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Article

Tackling Air Pollution in China—What do We Learn from the Great Smog of 1950s in LONDON

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Abstract: Since the prolonged, severe smog that blanketed many Chinese cities in first months of 2013, living in smog has become "normal" to most people living in mainland China. This has not only caused serious harm to public health, but also resulted in massive economic losses in many other ways. Tackling the current air pollution has become crucial to China's long-term economic and social sustainable development. This paper aims to find the causes of the current severe air quality and explore the possible solutions by reviewing the current literature, and by comparing China's air pollution regulations to that of the post London Killer Smog of 1952, in the United Kingdom (UK). It is hoped that China will learn the lesson from the UK, and decouple its economic growth from the detrimental impact of environment. Policy suggestions are made.

Keywords: China; smog; air pollution; lesson; London

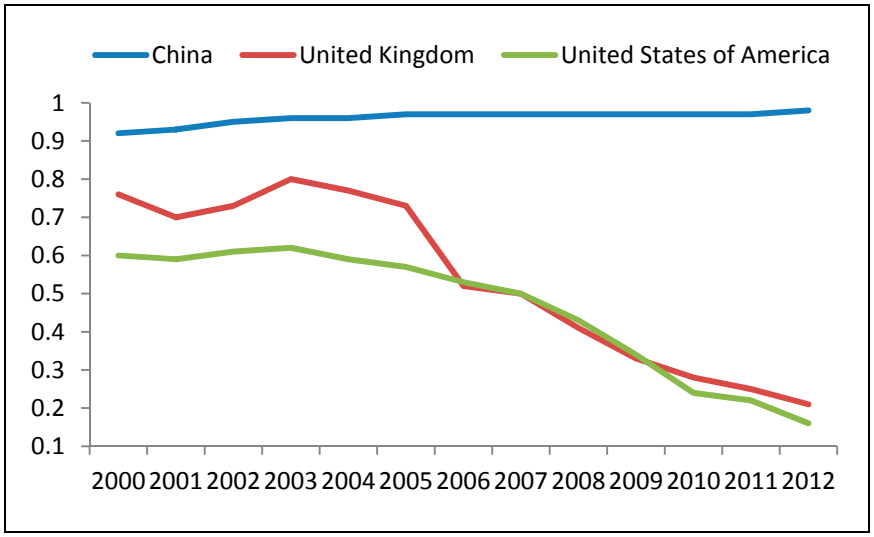
1. Introduction

The extraordinary economic achievement of China in the past more than two decades has lifted around 500 million people out of poverty, however, this achievement has rested on heavily polluting industries, on burning coal for energy, and on an explosion in the number of cars. Research by the

Chinese Academy of Social Sciences pointed out that the problem of haze and fog in China was hitting a record level, and China is currently suffering the worst air pollution problem since 1961 [1].

The problem of air pollution was first observed in the 1970s, with industrial emissions of sulphur dioxide (SO_2) and total suspended particulates (TSP). In the 1980s, acid rain was detected in major cities in the northern part of the country, and this was mainly caused by SO_2 from coal combustion, which accounts for more than 70% of the fuel consumption in China. In the 1990s, the number of vehicles on roads increased very rapidly, especially in medium-sized and large cities. In Beijing alone, the number of vehicles increased by a factor of 10, from 0.5 million in 1990 to 5 million in 2012. In addition, the emission factor (the amount of pollution emitted by one car) in China is much higher than in developed countries because China has much lower emission standards for automobiles [2]. Thus, the drastic rise in the number of vehicles and rapid development of industries in cities has led to worsening air quality, and concentrations of nitrogen oxides (NO_x) and particulates are especially high. High levels of ozone concentration were frequently observed in summer and fall in several big cities. Between 1981 and 2001, ambient concentrations of TSPs in Beijing were more than double of China's National Annual Mean Ambient Air Quality Standard of 200 μg/m^3 [3] and five times the level that prevailed in the United States before the passage of the Clean Air Act in 1970 [2]. Since 2000, more than 92% of residents in China have been exposed to PM2.5 (the tiny particles which penetrate deep into the lungs and give rise to asthma, cancer, heart trouble, *etc.*) concentration exceeding 10 μg/m^3, the exposure rate increased to 98% in 2012, while during the same period the proportion of population that were exposed to PM2.5 concentration exceeding 10 μg/m^3 in the UK decreased from 76% to 21%, and from 60% to 16% for the United States of America [4] (see Figure 1). The same study indicated that China is ranked as one of the bottom three countries, based on air quality, just above Nepal and Bangladesh (ibid.).

