Air Pollution Quotas and the Dynamics of Internal Skilled Migration in Chinese Cities

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November 23, 2020

[1]Presenter

Internal Migration: The Global Phenomenon

US (Molloy et al., 2011; JEP) and Europe (Cheng et al., 2014).

In China,

- Internal migrants exceed 225 million (NBS Census, 2010);
- Central-to-East Movement before 2010
- East-to-Central and West after 2010 (Wu et al., 2018; Khanna, 2019, NBER)

Air pollution spurs Chinese people's out-migration interests: Qin and Zhu (2017, J.Pop.Econ)

Air Pollution in China

Speaking of **Solution**

- Binary: Two-Control Zone (TCZ, "两控区") : Tanaka (2015, JHE)
- Continuous: Target-based 11^{th} Five-Year Plan: Chen et al. (2018, JEEM)

Speaking of **Policy Cost**

- Decrease employment due to Clean Air Act: Walker (2011; AER)
- GDP growth reduction in 11th Five-Year Plan: Chen et al. (2018b, JDE)

Speaking of **Identification**

- Cross-section: TCZ status and continuous SO_2 quota
- Time variation: 11^{th} FYP (2006 - 2010)
- thus, Diff-in-Diff

In This Paper

1. Investigate distribution effects of air pollution regulation on internal skilled migration using annual data

2. Explore the sectoral job transitions due to policy regulation

Comparing with Important Works

Air Pollution Induced Migration

1. Internal migration in China; four censuses data: Chen, Oliva & Zhang (2017, NBER)

2. Skilled worker leaves polluted areas and increases output (three census data and CLDS): Khanna et al. (2019, NBER)

Environmental Regulation Induced Migration

1. Labour Reallocation and decreased employment on Clean Air Act in 1990 in US: Walker (2011, AER; 2013, AER P&P)

2. Air Pollution Prevention and Control Law in 1998 in China (long difference of two censuses data for 286 cities; proxy SO2 for law; IV): Chen (2019, W.P.)

Contributions

1. Decomposing change of relative labour demand due to environmental regulations into industrial levels; investigating the redistribution in high-skill occupations

2. Addresses a policy-relevant question: to what extent do environmental regulations in developing countries redistribute high-skilled workforce?

3. One of very few papers looking at the unexpected effects of environmental regulation on internal labour migration dynamics in China.

4. Using continuous measurement in addition to binary treatment at Tanaka (2015; JHE) and Chen et al. (2018b; JDE)

Outmigration Variables

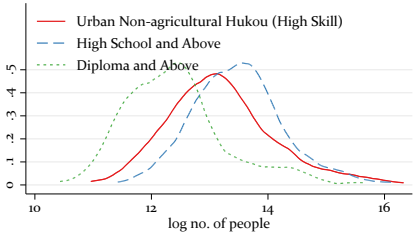
- **Total internal migration:** move Hukou (Qin and Liao, 2016, CER; Rafiq et al., 2017, Ener.Econ.)
- **High-skilled labour:** move urban non-agricultural Hukou
- **Low-skilled labour:** move rural Hukou

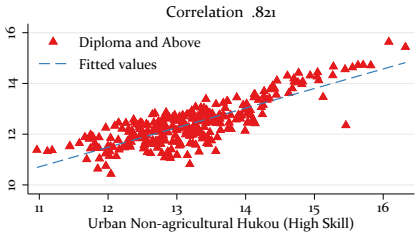
Formula: residual method (Feng et al., 2010, PNAS; Chen, Oliva and Zhang, 2017, NBER)

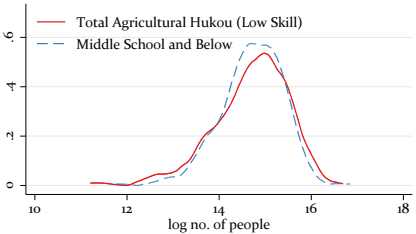
$$y_{c,t} = \frac{NonAgr_{c,t-1} - NonAgr_{c,t}}{NonAgr_{c,t-1}} - Natural\ Pop.\ Growth\%_{c,t}.$$

