Spring 2017

An Analysis of China's Regional Emissions Trading System: Challenges and Lessons

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An Analysis of China's Regional Emissions Trading System: Challenges and Lessons

Master's Capstone Submitted to the Faculty of the Bard Center for Environmental Policy

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In partial fulfillment of the requirement for the degree of

Mater of Science in Environmental Policy

Bard College

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May 2017

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May 2017

Acknowledgements

I would like to express my appreciation to Bard Center for Environmental Policy and Director **Eban Goodstein** for supporting me to study and helping me to pursue my goal.

Thank you to my advisors, **Gautam Sethi** and **Monique Segarra**, for making my thesis possible. I would not complete my thesis without your countless helps and support. Thank you to **Caroline Ramaley** for your continued support throughout my time at Bard. I also want to thank all staff members of the CEP program and the wonderful memories in the past two years will never fade.

I would like to thank all my friends at Bard and I want to let you guys know that I had great time in the past two years.

Finally, I want to thank my parents for their continuous encouragement throughout my years of study in the United States. I also want to send my profound gratitude to my uncle and aunt, **Charles Zhang** and **Sohpie Ren**, for their unfailing support in all aspects of my life. Special thanks to **Jenny Zhang**, who named me "Kevin" and constantly give me warm support throughout the years in the United States. Thank you!

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Abstract

China, the largest carbon dioxide emitter in the world, has faced environmental pressures both internationally and domestically over the last ten years. In early 2011, the Chinese government approved a carbon emissions trading program in seven cities and provinces, and started planning a national emissions trading framework. This thesis reviews these pilot programs and examines the issues that underlie them. Drawing lessons from the U.S. Acid Rain Program, the European Union's ETS, and California's CAT, the three largest emissions trading frameworks in the world, I find that: (1) lack of trades in China's pilot programs is a consequence of permit over allocation; (2) lack of stringent regulations and penalties have caused low compliance rates and biased data quality; and (3) the secondary market has low liquidity and permit prices do not imply true values. Based on these results, I suggest using benchmarking and auctions instead of free distribution to allocate permits to prevent loopholes and over-allocation. Further, I suggest that the regulatory agency should enforce stringent rules on quality data and encourage transparency by creating a publicly trackable online database.

Executive Summary

In 2013, the IPCC (Intergovernmental Panel on Climate Change) 5th Assessment Report for the first time admitted that the increase in carbon emissions caused by greenhouse gases would be directly harmful to people's health and quality of life. The increase in carbon emissions is due to the massive use of fossil fuels by humans. High energy consumption means elevated carbon emissions.

China's political and economic reform since the early 1980s have resulted in rapid economic development, population growth, and household income rise. The demand for energy and resources has increased dramatically as well. As a result, China surpassed the U.S. to become the largest carbon dioxide emitter in the world in 2007 (Vidal & Adam, 2007). Both China's international trading partners and domestic citizens awared this issue and kept asking for changes. As pressures started to mount both domestically and internationally, China quickly acted and pledged to cut its carbon intensity by 40 to 45 percent by 2020 relative to its 2005 levels during the Copenhagen Climate Change Summit in 2009. In early 2011, China approved an emissions-trading program in seven cities and provinces in response to the pledge. All pilots started running by the end of 2013.

The Pilots Program is an emissions trading system. Firms or industries that emits carbon dioxide will join the program across seven pilots. Firms will obtain their emission rights, which are permits, to emit carbon dioxide. Permits are tradable in the secondary market. Every year, the total emission of the system, which is called the cap, will decrease so that firms have to find ways to reduce their emissions, or buy permits from other firms to meet the emission obligation. There are penalties to punish violators.

My research asks: What is the current status of the Seven Pilots Program? What are the policy challenges for the seven pilots, and what could the Seven Pilots Program learn from other emissions trading programs?

To respond to these questions, I first explore the history of emissions reduction policies in China. I examine the national Five-Year Plans to trace the evolution of emissions reduction policies and how China shifted its focus on targeted emissions. Next, I focus on China's political structure and policy innovations. Understanding them helps to interpret policymakers' intentions. I also thoroughly analyze the policy details of the pilots program.

Then, I explore how other regimes implemented similar policies. From the several successful emissions reduction schemes, I chose the U.S. Acid Rain Program, EU Emissions Trading Scheme, and California Cap-and-Trade Program because they are large frameworks and have had significant emissions reduction results. I first compare the structure of these frameworks and then turn my focus to their allocation methods, enforcement mechanisms, and secondary market and price volatility. I review the literature in these areas and draw examples of how these policy designs have resulted significant outcomes. After reviewing these policies, I turn my attention to the Pilots Program.

Why focus on allocation method, enforcement mechanisms, and secondary market and price volatility? Allocation method is the way to distribute permits to firms. Insufficient allocation method will result over-allocation, meaning firms obtained more permits than they were emitting. This will fail the emissions trading system. Enforcement mechanisms are also important measures for an emissions trading system. Without sufficient enforcement mechanisms, firms will not meet their emission reduction goal and they will neglect the whole system, which will fail the system. The secondary market and price volatility are also important indicators for an emissions trading system. Price volatility is the flow of the permits prices in the secondary market. It indicates if the secondary markets functions well or not. Most importantly, price volatility also reflects the marginal abatement costs.

My analysis focuses on three specific aspects of the program: allocation method, enforcement mechanisms, and secondary market and price volatility. In order to analyze the problems of the permit price and price volatility, I obtained the permits trading data, including permits price and permits trading transactions, since late 2013. My analysis also draws on the political factors that have challenged the seven pilots in local-level government.

Out of this analysis, I find that:

- Distributing permits freely to program participants has caused over-allocation in all of the pilots. This is due to a lack of historical emissions data and an overestimated cap. As a result, the permit prices in the secondary market remain low in most pilots. For example, the Chongqing pilot's permit price has fluctuated between 10 Yuan (about 1.5 USD) and 20 Yuan (about 2.85 USD) in last four years. Overall, over-allocation has cost carbon prices in most pilot projects in the 20 Yuan (2.85 USD) range most of the time.
- The Monitoring, Reporting, and Verification (MRV) process is chaotic across all pilots. All emissions data were not disclosed to the public and firms have found loopholes to report biased emissions data. In many cases, the emissions data are shown differently from the official statistics and third party reports. The lack of sufficient monitoring instruments, reporting mechanisms, and stringent verification regulations have prevented the success of the pilot projects.

- There is no secondary market management across all pilots, and price volatility has shown low market liquidity. The Beijing market only traded 2.6 percent of its total permits in last four years. Due to the over-allocation and lack of sufficient MRV, all pilots have low transaction volumes and most firms hold their permits and never trade with others.
- Political incentive is an important support to the pilot programs. Unfortunately, studies have shown that city cadres and officials often seek economic growth as their prioritized target so that they have higher chances to be promoted. Increasing environmental amenities tends to decrease economic growth at the local level, and therefore environmental investments were commonly neglected or unprioritized by the city officials. As a result, the pilot projects lack political support at the local level.

The results of my work show that the Pilots Program needs significant structural adjustments and policy revisions. Even though the pilot projects have demonstrated the potential to reduce carbon emissions, these are not enough for China to meet its Copenhagen pledge. Therefore, my thesis provides the following policy recommendations for the pilot programs:

- The allocation method should change to benchmark and auction. Because there are insufficient historical emissions data and monitoring processes in China, using a universal industry standard would help to promote emissions reductions and compliance rate. Auctioning would be a supplement tool to help manage the permit price and distribute more permits to the participants.
- The regulatory agency should create an online database to ensure data quality and data transparency. Using this database, the public could then trace

the emissions reductions and help to monitor any violations. All other emissions trading programs, such as APR, ETS, and CAT, have similar mechanisms to ensure data quality and compliance.

- A strict penalty system is also necessary. Currently, most of the pilots have chaotic penalty systems and the fines are so low that many firms prefer to pay them instead of reducing their emissions. All pilots should connect with a legal system and create mechanisms to sufficiently punish violators.

In its most recent Five Year Plan, the Chinese government pledged to establish a national emissions trading program before 2020. Even though China's pilot program faces significant structural and political challenges, it represents a serious effort by China to reduce its carbon dioxide emissions. If the regulatory agency is able to meet these challenges and keep the framework running efficiently, China's national carbon emissions trading system will be a relevant goal in the next three to five years.

Introduction

Over the last two decades, China has experienced rapid economic growth, which has generated an unprecedented improvement in the standard of living of its citizens. However, this prosperity has not been without cost; pollution in China has been raising serious concerns about quality of life. In 2006, 13 of the 20 most-polluted cities in the world were in China (World Bank, 2006). Public concerns about air pollution were first raised by an air quality report from the US Embassy in Beijing in early 2012 (Yu, 2013), which indicated that in the local Beijing area particulate matter levels were far above international norms (Yu, 2013).[1] In several days of January 2012, Beijing reached 700 micrograms per cubic meter (units? PM 2.5?), which is a level that can be considered extremely hazardous (Tang, 2013).[2] According to other reports, Shanghai, the economic center of China, had an average particulate matter of 60.7 microgram per cubic meter in 2013, which is more than double the international safety standard (Greenpeace, 2014).

The driving forces behind the skyrocketing economy and decreasing air quality in China are coal and other fossil fuels (Ohshita & Ortolano, 2006). Coal not only releases large carbon dioxide emissions but also emits other toxic particles into air when combusted. Coal is largely used in heating systems, electricity generation, and steel production. With more than 1.3 billion people, China consumes nearly 50 percent of global annual coal production, which accounts for a large amount of carbon emissions and environmental degradation (U.S. and World Population Clock, 2016; U.S. Energy Information Administration, 2013) and has made China the world's largest carbon emitter in the world, contributing about 25 percent of

[1] Particulate matter can cause asthma and bronchitis and can eventually lead to premature death (Rasschou-Nielsen et al., 2013).
[2] The international safety guidelines for particulate matter, which was set by the World Health Organization, is 25 micrograms per cubic meter (Yu 2013).

global carbon emissions in 2012 (Liu, 2015). As Figure 1 shows, the major fuel source of energy consumption in China is coal, which explains poor air quality and large carbon emissions.

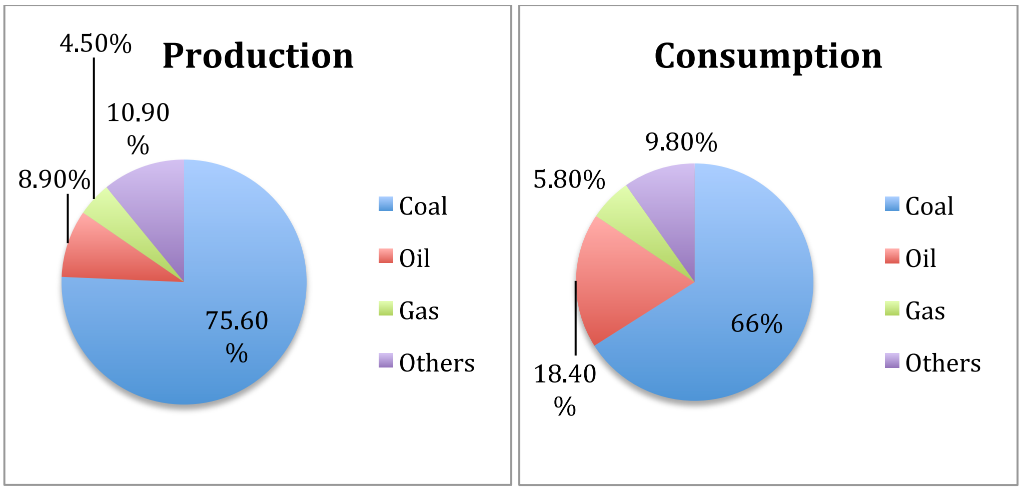

Figure 1: China's energy production and consumption structure in 2013 (Xu et al., 2015)

China has responded to these environmental concerns by enacting various policies through the last three Five-Year Plans.[3] In 2006, in its 11th Five-Year plan, China aimed to reduce its sulfur dioxide emissions by 10 percent and install flue-gas desulphurization technology on most thermal power plants by 2010 (Schreifels et al., 2012), which was successfully achieved. In the 12th Five-Year Plan, which began in 2011, the targets were expanded to 8 percent and 10 percent emission cuts for sulfur dioxide and nitrogen oxide, and 16 percent and 17 percent reductions in energy and carbon dioxide intensity (The State Council of the People's Republic of China, 2011). Solar and wind facilities have increased significantly and China has become the largest solar panel producer and consumer in the world; nearly 25 percent of global solar panels were installed in China in 2015 (Fehrenbacher, 2015). According to

[3] The national FYP outlines a series of social and economic development policies and initiatives for the entire country (Zhang et al., 2012). It is a document planned by the CCP to set targets for the next five years and to signal to lower level officials within China the intentions of the party's top leadership (Zhang et al., 2012).

reports, coal use in China peaked in 2014 and started declining by 3.7 percent in 2015 (Carrington, 2016).

Most importantly, China pledged to cut its carbon intensity by 40 to 45 percent by 2020 relative to its 2005 levels during the Copenhagen Climate Change Summit in 2009. As a result, China started to set an energy-intensity reduction goal in the FYPs and seriously planned to reduce emissions. The low-carbon city project was launched in five provinces and eight cities in 2010 and later expanded to 29 provinces and cities in 2012. Aligned with the low-carbon development in these cities and provinces, carbon-trading schemes was brought on the table in 2011 and approved by the National Development and Reform Commission (NDRC) in the same year.

In early 2012, China established emissions trading systems in seven provinces and cities: the political center Beijing, “the business hub of Shanghai, the sprawling industrial municipalities of Tianjin and Chongqing, the manufacturing center of Guangdong province, Hubei province (home of Wuhan Iron and Steel), and Shenzhen, the special economic zone across the border from Hong Kong (Zhang, 2015, p.3).” In last three years, the seven pilot projects traded 49 million metric tons of carbon dioxide emissions and auctioned another 17 million metric tons, which generated 1.2 billion yuan (about 200 million USD) between 2014 and 2015 (China Carbon, 2015).

Deeming these seven pilot projects an experiment, the central government planned to deploy a national Emissions Trading System (ETS) between 2017 and 2020, which will involve 11 major industries and more than 7,000 firms (“National Carbon,” 2016). This is part of China’s aim to reduce its emissions by 60 to 65 percent, relative to its 2005 levels, by 2030 (*China Economic Times*, 2016). As China tried to mitigate air pollution and regulate industries that produce massive carbon emissions, China’s next step, a national Emission Trade System, will be the key to determine whether China can meet its 2030 goal.