Figure 1. Proportion of the population exposed to a PM2.5 concentration of 10 μg/m^3.

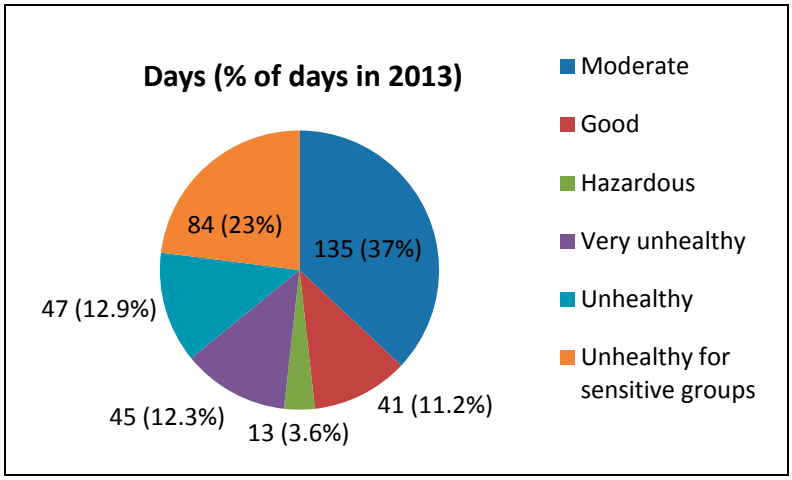


Source: [4]

Along with smog becoming a fixture of life, the public concern exploded in 2013 as the skies over many Chinese cities grayed. In Beijing, levels of PM2.5 were stuck at hazardous levels for weeks in early 2014 and peaked at 35 times the World Health Organization's (WHO) recommended limit.

A total of 51.8% of days in 2013 were unhealthy or worse [5] (see Figure 2). The capital's 21 million residents put on face masks, kids were kept indoors, and social networks exploded with complaints about the heavy blanket of smog. In Harbin, a city in northern China, a dense wave of smog began on 20 October 2013, the day when the coal-powered district heating system started, visibility was reduced to below 50 meters in parts of Harbin and below 500 meters in most of the neighboring Jilin province. It was reported that the daily particulate levels in parts of Harbin municipality were more than 40 times the WHO recommended maximum level. All highways in the surrounding Heilongjiang province were closed. All primary and middle schools, and the airport, were closed for three days in Harbin. The hospital reported a 23% increase in admissions for respiratory problems. While the situation in Beijing and Harbin is alarming, they are not unique; many cities in Northern China, which is home to several of the world's most polluted cities [6], air quality is especially poor. Even state-supported media provided surprisingly critical coverage of the crisis and many foreign media called it an "airpocalypse".

Figure 2. Beijing pollution levels: days in 2013 at Air Quality Index ratings.



Source: [5]

The air pollution problems in China now are actually in parallels with the killer smog in London 60 years ago in December 1952 when a heavy motionless layer of smoky, dusty fumes from the region's millions of coal stoves and local factories appeared in the sky. This smog brought traffic and people to a standstill. Hospital admissions, pneumonia reports, applications for emergency bed service, and mortality followed the peak of air pollution. The mortality stayed high in the following two months, and it was suggested that 12,000 unexplained deaths during this period were owing to the smog. This smog became known as the "Great Smog" because of its lethality and the unprecedented public reactions to it [7].

Not accidentally, in 1952, the UK's stage of economic development, its real GDP per capita, was approximately the same as China's is today [8]. Along with the change of policy, London's air quality improved soon after 1952. China's Premier Li Keqiang declared the country's "war on smog" at the opening of China's National People's Congress, on 5 March 2014. China's winning or losing of this war will not only affect its own long-term sustainability but will make the most important turning point in the global scene on climate change. Looking at the lessons of London's air pollution catastrophe and how subsequently the situation was improved may cast some useful lessons for China. This paper aims

at looking at the causes of smog in China and find possible solutions by review the current literature and by comparing the air pollution policies in China and post 1952 in the UK.