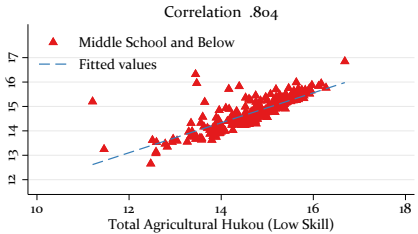
Positive $y_{c,t}$: net out-migration rate; Negative: net in-migration rate

Compare with 31 Provincial Census Books (2010)

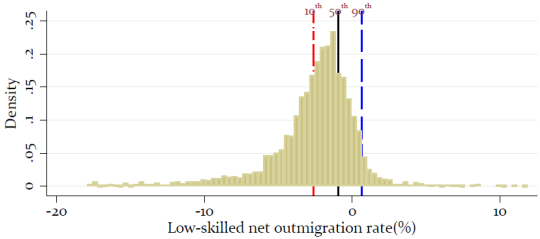


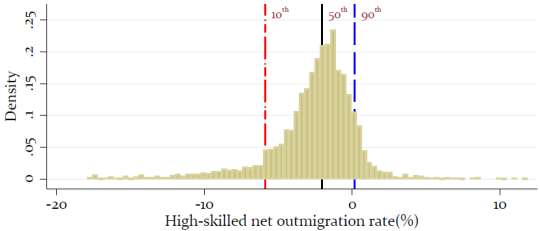




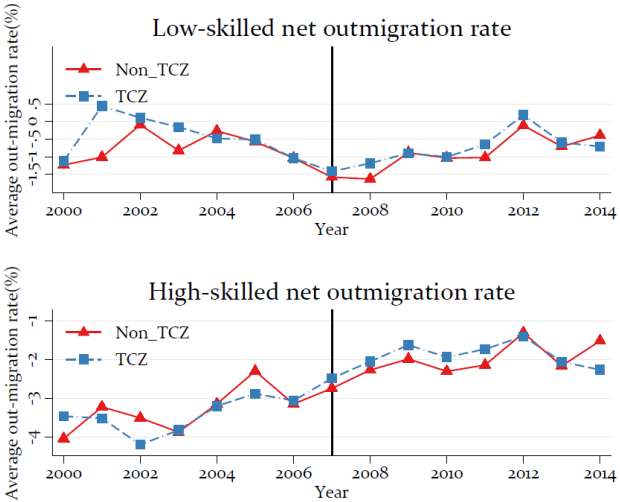


Distribution of Migration Variables





Outmigration Trends for Low and High Skills



Continuous Measurement: SO_2 Quota

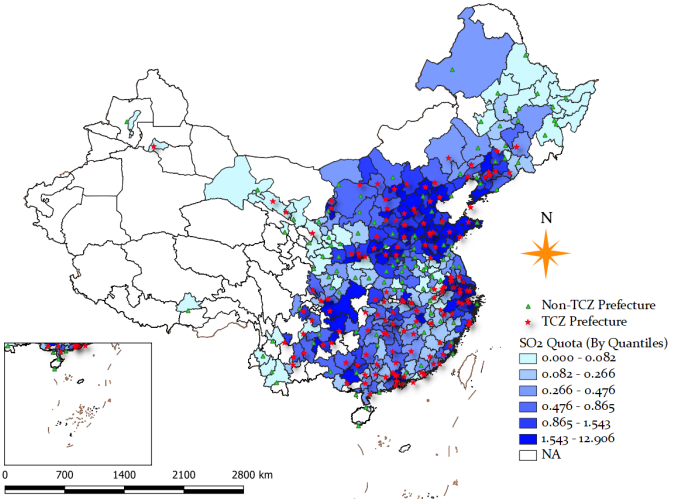
- Measured by production activity in 2005 using industrial firm data: Chen et al. (2018b, JEEM)

$$SO_2\ Quota_{c,05-10} = \Delta Quota_{p,05-10} \cdot \sum_{i=1}^{39} \mu_i \frac{output\ value_{i,c}}{output\ value_{i,p}}.$$

- μ_i is proportion of industrial SO2 emission.

- $Quota_{p,05-10}$ is reduction amount of provincial SO2 emission in 5 years.

