D B, (2016). New provincial CO2 emission inventories in China based on apparent energy consumption data and updated emission factors. Applied. Energy, 184: 742-750

Yang Q, Hu X R, Wang Y Q, Liu Y, Liu J F, Ma J F, Wang X J, Wan Y, Hu J Y, Zhang Z B, Wang X L, Tao S, (2021). Comparison of the impact of China's railway investment and road investment on the economy and air pollution emissions. Journal of Cleaner Production, 293: 126100

Buonanno P, Carlo C, Marzio G (2003). Endogenous Induced Technical Change and the Costs of Kyoto. Resource and Energy Economics, 25 (1): 11–34

Bye B, Karl J (2011). Restricted Carbon Emissions and Directed R&D Support; an Applied General Equilibrium Analysis. Energy Economics, 33 (3): 543–55

Jin Wei (2012). Can Technological Innovation Help China Take on Its Climate Responsibility? An Intertemporal General Equilibrium Analysis. Energy Policy, Special Section: Fuel Poverty Comes of Age: Commemorating 21 Years of Research and Policy, 49 (October):629–41

Křístková Z (2012). Impact of R&D Investment on Economic Growth of the Czech Republic - A Recursively Dynamic CGE Approach. Prague Economic Papers, 21 (4): 412–33

Levy D M, Nestor E. Terleckyj (1983). Effects of Government R&D on Private R&D Investment and Productivity: A Macroeconomic Analysis. The Bell Journal of Economics, 14 (2): 551

Wang, K, Wang C, Chen J (2009). Analysis of the Economic Impact of Different Chinese Climate Policy Options Based on a CGE Model Incorporating Endogenous Technological Change. Energy Policy, 37 (8): 2930–40

Wolff E N, Nadiriand M I (1993). Spillover Effects, Linkage Structure, and Research and Development. Structural Change and Economic Dynamics, 4 (2): 315–31