This thesis aims to provide guidance for the design of the national Emissions Trading System by first taking stock of the existing regional emissions trading systems and draw lessons from other emissions trading systems around the world with a focus on the European Emissions Trading Scheme (ETS). To this end, I review the literature on existing emissions trading systems, summarize the status of the regional pilot carbon emissions trading systems in China, and draw comparative lessons, which I use to make recommendations for China’s emerging national emissions trading system.

Chapter 2: Background, Policy Innovation, and the seven pilot projects Emissions Trading Experiment

2.1 History of Developing an Emissions Trading Scheme in China

A primary impetus behind the emission reduction plans that began in 1996 was participation in the Kyoto Protocol (Sun, 2012). Secondarily, rapid urbanization, industrialization and energy consumption caused air quality to fall significantly in many of its cities, raising concerns over quality of life and human health costs (Schreifels et al., 2012). In 1996, the Chinese National People's Congress passed plans to protect the environment and set goals for 2010 (Sun, 2012). Despite the adoption of this new strategy, actual progress remained limited because the government was primarily focused on economic growth. The focus on economic growth sent signals to lower levels of government that created low level of implementing regulations in cities and towns (Schreifels et al., 2012). It is not surprising, therefore, that by the end of 9th and 10th Five-Year Plans, China had not met most of its environmental targets.

Table. 1. Five-Year Plan Timeline

Five-year plan	Timeline
9th	1996-2000
10th	2001-2005
11th	2006-2010
12th	2011-2015
13th	2016-2020

Source: Organized by author

In 2001, emission reduction targets were set at all levels of the government. By setting these targets, the government hoped that the local and city levels would see significant pollution reductions. However, the plan failed and total emissions increased 28 percent during the 10th

Five-Year Plan (Schreifels et al., 2012). Sulfur dioxide emissions, for example, increased 5.5 percent annually during the 10^{th} Five-Year Plan (Schreifels et al., 2012).

Scholars have identified several reasons for the failure of the emission reduction plan, including lax enforcement, high cost, lack of technology, and internal politics. All levels of government did not strictly follow the policies (Schreifels et al., 2012). In addition, many factories were unwilling to install technologies to reduce emissions because of the high costs (Schreifels et al., 2012). The electoral cycle in early 2000 also delayed the environmental strategies (Schreifels et al., 2012). More importantly, the evaluation for local-level governmental promotion was largely based on economic achievements, which did not motivate local officials to promote emission reductions (Schreifels et al., 2012). Furthermore, emission reports lack accountability, and there is no penalty for failing to enforce the policy or violating environmental laws (Schreifels et al., 2012). Even though the 10^{th} Five-Year Plan failed, however, it established a general structure for the system and general guidelines for future regulations.

Many scholars believe that the third stage of the national Five-Year Plan got off to a good start and that the 11^{th} Five-Year Plan has been very successful (CITE THESE SCHOLARS HERE). Many emissions reduction goals were met. For example, Chemical Oxygen Demand (COD) emissions were reduced by 12.45 percent and sulfur dioxide emission were reduced by 14.29 percent (National Energy Administration, 2011). The third stage began in 2006 with the 11^{th} Five-Year Plan and is still ongoing. After the failure of most policies during the 10^{th} Five-Year Plan, the Chinese government put greater emphasis on sulfur dioxide reduction goals (Schreifels et al., 2012). Schreifels et al. (2012) argue that the success of the 11^{th} Five-Year Plan was due to better political instruments, including "binding agreements with provincial governors, performance audits, ... and stronger enforcement of existing laws by the central government," which allowed the sulfur dioxide reduction goal to be met at the end the 11th Five-Year Plan (Schreifels et al., 2012, p.781). At the end of 2010, China reduced its sulfur dioxide emissions 10 percent below 2005 levels and installed flue-gas desulphurization technology on 86 percent of thermal power plant capacity (Schreifels et al., 2012).

In the National Environmental Protection 12th Five-Year Plan, the new targets were further expanded to 8 percent and 10 percent emission cuts for sulfur dioxide and nitrogen oxide and 16 percent and 17 percent reductions in energy and carbon dioxide intensity (The State Council of the People's Republic of China, 2011). Furthermore, the plan promoted more policies and technologies. For example, wind and solar electricity generation capacities increased at a high rate, around 72 percent and 55 percent annually, during the 11th and 12th Five-Year Plan periods (The State Council of the People's Republic of China, 2011).

In addition to these factors, the clean development mechanism (CDM), which was initially created by the UNFCCC in 1996, also gradually began to play an important role in early 2000. By April 2012, China became the major player in the CDM market with 51 percent of all registered CDM projects worldwide (UNFCCC, 2016). Even though CDM projects were relatively successful in China, there were no other instruments that could help to regulate carbon emissions at that time. The government was mainly focusing on regulating sulfur dioxide.

Emissions trading systems were added to the policy mix during the 11th and 12th Five-Year Plan. A cap, the total emission, is often set when implementing the emissions trading system. It normally decreases annually so that total emissions decrease overtime (EDF, 2016;

European Commission, 2016; UNICAO, 2016). Companies who emit carbon dioxide have to buy or trade permits and cannot emit above the permitted amount (EDF, 2016; European Commission, 2016; UNICAO, 2016). Since the total emissions fall and fewer permits are issued, companies are incentivized to innovate emission reduction technologies or switch to renewable energy to meet the regulation (EDF, 2016; European Commission, 2016; UNICAO, 2016). This market-based instrument is efficient in reducing pollution and eases the tension between economic growth and environmental sustainability. Moreover, since coal combustion is the main source of air pollution, limiting air pollution emissions unavoidably leads to a decrease in the use of fossil fuels. A more resource-efficient and environmentally friendly development pathway can then be achieved.

The Copenhagen Pledge pushed China further to reduce its carbon dioxide emissions in 2009. In the following year, the 12^{th} Five-Year Plan was established and the reduction of carbon emissions became the priority goal (Sun et al., 2016). Low-carbon development zones were designated and developed in five provinces and eight cities by NDRC (National Development and Reform Commission) (Sun et al., 2016; Zhang et al., 2014). These zones were created as an initial test to use a market mechanism to regulate greenhouse gas emissions. And, cities and provinces in these zones are mandated to create their own strategies and emission reduction goals (Liu et al., 2015).

In 2011, pilot programs on carbon-trading were established in seven provinces and cities after they received official approval by the NDRC (Zhang et al., 2014). These pilot projects are the testing ground for the national emissions trading scheme after 2016. As required by law, all pilot projects are self-mandated, meaning that pilot projects may determine how carbon-emission targets would be allocated, how much funds may support the carbon-trade market, and how to implement the plans in the region after they received approval from the State Council (Liu et al., 2015). All pilot projects may also decide the means of capping, and selected capped sectors themselves (Liu et al., 2015). From June 2013 to June 2014, all seven pilot projects began full operation and estimates have shown that about 1 billion tons of carbon dioxide are regulated (Liu et al., 2015), with the program in Guangdong becoming the second-largest emissions trading scheme globally after the EU ETS.

2.2 The Political Structure and Policy Innovation

In order to better understand these developments, it is important to be familiar with the Chinese political structure, and how these policy innovations came into effect.

2.2.1 China's Political Structure

Many western scholars have studied China's political structure and have all agreed that China follows Leninism patterns (CITE THEM), where the Communist party remains as the only mandated authority in the nation and creates an elite class to support its legitimacy. Therefore, the unique government structure and political hierarchy had been created to demonstrate the Communist party's authority. In such a system, the government and party are separated entities but are simultaneously tightly connected.

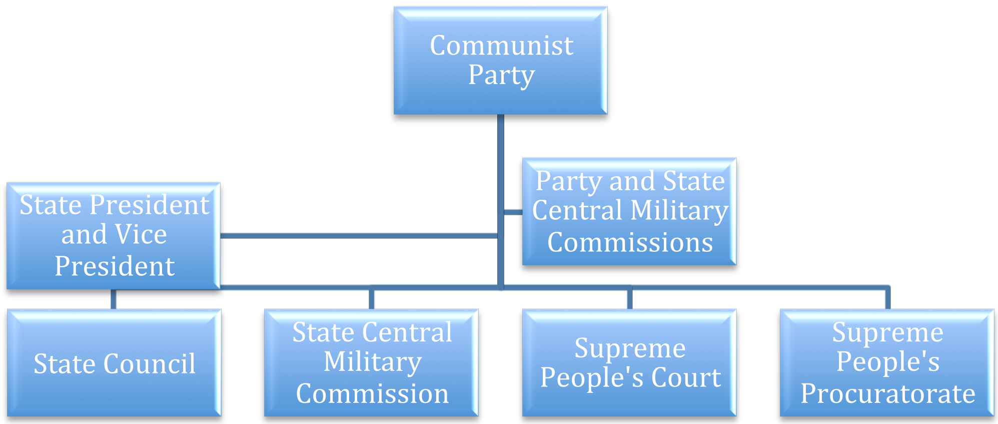

Figure 2: China National Level Political Power Structure. Source: Organized by author.

Figure 2 shows the political structure of China. The Chinese Communist Party (CCP) remains the authority over the State Council and has direct control of the military. The State Council is the government that people refer to most of time. For example, the State Council regulates the State Environmental Protection Administration (SEPA), the national environmental administration. The CCP's role is to manage personnel within the government. CCP has the power to promote or demote governmental officials. The State Council is the entity that regulates daily matters and governs the country. In other words, CCP governs the State Council, or the government, and the government governs people. Therefore, the State Council is the place that normally generates policy.

Then, what is the structure and relationship of the State Council in all levels of government? Here is an example of the hierarchy structure in the State Council.

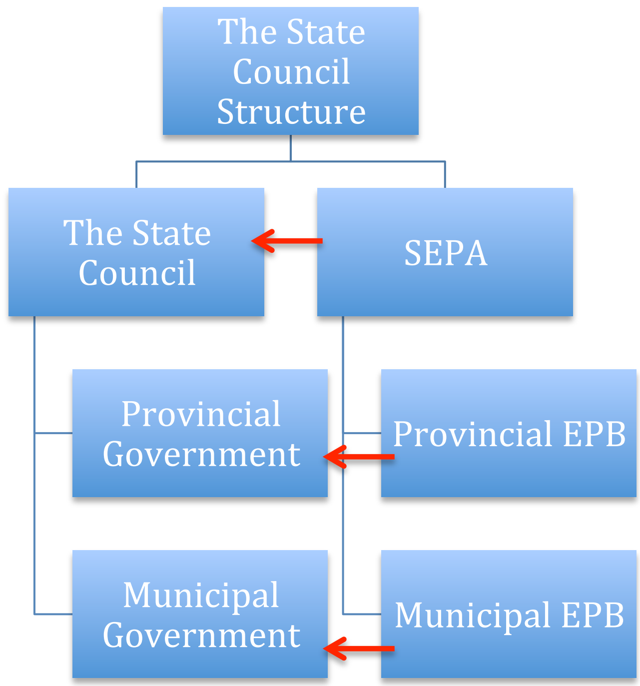

Figure 3: Administrative Structure. Source: Organized by author.

The State Council regulates SEPA and lower levels of government. SEPA often generates policies and the provincial EPB (Environmental Protection Bureau) will implement these policies under the oversight of SEPA. Then, the provincial EPB will acknowledge the municipal EPB to implement policies at the city level. Policies flow vertically in the State Council. Horizontal relationships were also established between the same levels of government. For example, the municipal EPB must report to the municipal government and the mayor.

2.2.2 Policy Innovation

The idea that China's bureaucracy is fragmented is not new. Western scholars have defined fragmented authoritarianism to explain policy innovation in China (Lieberthal & Lampton, 1992; Lieberthal & Oksenberg, 1988). Fragmented authoritarianism emerged because (?) the current Chinese bureaucracy has left spaces for bargaining to generate policies (Lieberthal &

Lampton, 1992; Lieberthal & Oksenberg, 1988). The idea is that the responsibility of each department in the government distracts bureaucratic decision-making power, creating consensus bargaining and leading to a long-term progressive policy-making process (Lieberthal & Lampton, 1992; Lieberthal & Oksenberg, 1988).

As a result, local governments often take their own initiatives in defiance of the central directive and often form tensions between the center and local government. This was due to the vertical and horizontal relationship within the Chinese government. Local leaders can resolve disputes and mediate interests from vertical hierarchies and other institutions to advocate his or her own interests. As a result, policies may not be implemented at the municipal level. Even if the policy went through local channels, municipal leaders have the autonomy to find ways to prioritize other projects and policies, which meet his or her interests.

2.3 The Seven Pilot Programs

China began to develop an emissions reduction framework as part of its agenda ever since it started to reform environmental protection policies. The Seven Pilots Program proposal was approved in 2010. By the end of 2013, all pilot projects were implemented and started trading permits. Since then, all participants in the seven pilot projects must commit emission reduction goals, and the compliance dates are in middle of each year. Each pilot project has a slightly different compliance date, but overall it is in June or July. Here are the locations and details for the seven pilot projects' emission-trading scheme.

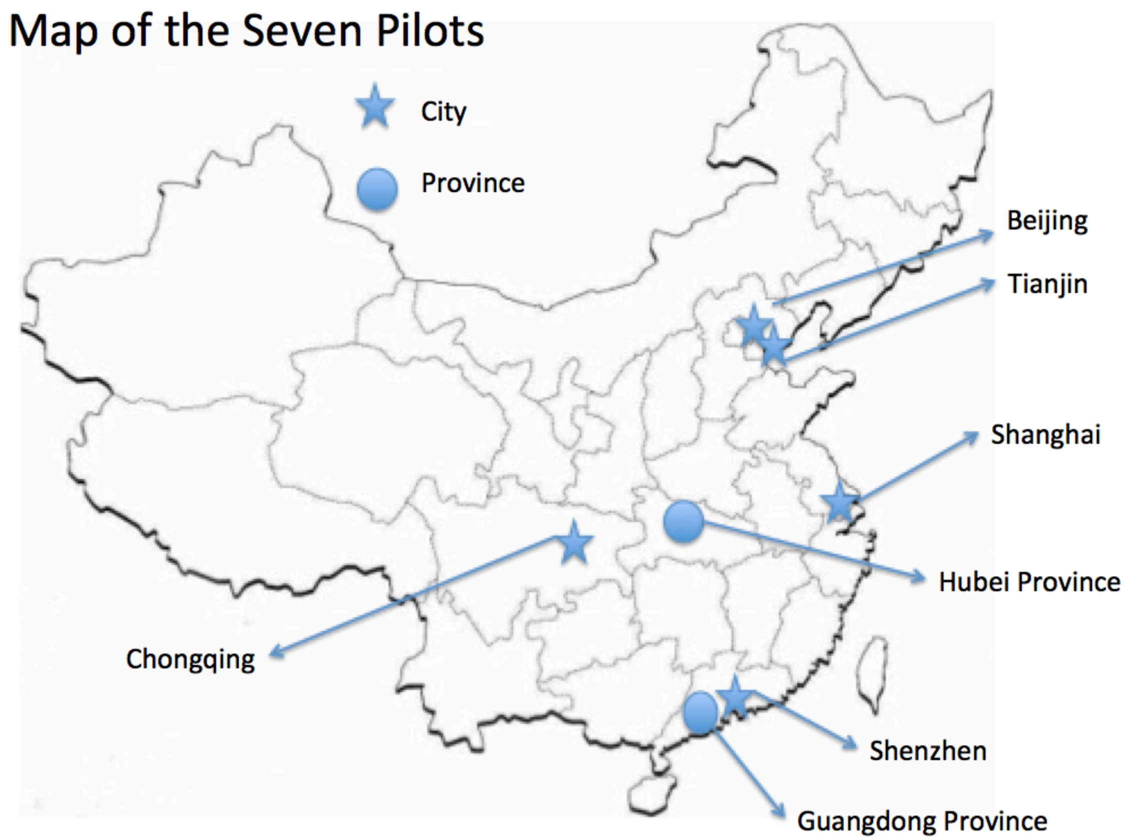

Figure. 4. Location of the 7 pilot projects. Source: Organized by author.