Two-Control Zone vs Continuous SO_2 Quota



TCZ vs Non-TCZ Prefectures

Description	(1) TCZ Mean	(2) Non-TCZ Mean
Sectoral Employment (2000-2005):		
Share of employees of primary industry (%)	3.48	7.23
Share of employees of secondary industry (%)	44.92	37.17
Share of employees of tertiary industry at urban district (%)	48.20	51.87
Unemployment in log form (ppl.)	9.82	9.44
Provincial employment share for air polluted industries (%)	3.67	1.96
TCZ Selection Variables:		
Average SO2 concentration 1990-1995 (ug/m3)	16.63	12.50
Average Elevation (metre)	309.9	455.2
Average tempurature 1990-1995 (℃)	15.23	13.03
Sunshine Duration 1990-1995 (0.1 hrs)	5.34	5.91
Average humidity 1990-1995 (1%)	0.72	0.70
Average daily precipitation 1990-1995 (0.1 mm)	10638	8708
Average wind speed 1990-1995 (0.1 m/s)	22.23	22.40
Percentage of days in a year no greater than 5 ℃ 1990-1995 (%)	0.17	0.24

Identification

$$y_{c,t} = \beta_1 \times TCZ_c \times Post_t + \mathbf{X_{ct}} + \mathbf{Z_c} \times \mathbf{f(t)} + \delta_c + \lambda_t + \epsilon_{c,t}$$

$$y_{c,t} = \beta_1 \times Quota_c \times Post_t + \mathbf{X_{ct}} + \mathbf{Z_c} \times \mathbf{f(t)} + \delta_c + \lambda_t + \epsilon_{c,t}$$

- Z_c is a vector of TCZ selection variable averaged from 1990 - 1995
- f(t) is a third-order polynomial time trends
- $\mathbf{X_{ct}}$: Push-pull factors that explains outmigration
- δ_c, λ_t: prefecture and year fixed effects

Balancing Test

	(1) **Non-TCZ**	(2) **TCZ**	(3)	(4)	(5)	(6)
VARIABLES	Mean	Mean	Unconditional difference	**Conditional Difference (Prior)**	**Conditional Difference (11th FYP)**	**Conditional Difference (Whole)**
High student/Teachers at urban (%)	17.461	16.304	1.156	-0.668	0.465	-0.051
Doctor × Hospital beds/Hospital no. (log unit)	11.621	12.255	-.634***	-0.030	0.034	0.067
Green coverage rate (%)	27.358	29.253	-1.895	0.301	-1.041	-0.805
Prefecture GDP value (log 10,000 CNY)	14.358	14.913	-0.555***	-0.029	-0.012	-0.013
Social commodity consumption in log (10,000 CNY)	13.279	13.921	-0.642***	0.059	0.010	-0.003
Constructed areas (log hectare)	3.558	3.985	-0.427***	-0.012	-0.031	-0.016
Green land (log hectare)	6.815	7.344	-0.529***	-0.024	-0.040	-0.058
Retail Sale (log billion CNY)	13.123	13.991	-0.868***	0.109	-0.016	-0.038
Total Paved road (log KM2)	5.552	6.041	-0.489***	0.006	0.016	0.019
Urban unemployment (log)	8.411	8.963	-0.664***	0.144	-0.010	-0.055
Year coverage	2000	2000		2000	2000-2010	2000-2014

The Effect of SO2 Quota on Internal Migration

	(1)	(2)	(3)	(4)
Panel A: Total Net Outmigration Rate				
TCZ × Post2006	0.206	0.048		
	(0.131)	(0.106)		
Quota × Post2006			0.073*	0.024
			(0.038)	(0.026)
Observations	3,021	4,140	3,021	4,140
Panel B: Low-Skilled Net Outmigration Rate				
TCZ × Post2006	-0.101	-0.173		
	(0.226)	(0.198)		
Quota × Post2006			-0.032	-0.034
			(0.127)	(0.097)
Observations	2,857	3,919	2,857	3,919
Panel C: High-Skilled Net Outmigration Rate				
TCZ × Post2006	0.413	0.140		
	(0.285)	(0.218)		
Quota × Post2006			0.150*	0.133
			(0.085)	(0.083)
Observations	2,849	3,919	2,849	3,919
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
TCZ Controls × f(t)	Yes	Yes	Yes	Yes
Prefecture Controls	Yes	Yes	Yes	Yes
Year Coverage	2000-2010	2000 - 2014	2000-2010	2000 - 2014

