ABSTRACT

Title of Dissertation: Do regional integration plans promote joint prevention and control of air pollution?
- Lessons from China's major city clusters

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Doctor of Philosophy, 2019

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China has been actively developing its city clusters in recent years, hoping to use them as levers for both integrated economic development and the attainment of other goals such as collaborative environmental management (CEM). According to the existing literatures, an important share of China's CEM experiments focuses on air pollution abatement. However, to what extent have China's city clusters promoted joint prevention and control of air pollution? The empirical evidence has lagged behind practice. Most of the research on China's regional air pollution management either focuses on just the Beijing-Tianjin-Hebei region, or discusses the characteristics of an ideal CEM framework and the challenges that CEM present. Very few have paid

attention to CEM experiences from the rest of China or discussed the actual outcomes of such practices.

Using a three-essay approach, this research first looks at the city clusters along the Middle Reaches of the Yangtze River, also known as the Central China Triangle, and answers whether this regional integration plan and its embedded call for CEM have brought observable process changes to the involved cities' air quality management system. It then looks at how the venture capital investors, an increasingly important type of private capital provider, have perceived this policy, and whether a more collaborative environmental governance framework has any influence on how these investors make their cleantech investment decisions. Lastly, this research creates an original dataset containing 137 Chinese cities' information on their local environmental protection bureaus' (EPBs') resource adequacy and regulatory enforcement power, industrial polluters' degree of compliance, and these cities' average air quality outcomes for the Year 2017, and uses Structural Equation Modeling method to analyze whether clustered cities and their un-clustered counterparts exhibit observable variations, both in terms of how the enforcement-compliance mechanism functions, and how this mechanism influences the environmental outcomes.

I found improvements in joint prevention and control of air pollution in both the clustered cities and their un-clustered counterparts since 2015, and learnt that certain CEM practices may mobilize private capital in cleantech investment. Moreover, I identified important elements of the enforcement-compliance mechanism that could potentially explain differences in cities' air quality outcomes.

DO REGIONAL INTEGRATION PLANS PROMOTE JOINT PREVENTION AND CONTROL OF AIR POLLUTION? - LESSONS FROM CHINA'S MAJOR CITY CLUSTERS

by

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Dissertation submitted to the Faculty of the Graduate School of the University of Maryland, College Park, in partial fulfillment of the requirements for the degree of Doctor of Philosophy

2019

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Acknowledgements

I would like to thank my advisor Nathan Hultman for bringing me to this PhD program, and for being the best advisor that I could have ever hoped for. He has been such a great teacher, mentor, friend, and role model. I am truly grateful for all he has taught me, both about environmental policy analysis itself and the profession of being a teacher and scholar.

I also want to thank all my other committee members for their guidance and support. Thank you to Prof. Reuter for teaching me the invaluable skills of qualitative analysis and bearing with my mistakes when I made my preliminary analysis unnecessarily complicated. Thank you to Prof. Pearson for being so kind and supportive every time I talk to her and for all the insights that she has generously offered. Thank you to Prof. Patwardhan for challenging me along each step of the way and, as a result, allowing me to produce more value-adding analysis. Thank you to Prof. Hancock for introducing me to the fascinating world of SEM, for being such a nice mentor, and for holding my hands through each step of the way. I feel very privileged to have had such a great committee.

In addition, I want to thank Dr. Kavita Surana for having offered me tons of valuable suggestions, thank Poorti Sapatnekar and Simran Singh for their kind help with proofreading, thank my pukina-panda sisters for laughing and crying with me through good times and bad times in the small-but-cozy PhD lab, and thank my friends at University of Maryland Center for Global Sustainability for all their support. Also, a special thanks to my music teacher Li Lan, who is in China, for all the care and support he has given me throughout the past 20 years!

Finally, I would like to thank my parents, my parents-in-law, and my husband for being so supportive and encouraging all the time. This project would not have been possible without their unwavering love and support. And, to my little baby Sophie, thank you for bringing me so much happiness.

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Chapter 0 – Introduction

China's "Blue Sky Battle"

China's impressive economic growth in the past decades comes with environmental costs, and "the increasingly widespread and frequent outbreak of severe air pollution is amongst the most difficult policy challenges" that the country faces (IEA, 2014). In 2013 alone, long-lasting and large-scale hay weather affected 600 million people living in 17 provinces across China (Zhao, 2014).