2.3.1 Trading Period and Emission Target

The emission targets are unclear in most pilot projects. However, all pilot projects have committed to reduce carbon intensity. For example, Beijing will reduce its carbon intensity by 10 percent from 2013 to 2015, and Guangdong Province will reduce its carbon intensity by 19 percent in the same period.

2.3.2 Emission Type and Emission Threshold

Currently, all pilot projects only regulate carbon dioxide emissions. No other type of gas was included in the scope. In terms of emission threshold, firms that emit more than 10,000 tons of carbon dioxide annually between 2009 and 2011 must participate in the regional pilot projects. For example, firms that emit more than 20,000 tons per year from listed sectors in 2010 or 2011 must participate in the Shanghai pilot.

2.3.3 Coverage and Baseline Years

All pilot projects have covered power and the iron and steel sectors, since these two sectors generate the most carbon dioxide. Sectors such as heating, chemical production, and cement are also included in most pilot projects. The baseline year is mostly between 2009 and 2011 across all pilot projects.

2.3.4 Allocation Method

All pilot projects used the historical emission data from 2009 to 2011 and distributed permits freely to participants. Only Shanghai applies auctioning as an alternative method, and only small portions of permits were auctioned. All other pilot projects stated that they plan to use auctioning method in the future.

2.3.5 Monitoring, Reporting, and Verification

Firms must provide an emissions report to the regulatory agency annually. All pilot projects required a third-party verifier to verify the emission report from each participant. Hubei and Chongqing pilot projects only require MRV procedures for emitters, which consume more than 8,000 tons of coal each year.

2.3.6 Offsets, Borrowing/Banking, and Penalties

Firms that have or are currently involved with a CDM (Clean Development Mechanism) project are allowed to use Chinese Certified Emission Reductions (CCER) offsets. It limits up to 10 percent in most pilot projects. No borrowing is allowed but banking can be used in all pilot projects. Violators will be penalized with criminal sanctions. Only Hubei and Shanghai pilot projects have announced a penalty price. The rest of the pilot projects did not provide any further information.

The next chapter discusses the drivers of success and how China can draw lessons from other emissions trading systems.

Chapter 3: Drivers of Success in Emissions Trading Systems

Currently, there are many well-running emission-trading programs around the world, such as EU ETS, RGGI and California CAT. Even though these emission-trading systems have different system structures and methods, the fundamental goal for all of them is simple: reduce carbon dioxide and other related emissions. This section will first provide a structural comparison of the U.S. Acid Rain Program, EU ETS, and California CAT. Then, it will dive into three fundamental sectors of these emission-trading systems: initial allocating permits, reinforcement mechanisms, and secondary market and price management.

3.1 Current Emission-Trading System Structure

3.1.1 The U.S. Acid Rain Program

The U.S. Acid Rain Program (ARP), the first large-scale emission-trading program in the United States, was designed to reduce the risks of acid rain in the 1990s. The primary targets for this program were coal burning power plants so that they could trade emission permits to reduce Sulfur dioxide and nitrogen oxides emissions.

Based on EPA's statistics, ARP had successfully "decreased annual SO_2 and NO_x emissions by more than 40 percent in 2006 (p. 47)." The ARP had 2 phases. Phase I was from 1995 to 1999 and included 110 large SO_2 emitters (EPA, 2011). Phase II began in 2000 and included all emitters with a 25 megawatts capacity or greater (EPA, 2011).

3.1.2 European Union's Emissions Trading Scheme

EU ETS (European Union Emission Trading Scheme) was the first to launch a large emission-trading framework that regulated greenhouse gases in 2005. The ETS covers 45 percent of EU GHG emissions and 31 countries have participated in the framework (IETA, 2015). Under the regulation from the European Commissions, the ETS was divided into several phases, each with distinct successes.

Phase 1 was from 2005 to 2007. Phase 1 established a price for carbon and promoted free trade of allowances across EU (IETA, 2015). The Commission also started to build a monitoring, reporting and verification system and infrastructure across the EU (IETA, 2015). Phase 2 was from 2008 to 2012 (IETA, 2015). Phase 2 included more gas emissions and more countries (IETA, 2015). The emission cap was lower and auctions were encouraged (IETA, 2015). The penalty was created and many other features were established as well (IETA, 2015). Phase 3 was from 2013 to 2020 (IETA, 2015). More gas emissions were included in ETS in Phase 3 (IETA, 2015). A single EU-wide cap was created to replace the old caps for each country (IETA, 2015). More instruments were created to encourage renewable energy development (IETA, 2015).

3.1.3 California's Cap and Trade Program

California's Cap-and-Trade program was created a year later than the EU ETS in 2006. However, the program did not start until 2013. Seven major emission areas were included in the program: energy, transportation, agriculture, water, waste management, and natural and working lands (ICAP, 2015). Like the EU ETS' phases, California's cap-and-trade program has a timeline as well. It is the called compliance period (ICAP, 2015). Therefore, the first compliance period was from 2013-2014 (ICAP, 2015). The second compliance period is from 2015 to 2017 (ICAP, 2015). The third compliance period is from 2018-2020 (ICAP, 2015).

In the first compliance period, firms and industries that emit more than 25,000 tons of carbon dioxide per year were required to participate the program (ICAP, 2015). California also linked with Quebec's emissions trading system in the beginning of 2014 (ICAP, 2015). In the second compliance period, California CAP included other emissions from transportation fuels and retail sales of natural gas (ICAP, 2015). About 85 percent of California's GHG were included in the program (ICAP, 2015). The goal was simple: to reduce GHG emissions to 1990 levels by 2020 (ICAP, 2015). Here is the framework summary for EU ETS and CA CAP.

3.1.4 Setup of the Program

The ARP was established in response to the 1990 Clean Air Act. The phase I of the program was from 1995 to 1999. The goal was to decrease sulfur dioxide emissions to 50 percent of 1980 levels. For phase II of the program, which began in 2000 and is ongoing, the goal is to have an absolute cap of 8.95 million tons emitted per year.

The EU ETS emission target for 2020 is 20 percent below 1990 GHG levels (IETA, 2015). For 2030, the emission target is at least 40 percent below 1990 GHG levels. Emission types for EU ETS are shown in Table. 2. CAT's emission target is similar to EU ETS: return to 1990 GHG levels by 2020 (ICAP, 2015). For 2040, the goal is a 40 percent reduction from 1990 GHG levels. There are more emission types in the CAT goals than there are in the EU ETS (ICAP, 2015). Besides the gases shown in the table. 2, CAT also regulates methane

(CH_4), sulfur hexafluoride (SF_6), HFCs, nitrogen tri-fluoride (NF_3) and other fluorinated GHGs (ICAP, 2015).

Table 2: Regulation Emission Type in both ETS
Carbon Dioxide (CO_2)
Nitrous Oxide (N_2O)
per-fluorocarbons (PFCs)

Source: IETA, 2015. Organized by author.

The primary reason for regulating other greenhouse gases is because these gases will expose us to global warming. Even though carbon dioxide (CO_2) is commonly known for the cause of such effect, other gases such as nitrous oxide (N_2O) are also hazardous for human health.

3.1.5 Covered Sectors

The APR only covers coal-burning power plants. Both ETS and CAT cover an important sector: energy. As energy production often creates massive emissions, covering this sector would help to maximize the emission reduction efforts. The ETS also covers industries such as paper and construction, commercial aviation, and other chemical production (IETA, 2015). For CAT, other six major emission sectors were included: energy, transportation, agriculture, water, waste management, and natural and working lands (ICAP, 2015).

3.1.6 Distribution of Permits

For ARP, the allocation method was purely grandfathering and only 2.8 percent of allowances were auctioned every year. The baseline year was from 1985 to 1987. For both schemes, the allocation method was dynamic. During the phase 1 (2005-2007) of the EU ETS, firms received their permits freely through grandfathering distribution (IETA, 2015).

Few permits were auctioned and benchmarked in some member states (IETA, 2015). During phase 2 (2008-2012) of the EU ETS, auctions and benchmarks were used in a small scale and the remaining permits were distributed through grandfathering (IETA, 2015). During phase 3 (2013-2020) of the EU ETS, 40 percent of total allowances were auctioned (IETA, 2015). The electricity, manufacturing and aviation sectors have different regulations (IETA, 2015). Benchmarks were widely used and free permits were limited (IETA, 2015).

For California's CAT, all compliance periods (1 and 2) were using benchmarks in every sector (ICAP, 2015). "Publicly owned and regulated investor-owned electric utilities receive allowances on behalf of their ratepayers. Industrial facilities receive free allowances for transition assistance and prevention of leakage. The remainder of allowances is auctioned" (ICAP, p.13, 2015).

ETS used a smooth approach for allocation method. Due to lack of emission data in the early phase of ETS, ETS used grandfathering to distribute permits. Starting in phase 2, benchmarks and auctioning played a more important role, which essentially led to a stable system. CAT was in a different scenario. Since California had detailed emission data from most participants, it was easy to start with the benchmark method and then gradually increase shares of auctioning. Since ARP had detailed emission data from participants, EPA used the grandfathering method to distribute permits.

3.1.7 Offsets Features

ARP did not allow any offsets. It was mainly because the program only regulates coal-burning power plants. In contrast, ETS and CAT have offsets since both programs regulate various industries. ETS has an offset to help promote smooth emission reductions. Offsets are only allowed to use between 2008 and 2020 (IETA, 2015). Firms that have reduced their emissions by more than 50 percent, compared to 2005 levels, are allowed to use credits from Clean Development Mechanism (CDM), Joint Implementation (JI) and others that were established in the Kyoto Protocol (IETA, 2015). "Unlimited banking of allowances was also allowed in Phase II and III (IETA, 2015, p.11)." Borrowing is not allowed in the EU ETS.

For California, firms are only able to offset 8 percent of their total emissions (ICAP, 2015). California has created many offsets programs, such as early-action offsets, international sector-based offsets, and ARB offset credits, to help promote smooth emission reductions as well (ICAP, 2015). Banking and borrowing are both allowed but are subject to holding limits (ICAP, 2015).

3.1.8 Monitoring and Enforcement

ARP has its own unique monitoring regulations. All power plants in the program must install a continuous emission monitoring (CEM) system to verify compliance. Participants must report their hourly emission data to EPA quarterly through the Internet (EPA, 2011). Moreover, EPA developed an emission tracking system that requires all participants to record their emissions transactions, and record it in the online database (EPA, 2011). The penalty was $2,000 (USD) per ton of SO_2 emission if "a regulated source exceeds its SO_2 allowances (Napolitano et al., 2007, p.50)."

Both Europe and California have feasible plans for monitoring and enforcement. EU ETS has a monitoring plan for every installation and aviation sector (IETA, 2015). Firms in the ETS will self-report emissions annually (IETA, 2015). A third-party verifier ensures that the reported data are accurate before March each year and reports to the central agency (IETA, 2015). The central agency will then record the data and plan for the following year's allowance distribution and cap (IETA, 2015). If firms did not comply or emitted more than they were permitted to, a €100 per ton penalty is applied (IETA, 2015). The name of the firm will be published (IETA, 2015). Besides the central penalty, each state in European Union also has series of penalty to punish firms who ignore the rules (IETA, 2015).

California follows similar regulations as well. The reporting frequency is also annual (ICAP, 2015). A third independent party is required to verify the emission data. But only firms that emit 25,000 or more tons of CO_2 are required to hire a third party to verify the data (ICAP, 2015). The "Operator also must implement internal audits, quality assurance and control systems for the reporting program and the data reported (ICAP, p.12, 2015)." California also has series penalties for violators. Failing to submit emission reporting or emitting excess greenhouse gases will result in serious fines, up to \$1000 per day and up to \$1,000,000 for intentional violations, and violators may even be jailed up to a year (ICAP, 2015).

There are many differences in these three systems as well. For example, the scope coverage is quite similar but not completely the same between ETS and CAT. ARP only focuses on coal-burning power plants. ETS focuses on the power sector, heavy industries, chemical production and commercial aviation. CAT focuses on agriculture, water, waste management, energy and transportation. Even though both frameworks focus on GHGs, emission types are not the same as well. ETS is more centered on Carbon Dioxide (CO_2), Nitrous Oxide (N2O), and perfluorocarbons (PFCs). CAT also concentrated on CO_2 and PFCs but fluorinated GHGs were also added in the scope. On the other hand, ARP only focused on SO_2. The next section will dive into three main categories of an emission-trading scheme: allocation method, reinforcement mechanism, and price volatility and secondary market.

3.2 Allocation Method Discussion

Allocation is a key design in an emission trade system. It not only provides statistics for setting up the emission cap of the system but also influences the permit price during trading. There are two major allocation methods in the current emission trade systems: grandfathering and benchmarking. In grandfathering, the regulator issues free tradable permits based on either historical emissions or on historical emissions intensity (Ernst & Young, 2014). On the other hand, benchmarks are based on the best-performing firm in each industry, whose emissions serve as the standard for others in the same industry (Zetterberg, 2014).