Beyond ATT: SO_2 Quota for Non-Top 10 Cities

$$y_{c,t} = \beta_1(Quota_c \times Post_t \times Non\_Top10_c) + \mathbf{X_{ct}} + \mathbf{Z_c} \times \mathbf{f(t)} + \delta_c + \lambda_t + \epsilon_{c,t},$$

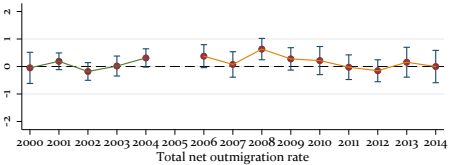
VARIABLES	(1) Low-Skilled Net Outmigration Rate	(2) Low-Skilled Net Outmigration Rate	(3) High-Skilled Net Outmigration Rate	(4) High-Skilled Net Outmigration Rate
TCZ × Post × Top10	-1.293		-0.862	
	(1.431)		(0.633)	
Quota × Post × Top10		-0.044		-0.088
		(0.171)		(0.096)
TCZ × Post × Non_Top10	0.034		0.519*	
	(0.238)		(0.270)	
Quota × Post × Non_Top10		-0.017		0.290***
		(0.168)		(0.088)
Observations	2,857	2,857	2,849	2,849
City FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
TCZ Controls × f(t)	Yes	Yes	Yes	Yes
Prefecture Controls	Yes	Yes	Yes	Yes
Year Coverage	2000-2010	2000-2010	2000-2010	2000-2010

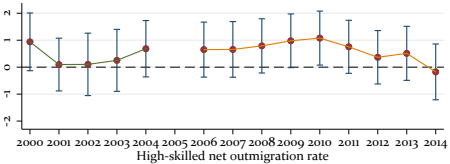
Mechanism 1: Change in Industrial Relative Labour Demand

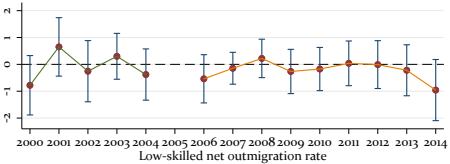
Data: Annual Survey of Industrial Manufacturing Firms Cons

- survey firms with 500 million revenue plus (omitted firms due to inflation)
- survey firms with 2000 million revenue plus (incomparable)

Decomposing Effects of Air Regulation for Non-mega Cities







Mechanism 1: Change in Industrial Relative Labour Demand

- Data: Annual Survey of Industrial Manufacturing Firms (ASIF, 2000-2013)
- Adjusting survey cut-off
  1. Using total employment in each province at each year

$$EmpShare\_Prov_{i,c,t} = \sum \frac{Employment\ at\ industry\ i\ in\ city\ c\ at\ year\ t}{Employment\ in\ Province\ p\ at\ year\ t}.$$

  2. Using national employment at each year

$$EmpShare\_Total_{i,c,t} = \sum \frac{Employment\ at\ industry\ i\ in\ city\ c\ year\ t}{Employment\ in\ year\ t}.$$

An illustration: Power Plants Location

DiD for Relative Labour Demand

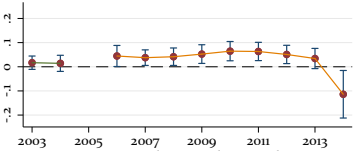
VARIABLES	(1)	(2) EmpShare_Province	(3)	(4)
Panel A: Six Top Polluting Industries (SO2: 89%)				
TCZ × Post2006	-0.030*		-0.050***	
	(0.016)		(0.019)	
Quota × Post2006		-0.011		-0.023**
		(0.009)		(0.011)
Observations	16,601	16,601	21,176	21,176
Panel B: Electricity, heat production and supply industry (SO2: 59%)				
TCZ × Post2006	0.073*		0.081	
	(0.041)		(0.053)	
Quota × Post2006		0.022		0.010
		(0.028)		(0.041)
Observations	3,012	3,012	3,830	3,830
Panel C: Non-metal mineral products (SO2: 9%)				
TCZ × Post2006	-0.062***		-0.085***	
	(0.021)		(0.030)	
Quota × Post2006		-0.038***		-0.061***
		(0.010)		(0.021)
Observations	3,037	3,037	3,848	3,848
Panel D: Ferrous metal smelting and pressing (SO2: 7.2%)				
TCZ × Post2006	-0.082*		-0.133**	
	(0.046)		(0.054)	
Quota × Post2006		-0.050**		-0.076***
		(0.023)		(0.023)
Observations	2,797	2,797	3,537	3,537
Panel E: Chemical materials and products (SO2: 5.9%)				
TCZ × Post2006	-0.005		-0.048	
	(0.029)		(0.033)	
Quota × Post2006		-0.031**		-0.035***
		(0.013)		(0.011)
Observations	3,031	3,031	3,848	3,848
Year Coverage	2000-2010	2000-2010	2000-2013	2000-2013

