

**COMPARING POLLUTION BY
ASIAN GIANTS: CHINA VS INDIA**

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Executive Summary

1. Spectacular economic growth in China and India has serious environmental consequences. One of these consequences is pollution which has led to poor urban air quality in many cities and contamination of rivers and underground water in both countries.
2. The industrial sector and motor vehicular emissions are the main sources of air pollution. There is however variation among the regions or states as well as across the sectors in the two economies.
3. China and India are two of the largest carbon emitters in the world. The two giants' emission intensity (the amount of carbon emissions discharged per unit of output) is relatively high, implying potential for improvement and for catching up with the world's advanced economies.
4. Both countries are still in the process of industrialization and urbanization which will exert more pressure on the environment. Whether China and India follow a more or less emission intensive development model has important implications for the environment both domestically and globally.
5. To control pollution, China and India have to improve energy efficiency and promote changes in energy consumption patterns and economic structure so as to adopt an environment-friendly development model.
6. Energy consumption is the main source of pollution, particularly air pollution. Therefore energy efficiency is closely related to emission intensity. There is still a large gap in energy efficiency between the two giants and advanced economies such as Japan and the US. Improvement in energy efficiency is hence vital for the control of pollution in China and India.
7. Another important factor is the pattern of energy consumption. Both China and India rely largely on fossil fuels for energy. There is room for the growth

of non-fossil fuels such as hydro electricity, solar energy and so on. In the short run, the two countries can at least increase the use of natural gas and adopt cleaner coal mining technology.

8. Both governments would need to implement more stringent environmental regulations and, in the meantime, strengthen their enforcement. As for the transformation of economic structure, China has an advantage over India. In the midst of the current US financial crisis, the Chinese government initiated a large stimulus package. Ideally part of the fund could be spent on industrial upgrading and the improvement of energy efficiency.

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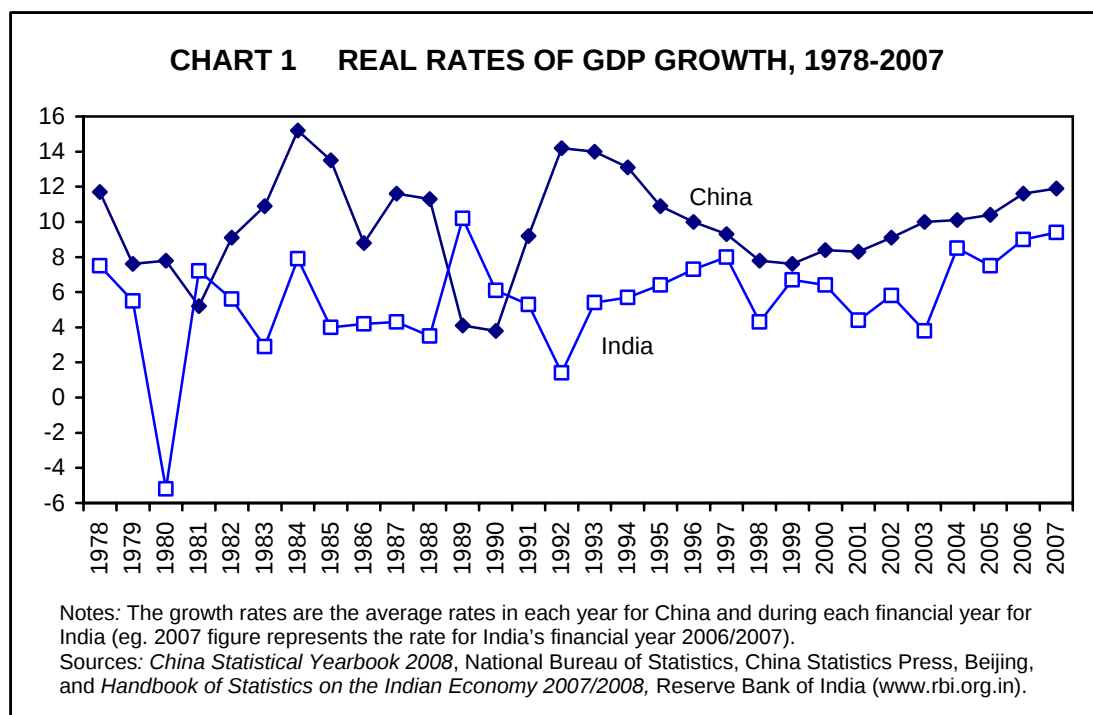
High Growth at the Expense of the Environment