The main cause of air pollution can be attributed to China's heavy reliance on coal for its energy consumption. In 2014, 45% of PM2.5 (one of the most harmful air pollutants) in Chinese cities comes from coal burning and its secondary sulfate and nitrate (IEA, 2014). In recent years, economic deceleration, industry restructuring, and stringent energy and environmental policies have slowed the growth of coal consumption in China, but the amount of coal that China consumes is still gigantic. In 2016, China's total coal consumption was roughly 1887.6 million tons of oil equivalent, accounting for 51 percent of the world's entire coal consumption (BP, 2017). Having said that, since 2016, the Chinese central government has imposed a number of restrictive policies, which resulted in the cancellation or suspension of a total of 222 GW proposed coal power projects (Cui et al., 2018; NEA, 2016). However, despite this significant cutback, many people still expect coal to maintain its dominant share in China's primary energy demand (APEC & ADB, 2013; Shearer et al., 2018; Cui et al., 2018).

At the same time, rapid urbanization and China's soaring vehicle population puts tremendous pressure on air pollutant abatement, especially for metropolitan cities. According to data from China's Statistical Yearbook (various years), China's urban population has increased from 20 percent in the 1980s to 45 percent in the 2010s. By 2070, China's urbanization rate is projected to reach a whooping rate of 70 percent (Seto, 2015), straining existing cities' resources and social services provision capacity. As for China's vehicle fleet, it has grown at an astonishing rate of more than 20% annually (IEA, 2014), and the International Monetary Fund forecasts car ownership in China to reach a level of 400 per 1000 population by 2050 (Le Vine, Wu, & Polak, 2017). This large number of vehicles has not only contributed to traffic congestion in urban cities, but also led to serious impacts on ambient air quality because motor vehicles are main sources of air pollutants such as hydrocarbons and nitrogen oxides.

To tackle this policy challenge, China has looked into various options, including: restructuring its industrial sectors, developing alternative sources of energy, shutting down some coal-fired power plants, encouraging the use of public transportation, and so on. To support the implementation of these air pollution control measures, it has also come up with a wide range of laws, regulations, and action plans, for example: the Law on the Prevention and Control of Air Pollution, the 12th Five Year Plan on Air Pollution Prevention and Control in Key Regions, and the Action Plan on the Prevention and Control of Atmospheric Pollution, which was adopted in 2013. This Action Plan set 2017 as the achievement year for two major goals: a 10 percent reduction in concentrations of large particulate matters in major cities; and up to a 25 percent decrease in concentrations of fine particulate matter in targeted regions (CAAC, 2015; CCICED, 2014). Many believe that this Action Plan represents the strictest air pollution control measure ever adopted in China. In June 2018, China again set a three-year action plan aimed at cleaning the nation's air, which is called the "Blue Sky Battle", hoping to further bring down the total emissions of sulfur dioxide, nitrogen oxide, and PM2.5 so that cities will enjoy "good" quality air days for about 80 percent of the year (Li, 2018).

Interestingly, "joint prevention and control of air pollution" is a popular phrase that frequently appears in all the above-mentioned major policy documents. Realizing that air pollution often brings with it negative spillovers, and cannot be effectively managed unless different stakeholders take concerted effort towards a common goal, China started promoting this collaborative environmental management model since the early 2000s, experimenting this new tool to stamp out air pollution.

However, there are major challenges in winning this "Blue Sky Battle". One of the problems in China's existing environmental protection laws and regulations is that "legal provisions are ambiguous and the authority of legislative bodies, law enforcement agencies, and judicial bodies are vaguely defined" (Yang & Hu, 2008). Another prominent issue is the weak environmental management enforcement at the local level. This is partially contributed by China's decentralized environmental governance structure, which leads to the nation's complicated central-local power dynamics. To elaborate, even though local environmental protection bureaus (EPBs) receive guidance vertically from the Ministry of Ecology and Environment (MEE), "they are institutionally and financially subordinate to provincial and local governments" (IEA, 2014), so top-down orders do not necessarily get implemented. In recent years, the MEE has put increasing emphasis on exerting its "vertical control" (or direct control) over the local EPBs, but environmental management effort at the local level remains largely heterogeneous. Meanwhile, achieving collaborative environmental management is also easier said than done, and the next two sections will discuss this in greater details.

