

Supplementary Materials: High spatial resolution emission inventory of air pollutants and carbon in China's independent coking industry

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Section S1: The relationship between the production of coke and GDP.

According to our estimates, the GDP of China can be accurately predicted by Linear fitting method in Figure S6. We found that the natural logarithm of GDP is a strong linear predictor of the natural logarithm of production of coke. According to the GDP values of several years and the investigated data of the renewal production of coke in independent coking industry, this paper predicted the production of coke in independent coking industry in the next decades (Figure S7).

Table S1. Emission concentration and theoretical flue gas rate for coking.

Emission source	level	Scale Structure	Concentration (GB 16171-2012) (mg/Nm ³)			Concentration (GB 16171-1996) (mg/Nm ³)			Theoretical flue gas rate (Nm ³ /t)
			SO ₂	NO _x	PM ₁₀	SO ₂	NO _x	PM ₁₀	
Coal preparation	First	≥ 100,000 t/a	-	-	15	-	-	-	604
	Second	60,000 t/a-100,000 t/a	-	-	30	-	-	300	601
	Third	< 60,000 t/a	-	-	50	-	-	-	596.4
Coal charging	First	≥ 100,000 t/a	70	-	30	-	-	-	556.67
	Second	60,000 t/a-100,000 t/a	100	-	50	500	-	300	522
	Third	< 60,000 t/a	150	-	100	-	-	-	525.9
Pushing	First	≥ 100,000 t/a	30	-	30	-	-	-	1670.33
	Second	60,000 t/a-100,000 t/a	50	-	50	500	-	300	1624
	Third	< 60,000 t/a	100	-	100	-	-	-	1624.1
Coke oven chimney	First	≥ 100,000 t/a	200	500	15	-	-	-	1471.33
	Second	60,000 t/a-100,000 t/a	200	500	15	500	-	300	1548.67
	Third	< 60,000 t/a	200	500	15	-	-	-	1548.67
Quenching	First	≥ 100t/a	100	-	50	-	-	-	928
	Second	60,000 t/a-100,000 t/a	100	-	50	500	-	300	928
	Third	< 60,000 t/a	100	-	50	-	-	-	928

Note: Nm³ represents the volume of gas at 273.15 K and 1 standard atmosphere.

Table S2. Emission factors based on coking industry emission standards (unit: kg/t).

Emission source	level	Scale Structure	SO ₂		NO _x		PM ₁₀	
			2012	1996	2012	1996	2012	1996
Coal preparation	First	≥ 100,0000 t/a	-	-	-	-	0.009	-
	Second	60,0000 t/a- 100,0000 t/a	-	-	-	-	0.018	0.179
	Third	< 60,0000 t/a	-	-	-	-	0.030	-
Coal charging	First	≥100,0000 t/a	0.039	-	-	-	0.017	-
	Second	60,0000 t/a- 100,0000 t/a	0.052	0.263	-	-	0.026	0.158
	Third	< 60,0000 t/a	0.079	-	-	-	0.053	-
Pushing	First	≥100,0000 t/a	0.050	-	-	-	0.050	-
	Second	60,0000 t/a- 100,0000 t/a	0.081	0.812	-	-	0.081	0.487
	Third	< 60,0000 t/a	0.162	-	-	-	0.162	-
Coke oven chimney	First	≥100,0000 t/a	0.294	-	0.736	-	0.022	-
	Second	60,0000 t/a- 100,0000 t/a	1.549	1.549	0.774	0.774	0.023	0.465
	Third	< 60,0000 t/a	1.549	-	0.774	-	0.023	-
Quenching	First	≥ 100t/a	0.093	-	-	-	0.046	-
	Second	60,0000 t/a- 100,0000 t/a	0.093	0.464	-	-	0.046	0.278
	Third	< 60,0000 t/a	0.093	-	-	-	0.046	-

Table S3. Emission factors of coke oven chimney based on CEMS in 2015 and 2018 (unit:kg/t).