2. Social and Economic Consequences of the Smog in China

The stark consequences for each Chinese resident brought by the deadly pollution are obvious, and various studies have been trying to put a measurement on the economic and social impacts that the smog has had in China. One of the focuses of the studies has been the human health effects of the smog. It was reported by the World Bank [6] that the economic burden of premature mortality and morbidity associated with air pollution was estimated to be 157.3 billion Yuan in 2003, or 1.16% of its GDP. A more recently research found that air pollution has caused the loss of more than 2.5 billion years of life expectancy in China, and, because of air pollution, linked diseases, such as cardiovascular disease and lung cancer due to high consumption of coal in northern China, life expectancy there was 5.5 years shorter than that in southern China [9]. Another recent study found that if the world took action to reduce greenhouse gas emissions, more than 500,000 lives could be saved globally each year, and the air and health quality benefits for East Asia alone would add up to between 10 and 70 times the cost of reducing emissions by 2030 [10]. The same study also found that the health benefits of taking action to curb climate change were especially striking for China, with its large population now exposed to some of the worst pollution in the world (ibid.). A study focusing on the babies born in the southwestern Tongliang county, China just before a local coal-fired power plant was shut down a decade ago found that air pollution led to genetic changes that these babies had significantly lower level of a protein that is crucial to brain development in their cord blood than those conceived later, and poorer learning and memory skills were also found in these kids when tested at the age of two [11].

Non-human-health-related impacts have also been evaluated by some studies. Matus *et al.* [12] applied the method developed for the US and Europe to China to estimate the socio-economic costs generated by air pollution in China. It was found that air pollution in China has created a substantial burden to its economy and the estimated ozone and PM concentrations beyond background levels have led to US$ 16 billion to US$ 69 billion (or 7% to 23%) loss of consumption and US$ 22 billion to US$ 112 billion (or 5% to 14%) loss of welfare in China's economy. The World Bank [6] reported that, although the impacts of pollution on natural resources (agriculture, fish, and forests) and manmade structures (e.g., buildings) were estimated to be lower in economic terms, acid rain, caused mainly by increased SO_2 emissions due to increased fossil fuel use, causes over 30 billion Yuan in damages to crops, primarily vegetable crops (about 80% of the losses). This amounts to 1.8% of the value of agricultural output. Damage to building materials in the South imposed a cost of seven billion Yuan on the Chinese economy in 2003. In addition, although the impact of smog on forests in China has not been quantified due to lack of monitoring data in remote areas, clear widespread damage has been observed to trees, forests around sites of particularly high pollution [13].

A new research conducted by China Agricultural University indicated that if the smog persists, China's agriculture will suffer conditions similar to a nuclear winter because the air pollutants, by adhering to greenhouse surfaces, cut the amount of light inside by about 50% and severely impeding photosynthesis, the process that helps plants convert light into life-sustaining chemical energy [14].

The smog has also changed the way people live their lives. At a cost of five million Yuan, the International School of Beijing has built two domes that enclose the entire school outdoor areas so as to protect the students from the bad air. Students can play and exercise, year round, in the domes without being polluted by the smog [15]. According to a report produced by Hurun Research Institute, China is losing its most important residents to smog. The report shows that in 2013, 64% of China's rich (those with wealth above $1.6 million) were either immigrating to another country or planning to, a rise of 60% from 2011 [16]. The same report indicated that the pollution and food safety were the second biggest reason for the rich to leave China, after the general desire for security and financial well-being.

3. Causes of Smog

3.1. Coal Burning

It was generally recognized that one of the main causes of the smog in December 1952 was the widespread use of coal [7]. In China, coal is also regarded as the number one source of air pollution [17]. The grey sky in Beijing is mainly due to coal burning, vehicle exhaust, climate and geographical environment, and other factors, such as crop stubble burning and firework [1]. From 1950 to 1980, the Chinese government provided free coal for home and office winter heating systems for anyone living north of the Huai River and Qin Mountain range (see Figure 3). The reason to choose Huai River and Qin Mountain as the divide was that Chinese government could not afford supplying free heating to all of China and the Huai River follows the January 0 °C (32 °F) average temperature line. Northern cities received free unlimited central heating between November and March. In contrast, central heating facilities in the Southern areas did not exist until recently when some private heating providers came to the market. Indeed, it is widely recognized that it feels colder in parts of southern regions that are closer to the Huai River (*i.e.*, Nanjing, Shanghai, and Chengdu) in winter as the temperature is only slightly higher than the north but not as high as in the far south. After the marketization, China's free central-heating system has been replaced by heavily subsidized central-heating system, but the supply is still only for northern China.

