Comparison of Successful Tackling Experiences and Future Challenges of Air Pollutant in China and Japan

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Abstract. Within the global trend of environmental protection and emission reducing, many nations struggle with maintaining their industrial growth without cutting pollution controls at the same time more stricter promises of doing so. The article attempts to add a comparative outlook through the reflections on the experiences of two large Northeast Asian economies, China and Japan, both of which are typified with diverse dominant pollutants and governance environments. By placing emphasis on the major steps in their pollution control pathways, the review would be able to synthesize the processing of evidence on the regulatory changes, policy tools and the progressive development of manufacturing and technologies. Combining such institutional and technological changes, with the regional economic structure and long-term trends of pollutant concentration, the article focuses on how various development backgrounds determine viable actions of mitigation. Specific focus is put on the discovery of trends that are consistent across the national setting, and limitations that are closely tied to the region. Instead of proposing prescriptive measures, this review demonstrates the joint actions of phased policy interventions and incremental technological upgrading in leading to air quality improvements, as well as demonstrating the structuring constraints that come with energy reliance, industrial form, and transportation intensity. By employing this comparative synthesis, the article seeks to explain how air pollution in China and Japan has been addressed and to profile common approaches and lingering issues that can be used to shape future research and policy formulation in the exercise of similar transitions within economies.

1 Introduction

In recent years, atmospheric pollution has become a global concern, negatively affecting public health and ecosystem survivability, the control of which to serve as a constraint on productivity. The most straightforward strategies to handle air pollution include shutting down heavily pollutive industries and restricting traffic volume, as is often the first step countries like China start with, but the deficiency of these eco-nomic factors will also impede local economic development. How to minimize pollutant emissions while imposing the lowest possible economic and industrial costs has therefore become a central issue. For

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countries to control their emissions, the easiest way will be to mimic past examples of success. However, current sustainable development pioneers are com-posed of almost all highly developed countries, in many of which industrialization no longer goes on. Their experience of reducing emissions will not be feasible to countries with different traits. For more developing countries that finished industrialization not long ago, there are limited experience exchange or systematic guidelines that can be commonly applied and serve as reference. This article aims to fill this blank, and specifically picks China and Japan, a typical industrialized country actively transitioning to sustainable development and another which is like 20 years ahead of China. Most other existing studies keep track of a single country and its transition throughout years, while few compare the policies and technical advances of two typical countries to provide a viable approach. This article summarizes the governmental policies, regulations, and technological advances, and then combines with trackable data to dis-cuss their effectiveness. At the same time, as both countries have received only phased success, the challenges they have to overcome to attain complete accomplishment are listed.

2 Pollutants, solutions, and challenges

2.1 Coal & SO_2 and suspended particulate matter

As a consequence of rapid development over past decades, pollution-related costs in China are substantial, with air pollution control accounting for 6.6% of national GDP, in addition to a further 3.3% loss associated with water pollution and soil degradation [1]. Air pollution has long been a serious issue, and the government has increasingly undertaken systematic efforts to mitigate this problem. The major concern of air pollution in China comes from coal burning, as is featured by the heavy industrial cities in northern China, which face serious Suspended Particulate Matter (SPM, featured by PM2.5) and sulfur dioxide (SO_2) pollution from thermal energy. Mitigation is mainly done by three method-ologies: shutting down pollutant sources, shifting to cleaner energy, and improving the efficiency of existing energy-consuming matters [2].

Since China first began to address its air pollution problem, shutting down heavy industry plants and outdated pollution sources has been the most direct and effective way. An overview of the changes in Beijing’s air quality in 2013~2017 shows that, accompanied by the shutdown of all thermal power factories in this region and the elimination of 2.1 million high polluted vehicles, the concentration of PM2.5 has decreased to 58 μg/m3 in 2017, which is 35.6% lower than the value of 2013 [3]. Also, remaining factories are transferred out of residential areas to avoid direct effects on citizens. However, ideal resorts are never simply based on sacrificing the development of economy, which means shutdown will only play the role of a transitional approach. During this five-year period, Beijing’s GDP increased by 55.6%, and total energy consumption increased by 10%, signalling the ascendancy of other two methodologies.

The key challenge of China’s air pollution lies in the large-scale utility of coal as an energy source. Though China is trying to get rid of its reliance on coal power, this process is going rather slow. A 2023 governmental report indicates that by 2025 it will only cut down the proportion of coal use by 10% compared to 2020 [4]. Globally, natural gas has been treated as an ideal transitional energy source, with relatively lower carbon and waste gas emission, but China’s natural gas relies nearly half on importing, and its higher prices make it unfavourable for household if without subsidies [5]. Though recent detectives show abundant methane near coal bases in Beijing, the land use conflicts are making it hardly possible to exploit. Till 2019, only 8.8% of the total energy supply comes from natural gases, which was far lower than the global average of 24% [6]. Recently, China has been constructing LNG pipelines to connect with adjacent natural gas sources. A 2025 study expected that by 2027 it would be able to import a maximum of 102 billion cubic meters of natural gas through pipelines, which optimistically will signal further effort into the transfer to natural gas power [7]. Before that, to match the new stricter safety standards for SO_2 concentration revised in 2023, the central point will alternatively lie in the desulfurization of coal processing. Since 2013, coal washing and selecting has decreased the concentration of sulfur in coal to lower than 0.66% and allowed thermal power plants to run at an efficiency of 15% higher than before. In addition to physical methods, China is using chemical synthesis to generate various coal products, as it is already generating 70% of the world's coke output [8]. Such mastery of chemical tackling would enable it to partly change the composition of crude coal to avoid the emission of pollutant while burning. It is still important to note though, that this industry itself generates CO2 and pollutants, which accounts for 5.4% of the total carbon emission of China in 2023, so it will require further research to properly balance its pros and cons.