Province	PM ₁₀	2015			2018		
		PM ₁₀	SO ₂	NO _x	PM ₁₀	SO ₂	NO _x
AH	0.034	0.134	0.596	0.018	0.036	0.319	
FJ	0.034	0.134	0.596	0.018	0.036	0.319	
GS	0.029	0.045	0.596	0.012	0.055	0.027	
GD	0.034	0.134	0.596	0.004	0.014	0.162	
GX	0.034	0.134	0.596	0.011	0.072	0.404	
GZ	0.034	0.134	0.596	0.018	0.036	0.319	
HE	0.031	0.067	0.632	0.012	0.021	0.225	
HA	0.031	0.104	0.681	0.014	0.009	0.14	
HL	0.034	0.134	0.596	0.018	0.036	0.319	
HB	0.034	0.134	0.596	0.018	0.036	0.319	
HN	0.034	0.134	0.596	0.009	0.015	0.025	
JL	0.034	0.134	0.596	0.023	0.029	0.479	
JS	0.034	0.134	0.596	0.014	0.028	0.328	
JX	0.047	0.352	0.589	0.016	0.043	0.318	
LN	0.034	0.134	0.596	0.027	0.033	0.335	
NM	0.028	0.061	0.628	0.022	0.048	0.518	
NX	0.034	0.134	0.596	0.018	0.036	0.319	
QH	0.034	0.134	0.596	0.018	0.036	0.319	

SD	0.034	0.134	0.596	0.02	0.041	0.445
SX	0.034	0.11	0.501	0.02	0.042	0.295
SN	0.034	0.134	0.596	0.018	0.036	0.319
SH	0.034	0.134	0.596	0.018	0.036	0.319
SC	0.034	0.134	0.596	0.036	0.079	0.355
TJ	0.034	0.134	0.596	0.018	0.036	0.319
XJ	0.034	0.134	0.596	0.026	0.077	0.724
YN	0.034	0.134	0.596	0.018	0.036	0.319
ZJ	0.034	0.134	0.596	0.019	0.044	0.515
CQ	0.043	0.296	0.565	0.018	0.036	0.319
TOTAL	0.034	0.134	0.596	0.018	0.036	0.319

Table S4. Proportion of PM_{2.5} in PM₁₀ (%).

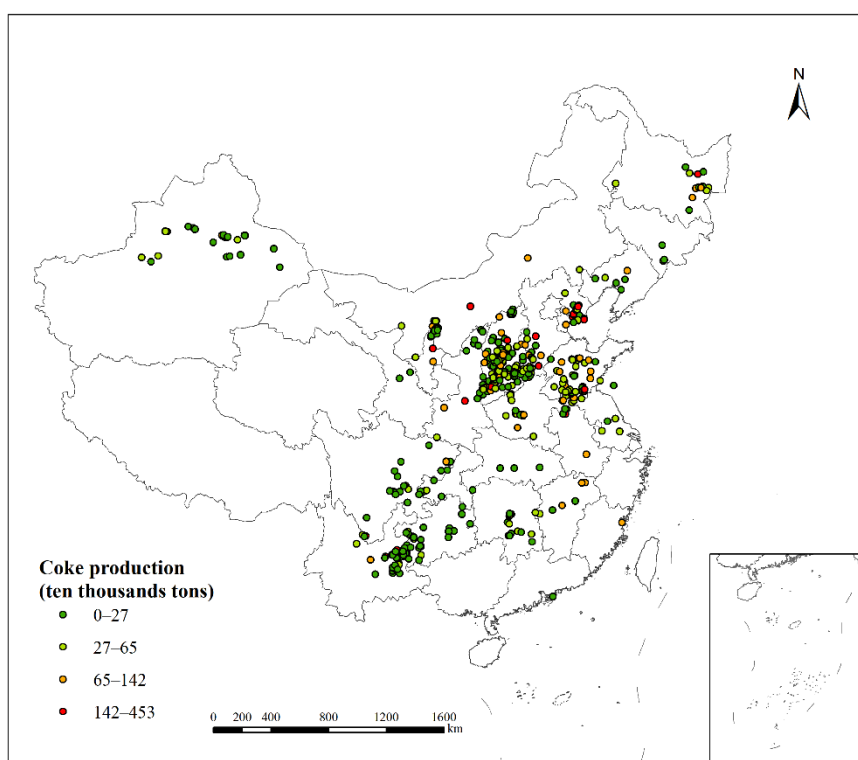
Quenching	Coal preparation	Coal charging and pushing	Coke oven chimney
30.46 ¹	37.78 ¹	40.97 ¹	40.97 ¹

¹(Zhang, 2015).**Table S5.** Emission factors for other pollutants.