Over-allocation was commonly agreed in the phase I of the EU ETS (Ellerman & Buchner, 2007; Anderson & Di Maria, 2011). Ellerman and Buchner (2007) provided a simple method to show over-allocation and over-estimate abatement efforts in the phase I of the EU ETS. Based on historical data of 2005 and 2006, they compare the total number of over-allocated and under-allocated allowance with overall distributed allowance in each state in EU ETS (Ellerman & Buchner, 2007). Despite economic growth and the rising trend of oil and natural gas prices in EU states, they found that “2005 and 2006 emissions were actually lower than historical baselines even though allowance were over-distributed by 3 percent (Ellerman & Buchner, p, 86, 2007).” Moreover, they used other variables to show that EU emissions were reduced significantly, “roughly between 130 and 220 million tons in each year, which is between 2 percent and 5 percent of covered emissions (Ellerman & Buchner, p, 90, 2007).”

Anderson and Di Maria (2011) arrive at a similar conclusion using a different method. They used the dynamic panel estimation by adding factors of European industrial emissions, industrial economic activity levels, weather effects, and energy prices to estimate the counter factual (business-as-usual) emissions scenario for EU states (Anderson & Di Maria, 2011). As they compare their results with historical allocated emission, their conclusion follows Ellerman and Buchner (2007) that both over-allocation and abatement occurred, and the estimated over-allocation was about 280 million tons of carbon dioxide between 2005 and 2007 (Anderson & Di Maria, 2011).

The benchmark-based allocation method was largely deployed in phase III of the EU ETS. Sartor, Palliere and Lecourt (2014) provided an assessment of using benchmarking method in EU ETS. Sartor, Palliere and Lecourt (2014) used the collected data from phase I and II and compared them with phase III, a period of using benchmarking to help firms allocating free allowance. At first, they found that phase III free allocation levels fell significantly, and benchmarking had reduced risk for windfall gains by firms and simultaneously lowered carbon leakage risks (Sartor, Palliere & Lecourt, 2014).

Overall, the benchmark method provides the potential for a more equitable system than grandfathering because it is more consistent with the future demand and provides greater incentives for emission reduction. Most importantly, the benchmark method offers a consistent method for both new entrants and existing facilities and often rewards early action. In contrast, grandfathering offers a universal standard for all participants. In some sectors, the grandfathering method is preferred due to the complexity of calculating the diversity of products and variables. However, current trends from both emissions trading systems suggest that the benchmark method is more commonly used.

3.3 Reinforcement Mechanism (MRV) Discussion

When constructing an emissions trading system, it is necessary to make sure that the regulator creates mechanisms to track the progress and effectiveness of the trading system. Normally, such mechanisms contains three main functions: measurement, reporting and verification; such a mechanism is often called the MRV system. Measurement or monitoring is often recorded and calculated by the firm. After reported to the central agency, the agency will verify the data and make a future emission reduction plan. A Measurement, Report and Verification system can help to value the effectiveness of the emissions trading system (Bellassen et al., 2015). Based on the collected data, a regulator may see the emission reduction scales in firms and adjust current or future emission reduction plan (Bellassen et al., 2015).

Both EU ETS and CA CAT used a similar MRV method to help to monitor the system. Both emissions trading systems use certified third parties to help to monitor emissions of firms with the sole distinction that while only large firms (i.e. those that emit more than 10,000 tons of CO_2 per annually) needed to comply with the law, all emissions trading scheme firms had to undergo verification). Then, why did both emission-trading schemes choose a third-party verifier? What are the benefits of MRV and what are the best standards for an effective MRV?

Bellassen et al. (2015) proposed a comparative analysis on a monitoring, reporting and verifying mechanism in the current and past carbon pricing management. By comparing key designs in 15 carbon pricing and management mechanisms, they found that current MRVs often neglect small-scale emission firms and constantly provide biased reporting due to emission uncertainty (Bellassen et al., 2015). According to IPCC, uncertainty refers to the "difference between the estimate (or reported) and the actual value (actual emission)," which is the key factor to test the effectiveness of an emission trade system (Bellassen et al., 2015). Bellassen et al., (2015) also focused on the economies of scale of MRV, verification and materiality, which means that MRV focuses more on larger numbers. They found that MRV costs decrease with size and phenomena such as materiality. Therefore, Bellassen et al. (2015) conclude that emission uncertainty is hard to eliminate when monitoring smaller scale firms and provided recommendations for future design (Schakenbach, Vollaro & Forte, 2006).

Instead of reviewing carbon emission trade systems, Schakenbach, Vollaro and Forte (2006) reviewed the U.S. Acid Rain Program (ARP) and nitrogen oxide Budget Trading Programs (NBTP). They found that the key success of a MRV system is data accuracy and strict quality-assurance requirements in the system design (Schakenbach, Vollaro & Forte, 2006). Furthermore, the MRVs in both programs concentrated on program development and maintenance (Schakenbach, Vollaro & Forte, 2006). Several reasons behind the success of these two programs were given: "compliance assurance through incentives and automatic penalties, and strong QA (quality control) (Schakenbach, Vollaro & Forte, 2006, p.1577)." The program benefited from a strong enforcement system and such a system would assure strong quality control (Schakenbach, Vollaro & Forte, 2006). Since all participants have followed the instructions and compliance they had agreed on, the ARP went extremely well (Schakenbach, Vollaro & Forte, 2006). Schakenbach, Vollaro and Forte (2006) also suggested that continuously implementing these strict MRV requirements would benefit the program and preserve long-term success in emission reductions. As these authors have provided detailed concerns towards various MRV systems, it is essential to create an effective MRV system to promote data accuracy.

3.4. Price Volatility and Secondary Market

The allowances or permits, which were allocated by firms, are tradable among emitters so that firms may "equalize their costs of compliance at the margin and thereby achieve the environmental goal at least total cost (Raymond & Shively, 2008)." Low-cost emitters, who may reduce emissions cheaply, can sell their allowances to large emitters to trade off the cost, and vice versa.

Both emissions trading systems do not have mechanisms to regulate the price of permits in the secondary market, which can lead to price volatility. The allowance's price volatility is an important indicator to reflect marginal abatement costs (Hintermann, 2012). Since price volatility can inhibit trades, it is essential to understand its drivers.

Creti, Jouvet and Mignon (2012) revealed the key factors that energy sources and weather conditions determine allowance price in EU ETS during phase I and phase II (Mansanet-Bataller, Pardo & Valor, 2007). As market agents and other scholars believe that energy source and weather conditions are the main elements of changing allowance price, Mansanet-Bataller, Pardo and Valor (2007) proposed an empirical analysis on energy sources, which are oil, natural gas and coal prices, and weather conditions' influence on the daily permits price in 2005. Based on their model, they found that the main cause of CO_2 price changes was natural gas prices (Mansanet-Bataller, Pardo & Valor, 2007). By drawing weather-influencing examples from Germany, Mansanet-Bataller, Pardo and Valor's results suggest that only extreme weather conditions may affect the daily price of CO_2 (2007).

However, Lutz, Pigorsch and Rotfu proposed a macroeconomic analysis on energy source and weather's influence on EUA's (European Union Allowance Units) price in EU ETS, and they found no connection with the weather factor (2013). Lutz, Pigorsch and Rotfu

(2013) proposed a Markov regime switching GARCH model to observe the relationship between EUA prices and its fundamentals, such as oil prices. They used the daily closing EUA prices from 2008 to 2013 (Lutz, Pigorsch & Rotfu, 2013). Their regression results identified a low and high volatility regime and reveal that gas price and stock market had positive impacts on EUA prices in both regimes (Lutz, Pigorsch & Rotfu, 2013).

Koch et al. (2014) opposed Lutz, Pigorsch and Rotfu (2007) and Creti, Jouvet and Mignon (2012), and proposed a policy approach focusing on climate policies and renewable development during the transaction period. Koch et al. (2014) focused on three criteria: economic recession, renewable policies and the use of international credits. Koch et al. (2014) used Mansanet-Bataller, Pardo & Valor's (2007) model but used an Ordinary Least Squares regression to observe the relationships between fuel prices, economic activity, renewable development and international offsets. Their results show that "abatement cost of fuels are not necessary reflecting the EUA prices; plus, economic recessions and renewable energy development had significant impacts on EUA prices (Koch et al., p. 677, 2014)." According to Koch et al.'s findings, only 10 percent of the variations of EUA price changes were determined by fuel prices changes (2014). The remaining 90 percent was still unclear and, therefore, Koch et al. (2014) conclude that "abatement-related fundamentals are not clear to fully explain the EUA price volatility" and they reject the idea that weather changes influence EUA prices (p, 677).

To address price volatility, McKibbin and Wilcoxen (2002) propose a hybrid policy (McKibbin & Wilcoxen, 2002). In their design, regulators can set a price floor and price ceiling through buying back excessive permits and selling additional permits to control price volatility (McKibbin & Wilcoxen, 2002). The ceiling and floor effectively act like a tax, allowing the regulator to combine the two policy instruments, taxes and permits, into a hybrid instrument.

Through the papers above, many important aspects were discussed and compared in EU ETS and CA CAT. As both emissions trading systems are running quite successfully, these aspects could provide significant lessons for China to modify its current trading pilot projects and establish a national emissions trading system. The next chapter will discuss the status quo of the Chinese regional pilot projects and then analyze the mistakes that were made in them.

Chapter 4: Lessons from the Pilots Programs

Many analysts have deemed the seven pilot projects in China unsuccessful for several reasons (Munnings et al., 2014; Lo & Howes, 2014; Xiong et al., 2015). There are many explanations for this outcome. The price is relatively stable in many pilot projects but permit trades were still in a slow process, meaning the liquidity of the market is still low (Munnings et al., 2014). The government has absolute control of the market, which created power asymmetry and a hierarchical relationship within the system and is thus unable to bring players from both private and public financial sectors (Lo & Howes, 2014). In addition, even though many innovations have been introduced, most of the pilot projects are unable to provide transactional transparency and data clarity so that local and international communities cannot track the emission reduction efforts (Xiong et al., 2015). Allowance oversupply is also a problem that is causing the regional ETS to be less productive. Finally, and most importantly, the seven pilot projects are unable to influence the national energy portfolio and carbon emissions (Xiong et al., 2015).

However, these pilot projects may provide useful experience to develop a national emissions trading scheme, and can potentially reshape firms' behaviors and attitudes toward energy consumption and carbon emissions (Jiang et al., 2016). Therefore, this chapter will discuss challenges for the Chinese regional pilot projects in four perspectives: allocation method, MRV challenges, other issues that have lagged these pilot projects, and political barriers.

4.1 Allocation Method Challenges

The most common method for allocating permits in these pilot projects is the historical emission method. The public auction method is also used or considered to be used in Shanghai, Guangdong, Shenzhen, and Tianjing (Wu, 2012). Overall, free distribution is the main theme in the seven pilot projects. Tietenberg brought several advantages for free allocation based on many successful U.S. emission-trading systems. Free allocation involves a smaller financial burden to small participants in the regional pilot projects (Tietenberg, 2006). This means that free distribution would increase the likelihood of adoptions for firms (Tietenberg, 2006). This approach also helps to protect firms who had invested in resource extraction (Tietenberg, 2006). It will also attract potential future emitters to the system (Tietenberg, 2006). Most importantly, free distribution helps to build the necessary political support to enforce the system (Tietenberg, 2006).

However, some of these advantages would not function as originally structured under China's economic and political structure. In most pilot projects, small emitters were excluded from the system. One reason is that small emitter's emissions were excluded when calculating the regional emissions due to an excessive number of firms. As small emitters have minimum impacts to a regional emissions trading scheme, there are no advantages for them to participate in the emissions trading system. Furthermore, large emitters, such as the electricity sector and steel sector, are mostly state owned or controlled. In that sense, these firms will automatically join the emissions trading scheme.

Political support is an unnecessary element in China's circumstances as well. Since the Chinese Communist Party has absolute control of the government, public opinions would have minimum impacts on governmental regulations. Political enforcement is exceptionally strong in China. The only reason for the lack of carbon market development is because emissions trading is not the prioritized target for the Chinese government. Overall, Tietenberg's conclusions are better suited for a democratic, market economy and these may not apply to China to the same degree.

As mentioned before, the historical emission method raises concerns because firms may manipulate their historical emission data. When the pilot projects tried to determine the total emission cap and emission reduction targets, only few firms had complete historical emission data (Liu et al., 2015). The accuracy in quota allocation could have a large impact when calculating future emissions (Liu et al., 2015). The advantage of using the historical emission method would be to distribute excessive permits in the initial stage.

However, too many distributed permits would lower the price, which would fail the emission reduction intention (Sun et al., 2016). This is exactly what happened in the regional pilot projects. From figure 2, the data show the lower carbon price in most pilot projects since 2014. Carbon prices in all pilots show a decreasing trend except Beijing's carbon market, which stays above 40 yuan (5.7 USD) most of the time. Shenzhen's pilot market started above 50 yuan (7.1 USD) in the beginning and then decreased at a constant rate and eventually stayed between 30 yuan (4.2 USD) and 40 yuan (5.7 USD). Shanghai's and Guangdong province's pilot projects show a similar pattern. Both markets' prices decrease at a constant rate but skyrocketed in the beginning of the 2017. Overall, carbon prices in most pilot projects are in the 20 Yuan (2.85 Dollar) range most of the time.

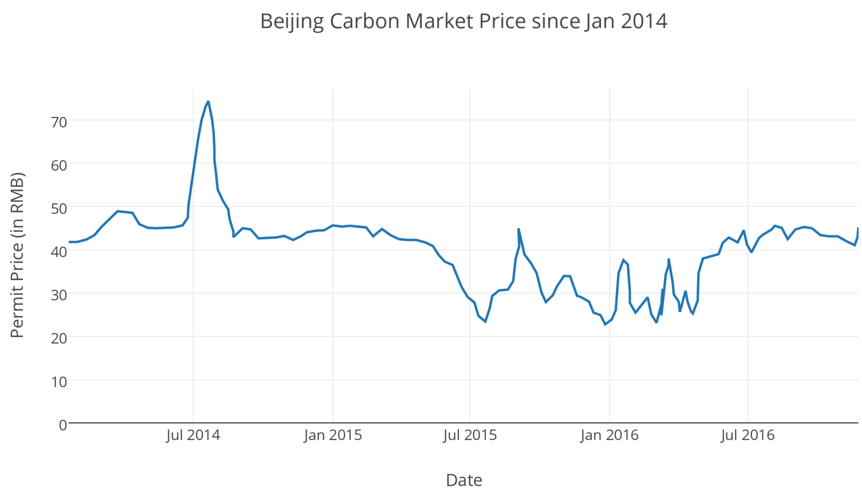

Figure 5. Beijing Carbon Market Price since November 2013. Source: Chinese Carbon Trade Net, 2016.