- 1.1 Over the last three decades, the world has been astonished by the miraculous economic growth of China and India. For instance, during 1978-2007, the average real rate of GDP growth is 9.9% in China and 5.6% in India (Chart 1). Though there is a gap in the growth performance between the two countries, India has caught up with China in the past decade, particularly in recent years. With both countries' governments being fully committed to the goal of high economic growth, the current development momentum is expected to continue for decades.
- 1.2 However, high growth has been achieved with severe environmental damages such as deforestation, widespread acid rain and deteriorating ambient air quality. These consequences threaten human living space and health, and are costly to deal with. A government report shows that the environmental cost accounts for about 3% of China's GDP.¹ In India it is estimated that the damage and degradation of natural resources is equivalent to about 10% of the country's GDP.² While these estimates may be debateable, there is no doubt that pollution has serious health and economic consequences.

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¹ This estimated figure was released by the Chinese government official website under the title "Green GDP Accounting Study Report 2004 Issued" (www.gov.cn, September 11, 2006).

² R.K. Pachauri, "The Future of India's Economic Growth: the Natural Resources and Energy Dimension", *Futures* 36, 703-713, 2004.



1.3 One of the notorious consequences is air pollution which has reached unprecedented level and is deteriorating in both countries. Though the measurement of air quality is complicated, there are a few pollutants which regulators keep a watchful eye on through regular monitoring. These are taken as indicators of air quality in a region or city. The most watched pollutants include particular matter (PM), nitrogen dioxide (NO₂), sulphur dioxide (SO₂) and carbon dioxide (CO₂).

1.4 Due to pollution, the ambient air quality in major cities in China and India is now very poor. For example, the annual average concentration of suspended particulate matter (PM₁₀) is very high in both Chinese and Indian cities (Table 1).³ In particular, many cities have exceeded the officially designated critical levels, not to mention the ambient air quality standards set by the World Health Organization (WHO). In China, the average concentration of sulphur dioxide and nitrogen dioxide is especially high.

³ PM₁₀ is used to describe particles of 10 micrometres or less in aerodynamic diameter.

**TABLE 1 AMBIENT AIR QUALITY STATUS (ANNUAL AVERAGE,
MICROGRAM/CUBIC METRE), 2007**

Chinese Cities	Particulate Matters (PM ₁₀)	Sulphur Dioxide (SO ₂)	Nitrogen Dioxide (NO ₂)	Indian Cities	Particulate Matters (PM ₁₀)	Sulphur Dioxide (SO ₂)	Nitrogen Dioxide (NO ₂)
Beijing	148	47	66	Kanpur	409	7	21
Urumqi	136	88	67	Delhi	384	9	47
Xi'an	135	53	43	Faridabad	353	9	22
Lanzhou	129	60	42	Patna	298	10	41
Shijiazhuang	128	43	35	Ludhiana	272	12	30
Taiyuan	124	76	27	Dehradun	269	25	28
Wuhan	123	61	55	Raipur	259	12	34
Shenyang	119	54	36	Kolkata	259	10	39
Jinan	118	56	23	Jaipur	239	5	43
Hefei	116	23	26	Mumbai	230	10	23
Xining	115	28	35	Ahmedabad	223	10	21
Chengdu	111	62	49	Guwahati	194	7	20
Chongqing	108	65	44	Chandigarh	189	6	12
Hangzhou	107	60	57	Bangalore	186	9	26
Nanjing	107	58	51	Jammu	182	na	na
Zhengzhou	105	69	45	Indore	176	6	13
Changsha	104	65	41	Chennai	176	7	10
Harbin	102	48	60	Jamshedpur	167	19	30
Changchun	99	30	38	Hyderabad	158	5	22
Tianjin	94	62	43	Dimapur	130	na	15
Yinchuan	92	49	25	Shimla	126	7	16
Shanghai	88	55	54	Bhubaneshwar	117	5	13
Guiyang	85	55	23	Pondicherry	117	8	12
Hohhot	84	66	48	Aizawl	96	na	11
Nanchang	83	54	34	Shilong	88	na	12
Guangzhou	77	51	65	Thiruvananthapuram	76	7	25
Kunming	75	68	42	AAQS			
Fuzhou	65	27	55	China	100	60	40
Nanning	64	59	48	EU	40	125*	40
Lhasa	57	7	25	India	60	60	60
Haikou	43	9	12	US	150*	60	100
				WHO	20	20*	40

Notes: Data in the table refer to 2006 statistics for India. The ambient air quality standard (AAQS) set by each nation defines the level of pollutants in the air which is considered to be harmful to public health and the environment. AAQS statistics in the table are obtained from relevant official web pages. There are three sets of AAQS in China. The lowest level (best air quality) is reported here.