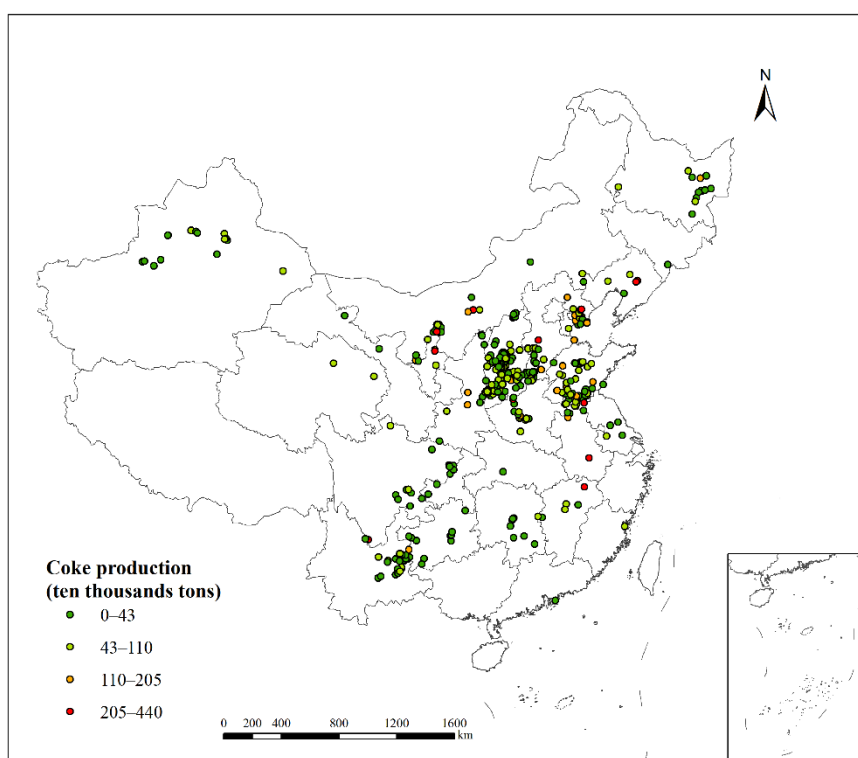
Pollutants	VOCs (kg/t)	CO (kg/t)	BC (%)	OC (%)
Emission factor	2.96 ²	1.6 ²	30 ³	35 ³

²(He, 2017) ³(Lei, 2008).**Table S6.** Emission concentration and emission factors for coking under the ULE index.

Emission source	Concentration (mg/Nm ³)			Emission factors (kg/t)		
	SO ₂	NO _x	PM ₁₀	SO ₂	NO _x	PM ₁₀
Coal preparation	0.000	0.000	10.000	0.000	0.000	0.006
Coal charging	0.000	0.000	10.000	0.000	0.000	0.005
Pushing	0.000	0.000	10.000	0.000	0.000	0.016
Coke oven chimney	30.000	150.000	10.000	0.046	0.232	0.015
Quenching	50.000	0.000	10.000	0.046	0.000	0.009