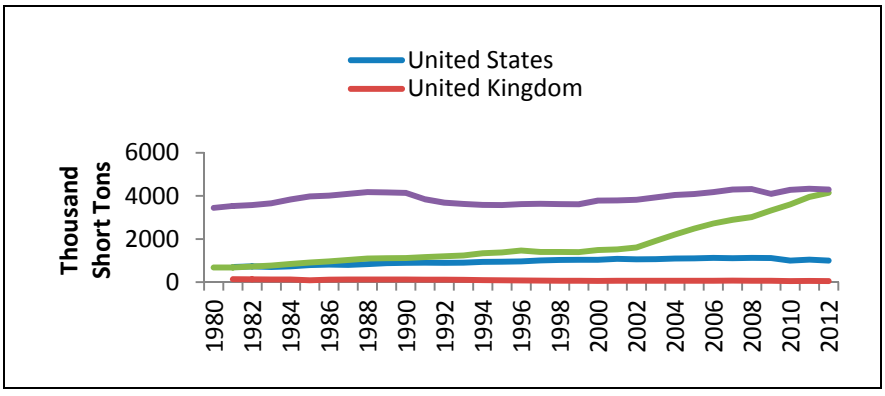
China's heating system is coal-based and technically inefficient [18]. Heat has been provided by coal-fired heat-only boilers or combined heat and power generators, which are inefficient in energy usage compared to electricity, gas, and oil heating systems in the industrial countries [19]. There are normally one or two heating providers in a city, hot water travels certain distance from the heating provider to each household, which causes substantial energy loss. The incomplete combustion of coal in these boilers leads to the release of at least three kinds of pollutant—total suspended particulates (TSP), CO_2 and NO_x. The amount of pollution produced varies depending on the type of coal used, which is relevant to the geographical area that the coal is produced. It is estimated that in China, coal combustion (including industrial and domestic use) is responsible for 87% of SO_2 and 76% of NO_x emissions [18].

Figure 3. Northern and southern China division according to domestic heating policy.

Source: Adopted based on the Administrative Map of China for 2013.

In additional to domestic use of coal, China's industrial use of coal is high too. China's ever-growing army of coal-fired power plants, of which there are currently more than 2300, including iron and steel and cement factories. According to the newly released international data from US Energy Information Administration), China's energy mix in 2012 contained 68% coal. China's total coal use grew by 325 million tons in 2011, accounting for 87% of the 374 million ton global increase in coal use. China's coal consumption in 2012 is 4.7 times of the US's, and almost 60 times that of the UK's. China accounts for 47% of global coal consumption in 2012—almost as much as the entire rest of the world combined for the same year (see Figure 4). Although China has made great progress in the investment in renewable energy, and its renewable electricity growth was double that of the US from 2010 to 2012, China's reliance upon coal is predicted to keep growing [20].

Figure 4. China's coal consumption comparing to the rest of the world.



Source: U.S. Energy Information Administration, International Energy Statistics.

3.2. Industrial Pollution

Research by the Chinese Academy of Science found that industrial pollution is the biggest source of PM2.5 problems, which cause Beijing's smog. Secondary inorganic aerosols, sulphates and nitrates are responsible for 26% of Beijing's PM2.5, followed by industrial production and coal burning at 25% and 18%. Soil dust accounted for 15%. The rest of the pollution comes from heavily industrialized neighbouring provinces and burning of trash, and Beijing's 5.5 million cars were found to be responsible for just 4% of the smog [21]. Zhao *et al.* [22] sampled PM2.5 of different seasons in Beijing, Tianjin, and Hebei, China, and analysed its chemical composition and seasonal variation from 2009 to 2010. The results indicated that the PM2.5 pollution was severe in Beijing, Tianjin, and Hebei, and the meteorological condition and pollution sources that affect aerosol pollution were season dependent in all areas. Thus, the concentrations of PM2.5 and its major chemical species were also season dependent *i.e.*, lower in spring and summer and higher in autumn and winter in all sampling areas.

3.3. Vehicle Emissions

Vehicle emissions have also become a key source of air pollution in China. Research has indicated that the causes of air pollution in China's megacities have shifted from coal-burning only to a mix of coal burning and vehicle emissions [23]. Although Zhang *et al.* [21] determined that motor vehicle emissions account for less than 4% of Beijing's hazardous PM2.5 readings, Wang [24] claimed that pollutants from vehicles contribute to more than 22.5% of PM2.5 in Beijing, and the management of Beijing Environmental Protection Bureau claimed the collective rate of vehicle emissions contribution to PM2.5 should be between 20% and 30% because the secondary inorganic aerosol (which contributes to more than one quarter of the PM2.5) is largely from car emissions.