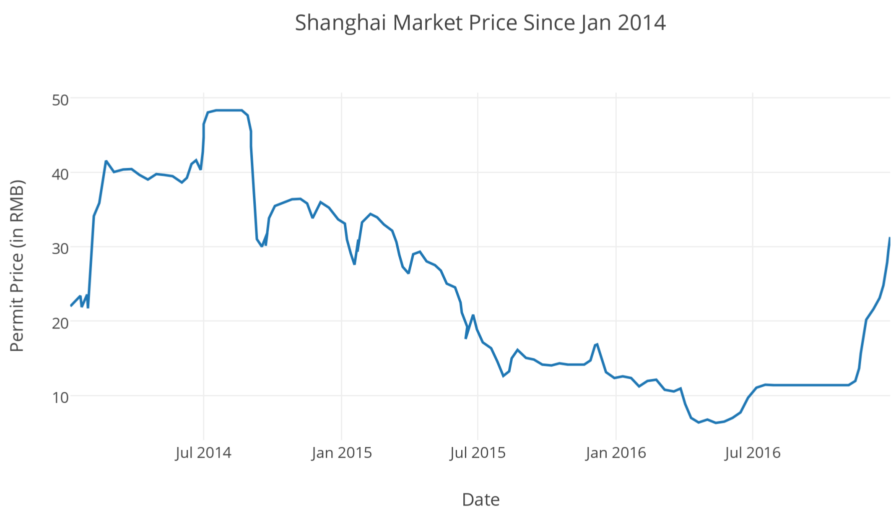

Figure 6: Shanghai Carbon Market Price since November 2013. Source: Chinese Carbon Trade Net, 2016.

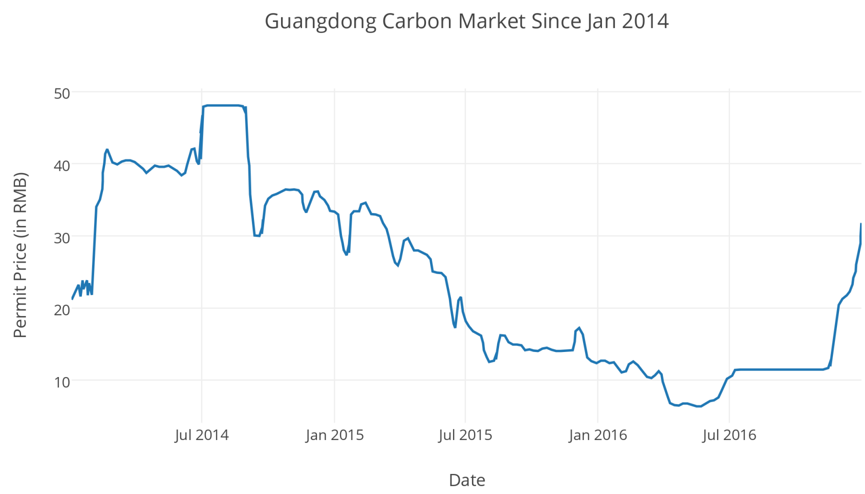

Figure 7. Guangdong Province Carbon Market Price since November 2013. Source: Chinese Carbon Trade Net, 2016.

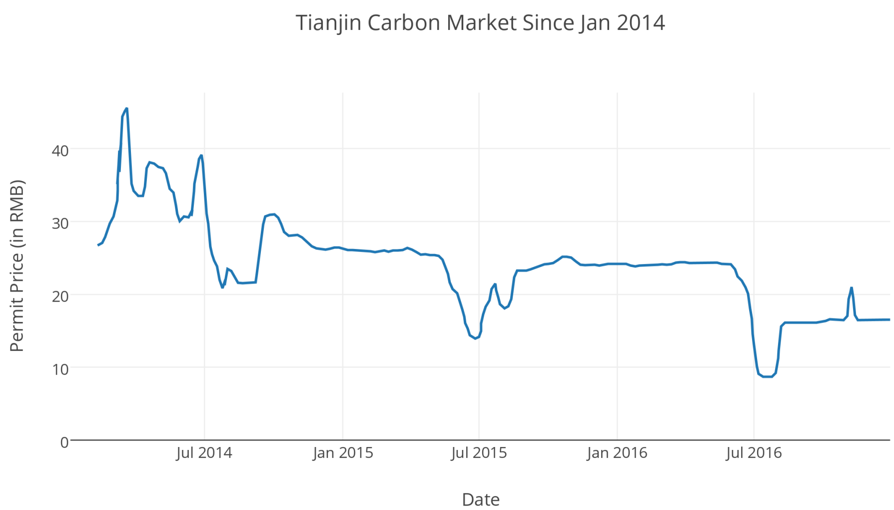

Figure 8. Tianjin Carbon Market Price since November 2013. Source: Chinese Carbon Trade Net, 2016.

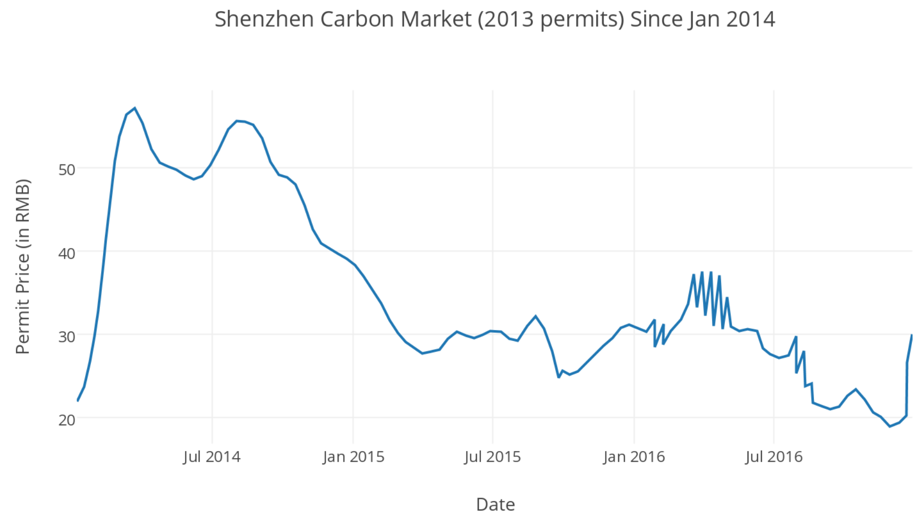

Figure 9. Shenzhen Carbon Market Price for 2013 Permit since November 2013. Source: Chinese Carbon Trade Net, 2016.

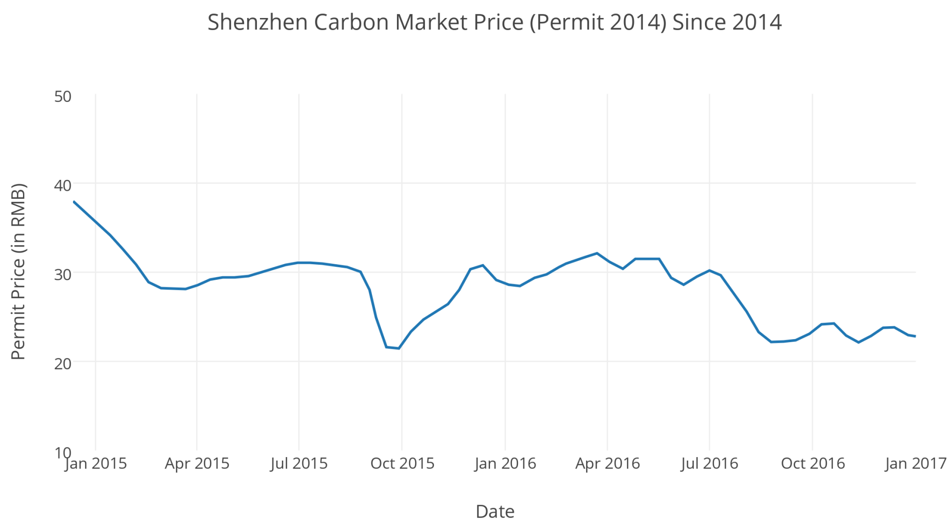

Figure 10. Shenzhen Carbon Market Price for 2014 Permit since 2014. Source: Chinese Carbon Trade Net, 2016.

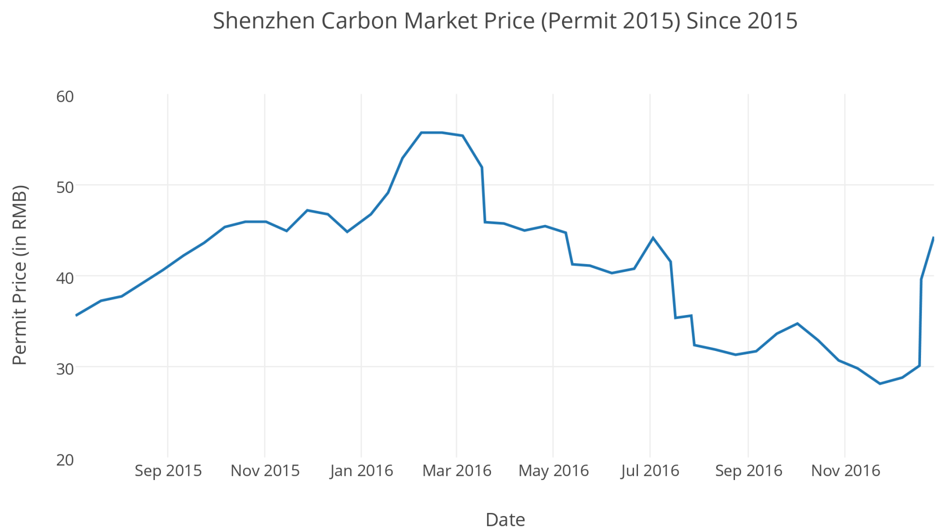

Figure 11. Shenzhen Carbon Market Price for 2015 Permit since 2015. Source: Chinese Carbon Trade Net, 2016.

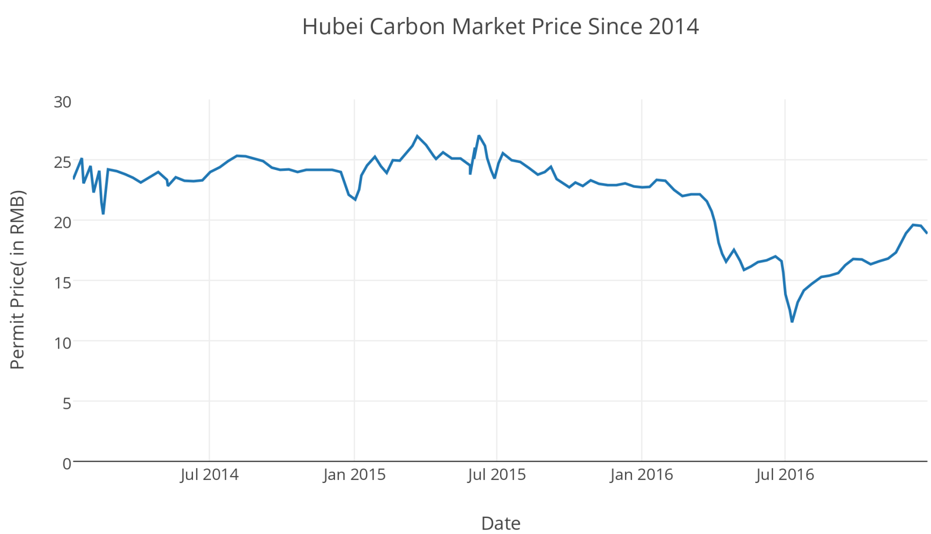

Figure 12. Hubei Province Carbon Market Price since November 2013. Source: Chinese Carbon Trade Net, 2016.

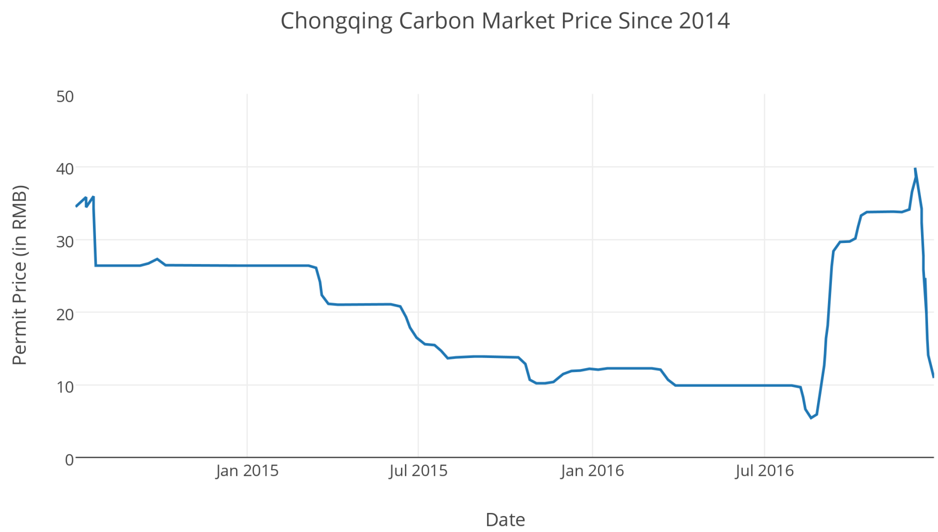

Figure 13. Chongqing Carbon Market Price since November 2013. Source: Chinese Carbon Trade Net, 2016.

On one hand, low carbon prices in most pilot projects are potentially caused by over-allocation. As mentioned above, distributing excessive permits would result in a lower carbon price. On the other hand, a high emission cap in those pilot projects also can lead to over-allocation in most pilot projects. Shenzhen's pilot caps were the same in 2013 and 2014: 33 million tons of carbon. In 2015, the cap increased to 35 million tons of carbon (China Energy Saving Network, 2017). Shanghai's pilot caps were the same between 2013 and 2015: 160 million tons of carbon (China Energy Saving Network, 2017). Beijing's pilot did not disclose the cap but the estimates showed it was about 45 million tons of carbon between 2013 and 2015 (China Energy Saving Network, 2017). Tianjing's pilot cap is the same as Shanghai's cap between 2013 and 2015: 160 million tons of carbon (China Energy Saving Network, 2017). Guangdong Province's pilot cap has been about 388 million tons of carbon since 2013 (China Energy Saving Network, 2017). These pilot projects' caps maintained same level from 2013 to 2015 (China Energy Saving Network, 2017). Considering the fact that the carbon price in those pilot projects stay relatively low, from 20 yuan (2.85 USD) to 40 yuan (5.7 USD), over-allocation would be an explanation for the phenomenon.