DDD for Relative Labour Demand

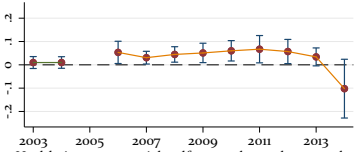
$$EmpShare_{i,c,t} = \beta_1(TCZ_c \times Post_t \times Dirty_i) + \delta_{it} + \gamma_{ct} + \lambda_{it} + \epsilon_{i,c,t}.$$

VARIABLES	(1)	(2)	(3)	(4)
	EmpShare_Prov			
Panel A: Dirty Industries				
TCZ × Post2006 × Dirty	-0.0409**	-0.0530***		
	(0.0201)	(0.0188)		
Quota × Post2006 × Dirty			-0.0145*	-0.0204*
			(0.0087)	(0.0109)
Observations	91,172	116,088	91,172	116,088
Panel B: Excluding Energy Industry				
TCZ × Post2006× Dirty	-0.0520***	-0.0787***		
	(0.0199)	(0.0212)		
Quota × Post2006 × Dirty			-0.0214**	-0.0274**
			(0.0089)	(0.0110)
Observations	88,123	112,207	88,123	112,207
City-Year FE	Yes	Yes	Yes	Yes
Ind-Year FE	Yes	Yes	Yes	Yes
City-Ind FE	Yes	Yes	Yes	Yes
Year Coverage	2000-2010	2000-2013	2000-2010	2000-2013

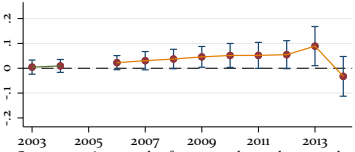
High-Skill Sectors Redistribution



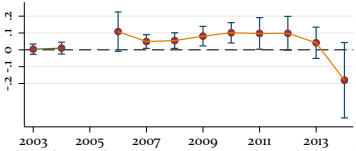
Finance Employment Share at urban



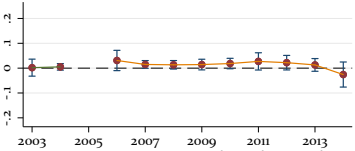
Health, insurance social welfare employee share at urban



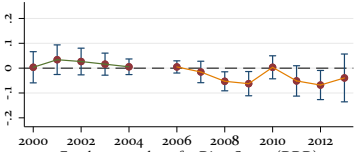
Computer science and software employee share at urban



Public admin and social organisation employee share at urban



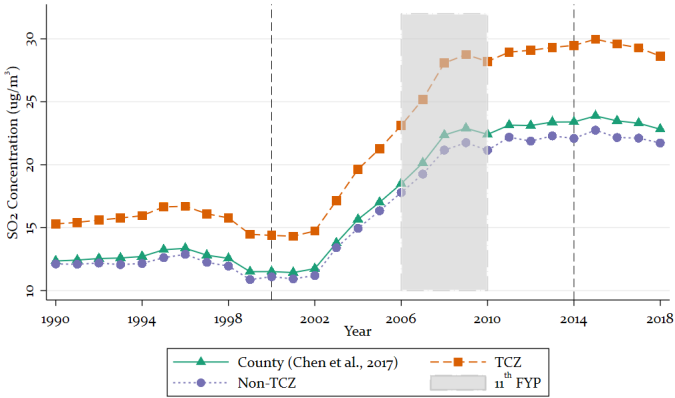
Environment mangement employee share at urban



Employment share for Dirty Sector (DDD)

Mechanism 2: SO_2 Concentration

- Alleviating skilled outmigration trend
- Skilled labour more sensitive to air pollution (Chen et al.2017; Khanna et al. 2019, NBER; Chen, 2019)