* refers to 24 hour average level.

Sources: *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing, and *Compendium of Environmental Statistics 2007*, Central Statistical Organization (www.mospi.nic.in), Government of India.

1.5 Another area is water pollution. For example, the two nations' main rivers are at the risk of being contaminated due to organic pollution. In China, the worst

affected rivers in 2006 include Huanghe, Songhuajiang, Huaihe, Haihe and Liaohe.⁴ In India, Baitani, Gandak, Godavari and Yamuna are some of the most polluted rivers.⁵ The main sources of water pollutants include domestic sewage, industrial effluents and run-off from activities such as agricultural irrigation (which carries fertilizers and pesticides into ground water).

- 1.6 In China, on an average, only 92% of the discharged industrial waste water complies with official standards according to the latest statistics.⁶ For some regions, this figure is very low such as 29% in Tibet, 50% in Qinghai and 65% in Xinjiang. Incidentally, these regions are all located in the less developed western China which is now rapidly catching up with the coastal area in terms of industrialization. Thus, environmental protection in western China needs to be strengthened so that the region would not follow the same development model as coastal China did with costly environmental damages. In major Indian cities, on an average, about 19% of urban waste water is discharged without treatment or collection. In some cities such as Bhopal and Ludhiana, less than a half of waste water was collected.⁷
- 1.7 Over time, China's waste water discharge tends to increase continuously, which makes it impossible for the economy to meet its target set in the 11th Five-year Plan (Chart 2). However, the discharge of SO₂, COD (chemical oxygen demand) and soot has shown a flat or declining trend over time. It seems that the 11th Five-year Plan targets can be met according to Chart 2.
- 1.8 In India, between the late 1990s and recent years, there is evidence to show a decline in the level of SO₂ in the air in major cities such as Ahmedabad,

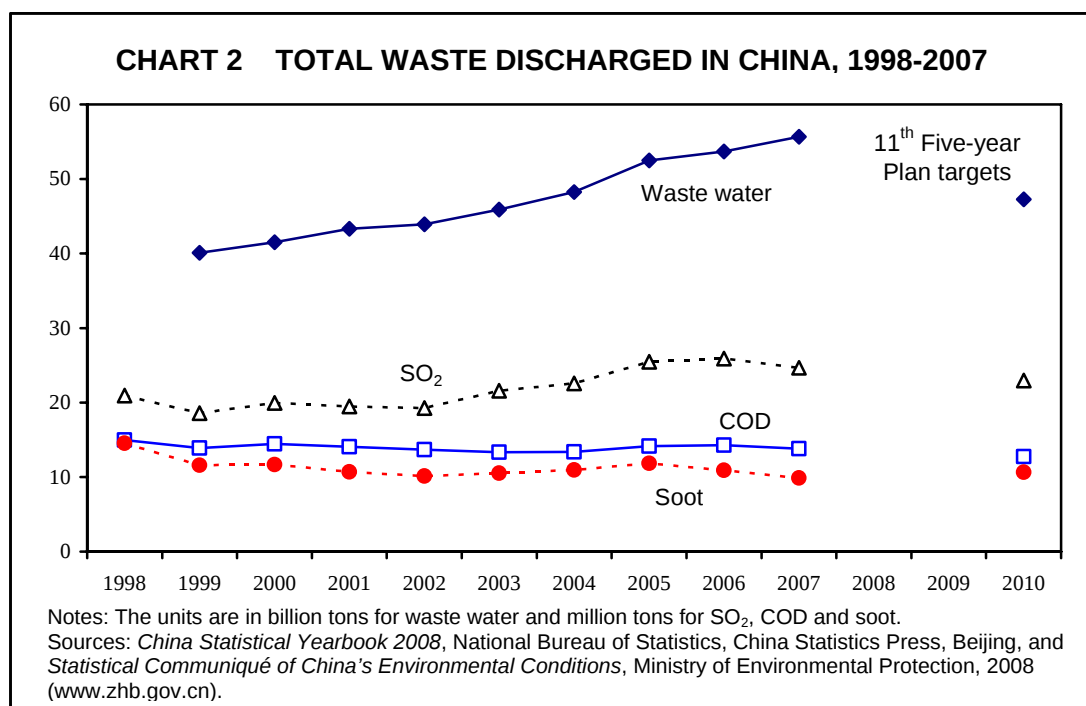
⁴ *China Environment Yearbook 2007*, Editorial Board, Xinhua Press, Beijing.