Nonetheless, only Chongqing pilot showed a decreasing cap. The cap was 125 million tons of carbon in 2013 and decreased to 116 million tons of carbon in 2014 (China Energy Saving Network, 2017). In 2015, the number decreased again to 106 million tons of carbon (China Energy Saving Network, 2017). Even though the cap was decreasing in Chongqing, low secondary-market trading volume shows over-allocation in the pilot projects. From 2013 to 2017, only 730 thousand tons of carbon were traded (China Energy Saving Network, 2017). This is about 0.8 percent of total trading in all 7 pilot projects in the last five years. If firms in the pilot did not receive excessive amounts of permits, trading volume would be higher and the carbon price would be higher.

However, there are exceptions. The Hubei pilot showed a decreasing cap since 2014 and maintained high levels of market transaction (China Energy Saving Network, 2017). The cap for Hubei pilot projects in 2014 was 324 million tons of carbon and was 281 million tons of carbon in 2015 (China Energy Saving Network, 2017). The cap decreased about 13 percent (China Energy Saving Network, 2017). At the same time, 34 million tons of carbon permits were traded between 2014 to 2017 in the Hubei pilot (China Energy Saving Network, 2017). This is about 40 percent of total trading across all 7 pilot projects (China Energy Saving Network, 2017).

4.2 Monitoring, Reporting, Verification (MRV) Challenges

MRV is a mechanism, including emission measurement, emission reporting, and report verification, that ensures a functional carbon trading system (Shen, 2013). As shown in all pilot projects, most pilot projects decided to have a third party to help process MRV. Yet even with a third party, the transparency of the reporting is in doublet. For example, the government usually picks local firms as third parties to do MRV since a local enterprise is more familiar with pilot participants (Shen, 2013). But, these local, government-preferred firms are normally connected with the government and therefore will create biased data (Shen, 2013) Therefore, it is uncertain that the data will truly represent the actual emissions (Shen, 2013).

Independent third party data verifiers may not be the reliable source to verify firms' emission data. In most cases, emitters often establish a verifier company to verify emitters' own emission data, which means that the firm is able to manipulate the emission data. Often, firms may report excessive allowances to the central agency for the next year and will not implement any efforts to reduce emissions. On the other hand, there is no enforcement after the verifier. There is no punishment for false reporting or manipulating emission data. No sufficient regulations will lead a chaotic MRV process and eventually, will hold back the emissions trading system as a whole.

Wu, Qian & Li (2014) also expressed concerns about data quality from MRV. For example, the Shanghai pilot never revealed historical data or sector emission data to the public; therefore, the public could not track emission reductions (Wu, Qian & Li, 2013). Not only in Shanghai but also in other pilot projects, the emission data are shown differently from the official statistics and third parties' reports (Wu, Qian & Li, 2013). The data inconsistency will also harm cap-setting and permit allocation since most pilot projects used historical emission allocation method.

In addition, data transparency and clarity are also problematic in the regional pilot projects. No emission data were disclosed to the public and no allowance data were publicized from the government. The lack of data transparency would essentially cost these regional pilot projects' emission reduction impartiality. As data transparency is an important tool to value the emission reduction of an emissions trading scheme in theory, it is hard to tell if firms are reducing emissions since the cap remains unchanged in most pilot projects. On the other hand, private investors would have difficulty identifying potential targets for investment. Since no data are available for the public sectors, investors are conservative toward the carbon trading market, which will not help to develop a healthy carbon trading market.

4.3 Secondary Market and Enforcement Problems

Secondary markets in the regional pilot projects are problematic and chaotic. The emissions trading system was invented to generate profits and environmental protection tools for firms through permits trading (Tietenberg, 2006). Without any sufficient enforcement system, firms are unlikely to comply (Tietenberg, 2006). "Insufficient monitoring and enforcement could also result in failure to keep a tradable permit system within its environmental limit. (Tietenberg, 2006, p.3)" This is exactly what happened in the regional pilot projects systems.

Across the seven pilot projects, only three pilot projects, Hubei province, Guangdong province and Shenzhen, maintain high volume of permits trading in the last four years. Beijing, Shanghai, Tianjin, and Chongqing pilot projects only traded 17 percent of the total trading since 2013 (China Carbon Trading Net, 2017). Figure 7 clearly shows the trading percentage for each pilot. The total trading volume for Chongqing pilot from last four years is only 734,000 tons of carbon (China Carbon Trading Net, 2017). Tianjin pilot only traded roughly 1.8 million tons of carbon (China Carbon Trading Net, 2017). Beijing pilot traded roughly 4.8 million tons of carbon (China Carbon Trading Net, 2017). All three pilot projects maintained a low trading volume. If we connect with the data from Figure 2, carbon prices are also

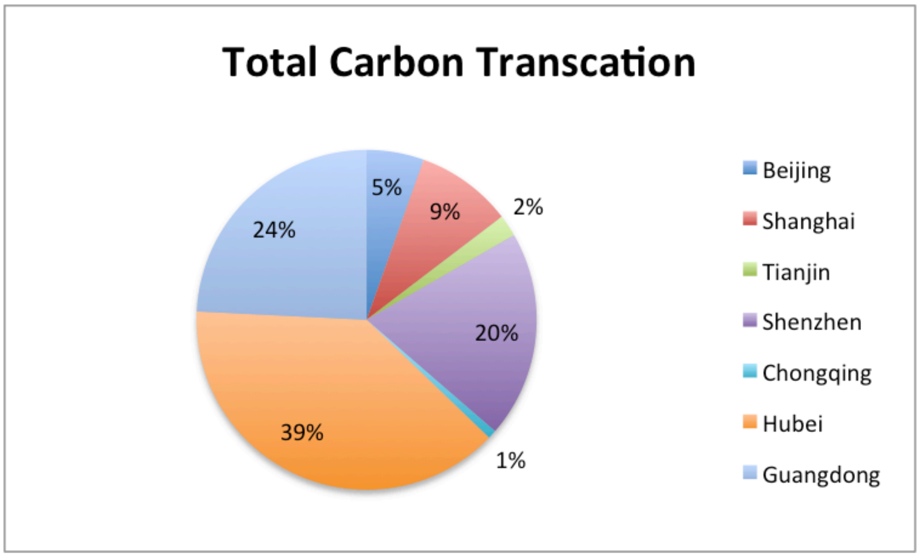

Figure 14: Total carbon transactions in secondary market. Source: China Carbon Trading Net, 2017.

generally lower in the Tianjin and Chongqing pilot projects. Unlike these three cities, the Shenzhen pilot project maintained a relatively active market, and transactions are higher than the three cities combined. It is because that Shenzhen distributed all three-year permits to firms at once. Firms are able to trade their 2013, 2014, and 2015 permits, which essentially increased the transaction volumes in the pilot projects.

Hubei province pilot and Guangdong province pilot have more active secondary markets, statistically. Guangdong traded roughly 21 million tons of carbon and Hubei traded around 34 million tons of carbon in the last four years (China Carbon Trading Net, 2017). The reasons behind the scene are the scale of the pilot projects and also policy enforcement. More firms have participated in these two provincial pilot projects and therefore, more carbon trading occurred. Plus, there are more state-owned enterprises (SOEs) in these two pilot projects. Since SOEs are regulated by the central government, carbon-trading policies are easier to cross through bricks at the local level. Therefore, these two pilot projects' markets are more active than any others.

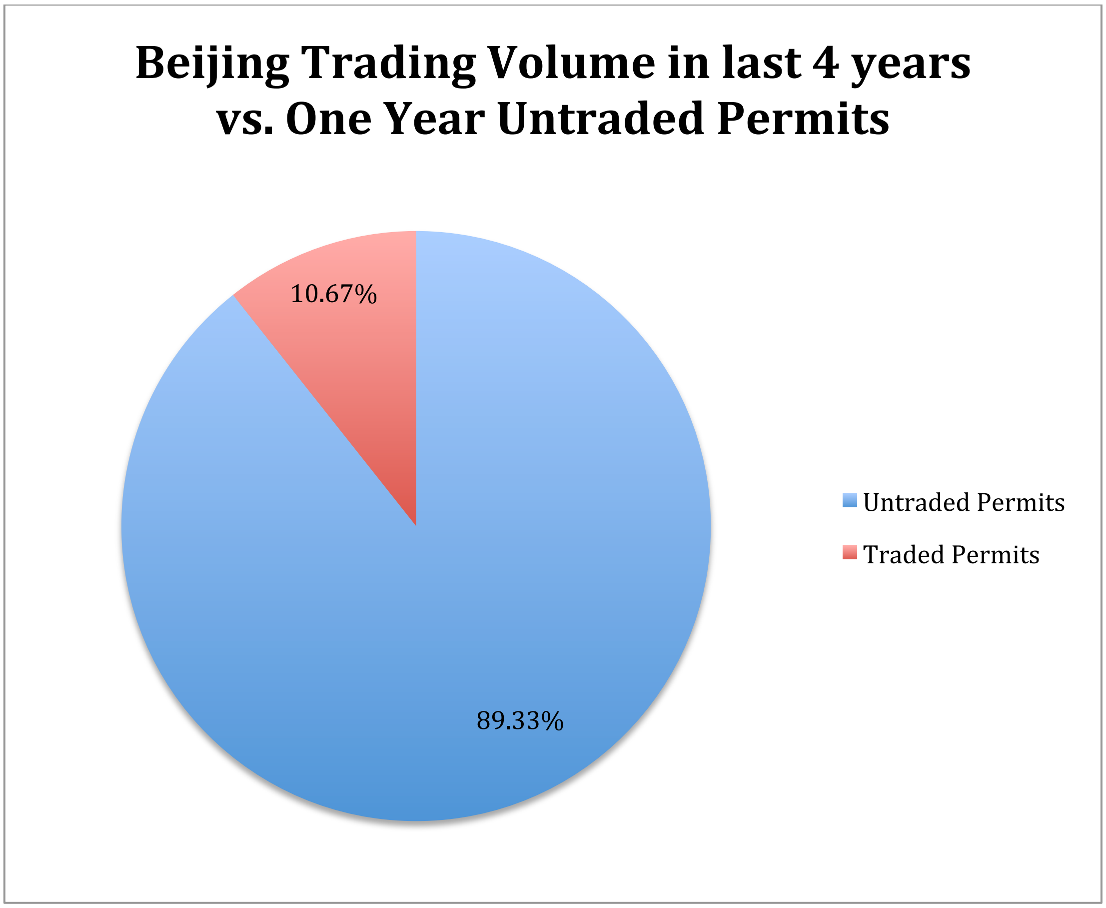

Figure 15: Beijing Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

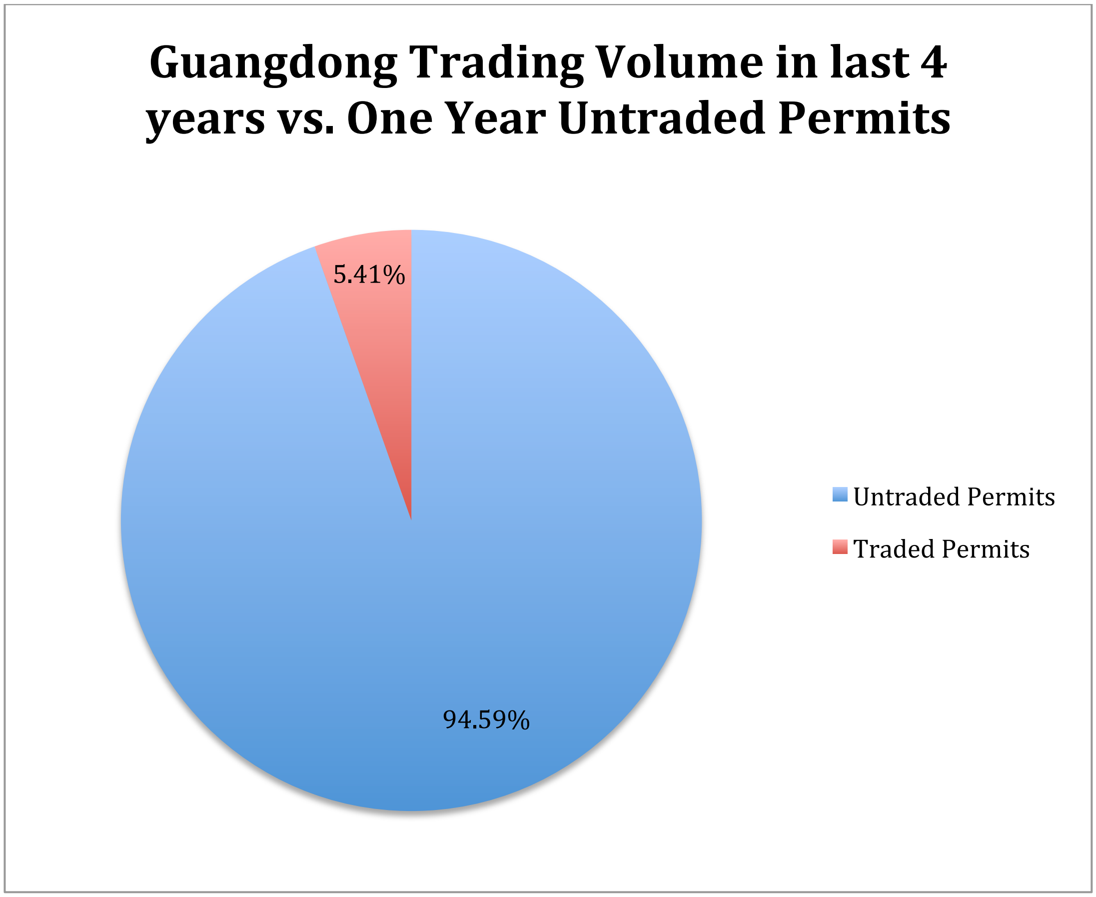

Figure 16: Guangdong Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

Another perspective to look at the secondary market is to compare the total traded permits and the total cap. Both Figure 8 and Figure 9 compare the total traded permits from the last four years and one-year cap from each pilot. Translating into percentage, Beijing traded about 10.7 percent and Guangdong traded about 5.5 percent. Turn these statistics into a larger picture, assuming the cap remains the same for four years, Beijing then only traded 2.6 percent and Guangdong traded about 1.3 percent of its permits in the last four years.

