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Master's Thesis of International Studies

Effectiveness of Air Pollution Control in China

중국 내 대기오염에 관한 규제의 효율성

February 2020

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Abstract

This paper focuses on analyzing the effectiveness of China's environmental policies. Since environmental regulation is a vague and general concept, this paper emphasized on air pollution control policy, using PM_{2.5} as a tool. Air pollution has become a serious issue in China. Due to rapid economic construction and urbanization, the side-effect of development was ignored for a long time. When people started to realize the urgency of treating air pollution, the problem has become irreversible. While a sequence of regulations has been issued during the past few years, the result isn't positive: statistics are showing that in 2015 more than 80 per cent of the days in over 300 cities in China suffered from toxic air. Hence this paper tries to figure out the reason behind it. To understand this, the first step is to use scientific method to ascertain those regulations have been working or not. If it doesn't, the second step is to find out the reason behind it. Using data and statistics from Chinese governments and independent organizations, this paper analyzes PM_{2.5} and industries' behavior in China. This paper also summarizes prior studies of environmental regulation. It is expected to make contribution for controlling air pollution in China, as well as raising people's awareness of protecting environment.

Keyword: PM_{2.5}, air pollution, policy, effectiveness, China

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초록

본문은 우리 나라 환경정책의 유효성에 대하여 집중적으로 분석했다.환경규제는 애매하고 명확하지 않는 개념이기때문에 본문은 초미세먼지(PM_{2.5})를 통하여 대기오염통제정책에 대하여 집중적으로 연구했다.우리 나라는 이미 대기오염을 엄중한 문제로 삼고 있다.경제건설과 도시화진전에 박차를 가하여 국가 발전의 부작용은 오랜 기간 동안 소홀히 했다.사람들이 대기오염 대처해야하는 심각성을 깨달았을 땐 이 문제는 이미 해결하기 어려운 상황에 이르고 말았다.비록 몇년전에 여러 규정을 반포했지만 결과는 이상적이지 못했다.통계수치에 따르면 2015 년도 중국에서는 300 여개의 도시 들이 80%이상의 날들은 나쁜 공기를 겪었다고 밝혔다.그래서 본문은 배후의 원인을 찾고자 한다.그렇다면 우선 과학적으로 이러한 규정이 효과적인지를 알아보아야 한다.만약 무효적이라면 그 다음은 배후의 원인을 찾아야 한다.본문은 우리 나라 정부와 조직의 통계수치를 통하여 우리 나라의 초미세먼지(PM_{2.5})와 업계행위에 대하여 분석을 진행했다.또 본문은 기존 환경규제에 관한 연구성과를 정리했다.우리 나라의 대기오염을 통제하고 사람들의 환경오염의식을 제고하는데 힘을 보태고자 한다.

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I. INTRODUCTION

In recent years, the problem of air pollution is becoming more severe than ever before owing to accelerating industrialization and large consumption of energy. The negative influence of air pollution can be damaging or even life-threatening, and it can cause respiratory illness, lung cancer, heart disease and even death. Among all of the countries struck by air pollution, China is particularly suffering from the hazardous air pollutants. During the past few years, haze weather caused by particulate matter (PM), with PM₁₀ and PM_{2.5} as primary pollutants, has been affecting large areas of China. While particulate matter can cause various respiratory disease including chronic lung and heart disease, the establishment of monitoring and controlling system aiming at PM_{2.5} was infant. As the environmental crisis gradually being recognized by Chinese leaders and the public, environmental policy has been significantly intensified. In the latest 13th Five-Year Plan (FYP), two key policies have been targeting environmental protection: *Air Pollution Prevention and Control Action Plan (Action 2017)* and the *Three-Year Action Plan for Winning the Blue Sky War (Action 2020)*. The FYP is a blueprint formulated by the central government including long-term social and economic policies and strategies. The 13th FYP enacts from 2016 and ends in 2020. However, even though a series of regulations regarding air pollution treatment have been implemented during the last few years, the result seems dim: China is still suffering from hazardous air polluted weather. Not only the fact that environmental condition in the majority of the nation hasn't remarkably improved, in some urban areas, typically the Northwest part of China has getting worsened.

1. Background

According to Shinya Murase's second report of the protection of the atmosphere, "Air pollution" is defined as the presentation and adoption from daily movements of chemical substances, particles, biomaterial or energy that go through or constitute a procedure of degradation or shifting in the atmosphere (Murase, 2015). And such process has or possibly has noteworthy bad influences on living creature on earth or the environment.¹ Air pollution is compounds of gaseous particles and solid particles, it is the pollutants that released into the atmosphere, destructing people's health and damaging the environment. NRDC² gives four categories of air pollutants: smog and soot, hazardous air pollutants, greenhouse gases, pollen and mold.

Smog is also called as ground-level ozone, mixed by fog and smoke. It is produced in the sunlight after fossil fuels being combusted. Smog is especially dangerous for people who work outside, as a result of irritating eyes, throats and also damaging the lungs. Soot, also known as particulate matter, is composed of minute particles of chemicals, smoke, allergens, dust or soil. It is mainly caused by burning coal, gas, and natural gas, or by emissions from vehicles, power plants, engines, or factories. Those tiny particles can be dangerous because they are airborne, and can be inhaled into lungs, bloodstream, worsening bronchitis and leading to heart attacks or even death.

Hazardous air pollutants are mainly toxic chemicals, including mercury, lead, benzene and dioxins, and these are either fatal or have damaging health risks even in a little bit of amounts. Hazardous air pollutants are usually emitted during coal or gas combustion, incinerating, except for benzene, which is found in gasoline.

¹ Shinya Murase. 2015. "Second report on the protection of the atmosphere." International Law Commission (67): 8-12.

² NRDC was an environmental protection organization founded by a group of environmentalists in 1970.

Greenhouse gases probably is the most familiar pollutant by human. We all know that greenhouse gases are responsible for warmer temperature, as well as other climate change: rising sea levels, extreme weather, etc. Carbon dioxide (CO₂) is responsible for almost 80 per cent of a nation's total greenhouse gas discharge, while methane is responsible of 11 per cent of them. What's the difference between those two sources is that, CO₂ comes from combusting fossil fuels, but methane comes from oil or gas drilling, or other natural and industrial sources.

Pollen and mold are from trees, grass and weeds, carried and spreading by the air. What we didn't know is that, those are exacerbated by climate change, since it lengthens the pollen production season and even certain pollens are more allergenic due to climate change. Pollen and mold are unlike hazardous air pollutants, which are regulated by the government, whereas, they are still recognized as air pollution.

According to the latest estimates from WHO, nearly 90 per cent of the people are now breathing polluted air, threatening seven million people's life every year³. People who have heart or lung disease, as well as the elder and the younger are at higher risk when exposing to toxic atmosphere. Air pollution has been a worldwide issue, especially for developing countries with a large amount of population like China. Among all the air pollutants including sulfur dioxide (SO₂), nitric oxide (NO), ozone (O₃), PM₁₀, PM_{2.5} and so on, PM_{2.5} has been regarded as significantly severe pollutants in China. Based on the statistics from air quality inspecting stations for China's 338 main cities in 2015, PM_{2.5} was the critical pollutant for more than 80.3 per cent of the days with serious pollution⁴(Lin et al., 2018). Whereas, despite

³ World Health Organization. 2018. "How Air Pollution Is Destroying Our Health." Accessed on 29 April 2019. <https://www.who.int/air-pollution/news-and-events/how-air-pollution-is-destroying-our-health>.

⁴ Yaolin Lin, Jiale Zou, Wei Yang & Chun-Qing Li. 2018. "A Review of Recent Advances in Research on PM_{2.5} in China." *International Journal of Environmental Research on Public Health* 15(3): 1.

of the fact that PM_{2.5} has become such a life-threatening pollutant, the foundation of monitoring and controlling system of PM_{2.5} in China was quite infant: it was not until 2012 did China establish today's Ambient Air Quality Standards, as well as incorporating the limiting concentration of PM_{2.5} into the Standard, which took place about thirty years later than the United States⁵.

According to studies from EPA⁶, PM refers to particulate matter, which is also known as particle pollution. PM is compounded by solid particles and fluid droplets from the air.⁷ Some of them are big or visible enough to be visible with unaided eyes, while others are so tiny that they can only be observed by electron microscopes. Particulate pollutant includes PM₁₀ and PM_{2.5}. The meaning of the number at the lower right corner is the figure of the matter's diameter, and the unit is micrometer. Hence PM₁₀ means diameters of particle pollutant are 10 micrometers or below. PM_{2.5} means diameters of particle pollutant are generally 2.5 micrometers or below. Both of PM₁₀ and PM_{2.5} are inhalable. People may wonder how small 2.5 micrometers are. How answer this, let's compare a hair: the average of one piece of single human hair's diameter is around 70 micrometers. Thus, it can be 28 times larger than PM_{2.5} in diameter.

In terms of the sources of PM, it can be composed of numerous different chemical matters including sulfur dioxide (SO₂), nitrogen oxides (NO_x). It can be found from construction sites, fields, fires, as well as power plants, industries and motor vehicles. As mentioned earlier, PM is extremely dangerous because it can be invisible, and it is tiny enough to be inhaled into

⁵ *Id.* at p. 2.

⁶ EPA: United States Environmental Protection Agency

⁷ EPA. 2018. "Particulate Matter (PM) Basics." Accessed on November 2, 2019. <https://www.epa.gov/pm-pollution/particulate-matter-pm-basics>.

lungs or even get into bloodstream. Hence exposure to PM can damage both of the lungs and the hearts. It can cause fatal disease including heart attacks, irregular heartbeat, aggravating asthma, increasing respiratory diseases.

The most authoritative method for measuring air quality in daily life is Air Quality Index (AQI), created by EPA. Five key air pollutants, including smog, SO₂, NO₂, CO and PM, have decisive effect when doing accurate calculation. And this was decided by the Clean Air Act⁸. AQI goes from 0 to 500. Larger the AQI number is, severer the situation is. An AQI value from 0 to 100 is considered to be relatively healthy set by the EPA. If the value is 100 or above, then the air quality is recognized to be not healthy. There're six categories in total:

AQI	Degrees of Health Concern	Representing Colors
0 ~ 50	Good	Green
51 ~ 100	Moderate	Yellow
101 ~ 150	Unhealthy for Sensitive Groups	Orange
151 ~ 200	Unhealthy	Red
201 ~ 300	Very Unhealthy	Purple
301 ~ 500	Hazardous	Maroon

As for the value that is over 500, it is considered beyond AQI. And EPA suggests it be categorized as hazardous. When the value of AQI goes over 151, there is possibility that

⁸ Air Now. 2019. "Air Quality Index (AQI) Basics." Accessed on November 2, 2019. <https://www.airnow.gov/index.cfm?action=aqibasics.aqi>.

every person starts to be affected healthily, especially sensitive groups, who probably have more serious symptoms. For instance, people who have heart and lung disease, the elder and younger are at a higher chance of suffering from the particulate matter, while people who have lung disease, the elder and younger people are probably suffer more from exposing to ozone.

2. Research Questions

According to South China Morning Post, over 200 Chinese enterprises were accused of damaging the nation's environment⁹. Statistics from Institute of Public and Environmental Affairs (IPE) even found that more than 40 per cent of the firms in mainland had records of violating environmental policies¹⁰. It is obvious that there's such strong relationship between China's air quality and enterprises' behavior. From the report at least half of firms in China are desperately deficient of awareness of environmental protection. People can't help but to question that, why those enterprises are fearless of violating environmental policy? It is because of lack of stringency in China's pollution control policy, or the penalty is not heavy enough for the firms to care about it, or is it because the punishment is so heavy that makes China's firms rebel?

Hence, the contradiction of emergency of this issue and lagging development of the environmental protecting mechanism, became an inspiration of this paper. I raise my topic by

⁹ Li Jing. 2014. "China's biggest polluting public companies named and shamed by green groups", South China Morning Post, December 10, 2014. Accessed on December 27, 2019. <https://www.scmp.com/news/china/article/1659235/green-groups-name-and-shame-chinas-publicly-listed-polluters>.

¹⁰ *Id.*

concentrating on the phenomenon of environmental degradation, as well as air environmental regulations and polluters' behavior.

As the answer of my first question is connected to all of other further questions, I raise my initial question as whether China's air control policy is working or not? I study whether the effect of the air protection policies has been positive or negative. Secondly, if air pollution control policies are not working, or there are not as effective as people have expected, what could be the causes of it? What could be the reasons of such ineffectiveness of air pollution control policy? Thirdly, since 'effectiveness' is such an abstract word, in order to obtain a full picture of China's situation, what might be the behavior revealing from such 'ineffectiveness' of environmental policies. When analyzing the last question, I tend to concentrate on major polluters in China, which are industrial firms. To conclude, the research questions in this paper are:

- 1) Whether the air control policy improved pollution outcomes?
 - 2) If it didn't, why air pollution control has been ineffective in China? What are the reasons of inefficiency in air pollution control regulations?
 - 3) What is the precise linkage between environmental policy and polluters' reaction? What is the actual behavior of such ineffectiveness, especially from the perspective of China's firms or industries? Is such behavior related to some certain weakness in China's policy or regulations?
3. The Concept of 'Effectiveness'

The definition of ‘effectiveness’ can be interpreted in multiple ways. It can be defined as the degree of air pollution which is successfully controlled based on certain approved standards. Air Quality Index (AQI), which is mentioned earlier in this Chapter, is usually used by governments to negotiate with the public regarding how the condition of air pollution is or will be. Different countries may have different air quality exponent corresponding to their own national air quality standards¹¹. For instance, Canada uses the Air Quality Health Index, while Malaysia uses the Air Pollution Index, and the Pollutant Standards Index is used by Singapore. Except the similarities in each country’s AQI: the formulas and units, several differences still exist in the types of observed pollutants, more importantly, the threshold. China’s State Environment Protection Agency (SEPA) takes responsibility when measuring how bad the air quality is in China. By observing the concentration of giving atmospheric pollutants: sulfur dioxide (SO₂), nitrogen dioxide (NO₂), suspended particulates (PM₁₀), carbon monoxide (CO) and ozone (O₃), SEPA inspected air quality of 86 big cities in China. For another, the definition of ‘effectiveness’ can also be interpreted by comparing air quality within different time period. When implementing this method, it is necessary to control the observants in different time period.

When analyzing China’s air pollution control policy, I found that there could be one more way to define ‘effectiveness’, considering the specialty of China’s policy. According to two key policies raised above, *Action 2017* and *Action 2020*, there has been different levels of goals on air pollution control towards different regions. This method is also called ‘targeting inspection’ by Michael M. Stahl, which will be covered in Chapter II. This method of promoting air quality helped re-interpret the definition of ‘effectiveness’. As for the

¹¹ Wikipedia. 2019. “Air Pollution Index.” Accessed on June 24, 2019. https://en.wikipedia.org/wiki/Air_Pollution_Index.

measurement of effectiveness, it is applicable to compare the average level of air quality before and after implementing policies. Precise conclusion is achievable when observing the fluctuation of the concentration of certain air pollutant. Additionally, China's enterprises, especially from heavy industry, have played a vital character in deciding China's air quality. The major sources of PM_{2.5}, which will be mentioned in Chapter III, come from emissions of air pollutant by enterprises. Hence, when describing 'effectiveness', accurate data of emissions of air pollutant is needed.

In this paper, I focus on evaluating 'effectiveness' by the combination of three methods. First of all I give a general understanding of the fluctuation of level of air quality in China by using historical statistics of PM_{2.5} in major cities. With the combination of observing the changing level of air quality as well as the corresponding time period, more findings will be achieved, which is connected to the second step: I will evaluate the policies by comparing the data of air quality before and after two key policies being implemented. Nevertheless, analyzing firms' reaction toward air pollution control policy is also necessary. Since 40 per cent of the firms in mainland has violated environmental policies, it is crucial to study this behavior in order to find a solution toward policy violation, which is my third step of defining 'effectiveness'.

4. Methodology & Data

Ministry of Ecology and Environment of the People's Republic of China (MEE) is an official website composed of State Environmental Protection Administration and its lower direct departments¹². This website contains abundant information regarding domestic environmental

¹² Ministry of Ecology and Environment of the People's Republic of China (MEE). 2019. "Website statement."

condition, including Environmental Quality, Pollution Treatment, Ecological Protection, Nuclear and Radiation, Information Disclosure, Interaction and other services. In the column of Environmental Quality, each year a statement of domestic ecological and environmental conditions has been published. In detail, more information regarding each province is also available in this column. In addition, more detailed section such was water quality, air quality, radiation, soil quality could also be found. In this column, a real-time AQI in each city has been wavily published, so as a general prediction of AQI in each region each month. In the Pollution Treatment column, general reports regarding performance if preventing water, air and noise are available. Ecological Protection column contains more information related to monitoring ecological function and nature preserve, as well as protection of biodiversity. With regard to the Nuclear and Radiation column, safety information regarding nuclear power plant, nuclear energy transportation, radioactive waste has been released respectively.

In Environmental Quality column, monthly released reports regarding air quality in major cities in China are also accessible in this website. These reports have been monthly publicity since January 2013. MEE has been performing quite well, except for the fact that there isn't a summary to gather the data to provincial level. MEE only does data collection in each city per month rather than expand to provincial level or even broader. City-level data is more detailed and accurate, which is certain. However, these reports provided data from major cities in China, and some of the cities were left out. Hence it is hard to evaluate the improvement of air quality in a broad way. Additionally, regulations and policies from local government is differentiated by province instead of city, therefore, perhaps it would be better to concentrate on provincial level data of PM_{2.5}.

(中华人民共和国生态环境部, 网站声明). Accessed on November 4, 2019.
<http://www.mee.gov.cn/home/wzsm/>.

MEE reports air quality of 74 major cities and key regions very month since January 2013. The data sources of air quality are from China National Environmental Monitoring Centre¹³, which was established in 1979 with support from the government. This monitoring center is recognized as the most authoritative organization for environmental quality monitoring. In MEE's report, it firstly summarizes the amount of days with excellent and good air quality, middle level pollution and heavy pollution respectively. After a general nationwide evaluation, it focuses on air quality in key regions and 74 major cities. Meanwhile, it provides concentrate of different contaminants: SO₂, O₃, CO, PM_{2.5}, NO₂ and PM₁₀, typically offering monthly concentration of pollutants in three regions: Region 1 (Jingjinji), Region 2 (Changsanjiao) and Region 3 (Zhusanjiao). The reports end up with two attached lists: rankings of air quality in 74 major cities and, rankings of average amount of PM_{2.5} in 74 major cities per month.

Berkeley Earth¹⁴ is a non-profit, independent institute which used to focus on monitoring land temperature, and data analysis for climate science since 2010. BE claims that it is an independent institute without concerns for policies of government or industries. Meanwhile, it promises to post raw data and analysis code online, for providing a transparent platform to allow further analysis by others. Four plates have been highlighted in this website: Land + Ocean Data Set, the part for summarizing the studies, Air Pollution and the part for giving conclusions. In Land + Ocean Data Set, global temperatures, as well as historical data of climate change comparison. In Summary of Findings, BE summarizes studies of climate variability, extreme events, as well as the role of the oceans.

¹³ China National Environmental Monitoring Centre. (中国环境监测总站). Accessed on July 10, 2019. <http://www.cnemc.cn>.