⁵ For details, refer to *Compendium of Environmental Statistics 2007*, Table 6.1.17(b), Central Statistical Organization (www.mospi.nic.in), Government of India.

⁶ *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing.

⁷ For details, refer to *Compendium of Environmental Statistics 2007*, Table 6.1.16, Central Statistical Organization (www.mospi.nic.in), Government of India.

Bangalore, Chennai, Delhi, Hyderabad, Kolkata and Mumbai.⁸ However, the level of NO₂ increased significantly in Ahmedabad, Bangalore and Kolkata during the same period while PM₁₀ concentration in the air remained very high.⁹ The national average indicators confirm the same trends in India: declining concentration of SO₂, modestly rising NO₂ level, and stable but high concentration of particulate matter (PM₁₀) during the decade of 1996-2005.¹⁰



Sources of Pollution

- 2.1 The industrial sector has been the main source of pollution in both countries, particularly in China where this sector was responsible for 44.3% of waste water discharged, 86.7% of sulphur dioxide emission and 78.3% of soot

⁸ According to *Compendium of Environmental Statistics 2007* (www.mospi.nic.in), Table 4.1.8, Central Statistical Organization, Government of India.

⁹ *Ibid.*

¹⁰ *Annual Report 2007/2008*, Ministry of Environment & Forests, Government of India (<http://envfor.nic.in/report/report.html>).

emission in the country in 2007.¹¹ Though India is less industrialized (than China), the country's industrial sector is expanding rapidly and has become a major source of pollutants discharged. This is particularly so in the more industrialized states such as Gujarat, Maharashtra, Tamil Nadu and Andhra Pradesh.¹²

2.2 The poor air quality in Chinese and Indian cities is partly due to the expansion of the transport sector, especially the growth in the number of motor vehicles. Over the past decade, the number of motor vehicles on the road has increased dramatically in both countries (Chart 3). This growth is particularly strong in recent years. During 2003-2007, for instance, more than one million units were added to the roads in Beijing alone.¹³ The latest data from India also show that nearly one million units were added to the roads in Delhi during 2000-2004 (an increase from 3.4 million units in 2000 to 4.2 million units in 2004) and that the number of registered motor vehicles in Tamil Nadu soared from 4.6 to 8.6 million units during the same period.¹⁴

2.3 The main polluting sectors in both countries are iron and steel, pulp and paper, petrochemical, mining, oil refinery and power generation, to cite a few. In particular, China's power generation accounts for about 60% of SO₂ and 23% of solid waste discharged in the industrial sector.¹⁵ In addition, China's mining sector generated almost 40% of the country's industrial solid waste. In terms of waste water discharge, the largest sectors are pulp and paper, petrochemical and textile industries in China. In India, it is estimated that the iron and steel

¹¹ *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing.