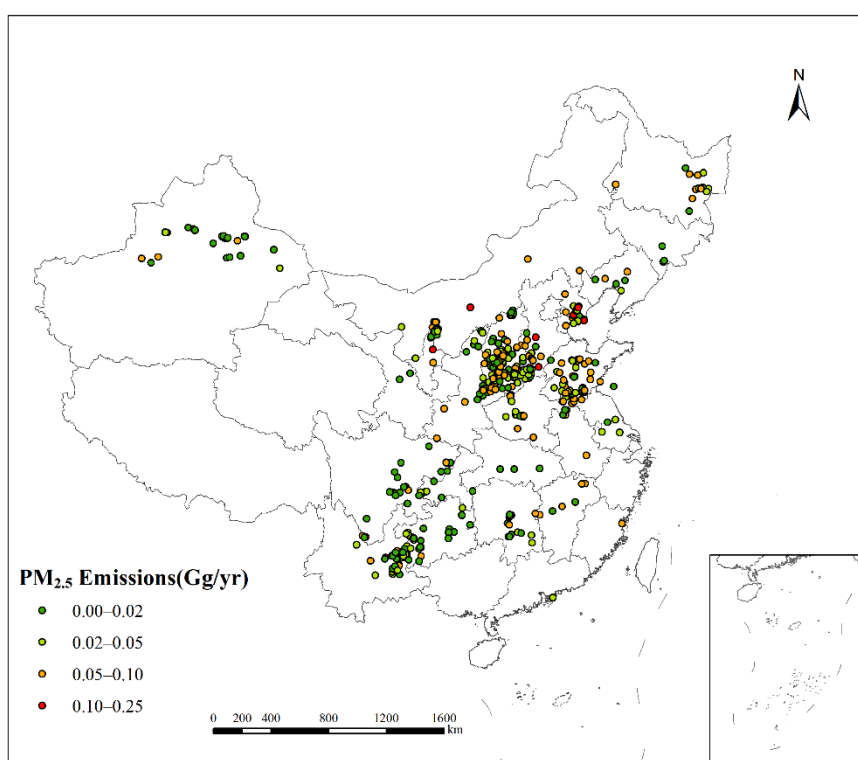
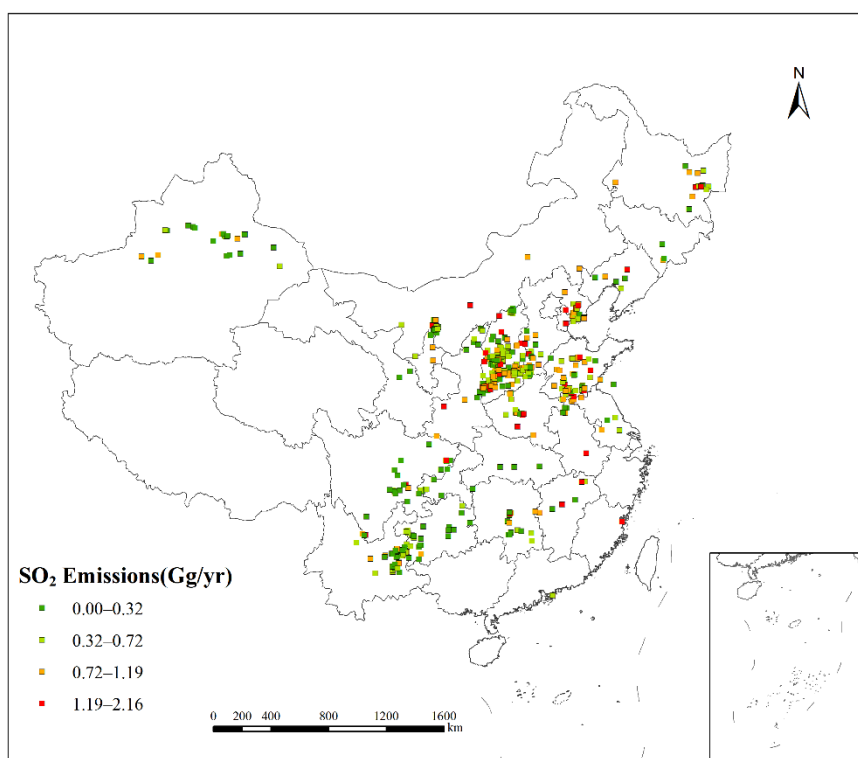


(a) 2012



(b) 2015

Figure S1. Distribution and scale of production of China's independent coking industry in 2012(a) and 2015(b).