¹⁴ Berkeley Earth (BE). 2019. "Description." Accessed on November 4, 2019. <http://berkeleyearth.org/air-quality-real-time-map/>.

Institute of Public & Environmental Affairs (IPE) was established in 2006, located in Beijing. During the same year the China Water Pollution Map website was launched, so as the Water Pollution Database¹⁵. In 2008, IPE released the Air Pollution Map and expanded the Pollution Information Transparency Index (PITI). The mobile version of Pollution Map was released in 2014, so as the Corporate Information Transparency Index (CITI). With regard to latest update, in 2018 IPE released Supply Chain Climate Action SCTI Index and the Environment Risk Assessment Tool.

Berkeley Earth has begun a brand-new project to gather and break down the world's air pollution data since 2014. At the head of the Air Pollution Overview page, BE provides a Real-time Map of Air Pollution. Since PM_{2.5} is quite destructive modality of air pollutants, stated by BE, this map concentrates on posting data of particulate air pollution which is less than 2.5 microns in diameter. Not only this, historical data of monthly concentrate of PM_{2.5} in China's 20 major provinces. BE stated the fact that every year 1.6 million people were facing death because of the poisonous air in China¹⁶. PM_{2.5} is an extremely dangerous form of air pollution, contributing to cardiopathy, stroke, respiratory infection, lung cancer and other disease¹⁷. While other pollutants are used to evaluate air quality, such as PM₁₀, nitrogen dioxide, sulfur dioxide and ozone, BE mainly aims at PM_{2.5} as an essential factor.

With the aim of answering the third research question of the relationship between enterprises' behavior and air pollution control policy, as well as the actual behavior of the ineffectiveness, as mentioned as the third research question previously as raised above, observation on

¹⁵ IPE. "About us." Accessed on November 4, 2019. <http://www.ipe.org.cn/about/about.html>.

¹⁶ BE. 2019. "A Measured Approach: Climate Science + Strategic Analysis." Accessed on July 10, 2019. <http://berkeleyearth.org>.

¹⁷ See note 14.

enterprises' reaction toward air pollution control policy is essential.

IPE is an individual also uncommercial studies institute located in Beijing. The foundation of IPE was in June 2006, it devoted itself to gathering and analyzing environmental information from the official and industries, in order to establish an environmental knowledge database. IPE provides two channels to process data for serving green procurement, green finance and official decision-making: Blue Map website and Blue Map application. Imposing coordination among private companies, government, NGOs, as well as other research, IPE contributes to leverage the power of a large-scale industries and enterprises to achieve environmental transformation, as well as to promote publicity of environmental knowledge and develop environmental supervision mechanisms.

IPE offers three programs as their fundamental projects: Green Supply Chain, Green Finance, as well as PITI¹⁸. Green Supply Chain reveals domestic and international industries with environmental management solutions. Green Finance is used for gathering and breaking down information from several stakeholders. PITI detects pollution sources and environmental quality to value the government environmental information.

IPE also provides reports examining publication of air pollution monitoring information, also called "Blue Sky Roadmap" (BSR). According to the BSR's latest observation (2019) on 168 cities, the average level of PM_{2.5} increased 16.1% comparing to last year. BSP shows evidence that the reversion of pollutant emissions from high energy-consuming enterprises, leading to the growth of PM_{2.5}. IPE also provides enterprises' behavior towards environmental protection. Take the Supply Chain Climate Action (SCTI Index) as an example, SCTI index reveals ranking of emission data from each industry. Meanwhile, the CITI reveals ranking of environmental management from each firm. Hence, by specifying observing time, enterprises'

¹⁸ IPE. 2019. "About US." Accessed on October 13, 2019. <http://www.ipe.org.cn/about/about.aspx>.

reaction towards air pollution control regulations is tangible. Since IPE provides reports examining publication of air pollution monitoring, information like enterprises' environmental management, discharge of air pollutants, as well as attitudes toward environmental protection, could be collected.

II. LITERATURE REVIEW

1. Existing Theories

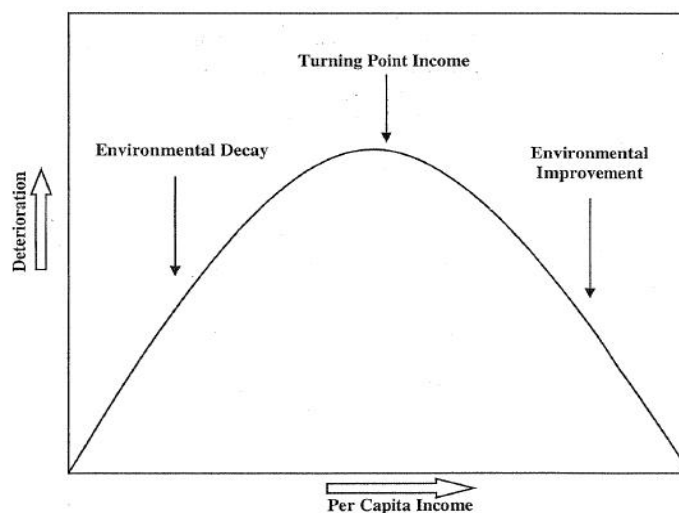
1-1. Economic Development and Environment

Michael Faure provides experimental evidence regarding the effectiveness of environmental laws and policies¹⁹(Faure, 2012). To explain the relation between economic development and environment, empirical studies have been dedicated to imposing the conception of “Environmental Kuznets Curve²⁰”. Simon Kuznets reviews the relation between unbalance in income and income level in a country: as economic develops, market forces first increase and then decrease economic inequality²¹. While various scholars provide empirically that economic development results in environmental degradation, while there is an inflection point where increase economic welfare improves environment.

Plenty of research is also committed to the “Porter Hypothesis²²”(Porter, 1995), claiming

¹⁹ Michael Faure. 2012. “Effectiveness of Environmental Law: What Does the Evidence Tell Us?” William & Mary Environmental Law and Policy Review 36 (2): 293-336.

²⁰ This concept is named after the Nobel Prize winner Simon Kuznets, who examines the relations between income inequality and income level in one country.



²¹

source: <https://www.perc.org/2011/02/10/mexico-and-the-environmental-kuznets-curve/>

²² Michael E. Porter & Class van der Linde. 1995. “Toward a New Conception of the Environment -

that a better environmental behavior issues in an increase in the potency of the company and as a result to more return. Traditionally speaking, if the environmental regulation is more stringent, then corporations will have to reduce emissions and production to show compliance. On the other hands, corporations may transform to use cleaner production technology. Whereas, the results of such transformation lead to either higher cost or lower profits. And this is the reason why most of the economists believe that more stringent environmental regulations impede economic development. However, Michael Porter raises an opposite argument. He argues that if the regulations are designed appropriate enough, it may inspire the corporations to innovate their technology, eventually reduce the cost of being compliance. Hence in his theory, strict but flexible regulations lead to better environmental performance, as well as better business performance. This hypothesis provides experimental proof for the existence of “Environmental Kuznets Curve”. It should be noticed that “flexible” is the essence, if the regulations pay more attention to remind the regulatees to innovate, the uncertainty during the process of investing money for protecting environment will be reduced. Under such circumstance, regulations will push technology innovation.

However, there are other scholars who examined to which degree a country’s supervisory system affects environmental quality²³, except for income levels. It suggests that for both developed and developing countries, environmental protection improves a country’s institution alongside with economic development (Daniel & Michael, 2005). In other words, not only economic growth can benefit a country’s environmental conditions, but also by developing and strengthening rules of law.

Competitiveness Relationship.” JOURNAL OF ECONOMIC PERSPECTIVES 9 (4): 97-98.

²³ Daniel C. Esty & Michael E. Porter. 2005. “National Environmental Performance: An Empirical Analysis of Policy Results and Determinants.” Environment and Development Economics 10: 391, 393.

1-2. Stringency of Regulations

The stringency of environmental regulations affects the behavior of firms or households. If private actors show compliance under those regulations, it will in turn generate an increasing market for international trade in environmental goods and services. Hence, regulatory stringency generates the development of a market for preventing pollution, such as local air and water pollution emissions²⁴ (Sauv, 2014). However, the measurement of regulatory stringency could be empirically and conceptually difficult, as mentioned by Jehan Sauvage. Some of the challenges exist in the multidimensionality of environmental regulations, for example. Since regulations and policies vary from medium, pollutant as well as sector, regulatory stringency is influential, also influenced by discharge of pollutants as well²⁵.

Dan Esty and Michael Porter examine to which degree a country's supervisory system influences environmental quality²⁶. The result of studies shows that a country's environmental condition can gain profit by not only economic growth, as mentioned by "Environmental Kuznets Curve", but also the strength of law. Esty and Porter's results convince that tightening the supervisory structure also helps the perfection of environmental quality. While "Environmental Kuznets Curve" illustrates a connection between higher environmental quality and economic condition, it doesn't mean that environmental law is not important. Studies from Esty and Porter show convincingly that the promotion of environmental quality is benefited from tighter regulatory structure²⁷ (Binder & Neumayer, 2005).

²⁴ OECD iLibrary. 2014. "The Stringency of Environmental Regulations and Trade Environmental Goods." Accessed on July 7, 2019. https://www.oecd-ilibrary.org/trade/the-stringency-of-environmental-regulations-and-trade-in-environmental-goods_5jxrjn7xsnmq-en.

²⁵ *Id.*, at p. 25.

²⁶ *Id.*, at p. 424.

²⁷ Seth Binder & Eric Neumayer. 2005. "Environmental Pressure Group Strength and Air Pollution: An

However, existing studies also show that a more balanced picture works better. For example, there are some scholars arguing that the laxer a nation's regulations, the higher chances the nation is to attract foreign investment²⁸(Xing & Kolstad, 2002). According to this theory, the laxity of regulations is essential for determining foreign direct investment. While other scholars argued that the influence of stringency of regulations is limited. It may have some effect on new corporations for deciding where to locate for the first time, but this doesn't affect the existing corporations. Meanwhile other criteria also matter, such as tax level or labor force, as well as public service levels²⁹(Jaffe, 1995).

Meanwhile, empirical evidence also shows strong connection between regulatory efforts and measurement. As provided by Esty and Porter, environmental gets better as a result of regulatory efforts. What's more, usually regulatory efforts tend to achieve the goals when estimated by the amount of reduced emissions.

1-3. Command-and-Control vs. Market-Based

Although it is argued by Michael Faure that it is impossible to compare traditional command-and-control system with market-based methods, because the regulatory of the one or the other is likely to depend on the concrete context, category of pollutant which is being regulated, institutional design and so on. A few studies can still show results from two different mechanisms.

Empirical Analysis.”, *ECOLOGICAL ECON* 55: 527, 528.

²⁸ Yuqing Xing & Charles D. Kolstad. 2002. “Do Lax Environmental Regulations Attract Foreign Investment?” *ENVTL. & RESOURCE ECON*.21 (1): 15.

²⁹ Adam B. Jaffe. 1995. “Environmental Regulation and the Competitiveness of U.S. Manufacturing: What Does the Evidence Tell Us?” *J. ECON. LITERATURE* 33(132): 157-158.

To define ‘command-and-control’ policy, it is a kind of policy which depends on administration, such as permission, prohibition, standard formulation as well as execution or performance. It is the opposite of financial incentives or economic instruments³⁰. According to the standard economic account provided by Cole and Grossman, this kind of policies are not as effective as it sounds, and should become more and more inefficient over time, as extra effort of controlling pollution becomes more expensive³¹(Cole & Grossman, 1999). Still, this article offers an exception of the Clean Air Act of 1970, which will be mentioned in Section 2-3.

“Market-based instruments” refer to direct regulatory instruments which make an impact on polluters’ behavior by transforming their economic incentive structure. The most common types of instruments are emissions trade, taxes, removal of preserve incentives, liability rules and deposit refund³². Usually firms have their own preference among those five different instruments. Taxation are usually not preferable by existing firms, as it represent an additional cost to them on the market. Taxes are more favorable by new firms. On the other hand, new firms prefer emission standard or emission trading less, as those could be seen as a barrier set to new firms³³(Hahn, 1989).

Another problem with taxation is that certain interest groups may manipulate the taxation system. Taxations are often seen as an added charge to the existing firms, and government has

³⁰ OECD. 2019. “GLOSSARY OF STATISTICAL TERMS.” Accessed on June 27, 2019.
<https://stats.oecd.org/glossary/detail.asp?ID=383>.

³¹ Daniel H. Cole & Peter Z. Grossman. 1999. “When is command-and-control efficient? Institutions, Technology, and the Comparative Efficiency of Alternative Regulatory Regimes for Environmental Protection.” *Maurer Faculty* 590: 935.

³² Climate Policy Info Hub. 2019. “Market-Based Climate Policy Instruments.” Accessed on June 27, 2019.
<https://climatepolicyinfohub.eu/market-based-climate-policy-instruments>.

³³ Robert W. Hahn. 1989. “Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor’s Orders.” *JOURNAL OF ECONOMIC PERSPECTIVES* 3 (95): 107-08.

been accused of using such money on public services instead of a tool of environmental policy³⁴.

Much evidence proved the success of imposing market-based instruments, such as the success obtained with environmental taxes in the Netherlands, for example³⁵. In the Netherlands, the original water pollution from fourteen industries were responsible for 90 per cent of entire water pollution in 1969. Whereas this number reduced by half in 1975, and by 20 per cent in 1980. 50 per cent of this reduction was because of an effluent charge. The effect of taxation is stronger in Germany's case, argued by Bongaerts and Kramer, since Germany reduces half of the charges for regulatees who meet the emission standard³⁶ (Bongaerts & Kramer, 1987).

Plenty of evidence also proofs the fact that environmental taxation can be inefficient. Belgian holds that individual energy producers run away from most of air pollution rules by implementing on the tax. China happens to belong to this criteria, and specific cases of China's failing to use market-based instruments will be covered later

1-4. Targeting inspections

Inspection is one of the most essential way to issue regulations, and to make sure actors' compliance. There are many activities which are relevant for most sectors where inspection happen, including targeting inspections, communicating with regulated subjects, organizing inspections and governing inspection authorities, preventing corruption, as well as promoting

³⁴ *Id*, p.107.

³⁵ Donald N Dewees, David Duff & M J Trebilcock. 1995. Exploring the Domain of Accident Law: Taking the Facts Seriously.315. New York: Oxford University Press.

³⁶ Jan C. Bongaerts & R. Andreas Kramer. 1987. "Water Pollution Charges in Three Countries: Control through Incentives", EUR, ENV'T REV. 1 (12): 15.

ethical behavior³⁷.

The difference between ‘target’ and ‘objective’ is that, targets are provide verifiable evidence which have actually met the objective³⁸(Conon, 2012). Targets are usually records composed with numbers, whereas objectives are documents and can be modified. Due to the fact that targets are involved with specific number which are difficult to modify, people usually pay attention not to set targets overly ambitiously. Setting targets is a relatively efficient way to standardize policy execution and make regulatees compliant.

Michael M. Stahl provides the definition of “targeting”: environmental procuration and prosecutors devote themselves on a sequence of regulatees or impediments to attain better results³⁹(Stahl, 2011). It is suggested by Rousseau that targeting inspections and operations may promote universal compliance⁴⁰(Rousseau, 2007). Take firms in the Flemish region in Belgium as an example, agencies in Belgium use different targets to select firms, and based on their compliance behavior, agencies judge those firms are ‘good’ or ‘bad’. Good firms only need to receive routine inspections and bad firms are inspected more frequently. Agencies found that firms tend to move to the ‘good’ side. Hence, Rousseau draws the conclusion that higher deterrence, stricter targets, will lead to firms’ compliance, for they trying to escape from being categorized as ‘bad’ firms.

Meanwhile, targeting inspections are important features of China’s environmental policy, although the effects may not seem remarkable as Rousseau examines.

³⁷ OECD. 2018. OECD Regulatory Enforcement and Inspections Toolkit, OECD publishing, Paris: 3.

³⁸ Clare Conon. 2012. “Setting environmental objectives and targets for ISO 14001 Compliance”, EHS Management. Accessed on September 11, 2019. <https://ehsdailyadvisor.blr.com/2012/09/setting-environmental-objectives-and-targets-for-iso-14001-compliance/>.

³⁹ Michael M. Stahl. 2011. Doing What’s Important: Setting Priorities for Environmental Compliance and Enforcement Programs. *Journal of Environmental Law* 25 (2): 343-345.

⁴⁰ Sandra Rousseau. 2007. “Timing of Environmental Inspections: Survival of the Compliant.” *Journal of Regulatory Economics* 32: 17, 20, 31.

1-5. Neil's Seven Models

Environmental intervention is progressed at supervisor level and display in an official policy which directs at field officers, regulated organizations and other stakeholders⁴¹(Gunninghan, 2011). Neil provides seven models of intervention strategies which have been imposed by four states: the Netherlands, the United States, the United Kingdom and Australia. Although these states have multiple environmental agencies who handle multiple environmental status, similarities can still be found in each agency. And those similarities can be categorized in each model. The seven models are: rules and deterrence, advice and persuasion, criteria-based regulation, responsive regulation, smart regulation, risk-based regulation and meta-regulation.

The US Federal Environment Protection Agency (EPA) is a typical example of using 'rules and deterrence' strategy. Traditionally the EPA focuses on compliance monitoring, once violations has been identified and the evidence has been collected, they take enforcement actions. The EPA emphasizes enforcement as a vital part of encouraging behaviors that meet with obligations, using stringent sanctions including behind bars to develop deterrence and make sure compliance from companies and others. Deterrence and enforcement are mentioned more continually in the EPA reports and documents, but is it really working? Neil argues that 'rules and deterrence' could exertive positive effect especially in reassuring organizations to comply, because according to this model, others who do not comply can't get away without any punishment⁴². While this model is effective when organizations are rational, it doesn't

⁴¹ Neil Gunninghan. 2011. "Enforcing Environmental Regulation." *Journal of Environmental Law* 23(2):169-201, 172-173.

⁴² US Environmental Protection Agency. 2019. "Enforcement." Accessed on June 28, 2019.

work well when enterprises tend to take legal risks. This model is likely to create a ‘regulatory resistance’ or a defensive stand for organizations, in that case they will fear sanctions as the agency expected.

‘Advice and Persuasion’ is a strategy imposed by the Australian Government’s Department of Environment, Water, Heritage and Arts⁴³(2009). Also known as ‘compliance strategy’, this model emphasizes on self-regulation and community’s coordination with legislation. The Victorian EPA in some degree faces to this model. This procuration’s determination is to ascertain compliance risks and to control the non-compliance risks. While ‘advice and persuasion’ is applicable when encouraging actors’ compliance, suggested by evidence, it may act poorly when actors are not willing to comply in the beginning. Neil provides evidence showing that this model may discourage complying actors when law breakers easily get away without any punishment. In fact, after failures of these compliance approaches in Australia, the section makes it distinct that they will use enforcement mechanisms.

‘Criteria strategies’ involve in an extensive scope of options, which are usually listed in agency’s document. Specific treatment will be used in different circumstances, and it’s been considered by decision-makers rather than according to some prescriptive formula. The Florida Department of Environment Protection (DEP) is an instance of using such model. This agency’s goal is to resolve violations efficiently and coerce violators to be compliant as fast as possible⁴⁴. Since many violations are targeted and dealt with by this agency, a mixed approach

<http://www.epa.gov/compliance/index-e.html>.