3.4. Other Factors

Smog in China can also be caused by other activities. Crop stubble burning is a method used frequently by farmers to deal with agricultural waste. About 40% of large portions of crop residues are used as biomass fuels in Hebei Province and Inner Mongolia, 55% in Heilongjiang Province and Liaoning Province, 70% in Tianjin City and Beijing City [1]. Firework is also a cause of the increase of PM2.5. According to Li [25], fireworks increased the level of PM2.5 by 80 times during the traditional Chinese New Year in 2012. A total of 260,000 cases of fireworks were used during the Chinese New Year in 2013 [1].

4. Tackling the Smog

4.1. Policy Changes in London after the Smog

Although it was slow, the government responded to the Great Smog, Clean Air Act 1956, which was later amended and extended to Clean Air Act 1968, was passed by the Parliament of the United Kingdom. Social, economic, and technological changes were introduced to help reduce smoke and SO_2 emission:

(1). "Smokeless zones" and "smoke control areas" were set up in some towns and cities in which only smokeless fuels could be burned.
(2). Sources of household heating were shifted from coal to cleaner coals, electricity, and gas.
(3). Measures were also introduced to relocate power stations away from cities, and the height of some chimneys were required to be increased.

The act had dramatic effect on reducing the use of coal for domestic use. In 1952, coal supplied 61% of London's energy needs, and 28% was for household use alone. The household use of coal started to decline in 1957 and was totally replaced by environmentally friendly energy supplies such as electricity, oil, gas, *etc.*, and SO_2 generated from household heating were significantly reduced [7].

Standards for ambient air quality were set for the first time in the Mayor's Air Quality Strategy and come into effect in 1980. The Environment Act 1995 required government to produce a national air quality strategy containing standards and objectives, and measures to achieve the objectives. It also established a system of local air quality management and required local authorities periodically to review and assess the current and future quality of air in their areas.

At the end of 1980s, along with the change of industrial structure and source of energy, road traffic became the major cause of NO_2 in London's air, accounting for approximately 60% of emissions in London [7]. A few measures were introduced to road traffic: investment in the public transport network, congestion charging, appropriate planning, and other mechanisms. To reduce emissions of vehicles already on the road, the following measures were taken:

(1). In the short term, targeting emissions reductions from the most polluting vehicles, mainly heavier diesel vehicles, such as buses, coaches, goods vehicles, waste vehicles, and taxis.
(2). Increasing the take-up of newer, cleaner vehicles and technologies.
(3). Increasing the take-up of cleaner fuels.
(4). Introducing low emission zones in London, which would exclude the most polluting vehicles from specified areas.
(5). For the long term, promoting zero emission forms of transport, such as hydrogen fuel cell vehicles.

Measures were also taken to reduce the emissions from air travel, from industry and construction. These measures effectively reduced air pollution in London. From 1950 to 2000, the annual average smoke and SO_2 concentrations in London were reduced by 95% and 98% respectively [7].

4.2. China's Way to Clean Air

4.2.1. Law Enforcement

The prolonged, severe smog in first months of 2013 has shone a spotlight on the need for strong environmental regulations in china and prompted the government to move forward with a number of new environmental policies and laws at national level, some of which have been languishing in the proposal stage for years:

- China's Air Pollution Prevention and Control Law (first adopted in 1995, first amended in 2000, and reopened in 2013 for new update)
- National 10 Measures (adopted in June 2013)

- Action Plan for Air Pollution Prevention and Control (Action Plan, adopted in September 2013)
- Environmental Protection Law (first adopted in 1989, reopened for update in 2012, and passed in April 2014)
- Performance Assessment Measures for Air Pollution Prevention and Control Action Plan (for trial implementation) (adopted in April 2014)

Regional environmental policies:

- Building a Beautiful Tianjin Programme (adopted in August 2013)
- Action Plan for Air Pollution Prevention and Control in Jing-Jin-Ji and Surrounding Areas—Details for implementation (adopted in September 2013)
- Action Plan of Beijing City for Clean Air 2013–2017 (adopted in September 2013)
- Implementation Details of Action Plan for Air Pollution Prevention and Control in Hebei Province (adopted in September 2013)
- Action Plan of Shanghai City for Clean Air 2013–2017 (adopted in October 2013)
- Action Plan of Guangdong Province for Air Pollution Prevention and Control 2014–2017 (adopted in February 2014)
- The 2014 Action Plan for Air Pollution Prevention and Control in Shan'xi Province (adopted in April 2014)
- Action Plan of Henan Province for the Blue Sky (adopted in May 2014)

National 10 Measures were disclosed in a strongly-worded statement to prevent and control air pollution. With 35 sub-sections, the 10 measure areas including the following:

(1). Strengthening the comprehensive efforts to reduce emission of multi-pollutants.
(2). Promoting industrial upgrading and restructuring.
(3). Accelerating companies' technology upgrading and increasing their technological innovation capacities.
(4). Accelerating energy restructuring to increase clean energy supply.
(5). Enforcing energy-saving and environmental protection as market entrance requirements.
(6). Imposing strict approval requirements for new investment projects regarding energy-saving and environmental protection, and restricting the investment of industries with high energy consumption and high pollution levels in environmentally vulnerable areas.
(7). Improving legal framework, implementation and enforcement.
(8). Establishing monitoring, alerting and emergency response systems for air pollution episodes.
(9). Defining responsibilities for environmental protection between the government, private sector and the public.
(10). Establishing a regional coordination mechanism to coordinate regional environmental governance.

To effectively implement the National 10 Measures, the Action Plan for Air Pollution Prevention and Control (Action Plan) was released by China's State Council in September 2013. The Action Plan is based on the 12th Five-Year Plan on Air Pollution Prevention and Control in Key Regions which was released in 2012 but contains much more stringent requirement. The objective of the Action Plan is to improve air quality and reduce the air pollution episodes in China, especially the three key regions Beijing-Tianjin-Hebei area (Jing-Jin-Ji), Yangtze River Delta (YRD), and Pearl River Delta (PRD).

It focuses not only on pollution targets, but also on industrial restructuring, industrial location, and technological innovation, as well as stronger governance. It is enforced by linking industrial project approvals to EIA with energy audits, and linking the pollution reduction targets with senior officials' performance evaluations [23]. It was regarded as a milestone document in China's air pollution control history, and in the history of environmental management and governance [26].

Different targets are set for Jing-Jin-Ji, YRD and PRD areas for improvement by 2017 and where the Jing-Jin-Ji region is the most stringently targeted:

(1). For all second and third tier cities, annual average concentration of PM10 should be reduced by at least 10% comparing to the 2012 level, and the number of days with clean air should be increased.
(2). For the three key regions, the annual average concentration of PM2.5 should be reduced by 25%, 20% and 15% respectively.
(3). For Beijing, the annual average concentration of PM2.5 should be controlled at 60 $\mu g/m^3$ level.

Specific targets for coal consumption and vehicle emissions control were set in the Action Plan:

(1). By 2017, the proportion of coal in total energy consumption in China will be reduced to 65% of that in 2012, while the proportion of non-fossil energy consumption will be increased to 13%. The three key regions shall make efforts to achieve negative growth of total coal consumption, and replace coal with natural gas for coal-fired boilers, industrial furnaces, and self-sustained coal-fired power stations.
(2). By 2015, all yellow-labelled vehicles (vehicle registered before the end of 2005) shall be phased out in the three key regions. By 2017, all yellow-labelled vehicles will be phased out nationwide.
(3). Cleaner gasoline and diesel will be provided step by step, and by 2017 China V gasoline and diesel will be used for all vehicles in China nationwide.

The Action Plan put forward new incentives for the local government to improve their local air quality. Firstly, central government will have to disclose 10 best and 10 worst air quality cities monthly. Secondly, meeting targets for PM2.5 in the three key regions and PM10 in other key areas other than the three key regions is considered as compulsory for provinces and is part of the performance evaluation indicators for provincial leaders. In addition, regional collaboration mechanisms in Jing-Jin-Ji and YRD are established with the participation of provincial governments and relevant central ministries in the region. Environmental protection and meteorological agencies will set up air pollution monitoring and alert system.

In response to the Action Plan, local governments have released their local action plans. Beijing and Hebei set up detailed targets including the tonnes of coal to be reduced. Beijing laid down more than 40 measures on vehicle emissions control, in particular, setting vehicle cap at the 6 million levels by 2017.

China's Air pollution Prevention and Control Law, which has not been amended since 2000 was reopened by China's Ministry of Environmental Protection (MEP) earlier in 2013, but the amending process has been delayed, indicating the huge conflict of interests among affected groups. However China's first Environmental Protection Law, which dates back to 1989, and after two years of debate,

had its first amendment in April 2014, approved by Standing Committee of National People's Congress The new law "sets environmental protection as the country's basic policy" [27]. A prominent change in this revision is that the administration of the environment has been given a legal framework, which means that in China now there is a stronger and more official system of duty. The new law will remove limits on fines for polluters, which are currently so low that many factories prefer to pay them than take long-term anti-pollution measures. It encourages "studies on the impact environmental quality causes on public health, urging prevention and control of pollution-related diseases" [27] and promises greater powers for environmental authorities and stricter punishments for polluters, for example it allows authorities to detain company managers for 15 days if they do not complete environmental impact assessments or ignore warnings to stop polluting. The amendment also includes a chapter on information disclosure stating that citizens have the right to obtain information about the environment.