(a) PM_{2.5} Emissions(b) SO₂ Emissions

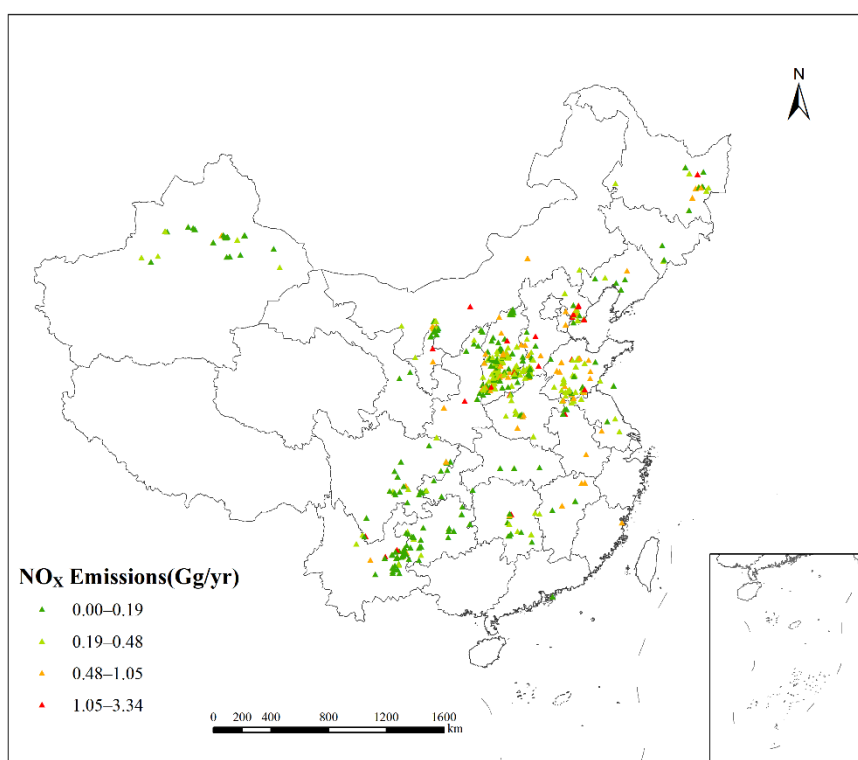
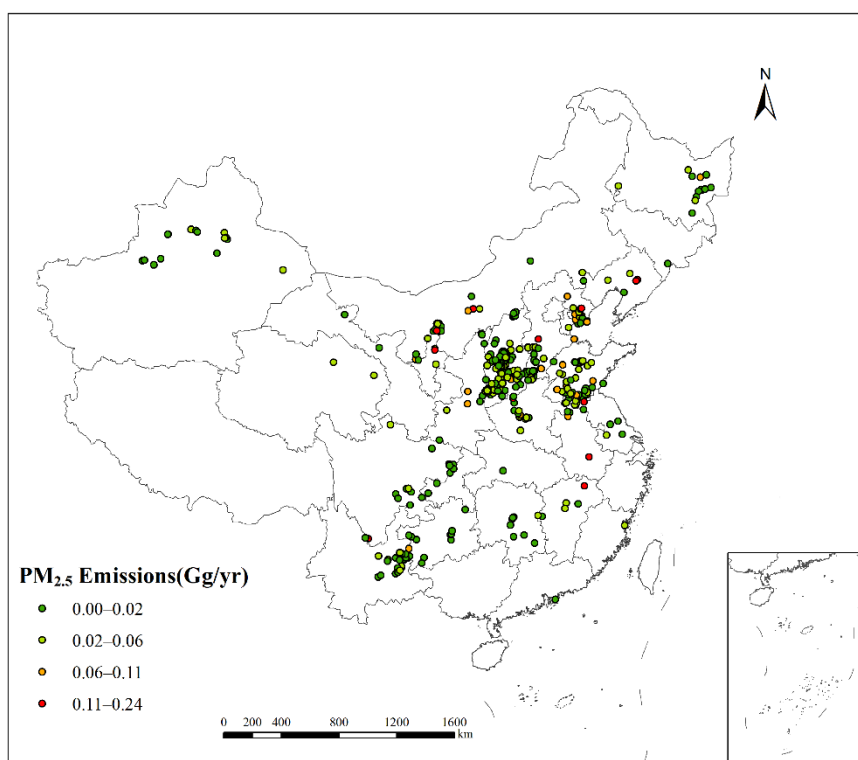
(c) NO_x Emissions

Figure S2. Spatial distributions of PM_{2.5}(a), SO₂(b), and NO_x(c) emissions of China's independent coking industry in 2012.