The secondary markets in the city pilot projects commonly share same characteristic: low market liquidity. As mentioned above, all cities maintained low trading volume and firms tend to hold their permits. This could mean that firms had implemented and invested emission reduction tools so that they do not need to trade any permits. Low compliance rate is common in most pilot projects. Shanghai, for example, had a 36 percent compliance rate in 2014 and a 67 percent compliance rate in 2015 (China Carbon Trading Net, 2017). This means that nearly half of the firms in the pilot projects were not able to reduce the amount of emission they had agreed to when they joined the emissions trading scheme. This also means that stronger enforcement policies are needed for the regional pilot projects.

Theoretically, facilities in emissions trading schemes would “control their emissions and sell excess permits, thereby providing an adequate supply (Tietenberg, 2006, p.7).” However, firms in the regional pilot projects often choose to install emission reduction tools to stay in compliance, or simply ignore the policy (Tietenberg, 2006). As the compensation amount is normally low, firms would ignore the regulation and pay the penalty since it is cheaper (Zhao et al., 2016). For those who chose to comply, they did not go above and beyond the line and create excessive permits to sale. One reason is that over-distribution had generated incentives for firms to do less. Another reason is that firms are unfamiliar with the policy, so they are very conservative and are not willing to sell their allowances back to the market.

Many investors’ intend to participate into the carbon market to earn profits. In many other emissions trading systems, individual and institutional investors would help to promote transactions and carbon market activity. However, as the market liquidity is quite low in most pilot projects, investors are able to manipulate permit prices and earn profits. Firms that participated in the pilot projects have to pay more to increase their holdings. As a result, carbon price would not reflect the true value and pilot projects participants face higher prices

(Zhao et al., 2016). Furthermore, only a small number of firms are able to participate in most pilot projects.

4.4 Political Barrier Challenge

Political barriers have failed the pilot projects program. There is a lack of legislation for the administrative supervision and control and the operation of trading markets in most pilot projects (Liu et al., 2015). Only the Shenzhen pilot has legislative power and many pilot projects are not connected with legal system (Liu et al., 2015). As a penalty policy is crucial to make a carbon trading market sufficient, the lack of legislative rights in many pilot projects can make the system fail (Liu et al., 2015). As shown the **Table 1**, all pilot projects have penalties to punish emission violations. However, there are no standardized rules, and the lack of penalty enforcement would be problematic for these pilot projects (Liu et al., 2015).

Even though the 7 pilot projects are led and managed by NDRC and other departments, there is still a lack of details of the specific division of work across agencies, distinction in rights and obligations, and coordination and cooperation in the management system (Liu et al., 2015). Moreover, NDRC has mostly focus on a clean development mechanism (CDM) and lacks carbon trading management experience (Liu et al., 2015). The government needs to separate its role of leader, rule maker and regulator in the carbon trading system in order to make it work (Liu et al., 2015).

The most important political barrier, however, is that local officials or cadres often promote economic growth to seek chances for their career advancement. In other words, local economic growth would bring cadres a higher chance for career promotion. Therefore, economic growth is their priority target. A great example can be seen from the Politburo Standing Committee of the Communist Party of China (PSC)[4]. 7 out of 6 members of PSC including Xi Jinping had worked in coastal provinces, where are the most economic developed areas in China. Note the fact that these members were promoting high economic growth of costal area in the 2000s. It is inevitable to disclose the fact that high economic growth was an important factor that helped them to reach today's career success.

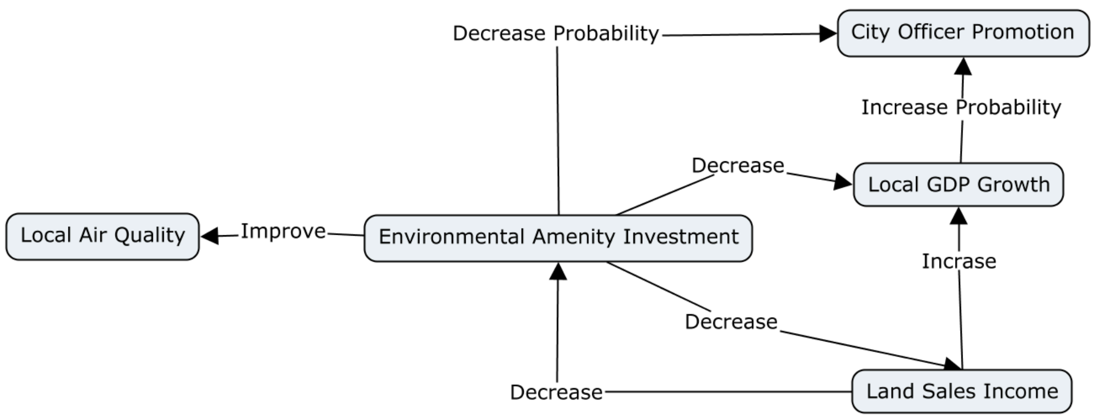

Figure 17: Local Governments' Incentives and Urban Infrastructure Investments. Source: Wu et al., 2013.

Wu et al. interviewed 283 Chinese city mayors and party secretaries about career promotion and concluded that a cadre who leads massive local transportation investment would have a higher chance to be promoted compared to leading environmental infrastructure (2013). Local cadres often face dilemmas to balance economic growth and environmental protection. Figure 3 show the relationships of the environmental infrastructure investments, GDP growth, and career advancement. "One standard deviation increase in average GDP scaled

[4] PSC is the committee consisting major top leaders of CCP (Chinese Communist Party), including Xi Jinping. In other words, this committee has the highest authority and mandate to conduct any policy discussion and establish any policy.

environmental improvement investment lowers the probability of promotion by 8.5 percentage points for secretaries and 6.3 percentage points for mayors (Wu et al., 2013, p.23).” Moreover, “one standard deviation increase in average GDP growth rate compared with predecessor raises the probability of promotion by 4.76 percentage points for secretaries and 10 percent points for mayors (Wu et al., 2013, p.22).”

However, if a cadre put no efforts into increasing environmental amenities, there is no way he or she will be promoted. As the new Five-Year Plan (13^{th}) stated, cadres who have no interests in promoting environmental amenities will not be promoted to the next level. This is a good sign of promoting environmental infrastructure growth since career advancement is the priority goal for local cadres. But, the scale of the growth would be questioned since environmental reform would lead less GDP growth. Balancing the dilemma would be the new challenge for local cadres.

As a lack of sufficient preparation and efficient system design, the Chinese seven pilot projects are still in the experimental stage. Plus, as most scholars pointed out, the pilot projects did not contribute much to reduce greenhouse gas emissions. Pilots need many improvements in order to achieve the eventual goal. Therefore, the next section will provide insightful policy recommendations for the existing regional emissions trading scheme.

5. Conclusions and Policy Recommendation

This thesis has identified a set of challenges for the regional Emissions trading systems. The goal for this chapter is to provide insightful and feasible policy recommendations as these schemes are scaled. It discusses two primary issues: allocation method and enforcement mechanisms. Other ideal recommendations will also be mentioned at the end.

An emissions trading system is a complicated system, and it is hard to establish the system nationwide in the short term, especially in China where the provinces have diverse characteristics. More pilot studies in more regions are recommended to gather more data and get further experience. All the lessons learned from past experiences, both domestic and internationally, I believe China is able to establish an effective and efficient national emission system in the near future.

The emissions trading system is an instrument designed to relax the tension between economic development and environmental sustainability. Although many enterprises currently consider that the system is against economic development because there is a limit for them to pollute, they will be used to the rules and find new opportunities for their industries to develop in a later stage. More specifically, with a rigid legal basis and a strengthened monitoring system in the future, the participating enterprises will have to follow the rules. Therefore, instead of seeking leakages in the law and considering pollution as the main pathway to develop, they will change their pathway, concentrating on using better technology to reduce the cost of pollution reduction or participating in the emissions trading markets to make profits. Plus, political support is also an essential element in China's political environment. As China has committed to the Paris agreement, I believe further support will be provided to promote national emissions trading system. Therefore, I am optimistic towards the national emissions trading system before 2020.

5.1 Allocation Recommendation

Use benchmark Approach to distribute permits.

Over-allocation due to political pressures has proven a lack of efficiency and accuracy in most of China's pilot projects. A benchmark and auction approach would solve the issue. Many scholars have indicated that auctioning allocation method will be the most efficient method to the regulatory agency in China's scenario. Plus, auctioning will also help to set the permit price in the secondary market, which will truly indicate the marginal abatement cost for the participants. If we analyze the EU emissions trading scheme's past experiences, it clearly shows a paradigm shift from grandfathering to a benchmark and auctioning approach.

In phase 3 of the EU emissions trading scheme, auctioning plays an important role in allocation method. Nearly 40 percent of total allowances were auctioned. Benchmark is also an indicator to help regulate the allocation method. Since most firms in EU ETS have started to record their historical emission data prior 2006, EU ETS has a well-constructed database to rely on at present time. The regulatory agency will use the obtained data to establish further emission distributing regulations and estimate the emission cap more accurately. Compared to EU ETS, California cap-and-trade also took a similar allocation methods. Since they had constantly recorded firms' emission data, they were able to start with the benchmark allocation method. Later, auctioning plays an active role in distribution allocation. About 25 percent of the total allowance was auctioned to the participants. California was able to use the generated revenue to invest in renewable energy development, transportation programs, and improve energy efficiency.

For the Chinese regional emissions trading systems, pilot projects can definitely borrow the experiences from EU and California and construct a policy that suits China specifically. Three years of free distribution have helped China to construct a better and more accurate emission database for the current participants in each pilot. Regional pilot projects should able to use the obtained historical emission data to set the benchmark for each industry. Also, benchmark approach is easier to accept new participants in the emissions trading system. It creates fairness for existing participants and new participants. Once the benchmark is set, firms would acknowledge their responsibilities and is obligated to meet expected emission reduction goal. Transforming allocation to benchmark is also necessary for the regional pilot projects to construct a more efficient and sufficient emissions trading system.

Use auction to distribute additional permits.

China must also borrow California's auctioning policy. It is not the first time that Chinese government has consulted expertise from other state. The government have consulted expertise from California's electric vehicle program to set up Chinese EV policies in 2014 and 2015. Based on this circumstance, the Emissions trading program can also learn from the CAT. Auctions are held every three months and firms can buy the remaining unsold allowances from previous year. Two crucial mechanisms, clearing price and reserve price, are needed when setting the auction. Clearing price is defined as higher price bidder wins the bid. Reserve price is "a minimum dollar amount that the owner of an item for auction will accept as the winning bid. (Citation needed)" As California used an Internet platform to process the auction, China should use a similar approach since the Internet is widely used nowadays. The auction should also be single-rounded and in a sealed-bid format. In this way, firms will often bid at a higher price than they had expected.

Overall, the allocation method must change in the current regional pilot projects. Currently, free distribution has caused over-distribution and no emission reduction in many pilot projects. As China is planning to establish a national emissions trading system in the next three or four years, a thoroughly designed distribution mechanism is crucial to make the national emission system work. Or, China at least needs to start recording emission data in local areas and update it annually so that eventually, China can move further in the emissions trading system.

5.2 Enforcement Mechanism

The MRV (Monitoring, Reporting, and Verifying) and penalty system need significant improvements in current pilot projects. The MRV policy in all pilot projects is the same: self-report to the agency annually and a third-party verifier would re-check the report and report to the government. As mentioned in Chapter 3 and 4, data quality and transparency were problematic in the regional emissions trading scheme. Plus, third party verifiers' rules have left loopholes for firms to cheat. Furthermore, the lack of penalty enforcement and compliance is crucial to the existing emissions trading system. Therefore, further policy modifications are needed to address these issues. Therefore, I will address a recommendation on MRV based on the U.S. SO_2 and NOx program from the past.

Ensure Data Transparency

The key for the success of the U.S. SO_2 and NOx program is the well-constructed MRV system. In the U.S. SO_2 and NOx program, firms first choose their monitoring equipment and report to EPA, the regulatory agency. Then, EPA reviews the plan and provide feedback to the firm. As a result, firms' equipment must conduct certified tests and send the results to EPA for approval. At the end, "facilities begin to monitor emissions and conduct ongoing quality assurance and quality control testing requirements. (Kruger & Egenhofer, 2006, p.3)" Facilities must report emissions to EPA quarterly and send feedbacks.

The highlights of such MRV system are reporting mechanisms and data transparency. EPA used various software to audit facilities "for potential discrepancies or issues to investigate (Kruger & Egenhofer, 2006, p.53)." These audits were able to review emissions data and examine the reports provided by firms (Kruger & Egenhofer, 2006). EPA also have field audits in local government to not only verify the MRV equipment in the facilities but also verify the data which was provided by the facility (Kruger & Egenhofer, 2006). As the U.S. ARP resulted significant air quality controls and emission reductions, ensuring the data transparency is inevitable in Chinese pilot program.

Impose strict penalty and ensure data quality.

The penalty system also needs to be strictly enforced to ensure the correct incentives for an emissions trading scheme. The U.S. SO_2 and NOx program had strict penalty rules on excessive emissions or non-compliances. The EPA was able to establish rules to access both civil and criminal penalties (Kruger & Egenhofer, 2006). "With an automatic penalty that is significantly higher than market price for allowances, and with a liquid market for allowances, there has been nearly one hundred percent compliance (Kruger & Egenhofer, 2006, p.54).”

Data quality and transparency also contributed efforts to ensure the success of the U.S. SO_2 and NOx program. All data were available online to the public and there were no confidentiality requirements (Kruger & Egenhofer, 2006). Public access to “emissions and trading data builds confidence in the environmental results of the program and provides an additional safeguard or incentive for compliance (Kruger & Egenhofer, 2006, p.54).” Non-governmental organizations were able to use the emission data to verify participants' emissions and help to supervise the system.

As mentioned earlier, Chinese regional pilot projects' MRV system have many problems. One of the problems is that many facilities were not able to install equipment to monitor emissions. As learned from the U.S. SO_2 and NOx program, the regulatory agency should create a universal equipment rule for all the facilities. Once all or most facilities installed the same equipment, the central agency would be able to manage and monitor the emission data accurately. Facilities in the pilot projects should also be able to report their emission data online and receive feedback from regulatory agency. As firms and the central agency are connected through this network, better communication will be created. As no emission data were disclosed to the public, there was no way for environmental NGOs and the public to help monitor the system. The regulatory agency should create an online database to display all emission data in the pilot projects.