⁴³ Australian Government, Department of the Environment and Energy. 2009. “Compliance and Enforcement.” Accessed on July 5, 2019. <http://environment.gov.au/epbc/compliance-and-enforcement>.

⁴⁴ Florida Department of Environmental Protection. 2009. “Compliance and Enforcement.” Accessed on June 28, 2019. <http://www.dep.state.fl.us/mainpage/ce/default.htm>, accessed on June 28, 2019.

would be better rather than adopting a single strategy. The Dutch VROM⁴⁵ and a quantity of Australian jurisdictions also employ this model. The Dutch VROM imposes the ‘Table of 11’ as a frame structure to decide which kind of intervention to take. The Western Australian Department uses ‘Enforcement and Prosecution Policy’ to determine what enforcement action is needed. However, since Neil argues that ‘criteria strategy’ is not a consistent preventive method, and theoretical development or empirical test is not applicable.

In the UK, ‘risk-based’ strategy was admitted by the Hampton Review⁴⁶ (Hampton, 2005). The England and Wales Environment Agency’s goal is to offer suggestions and guidance to the actors, as well as enforce laws when non-compliance is discovered⁴⁷. Depending on the risks exposed to the surroundings, the possibility of using compulsory action will be determined. In terms of how to assess risks, the agency uses plenty of tools, such as OPRA (operator risk appraisal), which is one of the principle methods to enable agencies assess risks objectively. The Australian New South Wales Department of Environment, Climate Change and Water (DECCW) also adopt this model, so as agencies from South Australia and Victoria. While this model enables supervisors to prioritize their action and maximize cost efficiency, whereas, challenges still come from the measurement of assessing risks, said by Neil.

‘Responsive regulation’ is a mixture of persuasion and coercion. Persuasive attitude will be taken when the actors are in a flexible and cooperative manner, but once organizations betray

⁴⁵ A Van Der Schraaf. 2004. “Incentive Framework to Comply with Regulations”, Paper for the OECD Conference on Economic Aspects of Environmental Compliance Assurance, Paris, December 2004.

⁴⁶ Philip Hampton. 2005. “Reducing Administrative Burdens: Effective Inspection and Enforcement.” Thomson Reuters. Accessed on July 8, 2019. https://www.nao.org.uk/wp-content/uploads/2008/03/HSE_Hampton_report.pdf.

⁴⁷ UK Environment Agency. 2019. “Compliance and Enforcement Policy Guidance.” Accessed on June 28, 2019. <http://www.environment-agency.gov.uk/business/regulation/31851.aspx>.

from cooperation, agencies will soon take deterrent attitude. But when actors start to act cooperatively again, agencies will also change attitude correspondently. The Australian Capital Territory (ACT) and the Northern Territory give priority to this model. This model is flexible enough to accommodate motivations from different actors, and it can also overcome imperfection from ‘rules and deterrence’ and ‘advice and persuasion’. Whereas, this model has been accused of not being respondent when coordinating with regulated companies. ‘Responsive regulation’ works best when regulating large organizations with frequent interactions, and only has effect on behaviors rather than attitudes.

2. Cases in Different Countries

2-1. The impacts of the Clean Water Act of 1972

Regulating the emissions of pollution into a country’s surface water, the Clean Water Act (CWA) is a United States federal law issued in 1972 and amended in 1977 and 1987. Conducted by the U.S. EPA, CWA also determines water quality criterion and enforces it on organizations⁴⁸. Although not legally bond, EPA requires that major parties regulated by CWA must be inspected at least once every two years, while minor parties regulated by CWA take over a comprehensive monitoring at least once every five years (Gray & Shimshack, 2011).⁴⁹ The original goal of CWA was removing the emissions of waste water which wasn’t being disposed by industries and municipalities, to make the waterways safe for swimming and fishing. Nevertheless, CWA also participated in applying for federal permissions to discharge

⁴⁸ INC. 2019. “Clean Water Act.” Accessed on July 1, 2019. <https://www.inc.com/encyclopedia/clean-water-act.html>.

⁴⁹ Wayne B. Gray & Jay P. Shimshack. 2011. “The Effectiveness of Environmental Monitoring and Enforcement: A Review of the Empirical Evidence.” *Review of Environmental Economics and Policy* 5 (1): 3-24, 9..

pollutants into surface water.

Way and Jay provide empirical studies on the relationship between regulator activity and water pollution discharges and compliance. Results are demonstrated that facilities' possibility of non-compliance will be much higher if they didn't receive inspection previously. Moreover, inspections also help reduce the possibility of facilities' being discharged⁵⁰. As for the effects of sanctions, they find that monetary sanctions have more noticeable impact on compliance comparing to non-monetary sanctions. Also, an additional fine works better than an additional inspection in terms of inducing substantiality⁵¹.

2-2. Environmental Inspecting System in Europe

The goal of stricter regulations is to help form more compliance. If there's no more compliance achieved in the process of implementing strict regulations, it will be useless and inefficient. In Jale Tosun's study of environmental inspection and enforcement in Europe, two main approaches have been discussed⁵²(Tosun, 2012). The first one is to require polluters to inspect activities by themselves, including filing and reporting information about operations and emissions. According to this strategy, polluters are supposed to provide information about details on their environmental conditions, as well as the emissions of all types of pollutants. The second one is to implement inspection visits of facilities, such as evaluating the data gathered in the process of self-monitoring by regulatees. In order to define minimum criteria

⁵⁰ *Id.*, at p. 21.

⁵¹ *Id.*

⁵² Jale Tosun. 2012. "Environmental Monitoring and Enforcement in Europe: A Review of Empirical Research." *Environmental Policy and Governance* 22: 437-448.

for organizations, as well as announce the results of environmental inspections, the European Parliament and the Council employed Recommendation 2001/331/EC in 2001. Since then this became the only promising avenue for domestic inspection regime in the member states. However, it's been doubted that whether the new member states are willing to follow this article and modify their environmental inspections.

Tosun analyzed both of the strengths and weakness of the dimension of environmental performance. The good thing is data availability is relatively high in Europe, from the perspective of results and its influences, as well as stringency of monitoring and enforcement from the regulatees' cognition. The imperfection is that there is need to develop more practical indicators, in order to meet the demand of criterion of construct availability⁵³. In terms of more imperfections of prior studies on the system of environmental inspecting in Europe, Tosun also supplemented that there was little evidence discussing the actual process of those activities, nor was any development of comparative work with previous department. Tosun also emphasized the necessity of case studies for individual European states⁵⁴.

2-3. The Clean Air Act of 1970

Clean Air Act (CAA), passed in 1970 and later amended, is a United States federal law which is framed to manage air pollution on a national level⁵⁵. CAA is characterized by heavily relying on administrative expertise, as well as using uniform, categorical rules as fundamental regulatory building blocks, which is to say, command-and-control⁵⁶. Not only did CAA enlarge

⁵³ *Id.* p. 443-444.

⁵⁴ *Id.* p. 445-446.

⁵⁵ Wikipedia. 2019. "Clean Air Act (United States)." Accessed on June 27, 2019. [https://en.wikipedia.org/wiki/Clean_Air_Act_\(United_States\)](https://en.wikipedia.org/wiki/Clean_Air_Act_(United_States)).

⁵⁶ See note 23.

the power of EPA, which contributed to constitute the National Ambient Air Quality Standards (NAAQS), but also founded the National Emissions Standards for Hazardous Air Pollutants (NESHAP). While the evaluation of compliance and emissions for small facilities are based upon regulatory inspections, major facilities are supposed to submit regular self-monitoring reports under CAA's regulation. Since facilities which don't file true reports will face heavy penalties or even criminal prosecutions, they often choose to offer the true reports. Meanwhile, EPA also assists to ensure the truth and accuracy of self-monitoring reports.

Empirical studies on outcomes of CAA drew conclusion that supervisor activity affects air pollution compliance. In Gray and Deily's 2007 study, it provides that plants being targeted by EPA enforcement activity are found more compliant comparing to those which haven't been targeted by any enforcement activity. Moreover, studies from Keohane, Mansur and Voynov demonstrate that, if plants predict themselves to face a high chance of lawsuit, they will be more likely to reduce their emissions relative to those facing lower predicted chance of lawsuit.

2-4. The Convention on Long-Range Transboundary Air Pollution (CLRTAP)

The CLRTAP was signed in November 1979 in Geneva. The background of this act traits back to the middle of 1970s, when East-West détente was in the process. At that time environmental issues were ascertained as a potential area for global cooperation. Chosen to negotiate environment-related concerns, the United Nations Economic Commission for Europe (UNECE) identified 33 contracting parties, and the Convention was in force since 1983 with a membership of 48 countries⁵⁷(Wettstad, 2002). The first step of this Convention is to make

⁵⁷ Jorgen Wettstad. 2002. "The Convention on Long-Range Transboundary Air Pollution (CLRTAP)", In

parties recognize of the current condition of air pollution. After knowing that, the goal of CLRTAP is to narrow down parties and, limit and dispute air pollution. It promotes parties to promote strategies and policies to deal with the discharges of air pollutants through monitoring, research and consultation⁵⁸.

In CLRTAP, it didn't specify any pollutants, but it has been suggested that monitoring and evaluating air quality through sulfur dioxide (SO₂). Since 1979, a series of acts aiming SO₂ has been issued. The Protocol on the Reduction of Sulfur Emissions in 1985 was the initial major regulatory step in global cooperation, which is also known as the Helsinki Protocol. Followed by the 1988 Sofia Protocol, which aimed at nitrogen oxides (NO_x), 25 countries signed this protocol including U.K. and U.S. The following movement was the 1991 Geneva Protocol, aiming at Volatile Organic Compounds (VOCs), which are chemical substances that related to ground-level ozone. Then more protocol concerning sulfur, heavy metals and persistent organic pollutants (POPs) have been in force in the 1990s⁵⁹.

To measure the success of CLRTAP, Jorgen evaluates this convention as a successful and substantial international regulatory regime, initiating a series of protocols, as well as national compliance and global cooperation. The positive aspects of political and scientific evolution bring people's cognition of environmental protection, and a substantially effective regime increase such knowledge.

2-5. Japan's Minamata Disease and its influence

Environmental Regime Effectiveness, edited by Edward L. Miles, Steinar Andresen, Elaine M. Carlin, Jon Birger Skjærseth, Arild Underdal, and Jørgen Wettstad, 197-221. The MIT Press.

⁵⁸ *Id*, p. 198.

⁵⁹ *Id*, p. 199-200.

In the middle of 1950s, a disastrous disease has swept Minamata, which is a small finishing town in Japan. The unusual symptom initially happened to cats. Cats in Minamata were going crazy and falling into the sea. Soon after, similar symptom was happening to people: shouting, uncontrollably screaming, etc. Other symptom from the people were also observed, including numbness in limbs and lips, having difficulty in hearing or seeing, as well as shaking and even brain damage. Eventually researchers discovered the reasons of the illness – severe mercury poisoning. And then this disease was named as Minamata Disease. Until March 2001, more than 2,200 victims had been officially diagnosed, among them more than 1,700 were died⁶⁰.

The cause of Minamata Disease is the large amount of methylmercury release in industrial outlet water from Chisso Corporation, which was a chemical plant continuing from 1932 to 1968⁶¹. The toxic methylmercury had been bioaccumulated by fish, which were eaten by animals and people, eventually causing this disaster. Unfortunately, the early delay of introducing the anti-pollution measures resulted in a broader spread of damage, as well as more people being harmed. Both of the corporation and government claimed to be responsible for letting such misery happen. By 2004, Chisso Corporation had paid \$86 million to compensate for its destructive misbehavior, and the lawsuits requesting for compensation has been continuing for today.

Having been through such destructive damage caused by Minamata Disease, Japanese government has been indicated to managing mercury, joining hands by Japanese industries and citizens. Gradually, a more powerful environmental protection measures were introduced in Japan, including legislation and revision of fourteen laws during the 1970s. According to the

⁶⁰ Sustainability. 2019. "Minamata Disease." Accessed on November 5, 2019. <http://www.bu.edu/sustainability/minamata-disease/>.

⁶¹ *Id.*

government's data from FY2010, the demand and supply chain of mercury have been fully monitored and controlled. Not only that, the Japanese government was also considering of designing a mechanism regarding mercury's collection, storage and disposal⁶².

3. Protection of the Atmosphere in International Status

Two reports regarding the protection of atmosphere from International organization has been published by Shinya Murase, in 2014 and 2015 respectively. In Mr. Murase's first report, it generally illustrates the evolution of international law on protecting air quality, and multiple treaty practices, as well as the scope of international law. As for the second report, it ulteriorly discusses the degradation of atmospheric conditions, as well as international cooperation. In the first report, Murase discusses the definition of atmosphere. Although it usually refers to "the envelop of gases surrounding the earth", a more appropriate legal definition is necessary. Eventually Murase provides a definition for a better understanding: "Atmosphere" refers to the thickness of gases around the earth. And in the "Atmosphere" the transportation diffusion of skyborne matter takes place⁶³(Murase, 2014). He also gives definition of "air pollution" in his second report, which was mentioned in Chapter I. In Murase's first report of the conservation of the atmosphere, causes pf atmospheric degradation has been discussed. He provides the evidence showing the causes are generally divided into two categories: the presentation of substances, or energy into the air, as well as the discharges of greenhouse gas, such as CO₂, Nitrous oxide (N₂O) and methane.

According to Murase, the most initial air-pollution cases happened in 1907. It took place in

⁶² Ministry of the Environment, Japan, Lessons from Minamata Disease and Mercury Management in Japan.

⁶³ Shinya Murase. 2014. "Frist report on the protection of the atmosphere." International Law Commission 66: 47.

an interior court in the U.S. Supreme Court. The title of case is, the *State of Georgia, Complainant, v. the Tennessee Copper Company and the Ducktown Sulphur, Copper and Iron Company, Ltd* in 1907 and 1915⁶⁴. Two corporations which mined copper in the State of Tennessee led through mining and smelting actions close to the border of the State of Georgia. Due to the mass amount of SO₂ emitted by the actions, sulphuric acid was carried to Georgia, causing destruction of trees, crops and forests, alleged by them. The supreme court declared that it was reasonable for the air over its territory being avoided by pollution, as a part of a sovereignty. At the end in 1914 the Tennessee Copper Company agreed to compensate for the loss and damages from its works. Whereas, there's no such agreement reached in 1915 for the Ducktown Company. The Supreme Court found that it was impossible to figure out the exact damages or loss caused by the emissions. The Court implemented restrictions for the company's emission levels instead.

It was in 1941 did the most basic principles in international law come out: the *Trail Smelter*⁶⁵ case between Canada and the U.S. This case implicated the traditional international environmental controversy in two methods: the results and influences of the harm are unable to identify, and a nation is obligated to ensure its activities won't harm other nations. This case also demonstrated some basic principles in international law. Later these principles, also called preventive principle was affirmed as principle 21 of the Declaration of the United Nations Conference in 1972. When it came to the 1980s, the global environment has been rapidly deteriorated in the form of climate variation and ozone layer depletion. The initial countermeasure was taken by the international legal community in 1985, known as the 1985

⁶⁴ United States Supreme Court, 13 May 1907, 10 May 1915, 237 U.S. 474, 477; reproduced in Cairo A. R. Robb, ed., *International Environmental Law Reports*, vol. 1, *Early Decisions* (Cambridge, Cambridge University Press, 1999), pp. 514-523.

⁶⁵ *Trail Smelter* case (United States of America v. Canada) (Final Award of 1941), United Nations, *Reports of International Arbitral Awards*, vol. III (United Nations publication, Sales No. 1949.V.2), p. 1907 ff.

Vienna Convention. Followed by the 1992 United Nations Framework Convention, and the 1997 Kyoto Protocol. However, there wasn't any material hard-law instrument imposed even in the 2000s. More conventions just mentioned the concept of integrating climate and pollution policies. Eventually, it was in 2013 in Gothenburg Sweden, attention was addressed on atmospheric protection. Participants stated that it a Law of the Atmosphere is necessary, so is the participation of International Law Commission. It was in 1992 did the UN raised the definition of the "common concern of humankind" during the process of environmental protective actions. In 1994 the UN again adopted the phrase "centre of concerns", and "urgent concern of the international community", as well as "problems of global dimension". In this regard, the aim of imposing such phrases above is to encourage people's participation and action. It was urgent to address the point that, environmental problem is not solely domestic jurisdiction but global consequences and importance for all.

Modern international law is always characterized as a law of cooperation. And such cooperation is often established upon common legal interests of the global community as a whole. It was not until the late 1960s did the UN begin to address environmental issues, including the promotion of international cooperation to protect environment. In 1968, the General Assembly made decision to convene the UN Conference on the Human Environment in 1972. And on the conference the UN declared to handle environmental protection in an integrated spirit by all nations, no matter big or small. Multilateral, bilateral arrangements should be taken to manage, reduce, stem and avoid adverse environmental effects. In 1992, the Rio Declaration on Environment and Development was proclaimed by the UN Conference on Environment and Development. The Rio Declaration stressed that people should cooperate, so as the states, to further develop international law in the territory of sustainable development.

Several global treaties were assigned during the past few decades since the middle of 1970s. The topic of those treaties targets different kind of air pollutants or different issues, such as ozone thickness, climate variation and so on. It is noteworthy to mention that, not only global treaties have been proclaimed, but also a bunch of regional ones have been indicated. Those regional treaties emphasize more on regional integration and cooperation, as well as environmental security.

4. Prior Studies of China

Thomas Stoerk evaluates air pollution control and the costs in China, as well as evaluates emissions control target in the 11th Five-Year Plan (FYP)⁶⁶(Stoerk, 2018). Through calculating the level of sulfur dioxide (SO₂) emissions, Thomas evaluates whether SO₂ control policy is constructive to improve pollution outcomes under the 11th FYP. Thomas chooses the data reported in the *China Energy Databook* as the official SO₂ emissions data. He also measures real SO₂ pollution from the NASA SO₂ satellite data. Thomas combines two types of data sources to aggregate the daily cross-sections to the province-month and the province-year levels. He concludes that the policy reduced air pollution by 11% as intended. His analysis also shows that the reason for high levels of pollution appears to be a lack of ambition in the design and implantation of policy.

Comparing to PM₁₀, Lin, Zou, Yang and Li highlight the hazards of PM_{2.5}⁶⁷. PM_{2.5} is invisible in size, broader in superficial area, and because of lighter weight, it's easy to transport, which

⁶⁶ Thomas Stoerk. 2018. "Effectiveness and cost of air pollution control in China." Grantham Research Institute on Climate Change and the Environment Working Paper 273 ISSN: 2515-5717.

⁶⁷ See note 2, p.2-29.

infers more harmful and severe than PM_{10} . Therefore, $PM_{2.5}$ has a more destructive impact on human body, as well as the quality of atmospheric environment. A statistical summary from Zhang and Cao, which is also the first long term datasets of $PM_{2.5}$, monitors 190 cities in China⁶⁸(Zhang & Cao, 2015). Zhang and Cao find that from 2014 to 2015, among 190 cities only 25 of them fulfill the National Ambient Air Quality Standards of China. Meanwhile, the global population-weighted mean of $PM_{2.5}$ was around $20 \mu\text{g}/\text{m}^3$, which was about one third of $PM_{2.5}$ in China. In addition, Zhang and Cao also find that the most and fewest amount of $PM_{2.5}$ usually takes place in the afternoon and evening hours, separately.