Improving the efficiency of existing industries is primarily achieved through the upgrading of equipment and production systems, offering the dual benefits of pollution reduction and economic stimulation. In regards to mitigating SO_2, the progress of the industrial facilities is approximated to contribute to 51 percent of the realized changes. Recent technological developments have made the selective separation of both NOx and SO_2 in fuel gases possible through high control of reaction temperatures, injection of sorbents, and circulation of by-products [9]. Combined with the massive installation of the sophisticated filtration systems, these steps have enabled the thermal power plants in Shanxi Province to decrease SO_2 emission by 43 per cent and at the same time increase the electricity production by twofold over a period of seven years [10]. Combined, these changes in household energy usage have caused the greatest PM2.5 reductions. Historically, coal or biofuels were burned in the fires of the individual stoves in northern China in order to heat the house during winter. Centralized urban systems of heating systems have ecstatically spread over the majority of cities and urban surroundings with the promotion of urbanization and modernization and the annual reduction of coal burning stoves within households. One of the remaining shortcomings is that about 66% of the energy supply to these systems is still achieved through the traditional coal burning, and, therefore, the present advantages can be largely explained by the figures related to the energy saving process, and not to fundamental energy replacement [11]. Additionally, despite a conceptual similarity between the application of centralized heating in China and district heating in most developed nations, implementation has additional structural limitations. In the absence of suitably optimised urban structures, and pipeline systems, energy efficiency relative to the theoretical increase at system-level is not likely to be attained.

2.2 NOx and VOC

Japan whose air pollution sources are largely ascribed to volatile organic compounds (VOCs) through industries of chemicals, and nitrogen oxides (NOx) through traffic emissions, their combination support the development of photochemical smog. The strong economic and technological base of Japan as a nation with complete industrialization allowed it to combat its biggest air pollutants at the dawn of the 21st century, when most of the extensive industrial closures were already achieved. In the current state, the main mitigation mechanism that Japan pays attention to is the technological upgrading, the areas of which include energy efficiency and exhaust-gas purification systems. In line with this, government regulation has been shifting to focused and consistent subsidizing of the substitution of old facilities with cleaner and efficient technologies that solidifies a policy framework coming to emphasize technological substitution over technological contraction.

To date, Japan has done much to reduce its NOx emission by enhancing its waste gas catalyse and capture systems. Being a global transportation center, it is virtually impossible to avoid the emission of NOx. The two largest airports in Tokyo alone will produce 8, 205 tons of NOx annually and this equals 2.78 million passenger cars [12]. In addition, it is ineffective to manage the currency in the traffic because the studies do not demonstrate significant dependence of road currency on the regional content of NOx in the air [13]. Secondly, filter and catalyze converter methods of waste gas have just been continuously developed, and other laws such as the Automobile NOx/PM Law are increasingly restricting the allowance of older cars. Even the big manufacturers of vehicles like Mitsubishi are obliged to incorporate Selective Catalytic Reduction systems in their products. Moreover, the engine de-design and fuel composition can also be optimized to lower the NOx emission greatly with working efficiency being higher [14]. With high traffic currency reaching the same high level, there is a drop of the emission of NOx by these vehicles to half the amount in 2000.

Japan has also significantly reduced its VOC emissions by updating to new equipment, while the effects vary according to entity size. Until 2019, Japan has reduced its total VOC emissions by 55%, signalling phase success, while this reduction has been driven primarily by large chemical factories, which have sufficient funds for technological upgrades. In contrast, VOC emissions from paint companies and print shops have proven more difficult to regulate, which is abundant in number but poor in budget. To address this challenge, Japan adopted a mixed administrative approach what includes legal regulation and voluntary emission reduction programs, with subsidies provided to those willing to participate [15]. With governmental support, UV printers are replacing traditional ones to prevent the volatilization of stock printing solutions. Car maintenance, wall paint and coating process also changed the composition and way of storage of necessary organic solutions to reduce VOC emissions.

3 Conclusion

China and Japan, as mentioned above, can serve as two examples of how a stage of high development rates, which it is often coupled with a deterioration of the environment, turns into a stage of high-quality development, when pollution mitigation and environmental safeguarding is becoming a more important priority. Because of the historical use of coal as a source of energy, China remains the country which embraces various preliminary and structurally oriented measures. Its policy structure lays emphasis on centralized power as well as governmental oversight such as direct factory shutdowns and forcible regulation on local emission rates.

In comparison, Japan has fewer structural inhibitions with regard to energy systems and the arrangement of industry as well as the technological progress has assumed the leadership in pollutive reduction. The Japanese government does not make use of robust administrative mandates, but mostly assumes a facilitative and regulatory position, promoting technological modernization by standards, incentives, and institutional backing. These variations imply that different countries, that possess different economic, political and structural bases, might need differentiated rather than homogenized transitional approaches and policies.

Irrespective of such differences, it can be concluded that the overall shift in the outdated technologies to newer and effective ones is the most widespread and efficient route towards achieving permanent reduction of pollution and also establish new prospects in economic growth. However, it is necessary to add that the two countries, China and Japan, have rather developed industrial foundations, and even the mass substitution of industrial equipment itself is a significant source of financial and technical problems, which may restrict the immediate transferability of the two beneficial experiences to the less industrialized economies.

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