(a) PM_{2.5} Emissions

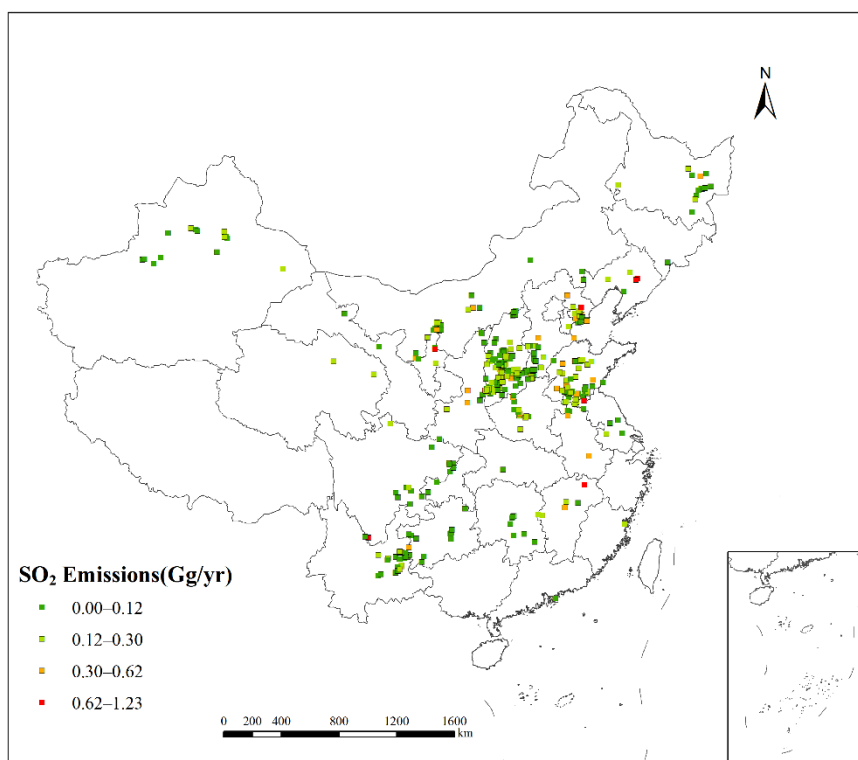
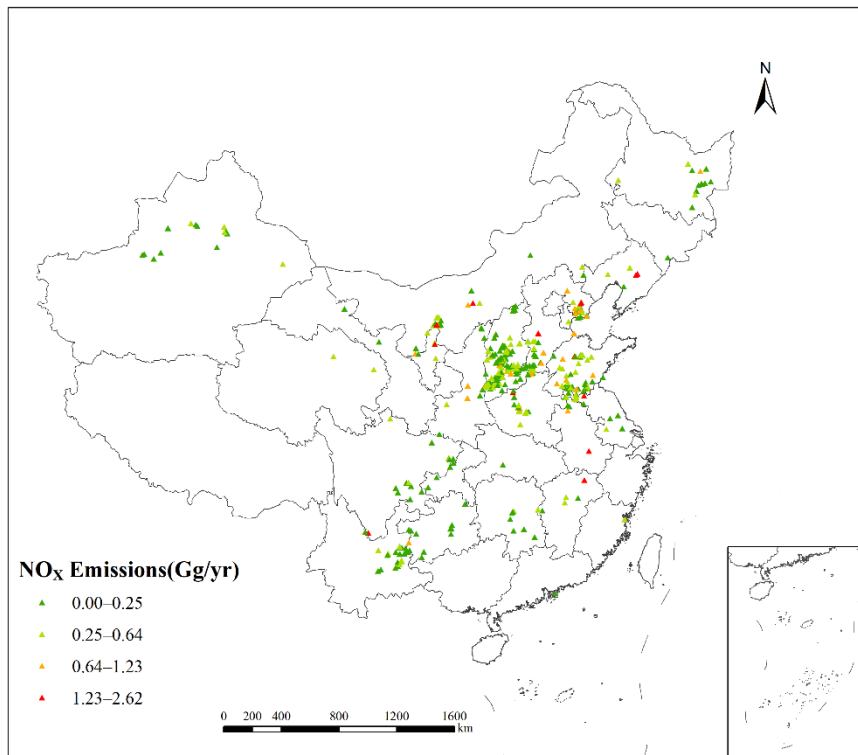
(b) SO₂ Emissions(c) NO_x Emissions

Figure S3. Spatial distributions of PM_{2.5}(a), SO₂(b), and NO_x(c) emissions of China's independent coking industry in 2015.

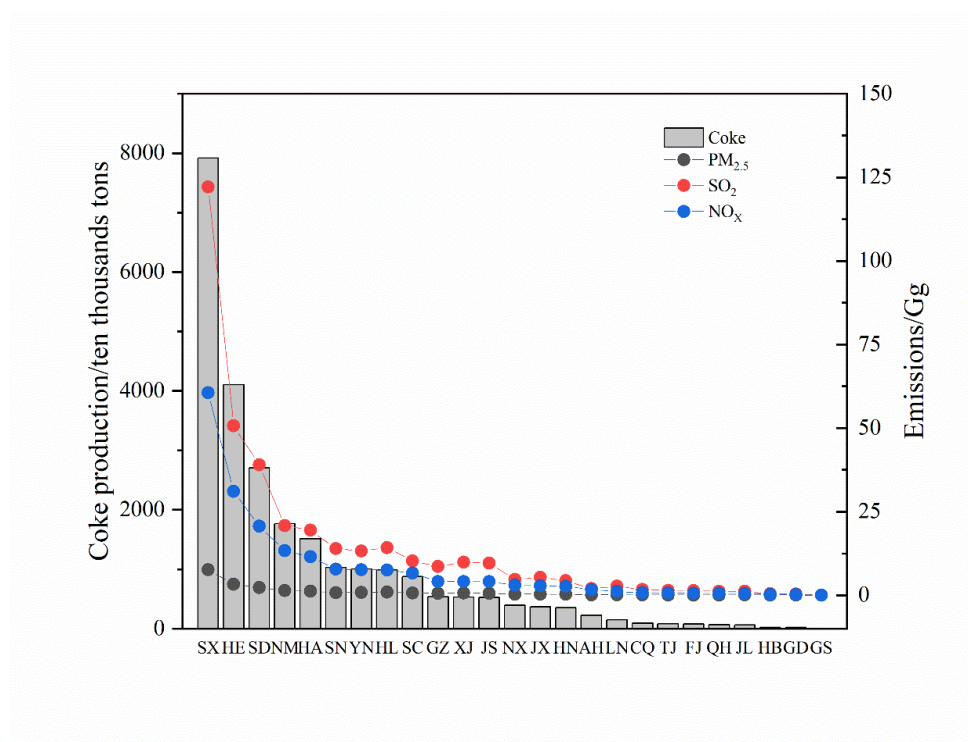


Figure S4. Provincial production of coke and emissions of SO_2 , NO_x , and $\text{PM}_{2.5}$ of China's independent coking industry in 2012.