Air pollution involves various pollutant emitters, as well as regulations of which involve different sectors: industry, manufacture, natural resources, public health, energy, etc. These factors make regulations toward air pollution control complex. Ying Li and Ke Chen mention that the Chinese government has been undertaking this problem since the late 1970s, during these years a sequence of polices, rules and plans have been implemented to mitigate pollution⁶⁹(Li & Chen, 2017). Whereas, Li and Chen find that even though different types of approaches have been used, the pollution levels are still serious. Therefore, question about the effectiveness of these policies is being raised. Meanwhile, Li and Chen argue that policies were effective in Western developed may not function well in a developing country for economic, social and institutional reasons. As a consequence, it seems urgent to testify such command-and-control policy in China.

⁶⁸ Yan-Lin Zhang & Fang Cao. 2015. "Fine Particulate Matter ($PM_{2.5}$) in China at a City Level." Scientific Reports 5: Article number: 14884.

⁶⁹ Ying Li & Ke Chen. 2018. "A Review of Air Pollution Control Policy Development and Effectiveness in China." IntechOpen. Accessed on July 5, 2019. <https://www.intechopen.com/books/energy-management-for-sustainable-development/a-review-of-air-pollution-control-policy-development-and-effectiveness-in-china>.

Existing research also provides studies showing the relationship between political corruption and environment in China. It is stressed that political corruption reduces effectiveness of environmental regulation, leading to degradation of environment. As political corruption also influences national income level, therefore, anti-corruption movement is beneficial for environment, which pressurizes officials and affects economic and social factors⁷⁰(Chen et al., 2018).

5. Summary & Analysis

The definition of ‘effectiveness’ varies when different approaches are used to describe it. According to CWA in 1972, the effectiveness of environmental policy is: “the results of emissions of untreated waste water from industries and municipalities⁷¹”. In CCA of 1970 it is described as “the evaluation of compliance and emissions for small facilities⁷²”. Whenever it comes to evaluating the effectiveness, no matter which regulations or policies are implemented, there’s one crucial procedure which is essential: inspection or monitoring. The approaches may be various: in Europe it is the combination of self-monitoring and inspection, in CAA it is regular self-monitoring, etc. When discussing about priorities for environmental regulations, in Section 1-4, it provides evidence showing that environmental regulators and prosecutors which concentrate on specific criteria of polluters or infringement are more likely to attain better results. It may be helpful to categorize corporations into different classes according to their behavior which can show their compliance, and target enforcement efforts

⁷⁰ Heyin Chen, Yu Hao, Jingwei Li & Xiaojie Song. 2018. “The impact of environmental regulation, shadow economy, and corruption on environmental quality: Theory and empirical evidence from China.” *Journal of Cleaner Production* 195: 200-214.

⁷¹ See Chapter 2-1.

⁷² See Chapter 2-3.

correspondingly.

Such targeting inspections show similarities of air pollution managing regulations in China. By evaluating China's air pollution control policy basing on the 13th FYP, which is a blueprint for long-term social and economic policies by the central government from 2016 to 2020. Meanwhile, under the 13th FPY, two key policies targeting air quality regulation have also been implemented: *Air Pollution Prevention and Control Action Plan (Action 2017)* and the *Three-Year Action Plan for Winning the BlueSky War (Action 2020)*. Chinese government has set different levels of goals on air pollution control towards each key region. As the question of how the regions has been divided is not explained clearly, I assume the government select and divide regions based on geographic location, level of industrialization, population, original environmental condition, etc. According to the key regions mentioned in Action Plan 2017 and Action Plan 2020, four regions are categorized: region 1 (Beijing, Tianjin, Hebei); region 2 (Shanxi, Shaanxi, Henan, Shandong); region 3 (Shanghai, Jiangsu, Zhejiang, Anhui); region 4 (Guangdong). Based on different environmental, social and geographic conditions in each region, the government has set different target correspondingly.

Targeting inspections has not only been implemented in air pollution control, but also other environmental supervising process: in 2018 China has planned to implement nationwide inspections aiming at the illegal emissions and pouring waste which pollutes water resources and soil⁷³(Xu & Mason, 2019). Criticism from Ministry of Ecology and Environment has claimed local authorities for only being targeting on air and water pollution, ignoring the damages of waste disposal. In spite of the similarity, there are differences between targets set by Chinese government and targets raised in prior research. In prior research, different classes

⁷³ Muyu Xu & Josephine Mason. 2018. "China's environment watchdog targets waste as pollution battle escalates." Yahoo News, May 11. Accessed on September 11, 2019. <https://www.yahoo.com/news/china-launch-nationwide-inspection-targeting-illegal-dumping-waste-023344151--sector.html>.

are divided depending on firms' compliance behavior, also the regulated objects are firms instead of provinces. Another difference is that, take environmental monitoring department in the Flemish Region in Belgium as an example, firms will still receive routine inspection even though the environmental problem being solved. Targeting inspection seems fail to explain the ineffectiveness of China's air pollution control due to these differences.

Inspection strategy is commonly implemented worldwide regardless of the issue is environment-related or not. Take Arizona Division of Occupational Safety and Health (ADOSH)⁷⁴ for an example, ADOSH Compliance is a programmed inspection plan for construction industry in Arizona. And it is a scheduled construction inspection conducted by all ADOSH compliance sections. With the aim of formulating specific selection categories and accessing monthly site inspection lists, ADOSH uses a special targeting application from an official website. To make sure the selection is randomly processed, supervisors have to keep modifying the selection process. Once the targets are determined, Compliance officers take responsibility to ensure compliance of industries under auditing. The whole process is complex and have more than six steps to finish one targeting inspection. And the essence is to keep selecting process randomly done, as well as to make sure of industries' compliance.

In section 3 of this chapter, Murase's analysis on historical evolution of international law on protecting air quality. It was not until the late 1960s did the UN start to address environmental issues, and in the 1980s the UN has begun to take issues such as climate change and ozone depletion seriously. Taking the fact that UN was established after the Second World War into consideration, it has taken almost 40 years since 1945, did the air pollution issue please into

⁷⁴ Industrial Commission of Arizona. 2019. "ADOSH Inspection Targeting." Accessed on September 10, 2019. <https://www.azica.gov/adosh-inspection-targeting>.

people's eye. As mentioned in this chapter earlier, the first lawsuit related to air pollutant was in 1907, which was about 70 years earlier than when the UN took action. Perhaps we can say that the whole international cooperation regarding atmospheric pollution is quite slow. One good thing is that, since 1980s there have been multiple global treaties and regional treaties being practiced. And if we take the 2019 European elections into consideration, people's awareness of environment protection has been increasing. A wave of environmentalism has swept Europe in the 2019 European election. Especially in Germany, Ireland and France, Green parties gained great success, which was beyond people's expectation. The biggest winner could be the German Green Party, who gained 20.5 per cent of the national vote, almost twice of their 10.7 per cent votes in 2014⁷⁵(Sullivan-Thomsett, 2019). Additionally, young generations' rising attention towards environmental issues also resulted in large number of youthful voters of Green party. It is obvious that people in several generations are taking environmental issues more and more seriously.

In Section 2-2, Jale Tosun organized the environmental inspecting system in Europe. Despite of the fact it may be efficient in Europe, neither of those two kinds of monitoring and enforcement strategy would be working in China. The first level strategic, which demands regulatees to monitor by themselves, it won't function smoothly unless the compliance of those regulatees reach to a certain level. For China's case, experience study tells that industries always find a way to dispose pollution in the most budget-friendly way, even though it sometimes means stepping to a legitimate grey zone. For the second level strategy,

⁷⁵ Chantal Sullivan-Thomsett. 2019. "How Germany's Green party took on the far right to become a major political force." THE CONVERSATION, May 29. Accessed on November 3, 2019. <http://theconversation.com/how-germanys-green-party-took-on-the-far-right-to-become-a-major-political-force-117927>.

implementing inspection visits of facilities may not function as well: If the visits are regular, regulates can easily manipulate the process of wastes treatment. For example, if they know inspection visits are coming, they can adjust and use standard equipment to dispose pollution in a standard way. However, when the visits are finished, they can switch to their nonstandard process. Implementing inspection visits may only operate well when the visits are irregular and unpredictable. Still if there's no stringent punishing, implementing inspection visits won't work on its own.

When it comes to the relationship between domestic economy and environmental condition, above reveals multiple approaches explaining its relations in different angle. If China follows the rules from "Environment Kuznets Curve", an important question will be whether China has reached the turning point where the relation between environment and income level has been positive, as mentioned previously. It seems that the best way for China to promote environment is to develop economy. However, important studies from four economists - La Porta, Lopez-de-Silances, Shleifer and Vishny⁷⁶ (Esty & Porter, 2005), is that legitimate regulations play the most vital role to determine economic growth. The empirical evidence suggests that the influence of income levels on environmental control is limited. On the other hand, even though we could have a clear clue about the progress of China's economic development, it has little impact on analyzing China's environmental regulation. Since this paper emphasizes on the effectiveness on environmental policies, more attention should be paid to the process of issuing a law, or the process of executing the law.

When analyzing China's intervention strategies on pollution control, Neil gives us good

⁷⁶ See note 23.

examples, according to his seven models mentioned in Section 1.5. Evaluating strengths and weakness of environmental strategies in Western countries also gives inspirations on evaluating China's environmental strategies. According to Neil's demonstration, neither 'rules-and-deterrence' nor 'advice-and-persuasion' is efficient when working in isolations. Since both of the two strategies work only for actors who are willing to comply and fear for legal punishment. If industries decide to take illegal actions, or the punishment is not fearful enough to make them comply, they will be more likely to take risks. As for the 'responsive regulation' and 'risk-based regulation', which seem to be seen as a compromise by Neil, the problem of this strategy is the limitation of changing actors' attitude. This strategy only acts responsively based on actors' behavior: more flexible and looser management for "good" actors and, stricter rules for "bad" ones. Starting from compulsory rules and management, regulations also should promote people's attention of environmental degradation, as well as raise the public's attention of protecting environment.

Despite the dark side of industrial evolution and energy consumption, in CLRTAP, the positive side of scientific and political evolution has led to states' cooperation in protecting environment. CLRTAP aims to monitor and evaluate air pollution mainly through sulfur dioxide (SO₂), nevertheless, for China's case the most damaging pollutant is PM_{2.5}, as mentioned in the beginning of this paper. Similar situation happens to Thomas Stoerk⁷⁷'s paper. Although Stoerk is the first scholar providing empirical evaluation of the total emissions control policy in China, focusing on the 11th FYP, it also uses the level of SO₂ to evaluate the emissions. It is rational to use SO₂ in the process of measuring China's industrial waste gas emissions. Whereas, projects related to environmental regulation need a larger scale of targeted

⁷⁷ See note 41.

pollutants than SO₂. Both of current air quality and official documentation emphasize the urgency of promoting the level of PM_{2.5}, but there hasn't been empirical evaluation of air pollution control policy by targeting it.

The inspiration of the CAA in Section 2.3. seems to tell us that, stringent policy works better than loose policy. Enterprise shows more compliance when the regulation is typical, accurate and stringent. If they find themselves have lower chance of being suit or, if they are not specifically targeted by EFA, they will show non-compliance. With regard to the stringency of China's regulations, people tend to focus on the problem of, how strict are pollution control regulations in China, or how much effort does the regime put into regulating air pollution? From an overview of China's environmental law, evidence shows that in China the laws are strictly enforced. Moreover, various enforcement measures can be taken by China's ecology and environmental administrative authorities, including on-site inspections, seizing and impounding the polluting facilities and equipment penalties and so on. Especially in recent years, China's environmental policy is seen as a 'zero tolerance' policy, which gives industries or polluters little chance to escape.

Under those circumstances, the question will be raised as: since the air pollution managing policy looks stringent enough, why China's air quality hasn't been getting better? Since the laws are so strict that industries and polluters have little chance to escape, why PM_{2.5} was still the major pollutant for more than 80 per cent of the days in 338 cities in 2015?

To answer the questions above, the first step is to verify whether China's air pollution control policy is efficient. This step demands the changing level of PM_{2.5} in China, and the level of PM_{2.5} being regularized by Chinese governments. If the environmental regulations have

proved to be inefficient, the second step will require analysis on the reasons behind it. It demands the combination of existing theories, as well as practical examples of policy implementation. With the addition of China's uniqueness, the cause of inefficiency of air pollution control policy can be provided.

III. ARGUMENT

In response to the questions raised in the first Chapter, I raise my argument by stating that, although a series of regulation has been issues in the pass decades, the improvement of air quality in China is not as significant as people's expectation.

To question the causes, I argue that there has been certain limitation, or boundedness in regulations, generating such inefficiency.

Empirical evidence proves that the best way to protect environment is to develop economy. It is true that, according to "Environment Kuznets Curve", promoting economy can degrade a country's environment, which is seen as a heavy but obligato cost. But once reaching to a certain level of high economic development level, the relationship between environment and economy is positive. However, since it is difficult to find the exact turning point, let alone the possibility that such turning point can be different based on different countries' economic mechanism, it seems impossible to make sure how develop China's economy is.

According to Neil's seven models of intervention strategies on pollution control, the reasons of the ineffectiveness of China's air pollution control could be result from certain weakness of environmental strategies. Since it is easy to cause such unsuccess in protecting environment once the intervention strategy is found problematic, as Neil demonstrates in Section 1.5. Hence I hypothesize that there could be some weakness in China's intervention strategies on air pollution control, which brought about unsuccess of environmental protection policy.

When analyzing the difference between China's targeting inspection and the ones in prior research, it is noticeable that Chinese government has enlarged the scope of targeted actors. From existing literature, such targeting inspection usually happened when targeting firms or individual actors. In China's case, it's used to target different provinces, rather than enterprises or industries. As there are 23 provinces in China, and four special cities with enormous amount of population, I question whether targeting inspection works the same as targeting organizations or firms. Moreover, in *Action 2017* and *Action 2020*, Chinese government divides provinces into five regions, and set different goals for each region. This action enlarges the targeted scope even more, which makes the efficiency of such strategy even more problematic.

Hence, I argue that in official regulation, the concentration on only short-term results, especially short-term targets set by the government, leading to the polluters' incompliance, eventually causes the ineffectiveness of China's air pollution control. I also argue that either enterprises in China can easily find a way to escaping the punishment of environment violation, or the risk of violating environment law is not high enough to make them stop.

IV. ANALYSIS

1. An Overview

1-1. Historical Development of Air Pollution Policies in China

Historical developing process of environmental regulation in China can be divided into four stages: 1973-1993, 1994-2004, and from 2004 until now. After the People's Republic of China being established in 1949, Chinese people were in extremely poverty due to long time of war. Restoring infrastructure and developing economy were even considered less prior when confronting famine, let alone paying attention to protect environment. During the early years of the new nation, massive plants had been cut down in order to grow food and keep warm, and forests had been cut and to build dams. Since then China has been suffering from extreme weather and unusual temperature, especially in the Northern part. It was in 1973 did the initial nation-level conference take place, targeting environmental control and conservation. Six years later, the first trial of Environmental Protection Law of the People's Republic of China was imposed in September 1979. Since then a sequence of environmental law has been implemented, which aimed different spectrum of phenomenon of pollution, such as water pollution, atmospheric pollution, grassland. In 1989, Environmental Protection Law of the People's Republic of China was formally put into effect. In March 1993, National People's Congress raised the framework of the legal system of environment and resources conservation. According to the statement from the Central People's Government, this action is recognized as a remarkable innovation, which means that the environment and resources legislation has been stepped into a new era.

The second stage was from 1974 to 2004. Since China moved to the stage of industrialization and urbanization in the 1990s, domestic pollution has become more severe.

And the sources of pollution have become more complicated. In 1992 the government decided to strengthen the legislature, hence multiple monitoring and inspecting system have been established during that time. In the middle of 1990s, Chinese government paid a lot attention on treating water pollution from the cities close to Yangtze River. And in the late 1990s, targets of controlling the waste water emissions in different cities have also been firstly established. People started to pay more attention on the sources of pollution rather than end treatment. Due to this transformation, a cleaner way of production, as well as a more recyclable economy have been rapidly developed. From 1999, a call for “return the grain plots to forestry” has been carried out. This goal is to restore ecological cycle from the nature, which has been seriously damaged in the early period of China. At the 9th the Standing Committee of the National People's Congress in 2002, Cleaner Production Promotion Law was carried out. The aim was to inspire and encourage more producers to take environmental issues seriously.

Since 2005, contamination accidents have been drastically increased in China. Those contamination accidents were characterized as high frequency, broad region and deep influence. Due to this, people's health was also being threatened. Pollution has become a serious issue threatening social safety. Due to this, the State Council announced a decision of “Implementing Scientific Outlook on Development and Enhance Environment Protection”. Meanwhile in the 11th Five-Year Plans (FYP), more strategies towards building a resource-saving and environment-friendly society have been imposed. According to the reports from the government, a lot of achievements have been made during the 11th FYP, from the perspective of reducing emission, transforming development mode, controlling air pollution, as well as improve environmental condition in rural area.

Since 1953, a sequence of economic and social development initiatives has been issued every

five years by the Chinese government, also known as Five-Year Plans (FYP). Determining national strategies and priorities, FYP is recognized as a guidance and direction of developing economy and society. Although not been mentioned in the 9th FYP, the Ministry of Ecology and Environment of China (MEE) has issued a program was not until the 10th FYP did China officially mention regulations about environmental protection. The 10th FYP was passed in 2000, and it was the first time that environmental issues have been categorized in a chapter: “Chapter 4 - Population, Resources and Environment”. In this chapter, the government emphasized the urgency of saving and protecting resources, in order to achieve sustainability and utilization. And the importance of ecological construction and environmental management has also been mentioned in this chapter. But in 2002, even though not included in FYP as one chapter, MEE has issued a strategic planning, urging a complete environmental managing system, as well as controlling environmental degradation and ecological damage. This strategic planning could be seen as a rudiment of China’s environmental control strategy, including many features such as, dividing key regions, as well as general targeting inspection⁷⁸.

In the initial stage of implementing environmental control regulation, several imperfection and misses can be easily found. After when MEE issued the initial strategic planning in 2002, the second version was soon issued in 2003, which had only one-year gap. FYP is a series of official strategy, being enforced every five years since 1953. In the early 2000s, not only did the environmental control strategy being included in FYP, but also seemed to be enforced hastily and without a comprehensive consideration.

It was in the 11th FYP did MEE enforce a comprehensive version of environmental strategic planning, starting from summing up the progress made in the 10th FYP, ended with a series of

⁷⁸ MEE. 2002. “The 9th FYP of State Environmental Protection and Visions of 2010 (Outlines).” November 13. (中华人民共和国生态环境部: 《国家环境保护“九五”计划和 2010 年远景目标 (摘要)》 Accessed on August 7, 2019.

specific protective action⁷⁹.