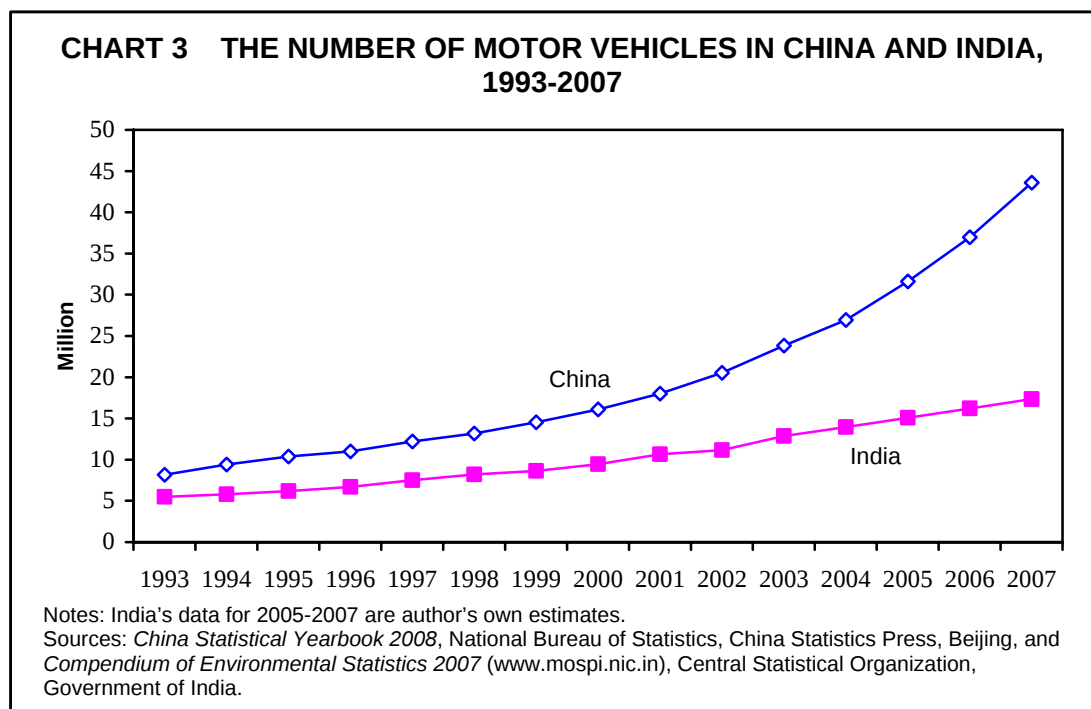
¹² *India: State of the Environment 2001*, Ministry of Environment & Forests, Government of India (<http://envfor.nic.in/mef/mef.html>).

¹³ *China Statistical Yearbook 2004* and *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing.

¹⁴ These figures are drawn from the web site of Motor Transport Statistics, Department of Road Transport & Highways (<http://morth.nic.in>), Government of India.

¹⁵ These Chinese data are calculated using statistics from *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing.

sector produces 87% of waste water, 71% of metal air pollutants, and 32% of total air pollutants.¹⁶



2.4 At the regional or state level, however, there is substantial variation. Among the Indian states, it is identified that a dozen of heavy polluters generated over 70% of total industrial pollutants (toxic, metal, water etc).¹⁷ In China, the top polluters are in coastal and more industrialized regions such as Jiangsu, Guangdong, Shandong, Hebei and Zhejiang which together accounted for over 40% of the country's industrial waste water, air pollutants and solid waste.

¹⁶ Rita Pandey, "Estimating Sectoral and Geographical Industrial Pollution Inventories in India: Implications for Using Effluent Charge Versus Regulation", *Journal of Development Studies* 41(1), 33-61, 2005.

¹⁷ These states are Bihar, Madhya Pradesh, Maharashtra, Orissa, Andhra Pradesh West Bengal Uttar Pradesh, Punjab, Tamil Nadu, Gujarat, Karnataka and Rajasthan. Rita Pandey, "Estimating Sectoral and Geographical Industrial Pollution Inventories in India: Implications for Using Effluent Charge Versus Regulation", *Journal of Development Studies* 41(1), 33-61, 2005.

Climate Change Responsibilities

- 3.1 In international perspective, China and India are also two of the world's largest carbon emitters and hence two major contributors to global climate change (Table 2). China was ranked the second largest emitter in 2006 and has probably overtaken the US to become the largest emitter in the world by the end of 2008. India's carbon emission exceeded Japan's in 2006 and is catching up with Russia's.
- 3.2 As per capita emission is still relatively low, especially in India, aggregate carbon emission is expected to increase in the near future in both China and India. In the long run, whether the two countries can achieve the goal of a fall in aggregate emission depends on the commitments of their governments. Between 1990 and 2005, most OECD countries recorded a reduction in aggregate CO₂ emissions ranging from 71% in the UK to 8% in Turkey.¹⁸ The most significant reduction is due to the fall in emissions from "mobile" sources (such as motor vehicles) which accounted for 69% and 54% of CO₂ emissions in the UK in 1990 and 2005, respectively.
- 3.3 However, as far as intensity is concerned, there is substantial scope for reduction. Emission intensity in China is one of the highest in the world, only behind Russia and Iran among the 16 top emitters in the world according to Table 2. Though India's emission intensity is well below China's, it is still higher than Indonesia's and Mexico's. Finally, it should be pointed out that the group ranking is slightly different if GDP is measured using international dollar which is of course controversial (Table 2). In terms of carbon emission per capita, the major developed economies can be divided into two camps, namely the more emission-intensive and less emission-intensive economies. The former includes the US, Australia and Canada and the latter is represented by Japan, France and the UK. The contrast between the two camps is that the former generates twice as much carbon emission as the latter. Which model China and India adopt will have important implications for their own