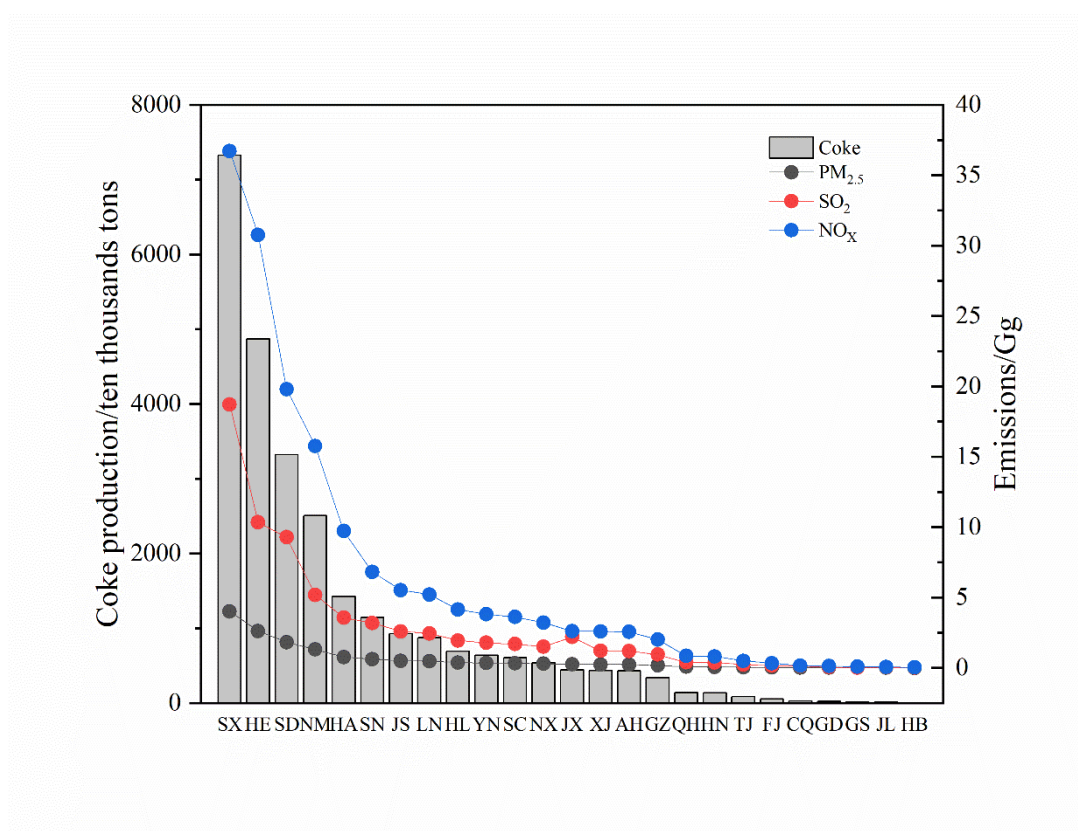


Figure S5. Provincial production of coke and emissions of SO_2 , NO_x , and $\text{PM}_{2.5}$ of China's independent coking industry in 2015.