The initial frame structure of Environmental Protection Law in China gained passage in 1979. Since then China has passed many laws regarding to environmental protection, including specific laws issued by the National People's Congress. The Law on Prevention and Control of Air Pollution is adopted in September 1987 and revised in August 1995 and April 2000⁸⁰. From the early 2000s, MEE specialized strategic planning, and started to target different contaminant and sources of pollutants. What's noticeable is that, there is no single planning aiming air pollution in the first decade of 2000, implemented by MEE. There has been 20 strategic planning from 2001 to 2010, almost all of them were aiming water pollution and none of them has mentioned air pollution. I assume that one reason is because of the fact that water pollution was more severe at that time, and the other reason is because China hasn't established current Ambient Air Quality Standards and the concentration limit of PM_{2.5} until 2012. The priority and urgency of controlling water pollution, as well as deficiency of a method to public air pollution, has determined such slow start of air pollution control policy.

The government became conscious of the severity of air pollution, and due to the increases in energy consumption, the pressure of controlling air pollution is expected to increase. During recent decades, China has issued more laws and regulations targeting air pollution, which are related to Ambient Air Quality Standards in 2012, vehicle emissions standards in 2013 and fuel consumption limits in 2015. The government prohibits many activities to reduce air pollution, such as illegal emission of atmospheric pollutants, importing and using non-

⁷⁹ MEE. 2007. "Announcement of Environmental Protection in the 11th FYP from the State Council." November 26. (中华人民共和国生态环境部：《国务院关于印发国家环境保护“十一五”规划的通知》) Accessed on August 8, 2019. http://fgs.mee.gov.cn/fg/gwyfbdgfwj/201811/t20181129_676435.shtml.

⁸⁰ Regulation of Air Pollution: China. 2019. "The Library of Congress." Accessed on July 1, 2019. <https://www.loc.gov/law/help/air-pollution/china.php>.

compliant fuel, changing atmospheric quality monitoring facilities and so on⁸¹.

At the beginning of the administration led by Xi Jinping and Li Keqiang, the State Council enacted the Air Pollution Prevention and Control Action Plan in September 2013. Aiming at economic and social development, China's 13th FYP (2016-2020) promised strongly to improve air quality and control emissions. In January 2014, China's Ministry of Environmental Protection (MEP) published the reports of "air pollution control and target responsibility" contracts, in order to coordinate all cities and regions in China, determining to control air pollution in 2014⁸². According to the contracts, leaders' performance is highly linked to their salaries and promotions. Moreover, those who fail to complete the targets set by MEP might be claimed responsibility.

1-2. *Action 2017 & Action 2020*

According to the Protection of Ecological environment from the 13th FYP, the strategy of improving air quality by imposing treatment in different regions is highlighted⁸³. It mentioned Jingjinji, which is Region 1 in this paper, Zhusanjiao, and Changsanjiao, which is Region 2 in this paper. As for the governance method, increasing inspection of the enterprises is also highlighted⁸⁴. The government tended to strengthen the establishment of emission standard,

⁸¹ Wu Qing, King & Wood Mallesons. 2019. "Environmental law and practice in China: overview." PRACTICAL LAW. Accessed on June 30, 2019. [https://uk.practicallaw.thomsonreuters.com/3-503-4201?transitionType=Default&contextData=\(sc.Default\)&firstPage=true&comp=pluk&bhcp=1](https://uk.practicallaw.thomsonreuters.com/3-503-4201?transitionType=Default&contextData=(sc.Default)&firstPage=true&comp=pluk&bhcp=1).

⁸² Angel Hsu. 2014. "Provinces in China Commit to Air Pollution Targets." Accessed on 1 May 2019. <https://datadrivenlab.org/air-quality-2/provinces-in-china-commit-to-air-pollution-targets/>.

⁸³ CPGPRC. 2016. The 13th Five-Year Plan (FYP) Planning for ecological and environmental protection." Chapter 4 Section 1: Separating Regions to Improve Air Quality. ("十三五"生态环境保护规划, 第四章, 第一节: 分区实施改善大气环境质量). Accessed on October 4, 2019.

<https://wenku.baidu.com/view/e5aa235e03020740be1e650e52ea551810a6c9b9.html>.

⁸⁴ CPGPRC. 2016. "The 13th Five-Year Plan (FYP) Planning for ecological and environmental protection."

build an assessment system of ecological destruction, as well as encourage the enterprises' obligation of protecting environment⁸⁵.

Air Pollution Prevention and Control Action Plan⁸⁶, also known as *Action 2017*, was enforced in 2013 by the State Council. This document emphasized the hazardness of fine particulate matter 10 and 2.5, especially PM_{2.5}. The aim of *Action 2017* was to reduce the days of heavy pollution in most of the cities, and to improve general air quality in China. What makes this action special is that, it selected about three regions as a center of gravity: Jingjinji (Beijing, Tianjin, Hebei), Changsanjiao (major cities in the East coast), and Zhusanjiao (major cities in Guangdong Province). It was specified in this Action that, by 2017, PM_{2.5} had to reduce by at least 10 per cent in general, the level of PM_{2.5} had to reduce 25 per cent, 20 per cent, 15 percent in Jingjinji, Changsanjiao and Zhusanjiao respectively.

The Three-Year Action Plan for Winning the BlueSky War⁸⁷ (*Action 2020*) was implemented in June 2018 by the State Council in China. During the 19th National People's Congress, the urgency of promoting air quality was emphasized. The aim of this Action is to cut down the average concentration of PM_{2.5}, reduce the days under heavy air pollution, thereby increase people's well-being. It was emphasized in *Action 2020* that, by 2020 the emission of SO₂ and NO_x has to reduce by at least 15 per cent, comparing to 2015. Moreover, days under heavy pollution has to reduce by 25 per cent. Another feature of this action, which

Chapter 8 Section 4: Emphasizing Industrial Inspection. (“十三五”生态环境保护规划，第八章，第四节：加强企业监管) Accessed on October 4, 2019.

<https://wenku.baidu.com/view/e5aa235e03020740be1e650e52ea551810a6c9b9.html>.

⁸⁵ *Id.*

⁸⁶ Central People's Government of the People's Republic of China (CPGPRC). 2013. “Announcement of Air Pollution Prevention and Control Action Plan.” (中华人民共和国中央人民政府：国务院关于印发大气污染防治行动计划的通知，国发【2013】37号，2013年9月12日) Accessed on November 7, 2019.

http://www.gov.cn/zwgc/2013-09/12/content_2486773.htm.

⁸⁷ CPGPRC. 2018. “Announcement of the Three-Year Action Plan for Winning the Blue Sky War.” (中华人民共和国中央人民政府：国务院关于印发打赢蓝天保卫战三年行动计划的通知，国发【2018】22号，2018年7月3日) Accessed on November 7, 2019. http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm.

is also similar to *Action 2017* is that, it determined key regions to monitor and control: Jingjinji and its surrounding area (Beijing, Tianjin, Hebei, Henan, Shandong, Shanxi), Changsanjiao (Shanghai, Jiangsu, Zhejiang, Anhui), etc.

To combine key regions mentioned in *Action 2017* and *Action 2020*, here are major provinces and special cities being monitored: region 1 (Beijing, Tianjin, Hebei); region 2 (Shanxi, Shaanxi, Henan, Shandong); region 3 (Shanghai, Jiangsu, Zhejiang, Anhui); region 4 (Guangdong).

2. Measuring ‘Effectiveness’

The restriction of data from Chinese government is that, air quality reports from MEE only give large amount of literal summary with limited actual data. Furthermore, none of the two attached lists contain regional data of concentration of PM_{2.5}. Regional level of PM_{2.5} and other pollutants are generally interpreted by percentage. For example, in MEE’s air quality report in April 2019, it mentioned that the average amount of PM_{2.5} in Jingjinji was 52µg/m³, which was increased by 8.3 per cent comparing to last month. The average amount of PM_{2.5} in Changsanjiao was 38µg/m³, which was reduced by 13.6 per cent, comparing to the data in March⁸⁸.

Hence, in this paper statistical data comes from Berkeley Earth (BE), in addition to literal analysis of China’s air quality from MEE’s reports. Since BE only provides monthly historical data, simple calculation for seasonal or annual data is needed. Also, as BE provides average level of PM_{2.5} of each province, calculation for regional data is also needed. As this paper

⁸⁸ China National Environmental Monitoring Centre. (中国环境监测总站). Accessed on July 10, 2019. <http://www.cnemc.cn>.

emphasizes two air pollution control policy implemented under the 13th FYP, time span will be limited from 2016 to 2020. Another restriction is that, BE only provides monthly data from July 2014. Therefore, observing time will be narrowed down from January 2015.

To estimate the efficiency of China's air pollution control policy, I provide numerical evidence by summarizing and comparing data collected from BE. I divide the unit of analysis into four regions as mentioned before: region 1 (Beijing, Tianjin, Hebei); region 2 (Shanxi, Shaanxi, Henan, Shandong); region 3 (Shanghai, Jiangsu, Zhejiang, Anhui); region 4 (Guangdong). If the regulations are working, the annual average level of PM_{2.5} in each region should be reducing since January 2015. The key approach is to observe the fluctuation of level of PM_{2.5}. Some fluctuation within a year in a region is due to natural and humane reasons. For example, the amount of PM_{2.5} tends to be higher in winter in region 1 and region 2, due to the fact that they are both north areas in China, and there's more fuel and coal consumption in winter. To except other unrelated factors, the ideal way is to compare annual average data or data from different year but the same season. Beside such longitudinal observation, horizontal observation is also achievable by comparing data from the same time period but different region. However, it is crucial in this step to except irrelevant factors, geographic location, wind direction and air flow, for example.

If my observation doesn't show a decreasing tendency of level of PM_{2.5} in each region, air pollution policy could be questionable. Meanwhile, I expect a more complex phenomenon, a drastic increase or decrease, a dramatic resilience for example. When observing such phenomenon, it is necessary to find out what actually happened in corresponding time period: big natural incident, policy changing, or humane action.

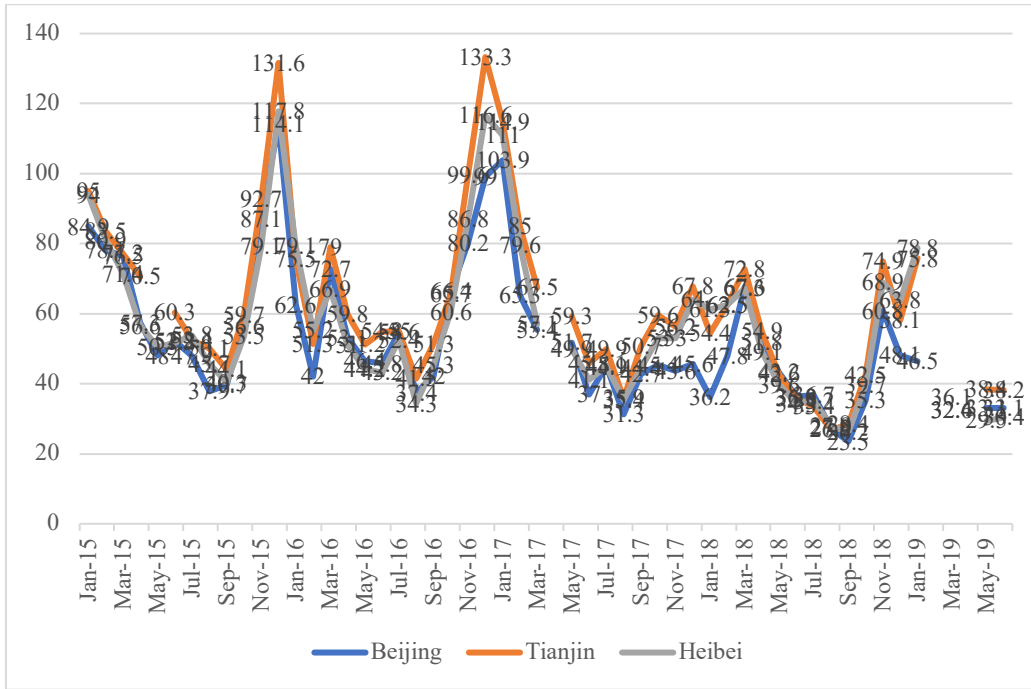
Once the observation successfully proves the in efficiency of China's air pollution policy, the next step is to figure out the reasons behind it. This step is largely inspired by the existing literature review in Chapter II. It is stated in Chapter II that, China's enforcement policy should be working because it is stringent and typical, and polluter will be facing a serious punishment if violating the regulations. From this perspective China's policy should be efficient and the air quality should be improving. Nevertheless, existing literature also tells that, 'rules-and-deterrence' policy won't be working well if it doesn't combine with 'advice-and-persuasion'. This could be a good inspiration to explain China's unsuccess. Meanwhile, the problem of enforcement strategy could also be only concentrating on polluters' behavior, rather than raise people's attention to protect environment. There is another probability of the weakness in targeting inspection, as discussed previously. Only focusing on short-time goals instead of long-time success could also be problematic. Such enforcement containing enforcement of achieving short-time goal could cause polluters' non-compliance, as well as a great slacking after achieving short-time goals. Since the official documents didn't mention any punishment after shot-time goals being realized, it's easy for them to violate the policy again.

2-1. Results from Berkeley Earth (BE)

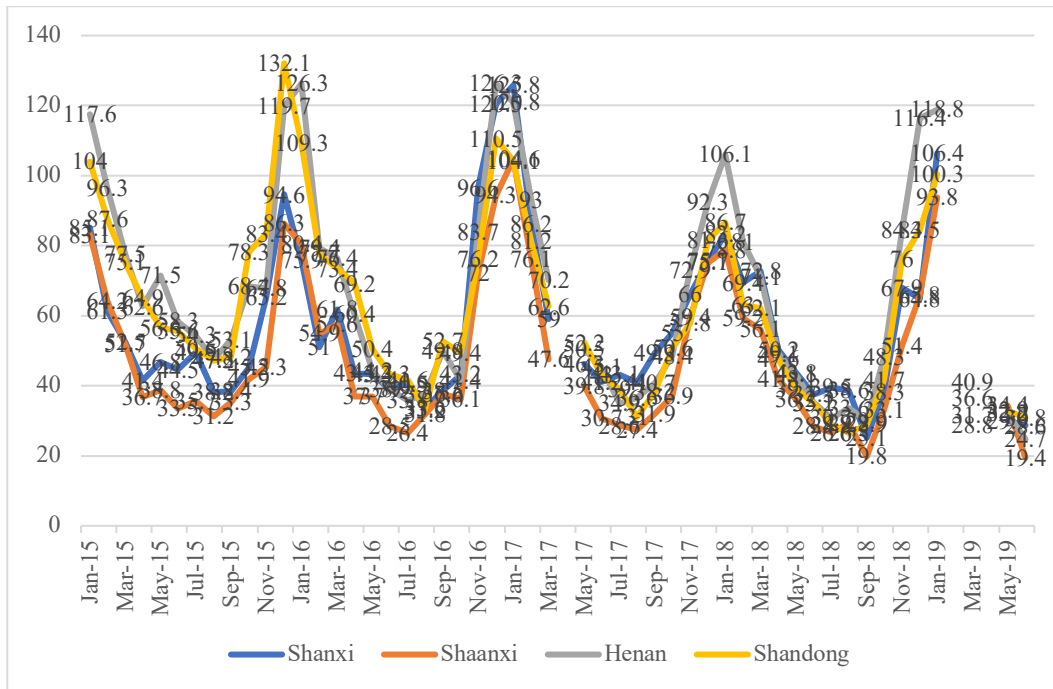
2-1-1. A general View of Monthly Average Level of PM_{2.5}

Below is the monthly average level of PM_{2.5} ($\mu\text{g}/\text{m}^3$) in four different regions and a national level overview from January 2015 to April 2019.

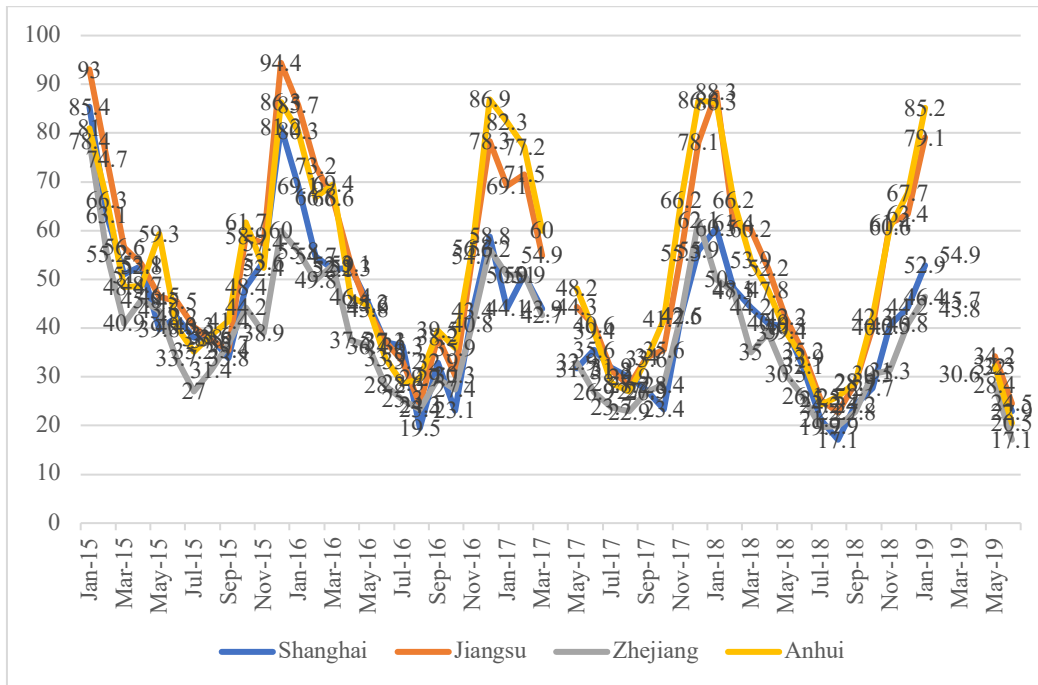
PM_{2.5} ($\mu\text{g}/\text{m}^3$) of Region 1: Beijing, Tianjin, Hebei



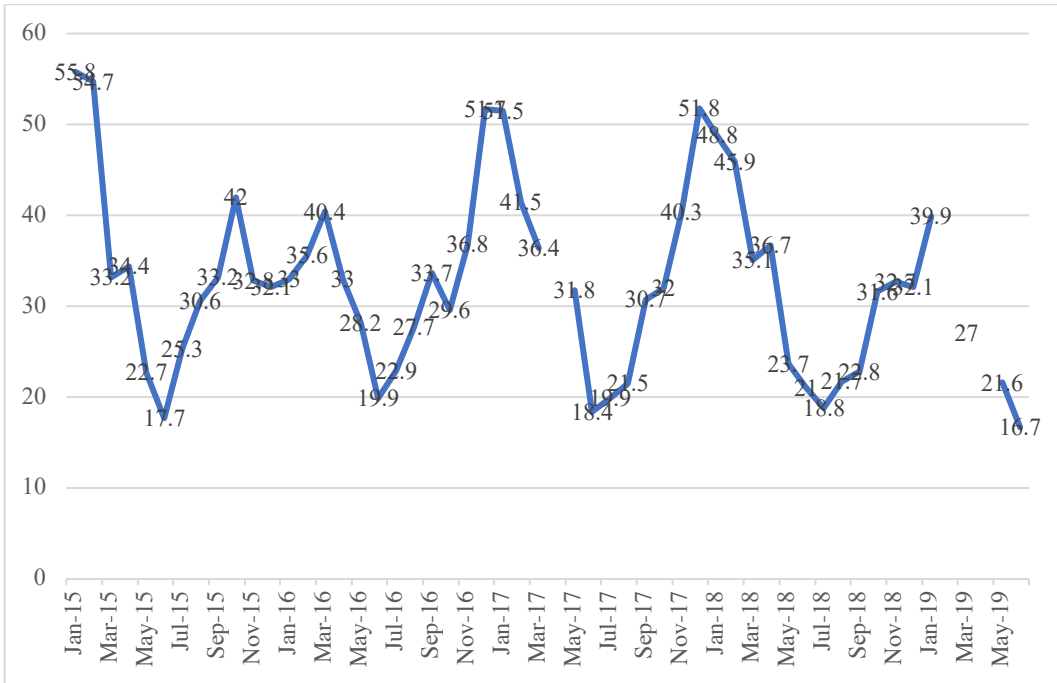
PM_{2.5} (µg/m³) of Region 2: Shanxi, Shaanxi, Henan, Shandong