Data transparency is also problematic in most pilot projects. In the seven pilot projects, an independent third party is required to precede the verification process. Stricter rules must apply when identifying a third party. The third party should also upload its verification results into the online database as well. However, the reality is that these third party verifiers may not always follow the rules and often find loopholes in the regulation. Showing the results to the public can be the first step to lead more stringent rules on these verifiers. As the public can compare the report and the verification results of firms, firms will be more serious and concerned about non-compliance. The U.S. SO_2 and NOx program had nearly 100 percent compliance rate because of the data transparency. As a result, pilot participants would reach the same outcome in the close future.

Appendix A. Total Traded Permits from Last Four Years vs. One Year Untraded Permits (Assuming cap remains the same every year).

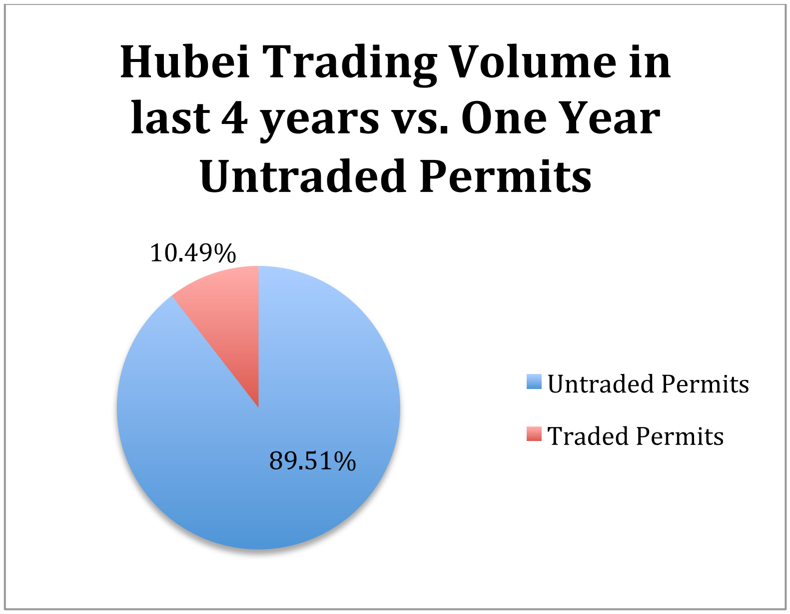

Figure 18: Hubei Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

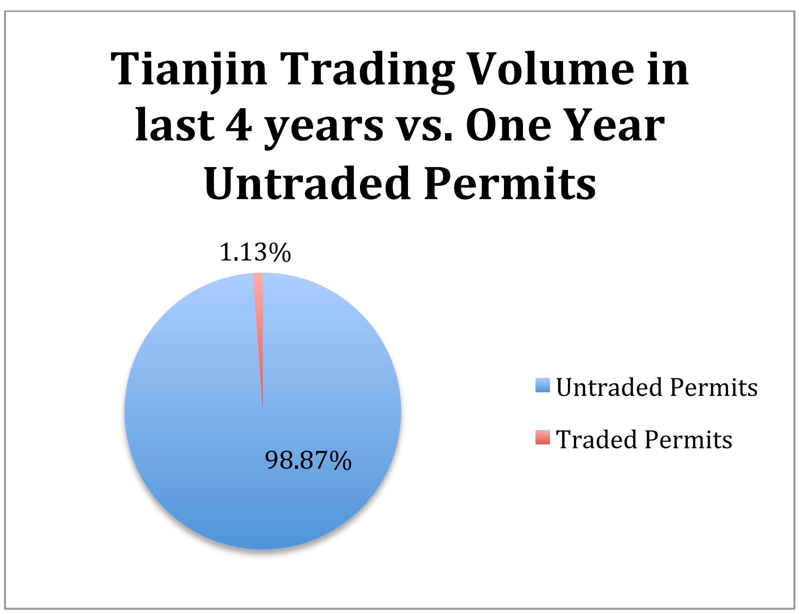

Figure 19: Tianjin Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

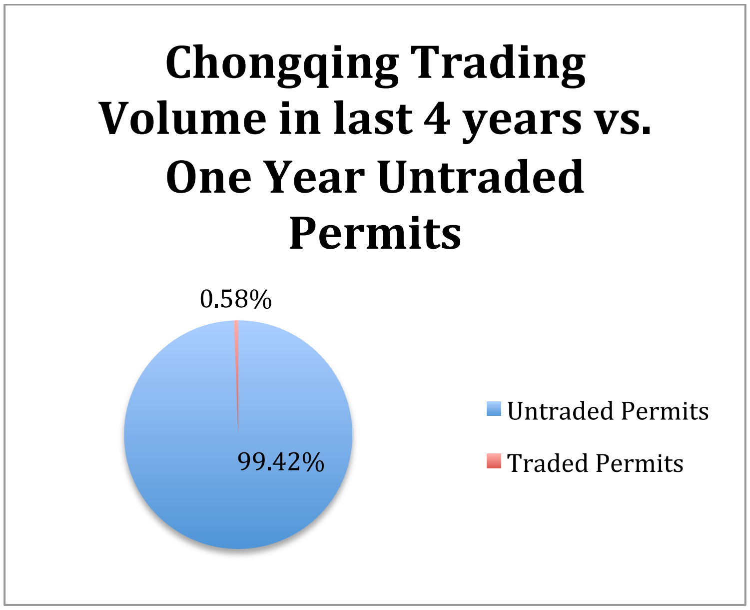

Figure 20: Chongqing Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

Figure 21: Shanghai Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

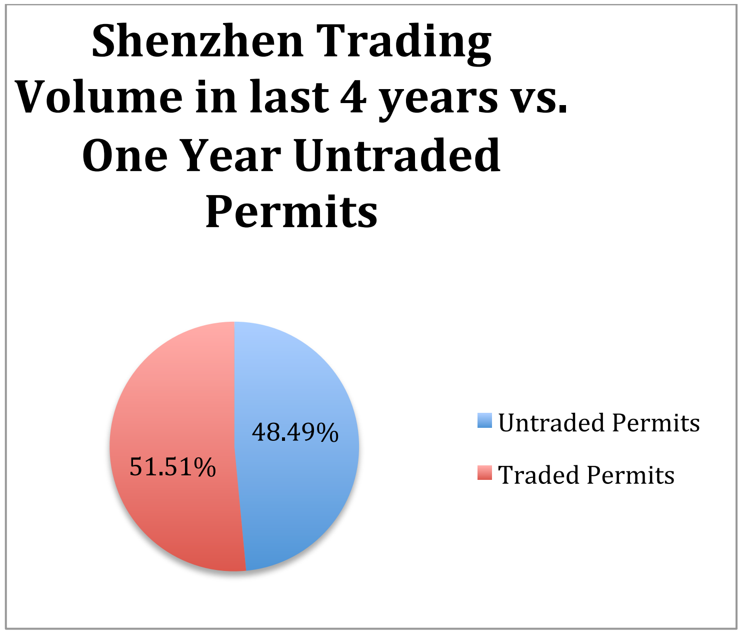

Figure 22: Shenzhen Total Traded Permits since 2013 vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

Appendix B. Average Trading per Year vs. One Year Untraded Permits (Assuming cap remains the same every year).

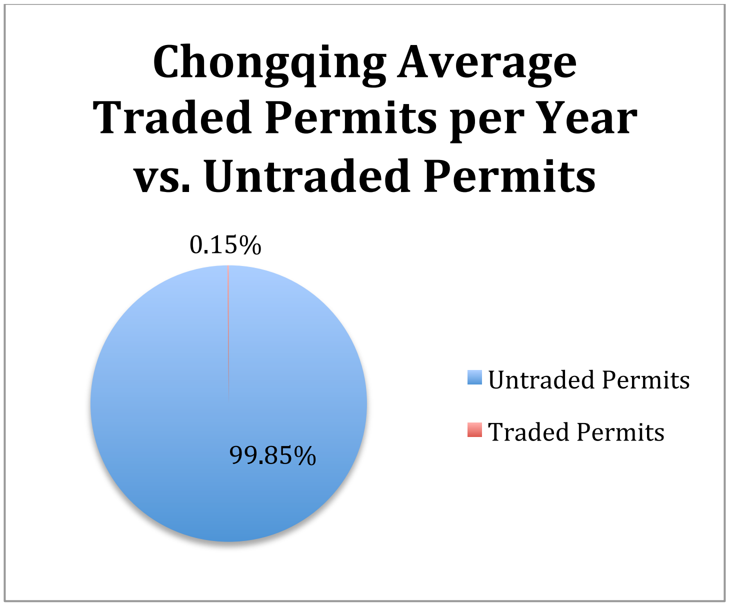

Figure 23: Chongqing Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

Figure 24: Beijing Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

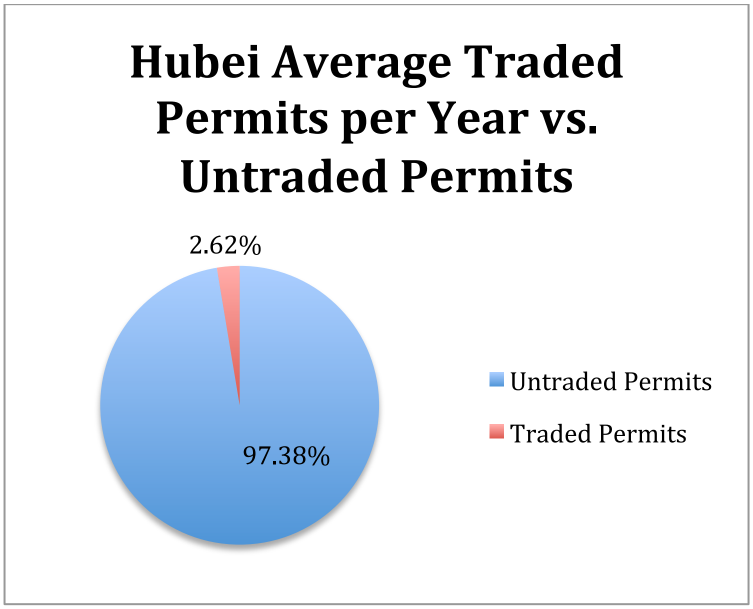

Figure 25: Hubei Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

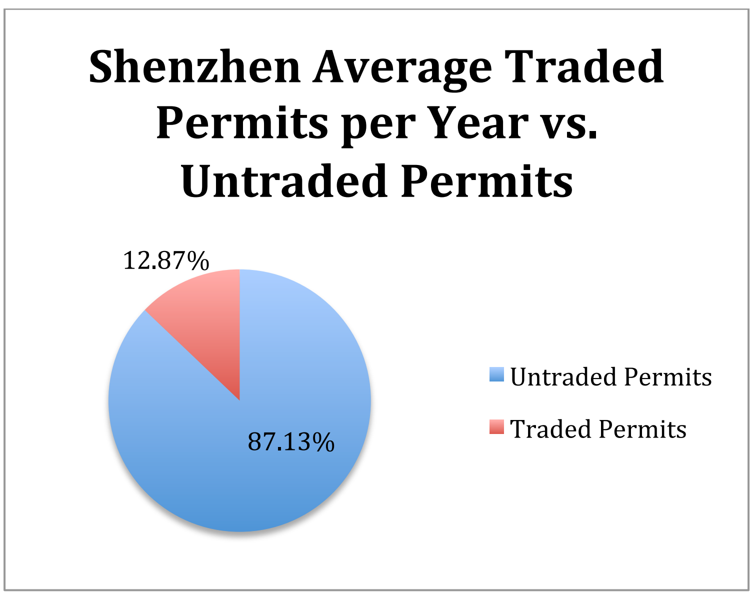

Figure 26: Shenzhen Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

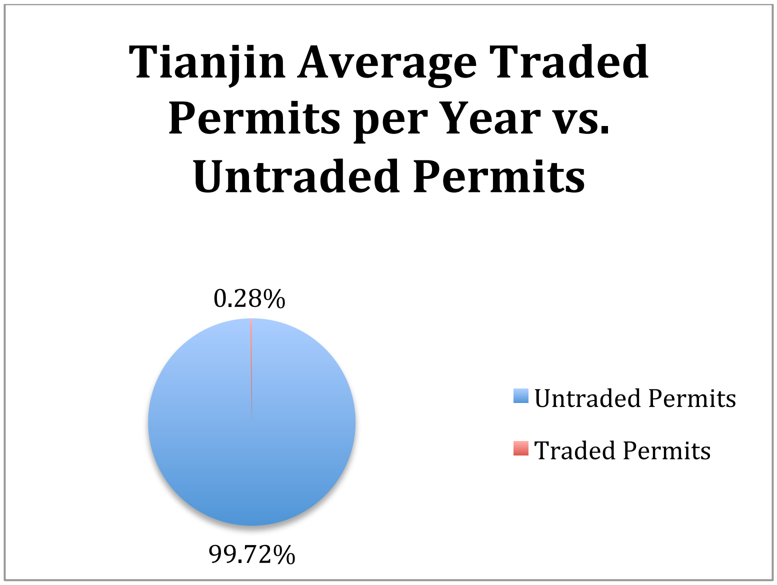

Figure 27: Tianjin Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

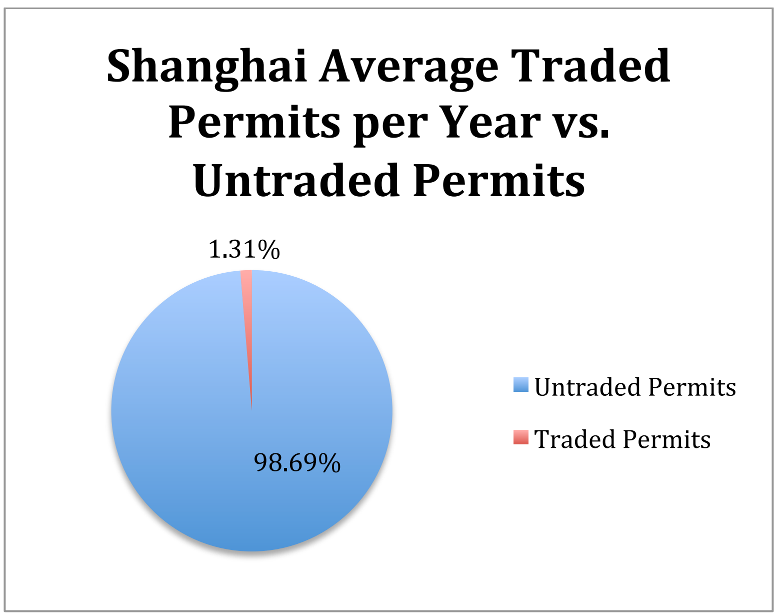

Figure 28: Shanghai Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

Figure 29: Guangdong Average Traded Permits per Year vs. One Year Untraded Permits. Source: Chinese Carbon Trade Net, 2016.

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