¹⁸ *OECD Environmental Data Compendium 2006/2007*, Organization for Economic Cooperation and Development, Paris (www.oecd.org).

environment in general and global climate change in particular. Given the increasing domestic environmental awareness and global campaign for climate change, China and India would probably have only one choice, that is, to adopt a clean or cleaner development model.

TABLE 2 CO₂ EMISSION AND INTENSITY, 2006

Countries	Ranking	Total CO ₂ (Mt)	World shares (%)	CO ₂ per head (t per capita)	CO ₂ per US\$ (t / US\$1)	CO ₂ per PPP\$ (kg / ppp\$1)
USA	1	5697	20.34	19.00	0.51	0.51
China	2	5607	20.02	4.27	2.68	0.65
Russia	3	1587	5.67	11.14	4.25	1.08
India	4	1250	4.46	1.13	1.78	0.34
Japan	5	1213	4.33	9.49	0.24	0.34
Germany	6	823	2.94	10.00	0.41	0.37
Canada	7	539	1.92	16.52	0.64	0.53
UK	8	536	1.91	8.86	0.32	0.31
Korea	9	476	1.70	9.86	0.71	0.47
Italy	10	448	1.60	7.61	0.39	0.29
Iran	11	433	1.55	6.17	3.08	0.85
Mexico	12	416	1.49	3.97	0.63	0.40
Australia	13	394	1.41	19.02	0.82	0.62
France	14	377	1.35	5.97	0.26	0.22
Saudi Arabia	15	340	1.21	14.36	1.42	0.95
Indonesia	16	335	1.20	1.50	1.53	0.42
Top-16		20471	73.10			
World		28003	100.0	4.28	0.74	0.49

Notes: kg, t and Mt refer to kilogram, ton and million ton. CO₂ emissions are from fuel combustion only.
Source: *Key World Energy Statistics 2008*, International Energy Agency, Paris (www.iea.org).

Potential Policy Responses

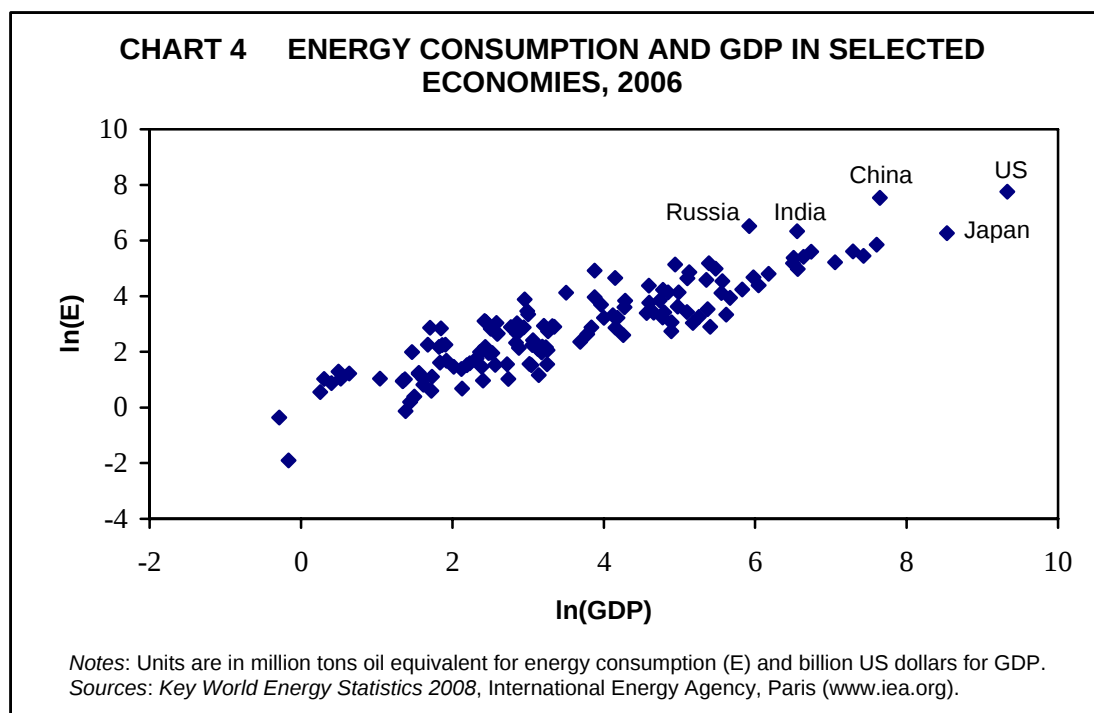
- 4.1 Both China and India are in the process of industrialization and urbanization which will add more pressure on the environment. Due to both external demand and domestic conditions, the two countries thus have to take drastic actions to control pollution. Immediate actions can be taken to address issues such as energy efficiency, the transformation of economic and energy structure and adoption of the world's best practice environmental regulations.