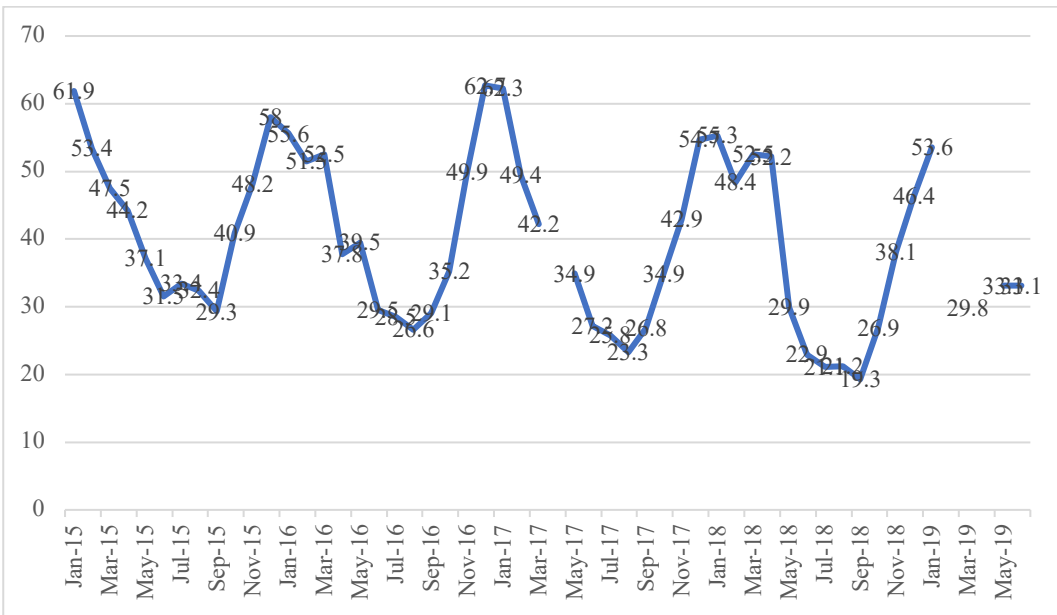
PM_{2.5} (µg/m³) of Region 3: Shanghai, Jiangsu, Zhejiang, Anhui



PM_{2.5} (µg/m³) of Region 4: Guangdong



PM_{2.5} (µg/m³) of National Level



Due to unknown reason, the data of April 2017, February 2019 and April 2019 is missing. Above five charts all prove that, with a whole year, the highest concentration of PM_{2.5} was from winter season, no matter where the region was located in North or South part of China. It is easily to understand that, for developing countries like China, new energy resources have been massively employed. Hence, in winter season, most of the cities use coal as fuel to provide heat for the families. As a matter of fact, 83 per cent of cities from North part of China are still using coal to gain heat in 2016⁸⁹. According to Chinese government, among two types of coal used in winter, which are ‘standard coal’ and ‘dispersed coal’, ‘dispersed coal’ is the major sources of air pollution. As for South part of China, although it’s not as cold as the North, people’s consumption of electricity still increases in order to keep warm in winter. Unlike the North, South part of China usually rely on air-conditioners to raise in-door temperature. Meanwhile, major part of China still depends on thermal power plant to generate electricity. Therefore, the problem once again returns to the consumption of coal, leading to serious PM_{2.5} in winter season. And the peach level usually was from December or January. The lowest concentrate of PM_{2.5} was from summer season, and the bottom was from July, August or September. When understanding the reason of high level of PM_{2.5} in winter, it is easy to explain that in summer season PM_{2.5} is relatively lower.

Another observation can be made is that, the mean level of PM_{2.5} in North part is thicker than the South. From Region 1 and Region 2 are typical provinces in Northern China, where the top can reach to 133 $\mu\text{g}/\text{m}^3$, which is almost twice as much comparing to national level. Region 3 are provinces in the Southeast part of China, and Region 4 is a typical Southern

⁸⁹ CPGPRC. 2018. “Understand the Project of Clean Energy Heating in Northern Region in Winter.” (中华人民共和国中央人民政府：北方地区冬季清洁取暖规划（2017-2021）解读) Accessed on October 10, 2019. http://www.nea.gov.cn/2018-01/24/c_136921343.htm.

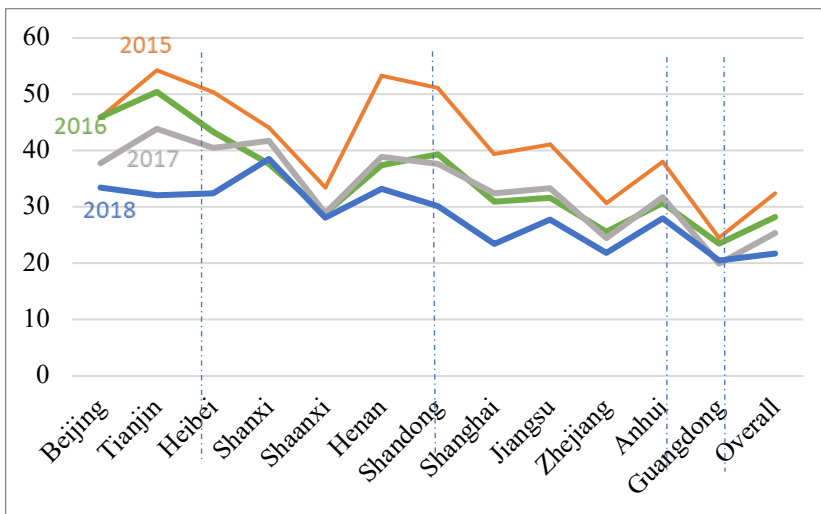
province. Region 4 shares the best condition among 4 regions, and it's below the national average.

What's the difference within all regions is that, even though it shares similar fluctuation in a broad way, at some short period of time the fluctuation could be different. Take region 1 for an example, from February 2016 to March 2016, basically PM_{2.5} from all regions (including national level) has been decreasing expect for region 1, which shows a drastic increasing according to the chart. And this phenomenon happened in all provinces in region 1: Beijing, Hebei and Tianjin. In the winter of 2018, region 1 did quite well, there was even no distinct peak in this season, which was distinguished from all other regions. Although the seasonal average level in region 1 was about 70 $\mu\text{g}/\text{m}^3$, which was still about 16 higher than national level, it's better to focus on the changing rather than specific number. Errors may happen during statistical process, yet the drastic decline is abnormal. It is questionable that there might be some policy causing such abnormal phenomenon.

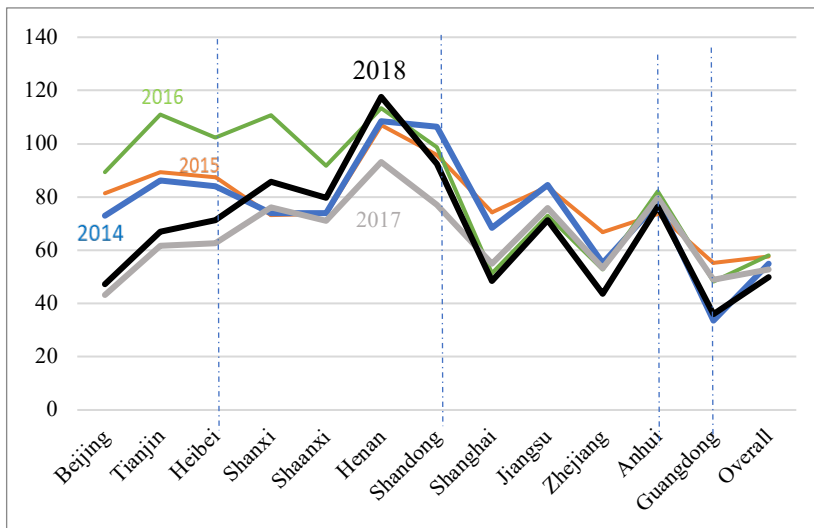
2-1-2. Seasonal Comparison

Collecting and dividing data into four parts seem to be a more direct way to expose the drastic difference within four seasons. It is decided that, within a year, spring is from March to May, June to August is summer season, autumn is from September to November, December, next year's January and February compose winter season. Since the statistics from Berkeley Earth is from January 2015 to June 2019 (last updated on September 30, 2019), I summarized the data and composed a seasonal comparison: the winter from 2014 to 2018; summer from 2015 to 2018; autumn from 2015 to 2018 and spring from 2015 to 2019.

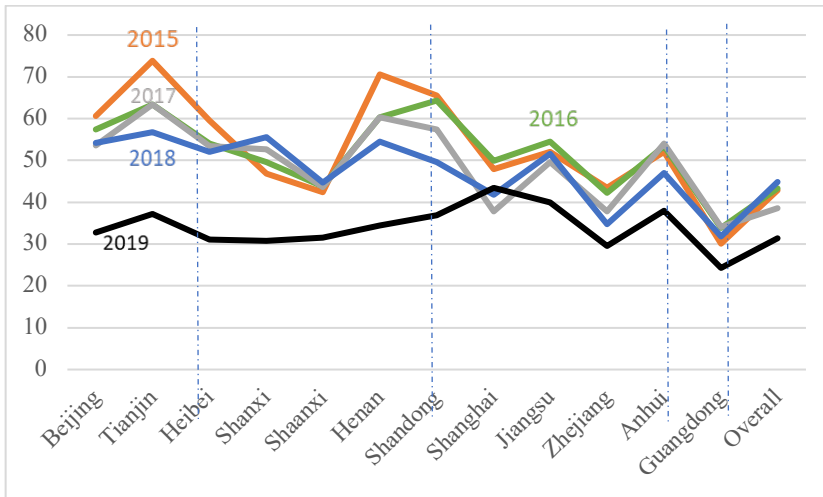
2015 - 2018 Summer (Unit: $\mu\text{g}/\text{m}^3$)



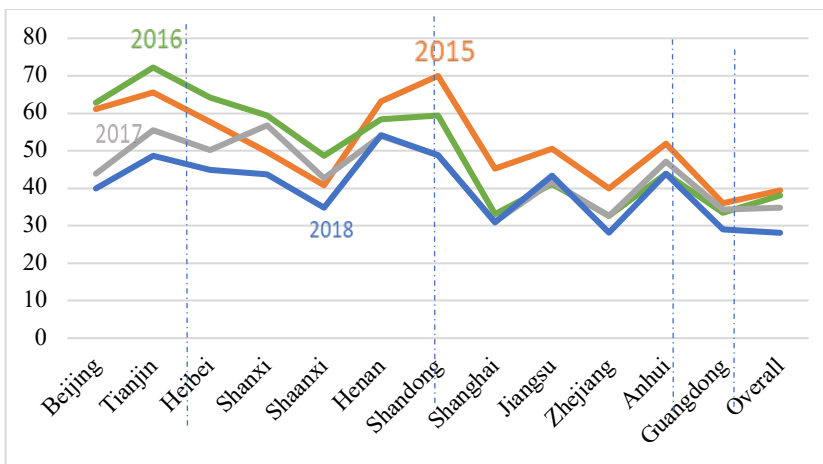
2014 - 2018 Winter (Unit: $\mu\text{g}/\text{m}^3$)



2015 - 2019 Spring (Unit: $\mu\text{g}/\text{m}^3$)



2015 - 2018 Autumn (Unit: $\mu\text{g}/\text{m}^3$)



The purpose of vertical imaginary lines is to divide four regions plus an Overall level. The first three provinces from each chart are Region 1, followed by Region 2, Region 3 and Region 4, and ended up with national average. It was quite obvious that winter season share the highest concentration of $\text{PM}_{2.5}$, reaching to almost $120 \mu\text{g}/\text{m}^3$ in 2016, Henan province.

Correspondingly, the lowest level was in summer season, and in spring and autumn.

Almost all Regions, except for Region 4 (Guangdong), were beyond nation average. Region 1, 2 and 3 are traditionally recognized as prosperous provinces in China, which locate traditional heavy industry even before the foundation of the People's Republic of China. During the middle 20th century, massive amount of plants was cut down as fuels and resources, thus air quality was getting worse and worse even from last century.

Overall, according to the statistical results from IPE, air quality in China hasn't experienced a remarkable improvement nor a drastic destruction. There has been a series of fluctuation since 2014, but there's no symbolic pattern yet. It is true that in the winter of 2017 the air quality was getting better since 2014, but a bounce-back phenomenon happened in the winter of 2018, which stopped the good momentum. However, such stability also implies the fact that air pollution control regulations may not be working as expected. Even though since 2002, there has been a series of environmental regulations implemented but there hasn't been a remarkable change of air quality in China, according to the results from IPE.

3. Analysis

3-1. *Action 2017 & Action 2020*

It is proved that, at least *Action 2017* has brought certain achievement, simply basing on the result reflected from the statistics above. From the seasonal comparison, the level of PM_{2.5} in the winter of 2017 has dropped since 2014, especially for Region 1 and Region 2. Unfortunately, this tendency didn't last long – in the winter of 2018, it quickly bounced back in terms of Region 1 and Region 2. Most of the provinces in these Regions have reached higher

concentration of PM_{2.5} compared to 2018 winter, and Henan province even reached the highest level since 2014. With regard to Region 3 and Region 4, as well as national average, it didn't show much continuous improvement nor any rebounding.

Concentrating only on one single season is restricted to evaluate a national policy. Take chart of 2015 – 2019 Spring as another example: there is a remarkable achievement in the spring of 2019. Especially in Region 1 and Region 2, the level of PM_{2.5} has dropped by almost 40 per cent comparing to 2018 Spring. However, since all data of February 2019 is missing, there might be possibility that the actual number hasn't dropped so drastically. Still, we could simply conclude that under Action 2020, there has been an improvement of air quality in China so far, but the result in 2020 is still unknown.

An interesting phenomenon in China is that, rebounding is quite common in many regions. Especially in winter, the level of PM_{2.5} gradually increased since 2014, which reached to a highest level in the winter of 2016. But when the 'deadline' mentioned in *Action 2017* has come, the number of PM_{2.5} suddenly dropped to the lowest level since 2014. However, this is when the rebounding phenomenon comes: the level of PM_{2.5} in the winter of 2018 didn't sustain in a good way. Instead it bounced back, even though the actual level of PM_{2.5} in 2018 winter is not disastrous as imagined, it still proves that there's little sustainability. As mentioned before, the most recent Five-Year Plan (FYP) in China is the 13th FYP, narrowing down the timeframe from 2016 to 2020. So far there have been two powerful Actions issued by the State Council during the 13th FYP: *Action 2017* and *Action 2020*. Although *Action 2017* was implemented in 2013, the effectiveness of this regulation still counted in the 13th FYP. Within those four years the air quality was not continuously improving as people expected.

Action 2020 was implemented in June 2018 by the State Council in China. As for this Action, it is still quite early to place any conclusion, at least there has been a good start: the air quality in spring of 2019 was delightful.

Here is the translation of some contents from *Action 2017* and *Action 2020*:

Action 2017:

Specific Indicators: by 2017, in all cities at prefecture level and above, the concentration of PM₁₀ declines by 10 per cent at least, days of fairly good quality increases. The concentration of PM_{2.5} in Jingjinji Area, Changsanjiao Area and Zhusanjiao Area declines by 25 per cent, 20 per cent and 15 per cent respectively, among which the average level of PM_{2.5} in Beijing will be 60µg/m³⁹⁰.

Action 2020:

2) Specific Indicators: ...By 2020, the emission of SO₂ and NO_x declines by 15 per cent comparing to 2015. Cities at prefecture level and above which didn't meet the standard of level of PM_{2.5} decrease by at least 18 per cent. Days of fairly good quality in cities at prefecture level and above will reach to 80 per cent. Days of heavily polluted and worse will decline by 25 per cent comparing to 2015⁹¹ ...

3-2. Analysis on Ministry of Ecology and Environment of the People's Republic of China (MEE)

⁹⁰ See note 86.

⁹¹ See note 87.

It is specifically mentioned in document of assessment results of *Action 2017* that, MEE only concentrated on whether those Regions or Provinces in China has accomplished the goals in the terminal duration⁹². The original text can be translated in English as: 1. In 2017, the concentration of PM₁₀ in prefecture or higher-level cities in China has declined by 22.7 per cent comparing to 2014. 2. The concentration of PM_{2.5} in key regions has declined at least 27.7 per cent comparing to 2013. 3. By accomplishing *Action 2017*, the goal of improving national air quality has completely achieved. 4. *Action* of pollution treatment must not stop, and all local government should carry out the environment regulation from the central government.

Basing on the analysis and statistics provided from Berkeley Earth, there are several problems about this final assessment results. First of all, I wonder why there's only assessment about terminal duration rather than a series of monitoring. In general, there's supposed to be several times of assessments for a better supervision, and those assessments are divided by different time period. Secondly, solely comparing results from 2017 and from 2013 is not rational enough for evaluating a policy. In this way it's quite easy for enterprises find a way to escape being regulated, since all they need to do is to cut down air pollutant emissions at the end of 2017. It is true that in 2017, especially in the winter of 2017, the level of PM_{2.5} has decreased to the lowest level since 2014, and this is proven by statistics from Berkeley Earth. Whereas from the winter of 2014 air quality had been getting worse and worse. Hence, in terms of the final assessment, *Action 2017* may not be a complete success as the government announced. As for *Action 2020*, it is still too early to evaluate whether it is successful or not, at least from

⁹² MEE. 2018. "Final Assessment Results of Action 2017." (中华人民共和国生态环境部：关于《大气污染防治行动计划》实施情况终期考核结果的通报) Accessed on October 11, 2019. http://www.gov.cn/zhengce/content/2013-09/13/content_4561.htm.

the data of 2019 spring, there should be certain progress.

Here is the partial translation of a report of the assessment result of *Action 2017* from MEE:

According to the Assessment of the Implementation of Action Plan (Trial) (2014), MEE alongside with the National Development and Reform Commission, imposed final assessment towards 31 provinces (areas, cities), the assessment result has been reported agreed by the State Council, and here is the situation:

t has been five years since the implementation of Action 2017...among 45 essential goals set in Action 2017, all of them have been completed on schedule. In 2017, the average amount of PM₁₀ in Cities at prefecture level and above has reduced by 22.7 per cent comparing to 2013. The average level of PM_{2.5} in Jingjinji Area, Changsanjiao Area and Zhusanjiao Area has reduced by 39.6 per cent, 34.3 per cent and 27.7 per cent respectively comparing 2013. The average level of PM_{2.5} in Beijing increased to 58µg/m³. Hence the goals have been fully completed.