Robustness

Results are explained by

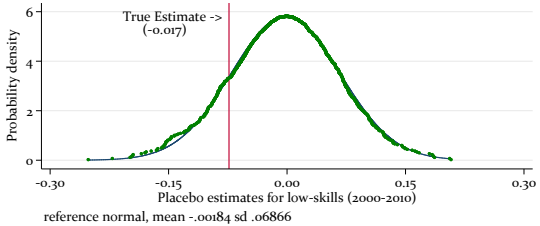
- Natural population growth rate (×)
- Within city variation (×)
- Alternative Quota Measurements (✓):

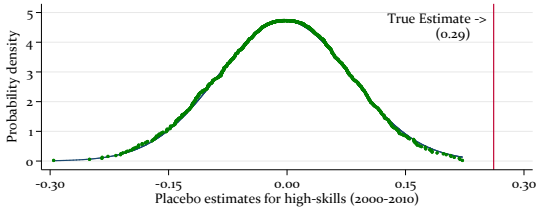
$$SO_2\ Quota_{c,05-10} = \frac{\Delta Quota_{p,05-10}}{Quota_{p,05}} \cdot \sum_{i=1}^{39} \mu_i \frac{output\ value_{i,c}}{output\ value_{i,p}}.$$

- Randomisation and falsification test (✓):
  1000 simulation of $Quota_c^{false} \times Post_t^{false} \times Non\_Top10_c$.

Randomisation of Treatment

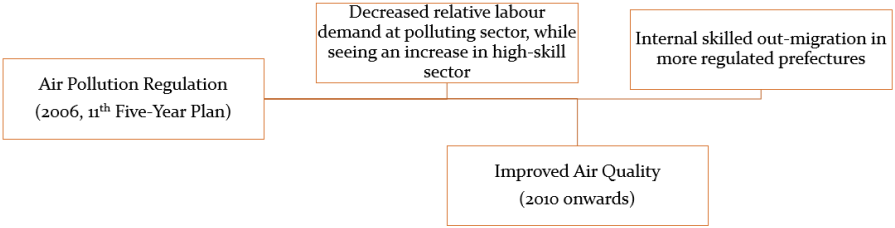
- 1000 simulation of $Quota_c^{false} \times Post_t^{false} \times Non\_Top10_c$ for low-skills and high-skills





What We Learn?

- The 11^{th} FYP redistributes approximately 41,000 net high-skilled outmigrants in non-mega cities per year



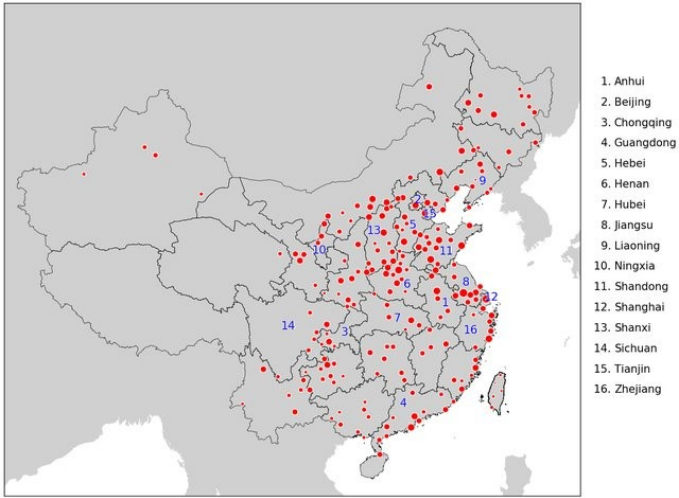
Implications

- One stone for two birds!
  - Reducing regional inequality: China Western Development, The Rise of Central China
  - A tool for skilled population redistribution and improving air quality
- Changing in spatial distribution of high-skills improves overall labour productivity in China (2×AEJ: He et al., 2019; Chang et al., 2019)
  - Migrants may move from heavily polluted to less polluted area
  - Possible increased output value could be included in social welfare calculation
- Relevant to other developing countries: India, Malaysia, Vietnam...

Thank you for listening!

@ Email: bo.yu@deakin.edu.au
Website: sites.google.com/view/boyulamont

Chinese Power Plant Location



Source: Regional Emission inventory in Asia (REAS) version 2 Proposed Solution

Table of Contents