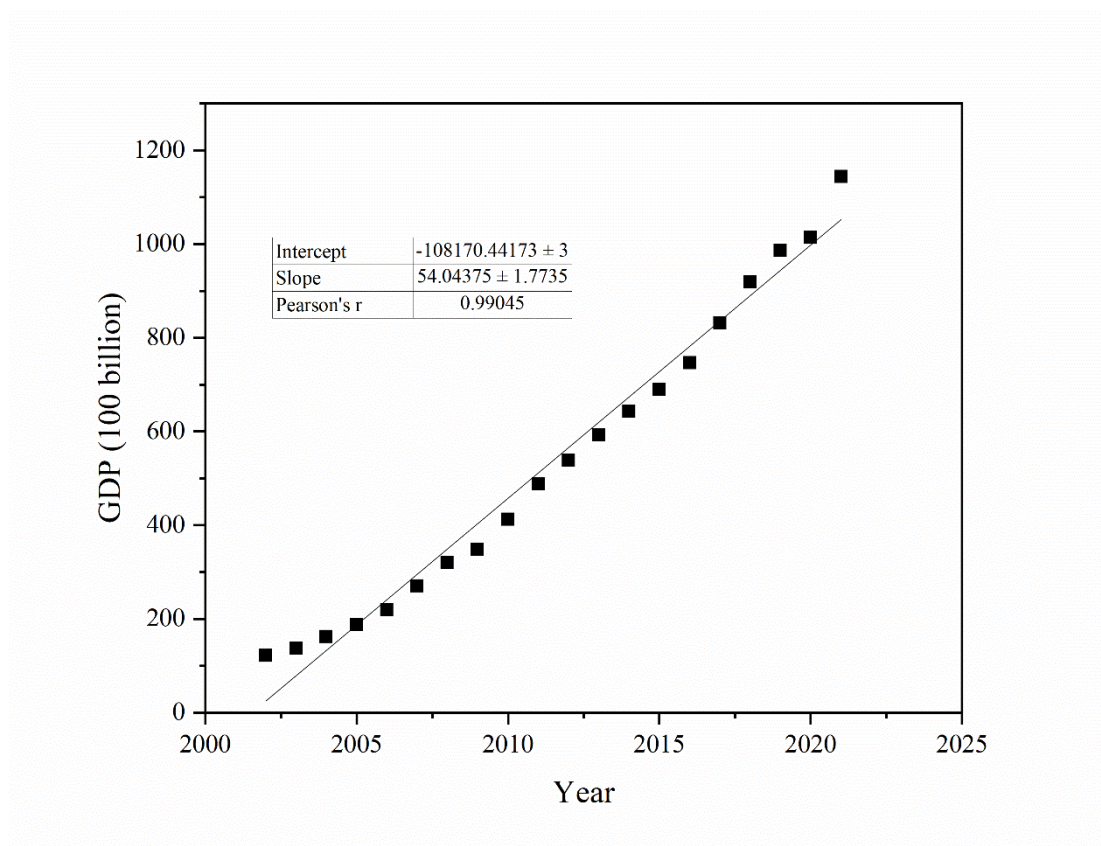


Figure S6. The prediction of GDP.

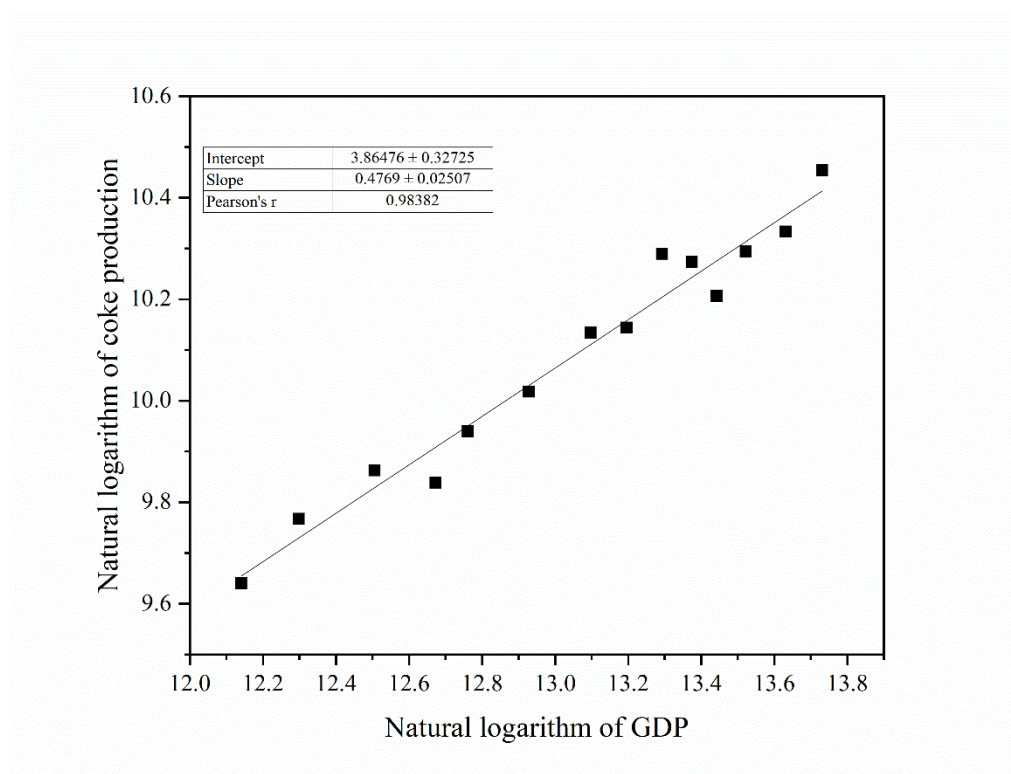


Figure S7. The relationship between production of coke and GDP.

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