Although within attempt of investigating the explanation of why using short-term target solely, the State of Council didn't leave much information. In the Policy Interpretation section of Central Government web page, Zhao Yingmin, the vice minister of MEE interpreted the structure of Action 2020: "Four adjustments have been made comparing to Action 2017: accuracy of implementation, reinforcement of source control, enhancement of scientific advancement and concentration on long-term mechanism."⁹³

⁹³ CPGPRC. 2018Focus on the point, Specify the strategy-Understanding Action 2020. (聚焦重点 精准施策—《打赢蓝天保卫战三年行动计划》解读) Xinhua News, June 20. Accessed on December 9, 2019. http://www.gov.cn/zhengce/2018-06/20/content_5300053.htm.

The features of Action 2020 is that, it changed the targets toward different regions within more practical consideration. For example, for Region 2, the reason of why the concentration of SO₂ remains high is because of the high coal consumption, which was close to 90 per cent.

Many steel and coking industry in Region 2 are still using scattered coal, with small scale and low-level equipment. Hence the targets toward Region 2 should be specified and strengthened especially.

The Minister of MEE Li Ganjie has also declared that the essence of Action 2020 is the "four key adjustments". And the key regions are Jingjinji Area (Region 1), Changsanjiao and Fen nutrient-laden plain (Region 2). The key seasons are the beginning of Spring, Autumn and Winter. The key industries are steel, thermal power and construction. Li also admitted that for Region 2 the air quality was not getting better but getting worsen instead⁹⁴.

Both of the interpretation of the Minister and Vice Minister of MEE admitted that treating air pollution is a standing and gradual process, and it is impossible to be achieved within a short haul.

The original attempted was to find more interpretation of both Action 2020 and Action 2017. However, historical records from Central Government webpage only keep the records from January 2016, reports before that has been deleted.

3-3. Reaction from the Industries

3-3-1. Analysis on the Institute of Public & Environmental Affairs (IPE)

⁹⁴ CPGPRC. 2018. "Our Country Deployed Action 2020" (我国部署蓝天保卫战三年行动计划) Xinhua News, June 13 2018. Accessed on December 9, 2019. http://www.gov.cn/zhengce/2018-06/13/content_5298560.htm.

IPE has been providing reports examining publication of air pollution monitoring information, also called “Blue Sky Roadmap” (BSR). However due to unknown reason, BSR has only published seven editions since 2010. For analyzing air pollution control under the 13th FYP, this paper only takes the 4th (2016) and 5th (2019) edition for comparison.

The 4th edition of BSR⁹⁵ published the progress of air quality monitoring, also recognizing the direction needs to be improved. The primary concern of air quality examining in China is that, detection sites are not covered in full scale. Massive amount of detection sites is located in Region 1 (Beijing, Tianjin, Hebei), whereas there are some apparent blanks in some part of Region 2 (especially Shandong and Henan Province). In addition, other provinces which are not included in key Regions but also under serious pollution, are in lack of detection sites. For example, air quality in Chongqing, Chengdu, as well as Urumchi is not considerable but there's not enough data in those Provinces, due to deficiency in detection sites.

The 4th edition of BSR also provides the information of sources of air pollution in the final Chapter. Basing on the Annual Report of China's Environment in 2014⁹⁶, the industrial emission of sulfur dioxide (SO₂), which reached to 17.404 million metric tons in 2014, taking over 88.1 per cent of overall emission of SO₂. The industrial emission of nitric oxide (NO_x) reached to 14.048 million metric tons, taking over 67.6 per cent of overall emission of NO_x. And the emission of industrial smoke/dust was 12.561 million metric tons in 2014, which was 83.6 per cent of overall smoke/dust emission. Additionally, there's not many channels for the

⁹⁵ IPE. 2016. “Blue Sky Roadmap Phase IV Managing the ‘Gap Effect’” (蓝天线路图报告 4 期：空白点影响精细管理) Accessed on November 18, 2019. http://www.ipe.org.cn/reports/report_18435.html.

⁹⁶ MEE. 2016. “China environmental statistics in 2014.” (2014 年中国环境统计年报) Accessed on September 17, 2019. http://www.mee.gov.cn/gzfw_13107/hjtj/hjtjnb/201606/P020160604812354990172.pdf.

public to gather information about industrial air pollutant emissions. As a matter of fact, there's only 46,506 records of environmental monitoring towards enterprises in 2015, which was only 24.3 per cent.

As a continuation of discussing air pollutant emissions from enterprises, the 5th edition of BSR⁹⁷ focuses on the issue of sources of air pollutant. In the beginning Chapter, it announces the rebounding of PM_{2.5} in 2018 winter as 'haze returned', which corresponds with the statistics from Berkeley Earth. The rebounding phenomenon not only happened in air quality, but also in air pollutant emissions from steel and coking industries. Take Hebei province as an example, in the beginning of three months in 2018, the output of crude steel has been dropping. However, from October 2018, there has been massive growth of crude steel production, among which the year-on-year growth rate in November has reached to 20 per cent.

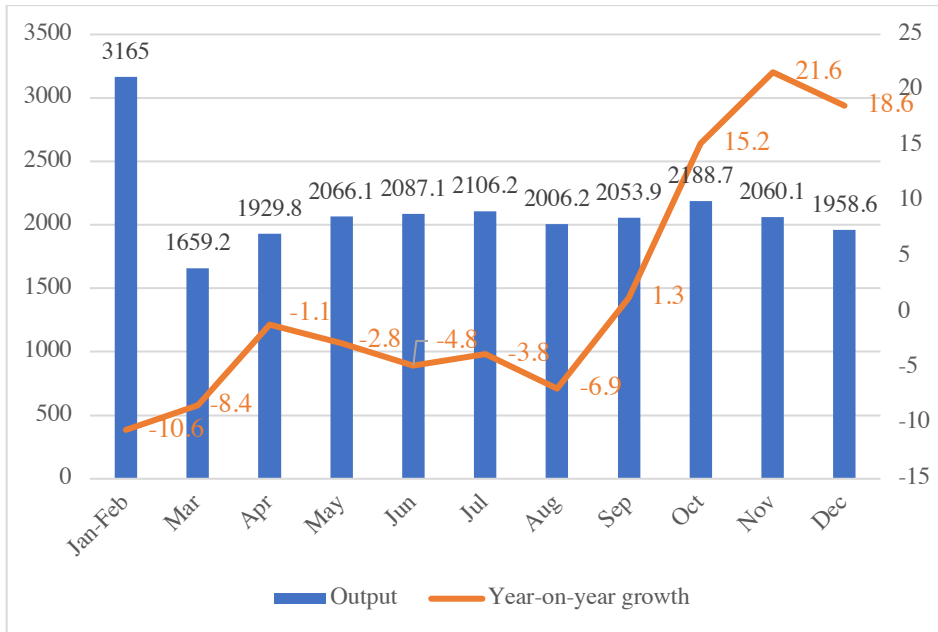
According to the data from the State Statistical Bureau⁹⁸ on March 14, 2019, the average daily production of rolled steel and crude steel was 2.906 million metric tons, 37.311 million metric tons respectively, which was 9.2 per cent higher than last year. During the process of ironing, a massive amount of coke is necessary. Hence the process of coking is also recognized as a part of steel industry, generally speaking. Using coal as raw material, coke was made during destructive distillation in a very high temperature. According to data from China Network Information Industry⁹⁹, in 2018 the coke production in Shanxi Province was 92.562 million metric tons, taking over 21 per cent of total output.

⁹⁷ IPE. 2019. "Blue Sky Roadmap Phase V Bounce back in Winter & Autumn season, managing by dividing the regions" (蓝天路线图报告 5 期：秋冬季污染反弹，考验“差别化”管理) Accessed on November 18, 2019. http://www.ipe.org.cn/reports/report_19894.html.

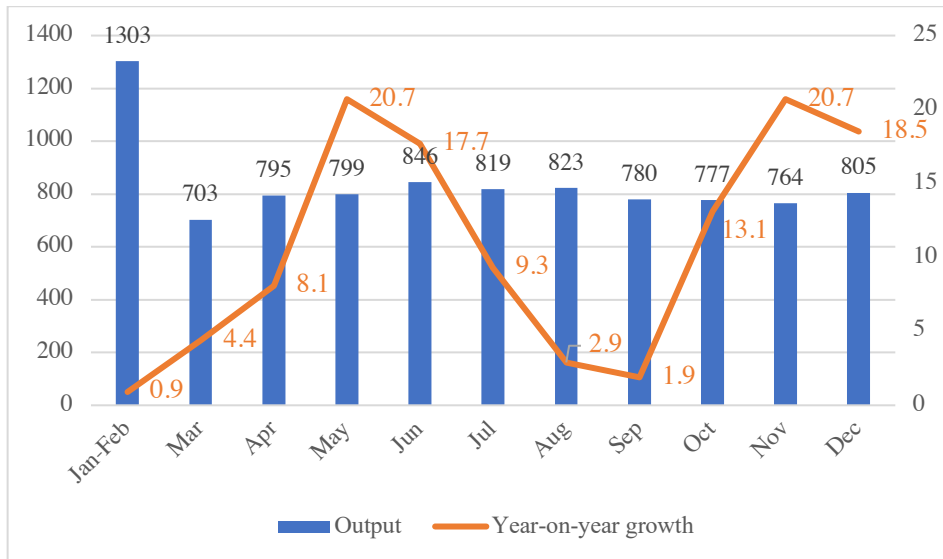
⁹⁸ 国家统计局

⁹⁹ 中国产业信息网

Output of Crude Steel in Hebei Province in 2018 (in ten thousand tons)



Output of coke in Shanxi Province in 2018 (in ten thousand tons)



Not only steel industry, as well as coking industry need emit tremendous pollutants, but also need tremendous energy consumption. That is to say, increasing production of steel and coke causes worse environmental condition and loss of energy.

3-3-2. Production and Revenue of Steel and Coke in China

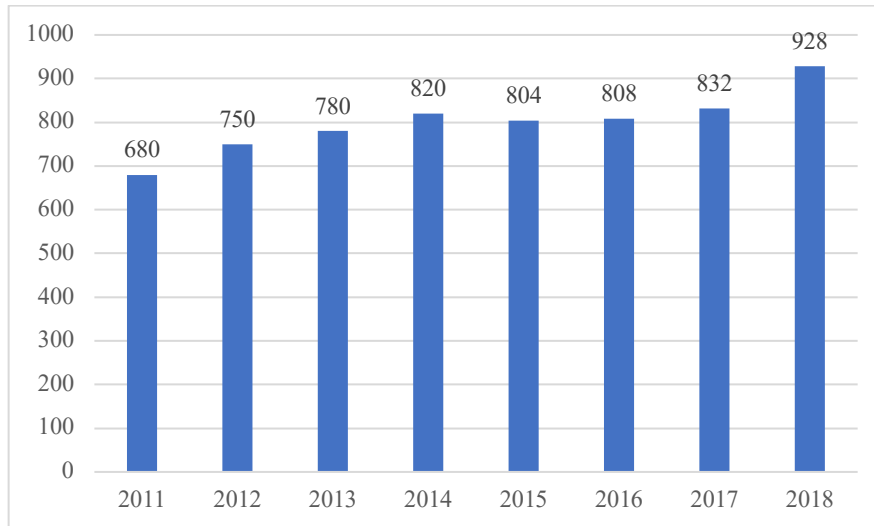
Since Steel and coke production is the main reason of bad air quality in China, I summarized the production and market price of crude steel and coke respectively, in order to show enterprise' reaction and behavior towards environmental regulation.

Based on reports from Ministry of Industry and Information Technology of People's Republic of China (MIIT), the production of crude steel in China has been growing steadily since 2011, with a slight decrease in 2015, and a drastic increase in 2018¹⁰⁰.

¹⁰⁰ Ministry of Industry and Information Technology of the People's Republic of China. 2018. "The Operation

The Production of Crude Steel in China from 2011 to 2018

((in million metric tons))



It seems that these figures didn't completely match with reports from MEE. In 2017, which was the year of "deadline" for *Action 2017*, the production of crude steel in China didn't decline, but with a steady growth instead. And in 2015 and 2016, it showed a slight decline. However, it should be noticed that crude steel production is just one cause of environmental devastation, and an unremarkable changing couldn't prove enterprises' behavior or reaction. Whereas, the crude steel production in 2018 increased drastically, which increased almost a hundred million metric tons comparing to 2017. Without considering a technological

Situation of Steel Industry in 2018.” (中华人民共和国工业和信息化部，2018 年钢铁行业运行情况).

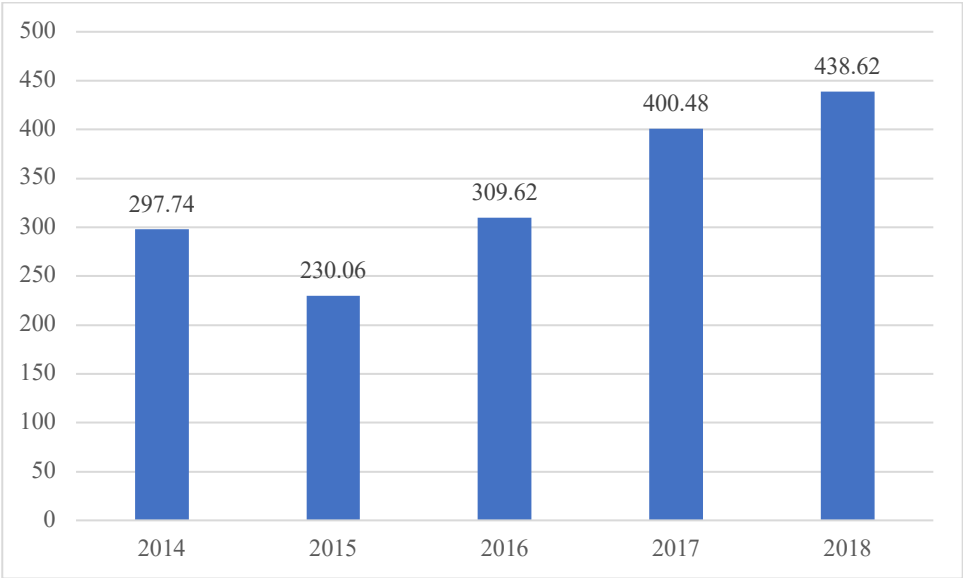
Accessed on 15 December 2019.

<http://www.miit.gov.cn/n1146312/n1146904/n1648356/n1648357/c6646594/content.html>.

innovation, this unusual increase corresponds with reports from IPE: there was a drastic growth of crude steel production in 2018, and this was just after the “deadline” of *Action 2017*.

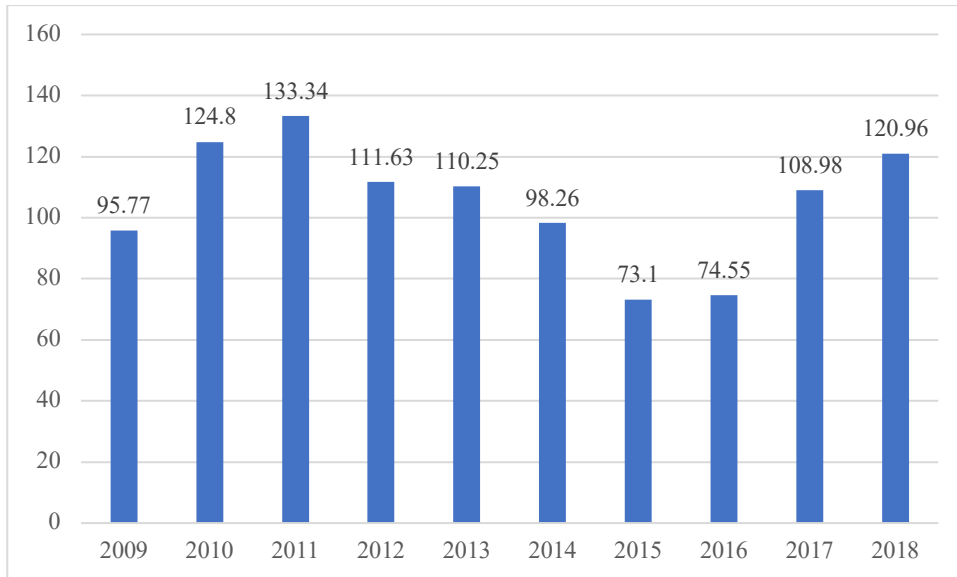
Below two charts show the steel revenue of two giant corporation in China, among which the Baowu Steel Group was the biggest steel company in China and second largest steelmaker worldwide.

Revenue of China Baowu Steel Group Co., Ltd. From 2014 to 2018¹⁰¹
(in billion yuan)



¹⁰¹ Revenue of Baowu Steel Group in China 2014-2018, Statista Research Department, 3 December 2019, retrieved from: <http://res.baowugroup.com/files/2019/08/30/1fd32d602f4b4965acca0401e3876e42.pdf>, p.85. accessed on 15 December 2019

Revenue from Operations of Hebei Iron and Steel (HBIS) in China from 2009 to 2018¹⁰²
(in billion yuan)

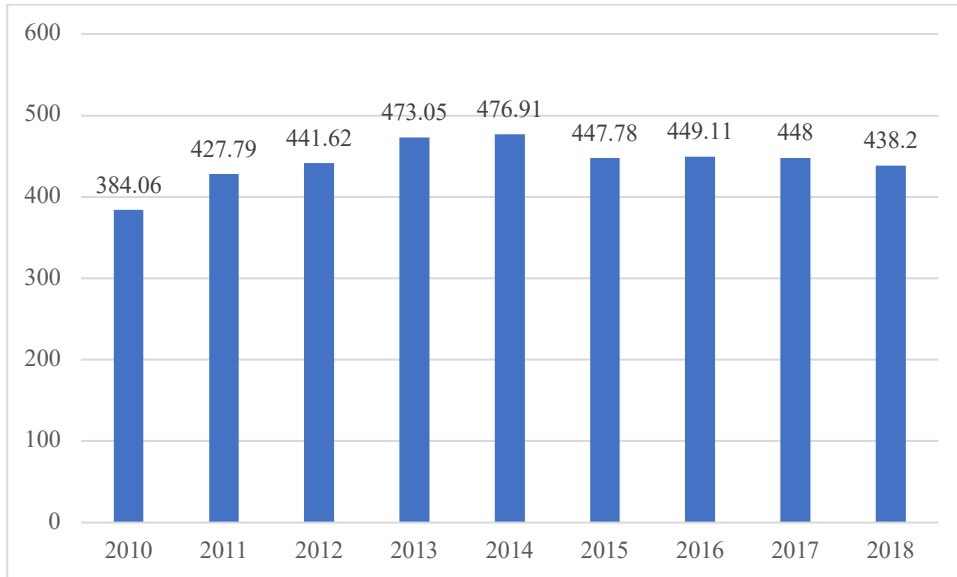


The revenue can show the production of steel in another aspect. And the figures basically correspond with the precious chart of crude steel production: a decrease around 2016 and followed by a bounce back in 2018 or before 2018.