4.2.2. The Gap between Legislation and Implementation

Although the new Environmental Protection Law is praised to have "provides smooth and orderly channels for the public to make appeals on environmental subjects" and have the potential to become the cornerstone for China's "war on pollution" [27], some environmental groups say that China's greatest environmental problems arise from a gap between legislation and implementation [28]. Can the new law fill in this gap? "Implementation presents problems in all the new provisions, there will be technical obstacles, problems in matching the new rules with existing situation on the ground, and issues when the changes in the law alter the power of interest groups", stated Xu Nan, Deputy Editor of China Dialogue a website that monitors environmental issues in China. The hope is that these revisions will give the Ministry of Environmental Protection the power it needs to enforce these new, high-minded eco-protection laws.

In addition, critics say the targets set for Beijing's annual average concentration in the Action Plan are conservative, because 60 $\mu g/m^3$ as annual average concentration of PM2.5 in 2017 is still higher than the 35 $\mu g/m^3$ limit set up by the National Ambient Air Quality Standard (issued in 2012 and to be implemented in 2016) for annual average PM2.5 concentration. Furthermore, targets for the annual average PM2.5 concentration in cities in the three key regions, except Beijing, are unclear, as they require percentage reductions in PM2.5 based on a base year. However, the annual average concentration of PM2.5 in those cities in the base year (2012) has not been reported and may not even exist because PM2.5 was only widely monitored and assessed in China since 2013.

4.2.3. Democracy and Pollution

Environmental degradation is the result of the single-minded pursuit of economic strength without democratic accountability [29]. The development of Taiwan's environmentalism is closely synchronized with successive stages in transition to democracy, and environmental protests in Taiwan in the 1980s over pollution caused by the island's industrialization improved people's sense of political efficacy and pushed Chiang Ching-Kuo to lift martial law in 1987, which ushered in Taiwan's process of democratization [30]. Although it is bold to say mainland China will follow Taiwan's step and the social unrest caused by mainland China's pollution could bring about democracy, it is evident that high profile protests against various polluting industries and the recent shocking air quality in mainland

Chinese cities have helped place the environment at the center stage in Chinese politics. Chinese official media used to describe the country's pollution problem as a necessary but temporary consequence of its economic transformation, but the heavy smog in early 2013 has made poisonous air the become lead item in the prime-time news, broadcast continuously by the state broadcaster China Central Television. The report was not just extensive, but also critical.

Why the change of tone? "Leaders are aware that people can wait 20 years or more for democracy but they cannot wait that long for clean air," says the editor of China Dialogue, which covers environmental issues in China [31]. Companies in China often ignore the environmental laws because of loose enforcement, weak penalties and a prevailing attitude of "I have money hence I can do anything". However, several successful public protests in recent years against polluting projects give China the hope of achieving democracy through environmental issues. The new Environment Protection Law proposed the mechanism of transparency promotion, which includes requiring companies to monitor and report real-time pollution data, clearly specifying criminal penalties for those who evade such monitoring systems or forge monitoring data [32]. In addition, the new law forbids improperly operating pollution prevention equipment and holds government agencies responsible for disseminating information publicly [33]. The new Law also moves close to democracy by permitting civil society organizations to initiate public interest lawsuits on behalf of citizens.

4.3. Public Awareness

Chapter 20 of China's Agenda 21 endorses the goal of increasing public participation in environmental governance [34]. Without the involvement of the public, it would be difficult to restructure institutions to serve necessary ecological rationalities such as the circular economy and sustainable development. Traditional top-down pollution control approaches are increasingly becoming inadequate in enforcing regulations. Based on the number of environmental tips received on official environmental protection hotline 12369, a recent report shows public tip-offs regarding environmental issues are increasing in China, indicating the rising public awareness of the problem. With 26% increase of the number of total environmental tips received on 12369 from 2012 to 2013, more than 70% of the tips concerned airborne pollution in 2013. According to the ministry's environmental emergency and accident investigation center, airborne pollution has become the hottest environmental topic among the public [35]. The same report found that public awareness of the pollution is higher in areas with lower level of air quality. Hebei Province, the most polluted province in China, set up a system in 2013 to reward residents who report environmental illegal behaviours, which obviously have contributed to increasing public awareness of environmental pollution in the province and nationwide.