- 4.2 Energy consumption is the main source of pollution, especially air pollution. Among the world's major economies, for example, the bulk of total CO₂ emissions comes from carbon emission due to energy consumption. Thus energy efficiency affects emission intensity directly. According to Chart 4, which illustrates the relationship between energy consumption and income in 137 economies, it is obvious that China and India are outliers regardless of whether Japan or the US is used as the benchmark economy. As a matter of fact, in 2006, energy intensity defined as the amount of energy required per unit of GDP was 0.9 KgOE (kilogram oil-equivalent) in China and 0.8 KgOE in India. These efficiency scores are much higher than 0.21 KgOE in the US and 0.15 KgOE in Japan in the same period.¹⁹ Thus there is scope for improvement in energy efficiency, hence reducing carbon emission intensity and slowing down the increase in aggregate emissions.
- 4.3 Energy structure is another important factor which influences the control of pollution, particularly air pollution. For decades China and India have mainly relied on fossil fuel for energy. Non-fossil fuels (renewable, nuclear and hydro etc) only had a small share over total energy consumption, that is, 7.3% in China and 10.2% in India in 2007.²⁰ There is room for an increase in the use of cleaner energies such as natural gas and renewable energies. Among the OECD economies, the average share over primary energy consumption in 2007 was 22.6% for natural gas and 17.3% for renewable, nuclear, hydro and others. In China coal still accounted for 69.5% of total primary energy consumed in 2007. Though Indian coal consumption had a smaller share of 45.3% in the same year, this is still much higher than the OECD mean of 20.8% in 2007.²¹ In the immediate future, new technology should at least be adopted in coal mining and washing in both countries even though the consumption of coal cannot be reduced significantly.

¹⁹ These energy intensity statistics are drawn from *Key World Energy Statistics 2008*, International Energy Agency, Paris (www.iea.org).

²⁰ These numbers are calculated using statistics from *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing and *Energy Statistics 2007* (http://mospi.gov.in/es07_main.htm), Central Statistical Organization, Government of India.

²¹ *Key World Energy Statistics 2008*, International Energy Agency, Paris (www.iea.org).



4.4 Traditionally developed countries followed a pollution-growth-clean model of development which is now conceptualized in the popular environmental Kuznet curve (EKC). The latter implies that the degree of pollution and level of development show an inverted-U shape. That is, pollution rises initially as an economy develops and then falls after economic development (normally measured by per capita income) reaches a certain level. This critical level of income is called the turning point in the literature.²² Over the past three decades China has basically followed this traditional development trajectory. It is now time for the Chinese economy to undergo a structural transformation and the Indian economy to adopt a more environment-friendly industrialization strategy. In fact empirical research shows that the “turning point” income level is much lower in developing economies such as China than that in the developed economies. This is called the leapfrogging factor or effect which means developing countries can reach their turning points at an earlier stage of development. It is found that China’s turning point is 19,422

²² G. Grossman and A. Krueger, “Economic Growth and the Environment”, *Quarterly Journal of Economics* 110 (2), 352–377, 1995; and D. Tyteca, “On the Measurement of Environmental Performance of Firms: A Literature Review and a Productive Efficiency Perspective”, *Journal of Environmental Management* 46, 281–308, 1996.