Below to charts are the coke production since 2010, and revenue since 2008 with a forecast of 2019 and 2020. At least from the charts below, there isn't much change of coke production and the revenue has been growing steadily since 2009.

¹⁰² Statista Research Department. 2019. "Revenue of Hebei Iron and Steel (HBIS) China 2018." Accessed on December 15, 2019. http://pdf.dfcfw.com/pdf/H2_AN201904251322746809_1.pdf.

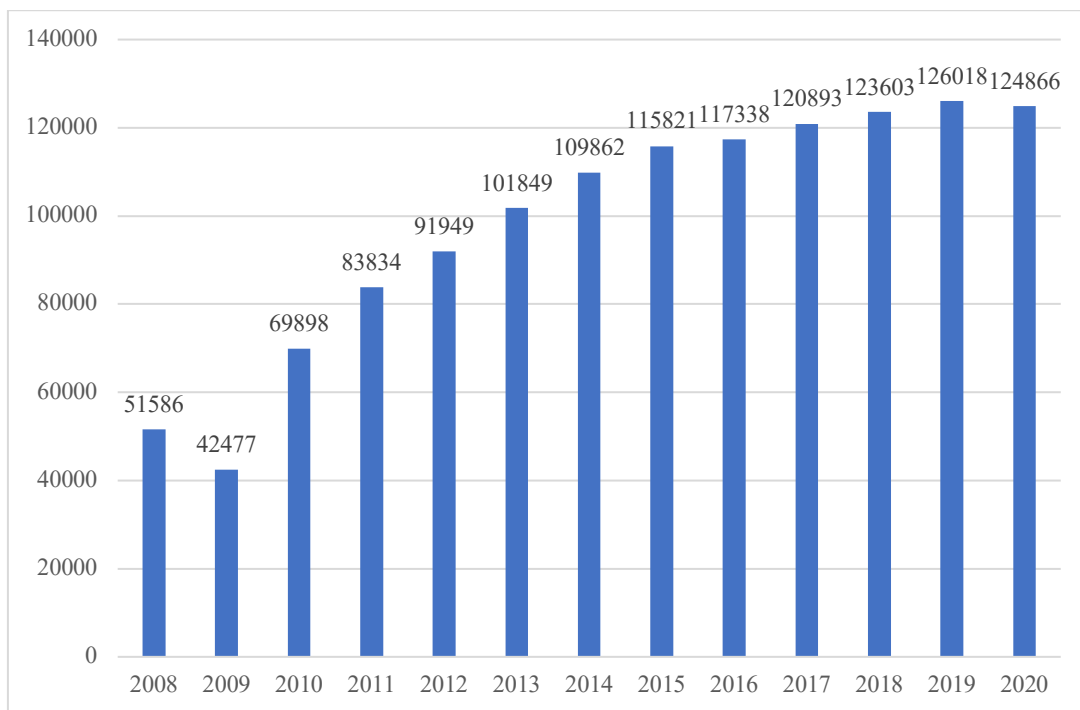
Coke production in China 2010 to 2018 ¹⁰³(in million metric tons)



Forecast coke revenue in China from 2008 to 2020¹⁰⁴ (in million U.S. dollars)

¹⁰³ M. Gariside. 2019. "China's coke production 1993-2918, United Nations." Statistik der Kohlenwirtschaft, Accessed on December 15, 2019. https://kohlenstatistik.de/wp-content/uploads/2019/10/silberbuch_2017.pdf.

¹⁰⁴ Statista Research Department. 2016. "Forecast: operating revenue coking China 2008-2020." Accessed on December 15, 2019. <https://0-www-statista-com.lib.rivier.edu/forecasts/414603/china-coking-operating-revenue-forecast-icnea-2520>.



3-3-3. Results from News Reports

The Central Committee of the Communist Party of China Environmental Protection Supervision Committee is a supervision organization, which was established in January 2016. It is composed of headers from MEE, the Central Commission for Discipline Inspection, as well as the Central Commission for Organization Department. It represents how CCP and the State of Council inspect relative local departments. After receiving complaints from the citizens, the Central Environmental Supervision Team (CEST) will take action and do further inspection¹⁰⁵. Since 2016 there have been two rounds of scheduled assessment for local industries.

¹⁰⁵ Baidu Baike. 2019. "The central committee of the communist party of China environmental protection supervision committee." Accessed on 15 December 2019. <https://baike.baidu.com/item/中共中央环境保护督查委员会/20208379>.

The online inspection of pollutant is an effective method to assess whether the industries are willing to coordinate with the government. News reports from China News are instrumental for analyzing compliance from regulatees. During the first round of environmental inspections from CEST, it was observed that many industries have forged the data of pollutant discharge. Currently many third parties are responsible for inspecting data in China, whereas, some regulatees can escape from being inspected by data fraud. When investigators assessed the emission level of air pollutant of a Carbon factory in Henan Province, the results turned out that the emission didn't meet the standard. However, when the investigators asked for online data for validation, it showed the result didn't exceed. The online data is supervised by a third party, and principally speaking, only the third party can have the authorization to access. However, the actual situation was that, everyone can access this online data managing webpage. What's more surprising is that, the data can be changed easily without any authorization.

The investigators further checked this third party, which was a firm located in Beijing. When confronted by such circumstances, it replied that, they had to comply with the industries because they got paid from them. If industries asked for authorization of managing data, they had no choice but open the access, or they can get easily fired and replaced by more third parties who are willing to share the authorization.

Another case happened in Hebei Province, a steel factory was reported by citizens, for its heavily emission of SO₂. When they arrived the spot, investigators from CEST found it astonishing that this firm was caught emitting SO₂ directly into atmosphere. Judging by the heavy dark smog around the factory, it was obvious that this firm didn't take any action to

control its emissions. However, the data still showed the emission meet the standard¹⁰⁶.

By the end of the first round of inspections, more than 212 thousand complaints have been managed. Among which 40 thousand are judicial cases, and the penalty reached to 2.46 billion Yuan, and 2264 people have had administrative or criminal detention.

As for the second round of inspection, until August 2018, CEST has received 18615 cases, among which 15105 were valid and being handled¹⁰⁷.

The improvement in the second round of inspections is that, central enterprises including China National Chemical Corporation and China Minmetals Corporation are under investigated¹⁰⁸. According to MEE, since 2013 there have been dozens of environmentally illegal behaviors from China Minmetals Corporation, but none of which are being investigated and punished. Local parties are usually unwilling to challenge big Central corporations, even though they are breaking the law¹⁰⁹.

4. Summary

To summarize, the behavior of enterprises in China is heavily affected by domestic regulations

¹⁰⁶ Pan Ye. 2018. "Central Environmental Inspector looked back: Jiujiang City Duchang County 'Pretend to Rectification'." China News, June 24, 2018. Accessed on December 10, 2019. <http://www.chinanews.com/gn/2018/06-24/8545227.shtml>.

¹⁰⁷ Haifeng Chen. 2019. "The First Round of Environmental Inspection and Looking Back was completed." (第一轮中央环保督察及“回头看”全部完成). China News, May 15, 2019. Accessed on December 11, 2019. <http://www.chinanews.com/gn/2019/05-15/8837841.shtml>.

¹⁰⁸ Jing Gao. 2019. "The Second Round of Environmental Inspection: So far 130 people have been questioned, and more than 1000 people were invited to talk." (第二轮第一批中央生态环保督察：已问责 130 人，约谈千余人) Xinhua News, August 8, 2019. Accessed on December 11, 2019. <https://news.china.com/domesticgd/10000159/20190808/36786523.html>.

¹⁰⁹ Ruihai Chen. 2019. "The Second Round of Environmental Inspection Started, What's the Feature of this One?" (第二轮中央生态环保督察正式启动，本轮督察有何特点) China News, July 10, 2019. Accessed on December 11, 2019. http://news.cnr.cn/dj/20190710/t20190710_524687066.shtml.

and policies, and it is hard to say the enterprises show compliance even though the regulations are stringent enough. When it was clearly mentioned in official documents that, regulatees who are not able to meet the standard would be facing heavy punishment, enterprises haven't shown enough compliance during the whole process. Whereas regulatees still meet the standard of air pollutant emissions right before the final assessments. This can be displayed as the fact that the number of PM_{2.5} declined drastically at the corresponding time period. Unfortunately, it cannot be described as success since there have always been a rebounding after the end of final assessments. Regulatees in China don't show complete compliance, not do they break the rules obviously.

The crucial reason of such behavior from regulatees is that, there are seriously problems in official monitoring and inspection. Concentrating on final assessments only, while ignoring the procedures of monitoring and inspecting enterprises regularly, is the major cause of enterprises' non-compliance. Historical evidence from Europe shows that, the most efficient method is a combination of self-monitoring and official inspection. Unfortunately, neither of two ways above is adopted by MEE. According to one of Neil's seven models – 'rules and deterrence', which was exactly being implemented by China, this model only works well when regulatees are realized that they won't get away with punishment once break the rules. It is obvious that regulatees in China have already found a way to escape from sanction, by following the path of concentrating on final assessments only. Hence it is not likely to say that 'rules and deterrence' is effective.

Rebounding is a quite common phenomenon, which has happened to all targeted Regions, covering the most developed urban cities in China. According to documents from IPE, the direct reason that triggered such rebounding is because of the increasing emissions of air pollutant from heavy industries, especially steel and coke industries. Industrial emissions of

air pollutant, including SO₂ and NO_x are major causes of such awful air quality in China. Currently situation shows that enterprises are unwilling to decrease the emission of air pollutants fundamentally, since they've found an 'economical' way to escape from being punished by the government, while keeping making profit at the same time.

In conclusion, it is the imperfection of regulation making which have caused enterprises' incompliance, eventually led to the continuously worsening air quality in China. Such imperfection mainly lies in the absence of regular self-monitoring and scheduled inspection. Even though some short-time promotion of air quality had been achieved owing to the stringency of rules, this improvement didn't last long since the enterprises are perfectly aware of such imperfection, and they can always find a way to escape from being punished of breaking such stringent rules.

V. CONCLUSION

1. Limitation of research

My research is mainly limited by the deficiency of available database. Most of the institutes which contribute to measure $PM_{2.5}$ only provide real-time data, and then the historical data is cleaned very quickly. Hence it is hard to find an institute which provide historical data of $PM_{2.5}$ from 2014 until now. What brings more difficulty is that, very few institutes could provide provincial level data. Sole national level data is too vague and general, and it doesn't match with what's been brought in *Action 2017* and *Action 2020* – regional targets. One institute which meets the most requirements was Berkeley Earth. It provides data of $PM_{2.5}$ since July 2014, the database covers most of the provinces in China except for Tibet, Xinjiang and Inner Mongolia.

Secondly, it is difficult to illustrate the definition of 'effectiveness'. As mentioned in Chapter I, there could be multiple ways of describing 'effectiveness', including the improvement of air quality, as well as the decreasing of emissions of air pollutant and so on. And based on different time period that has been focused on, different conclusion can be made. For example, if it is only concentrated on analyzing the air quality by the end of 2017, China's *Action 2017* is quite efficient. After all there has been a large decline of amount of $PM_{2.5}$ in the winter of 2017. Whereas, if it expands the time period to until now, *Action 2017* couldn't be described as success, since the drastic rebound since the beginning of 2018.

Thirdly, there aren't enough documents which keep tracking industries' behavior. IPE is a non-profit, independent institution in China, which was established in 2006. However, it was not until 2010 did it publish reports that concentrate on analyzing air quality. And from 2010 to 2019, there's only seven reports being published in total. Reports targeting air pollutant are

very limited, let alone reports on enterprises' behavior. Industries in China have been unwilling to reveal their behavior towards air pollutant emissions since always. Another reason could be lack of assessments from official institutes, which leave few records of emissions on air pollutant from industries.

2. Summary

To sum up China's policy, this paper mainly focuses on *Action 2017* and *Action 2020*, which are the most recent regulations targeting air pollution treatment. It should be admitted that since the establishment of monitoring system towards PM_{2.5} in 2012, the government's attention toward air pollution treatment has been increasing. And it is a wise strategy to divide China into several main regions, and set different targets basing on geographical factors, as well as economic development.

However, even though Chinese government has shown stringency on policy making, the result is not satisfying as people expected. It was mentioned in Chapter II that the goal of stringency is to form more compliance. And if there's no compliance accomplished during carrying out strict regulations, it will be useless and inefficient. China's environmental regulation is never mid or lenient. For what's mentioned in Chapter III, MEP published the document of "air pollution control and target responsibility" contracts, with the aim of uniting all cities and provinces in China, in order to control air pollution in 2014. In those contracts, leaders' performance is highly linked to their salaries and promotions. In addition, those leaders who fail to complete the targets set by MEP might be claimed responsibility¹¹⁰. The problem is, whether those stringent regulations lead to enterprises' compliance, and make them

¹¹⁰ See note 3.

obey the rule.

What's worse than enterprises' unwillingness of sharing monitoring records is that, government's inspection visits don't catch up. According to documents from MEE, for evaluating an *Action* is successful or not, final assessment matters the most. Usually final assessments happen right before the 'due date' of one *Action*. Assessment is not taken as a routine for making sure compliance. Correspondingly, take *Action 2017* for an example, there's no scheduled assessment during 2014 to 2017, hence it's easy for causing industries' incompliance until when 'due date' came. And the result was a drastic decline of PM_{2.5} in the winter 2017, following by a distinct rebounding in 2018.

Although IPE is dedicated to collecting, organizing and analyzing environmental information from enterprises and government, it is still a non-profit, third-party institute, which has restricted efficacy and prestige. Based on studies of Europe's environmental enforcement, inspection from government plays the most essential role. Appeal from independent organization like IPE may still cause incompliance from industries.

When talking about the relation between economic development and environment, from the analysis by IPE, the contradiction of environmental treatment and economic development has been raised again. On the routine press conference in January 2019, Ministry of Ecological Environment (MEE) pointed out that, the relationship between protecting ecological environment and developing economy is not contradictory, but of dialectical unity¹¹¹. In Chapter II, existing theories of testifying the relationship between environment and economy has been raised. Based on statistics above, developing economy might damage environment

¹¹¹ Environmental Protection Agency for Zhengzhou City. 2019. "Regular News Conference in January." Accessed on December 17, 2019. <https://baijiahao.baidu.com/s?id=1623344472992080345&wfr=spider&for=pc>.

under current China's economic structure. Since as mentioned previously, large number of cities in Northern China still depends on burning coal for heating in winter season, and traditional heavy industries such as coking and steeling lead economic development. If it still follows the rule of "Environmental Kuznets Curve"¹¹², then China may still be in the situation of the first stage: economic development leads to environmental degradation. If it follows "Environmental Kuznets Curve", as economic development grows, there's supposed to be a turning point leading to a reverse relationship. Since China's GDP has reached to the second highest in the world - 15608.15 billion US dollars in 2018¹¹³, it confuses people of wondering how developed a country's economy should be to bring a better environment.

When evaluating environmental monitoring and enforcement in Europe in Chapter II, two key strategies have been provided, which are self-monitoring and inspection visits¹¹⁴. Those strategies are essential for ensuring industries' compliance, and make sure they won't find a way to escape from environmental regulations. In China's case, according to IPE, not many industries are willing to go public about their air pollutant emissions. And among all environmental records, there're only 24.3 per cent of which are environmental monitoring related in 2015.

According to Neil Gunninghan's seven models of intervention strategies¹¹⁵, the closest description of China's strategy seems to be 'rules and deterrence'. This model is implemented when regulators request polluters to meet with obligations, and make sure they're compliant. During recent years Chinese government has issued multiple strict rules, announcing that those

¹¹² See note 21.

¹¹³ Trading Economics. 2019. "China GDP." Accessed on October 13, 2019. <https://tradingeconomics.com/china/gdp>.

¹¹⁴ See note 41.

¹¹⁵ SEE note 21.

who didn't obey would face heavy punishment. While as Neil stated, this model wouldn't work well once the polluters decided to take legal risks, especially when the profit of breaking rules are huge and the cost of treating pollutant is so high. Under this circumstance, regulatees from China are willing to take risks of breaking laws and facing sanctions. Neil also mentioned that this process was called 'regulatory resistance', which was exactly what's happening in China. Another reason for 'rules and deterrence' doesn't work well in China is that, as mentioned previously, there's not enough scheduled inspection visits to support the environmental rules. It is nature for companies to choose reducing pollutant right before the 'due date', but if there're several 'due dates', there's no way for them to escape.

The problem of PM_{2.5} pollution in China is serious. And more and more Chinese citizens begin to realize the harm of polluted air. It has severely threatened people's health. Additionally, as economy keeps growing the environment may keep being devastated. Comparing to developed countries, monitoring and controlling system for PM_{2.5} is still lagging behind. Whereas, the government, as well as independent institutes have begun to take actions. More and more detection sites have been established, and a series of Actions targeting PM_{2.5} control has been issued. Still, with the residents increasing the attention of environmental protection, compliance and awareness from the enterprises is not enough. The stringent rules plus deterrence is not efficient enough for controlling air pollution in China. To improve polluters' compliance, a routine inspection visit and a series of scheduled assessments are strongly recommended. What's more, it is essential for regulatees to understand the urgency of controlling PM_{2.5} damages. In addition, make sure the enterprises won't find a way to escape from being regulated during the whole process, rather than only right before the 'deadline'.

3. Suggestion

I suggest build a connection between the profits from the corporations and their behavior of environmental protection. For example, the more involvement in treating pollutant emissions, the higher possibility of the stock price. Linking enterprises' "green behavior" to their value is essential for contemporary market. For doing this, it is highly recommended to establish a more effective and rational monitoring and inspection system. IPE has been doing quite well as an independent environmental organization. Strength from such third parties is limited, hence they cannot intervene or punish the polluters directly. The best thing they can do is to promote advices, as well as to raise people's awareness of environmental protection. Hence, monitoring and inspecting system should be built from authoritative parties. Cases in Europe has been setting a good example – the combination of self-monitoring and official inspection may be working in China as well.

China has been doing great to settle different targets to different regions and provinces. It is beneficial to take different circumstances into consideration. However, the assessment and evaluation shouldn't be solely settled to the time when it is right before the "deadline". In this way, it is easy for polluters to find a way to reduce the emissions only in a quite short time, and then back to normal after the assessment is over. The procedure of assessment and evaluation should be during the whole time, accompanied with self-monitoring and unscheduled official inspection. The key is for enterprises not knowing when they will be inspected. They should be prepared the whole time and, their behavior of treating emissions will be improved. Self-monitoring is also promotable, especially for enterprises who have already done a good job in controlling their waste emissions. Building a trust relationship between the government and industries is also necessary for building a more harmonious

society.

The relationship between developing economy and preserving environment could be contradictory, especially for an under-developed country like China. In the early years of China, massive people were under poverty line. Everything was destroyed by wars and civil strife. It is understandable that the priority at that time was growing more food so people wouldn't starve, as well as developing economy to become strong. However, the time is different, and China has indeed made remarkable achievement in developing economy. Now it is time to consider transform, from production mode, energy consumption and people's mindset. Heavy industries such as coal and coke production are not considered as sustainable development of economy, and the consequence of massively producing is beyond bearable. For a better life in future, it is high time to reconsider the importance of sustainable development, and green economy.

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