However, to what extent would public awareness contribute to environmental protection? Van Rooij [36] found that Chinese pollution victims continue to face formidable institutional barriers to effective action including cost, slowness, lack of impartiality, corruption, legal and scientific knowledge, lack of intermediary institutions, *etc.*, while the polluting companies have enough resources and power to shed their responsibility and get away from punishment due to their close connection to the local government. The China General Social Survey of 2006 asked the respondents who considered themselves as pollution victims whether they had taken action on the most severe occasion. Only a quarter had done so. Of the types of actions taken, contacting the polluter or the

government departments were the two dominant strategies. Of the 169 people who took action, 63% were unhappy with the result, and the type of action taken seemed to make little difference. Only 4% said they went to the news media and only 1% went to court. Of the ones who did not take actions, 43% thought it would be of no use, 11% said they it would be too much trouble and pricy to take action, 19% did not what to do, and 22% said they could put up with the problem so the did not even thought of taking action [37]. Hence, it remains sceptical how the emergence of public participation in a country without tradition of participatory democracy. Zhao [34] found that the major constraints of public participation of environmental impact assessment (EIA) are the limited extent of public participation in EIA, limited access to information, limited import of the public in decision-making, and limited access to judicial redress and remedy.

5. Discussion and Recommendations

Air pollution has been killing people since the dawn of industrialization, and China's air pollution problem is no worse than London's great smog in 1952 and Japan's smog of the 1960s. However, more is known about its risk now and global warming raises the stakes: China overtook the US as the biggest source of greenhouse gases in 2006 and has put the globe on a path to exceed UN targets for the rise in the Earth's temperature. However, with coal still providing about 65% of China's energy, it will take years to reverse its dependence on polluting fossil fuels. As the issue threatens to expand from national environmental activism to a public obsession and global attention, China's leaders have pledged to be transparent about the air pollution in China and vowed not to repeat mistakes that cost them public trust during the SARS outbreak in 2003 and the tainted milk scandal in 2008, and a "war on smog" was declared by Chinese Premier Li Keqiang in March, 2014. Just like what happened in London after the killer smog in 1952, China updated Environmental Protection Law and issued relevant action plan and measures as weapons to help China win the "war".

However, it takes more than just weapons to win a war. The past track record of China in implementing environmental laws have not given people too much confidence in seeing China winning the war. With similar causes of air pollution such as coal burning, vehicle emissions, China can certainly learn from London's experience in the 1950s in tackling the smog problem. However, there are also differences in the scale of the events: London's smog primarily affected the city, while the recent smog events covered large areas over China. In addition, anomalies in the meteorological conditions in China, as well as wind blow dust deserts contributed to the severity of the recent smog events [38]. Therefore, the lessons learned from London may not be well suited for China. The aggressive pollution control measures during 2008 Beijing Olympic Games and Paralympic Games (20 July–17 September), such as factory closures and traffic control had effectively improved the air quality in Beijing. However, these pollution control actions were temporary, and the pollution came back more aggressively. Thus, a more consistent follow-up to the policies maybe more important than stringent policies themselves.

As long as China still worships GDP, China will have to burn more coal to power most of its factories. In fact, a few big emitters account for most of the pollution. For example, the eight dirties enterprises in Shandong and Hebei Province (the dirtiest province in China) produce 37 and 30 times emissions of NOx respectively. In Hebei, 21 power plants discharge more than 90% of the emissions.

If these plants actually adhered to the new limits set in the updated law, their emissions would fall by more than half. However, with the "Chinese dream" to realized, the GDP worship will continue. The giant state-owned polluters will still be pressured by the local government to boost GDP, PM2.5 levels will continue to surge.

The main obstacle is that the biggest polluters tend to be the best connected politically. They ignore the rules because it is cheaper to do so and because they can. In contrast, the implementation agencies are weak and overstretched, and lack the ability to enforce all their well-meaning rules and standards.

Hence, although it is crucial to be equipped with stringent environmental laws and regulations, shorten the gap between legislation and implementation, increase transparency and democracy regarding environmental pollution, and raise public awareness, Chinese government will have to focus on the core of the problem—tackling the pollution, and stop its GDP worship.

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Author Contributions

Dongyong Zhang contributed to the completion of the main body of the manuscript, Bingjun Li and Junjuan Liu contributed to all the literature review in Chinese language and part of the literature review in English.

Conflicts of Interest

The authors declare no conflict of interest.

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