yuan (about US\$2,408 or ppp\$9,635 in 2007).²³ Eleven out of thirty-one Chinese administrative regions reached this level of income per capita in 2007 and hence can afford spending money in pollution control.²⁴ While there is no empirical evidence yet, Indian states could reach their “turning point” at different time implying some states could take actions first. In fact, during the financial year 2005/2006, per capita income of India’s more developed states or union territories was about US\$1,925 in Chandigarh, US\$1,558 in Goa and US\$1,371 in Delhi. These figures are still below the derived “turning point” income in China.²⁵

- 4.5 In the case of China, the structural transformation of the economy implies the expansion of the service sector and development of high-tech and knowledge-intensive industries. China’s service sector development is lagging behind, hence hindering the structural transformation of the economy. In 2007, for example, services accounted for 40.1% of China’s GDP which is much smaller than India’s 53%, Brazil’s 64% and Mexico’s 71%, not to mention 75% of the UK, and 76% of the US.²⁶ Though the service sector is relatively large in India, it is still dominated by the traditional services.²⁷ In addition, there is considerable variation across Indian states. The share of service sector value-added over gross state product (GSP) ranges from the highest (about 85%) in Chandigarh to the lowest (about 38%) in Jharkhan during the

²³ Yanrui Wu, “Environmental Efficiency and Its Determinants in China’s Regional Economies”, *Economics Discussion Paper 07.21*, UWA Business School, University of Western Australia, 2007.

²⁴ These regions include Shanghai (66,367 yuan), Beijing (58,204 yuan), Tianjin (46,122 yuan), Zhejiang (37,411 yuan), Jiangsu (33,928 yuan), Guangdong (33,151 yuan), Shandong (27,807 yuan), Fujian (25,908 yuan), Liaoning (25,729 yuan), Inner Mongolia (25,393 yuan) and Hebei (19,877 yuan). Data are drawn from *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing.

²⁵ These statistics are calculated using data from *Handbook of Statistics on the Indian Economy 2007/2008*, the Reserve Bank of India (www.rbi.org.in).

²⁶ *China Statistical Yearbook 2008*, National Bureau of Statistics, China Statistics Press, Beijing and *World Development Indicators 2008*, the World Bank, Washington DC (www.worldbank.org).

²⁷ Yanrui Wu, “Service Sector Growth in China and India: A Comparison”, *China: An International Journal* 5(1), 137-54, 2007.

financial year 2005/2006.²⁸ Therefore, India's policy focus should be on the promotion of modern services such as finance, IT and healthcare. India's manufacturing sector has yet to take off. Policy makers should monitor carefully the activities of pollution-intensive sectors and the production of pollution-intensive products at both national and state levels.

- 4.6 Environmental regulation plays an important role in pollution control. China and India can do much more to implement more stringent regulations and ensure better enforcement. A series of laws and regulations were promulgated in both countries in the 1980s. There is however ample evidence to show the inadequacy and lack of enforcement of appropriate environmental regulations. In the case of India, Roychowdhury *et al.* argued that emissions from motor vehicles could be reduced by implementing an effective vehicle inspection and maintenance system, improving public transport services and controlling the explosive growth of private vehicles using proper tax policies.²⁹ These authors also presented Delhi, the capital city of India, as a case study. Stringent regulations in the form of tough emission standards, a ban on diesel cars and so on have led to an improvement in ambient air quality in Delhi (though the city is still far away from the clean air goal).
- 4.7 In China, during the Olympic Games, most cars in Beijing were banned from the roads and factories were closed temporarily. These actions resulted in dramatic improvement in the quality of air during the Games. While these actions may be controversial, they do remind us that a decrease in vehicular and industrial emissions does reduce significantly the amount of pollutants discharged into the atmosphere and hence improve ambient air quality in urban areas. Thus what Chinese authorities may do is to implement more stringent regulations instead of administrative orders. For example, to force structural transformation, regulations could target heavily polluted sectors and products which should either be reduced gradually or cleaner technologies adopted.

²⁸ *Handbook of Statistics on the Indian Economy 2007/2008*, the Reserve Bank of India (www.rbi.org.in).

²⁹ A.Roychowdhury, V. Chattopadhyaya, C. Shah and P. Chandola, *The Leapfrog Factor: Clearing the Air in Asian Cities*, Centre for Science and Environment, New Delhi, 2006.