Collaborative Environmental Management (CEM) and China's experiences with CEM

Collaboration is important for the governance of transboundary environmental issues, from local-level air pollution reduction to international climate action. Fragmentation issues present great challenges for local governments in effectively managing their environment (Yi, Suo, Shen, Zhang, Ramaswami, & Feiock, 2017). Negative environmental externalities and policy spillovers across jurisdictions make it sensible, if not necessary, for local governments to look beyond policy instruments that coordinate resources and management efforts within their governed domain, and seek collaboration with their neighboring jurisdictions (Feiock & Scholz, 2010; Durant, Fiorino, & O'Leary, 2004).

Collaborative environmental management (CEM) can be loosely understood as an environmental governance framework that brings together different stakeholders across boundaries to address a common environmental issue. These boundaries can be "inter-departmental, central-local, and sectoral (corporate, public, voluntary/community)" (Ling, 2002), the cooperation among participants can be horizontal, vertical, or diagonal (Yang, 2011), and the social construct that binds them together can be formal, informal, or imposed (Feiock, 2016). Such a governance model often involves “contracts or joint production with other local governments as a means to gain economies of scale, improve service quality, and promote regional service coordination across fragmented local government regions” (Agranoff & McGuire, 2003; Bel & Warner, 2016).

The history of China’s CEM experiments can be traced back to the early 2000s. “Realizing the limitations of unilateral actions, the local governments increasingly relied on inter-local collaborations to address various policy issues at a regional level” (Feiock, 2016). These policy issues include areas such as public service delivery (Jing & Savas, 2009; Yang & Peng, 2009), environmental management (Yi et al., 2017), and social services provision.

Win-win economic development was the initial target of inter-local collaboration in China (Feiock, 2016). However, since the natural environment in many regions of China has deteriorated rapidly in the last two decades as a byproduct of industrialization and rapid economic progress, the Chinese government became firm in restructuring its economy towards a more environmentally-friendly one since its eleventh five-year-plan (2006-2010), and as a result, inter-local collaboration has also expanded its scope to tackle issues of environmental sustainability (Feiock, 2016). There is general agreement that “achieving the next level of environmental improvement and sustainable communities” will not only require guidance from the central government, but also depend on the joint efforts made by the local communities, industries, non-profit organizations, and others” (Randolph, 2004).

Despite China's many years of attempts to address regional governance of environmental issues, researchers paid limited theoretical attention to China's CEM practices until recently. Feiock and colleagues were the first ones, who used the Institutional Collective Action (ICA) framework to rigorously examine the potential roles of voluntary agreements in local environmental governance. They even modified the ICA framework to fit the Chinese context (Feiock, 2009; Feiock, 2013; Feiock & Scholz, 2010). More researchers have followed their paths since then. Some of them focus on describing the mechanisms of corporation among local authorities and factors that could explain the choices of environmental collaboration agreements among Chinese cities (Yi et al., 2015; Feiock, 2016). Others talk about the characteristics of an ideal CEM framework and the barriers that confront effective inter-local collaboration on environmental management (Gong & Zhang, 2015; Lu, 2014; Gong et al., 2014). However, most of these studies do not discuss whether CEM practices led to positive process outcomes or improvement in environmental outcomes.

Challenges in unlocking CEM's promises and evaluating CEM's outcomes

There are many theoretical and empirical studies on system-level pre-requisites, managerial factors and participant characteristics that lead to successful CEM process or positive collaborative outcomes (Mandell & Steelman, 2003; Wondolleck & Yaffee, 2000; Heikkila & Gerlak, 2016; Siddiki & Goel, 2017). However, contractual schemes and multi-stakeholder coordination efforts must be carefully managed, or they will fail (Silvestre, Marques, & Gomes, 2018).

To elaborate: first, CEM requires a well-designed national framework that takes into account the role and mandates of all levels of government (GIZ, 2017), and this requirement can seldom be met. Second, the allocation of regulatory responsibilities and funding in a CEM setup is often ambiguous (Ling, 2002), and as a result, some participants' opportunistic behaviors (Kim et al., 2011) lead to inefficient collective outcomes. Third, the extent of collaboration is tough to measure because the principal participants of inter-governmental agreements are governments and public agencies, who emphasize voluntary adoption (Feiock, 2016). Fourth, there are inadequate performance evaluation guidelines and poor quality of information regarding collaborative environmental management (Ling, 2002). On top of these, there are also country-specific challenges related to the political environment and environmental governance structure in general. As a result, good intentions to collaborate often end up with Institutional Collective Action (ICA) dilemmas.

More importantly, the excitement over CEM has not been matched by evidence that these processes actually improve the environment. The most crucial questions often remain unasked, that is, does CEM lead to improvements in environmental outcomes? About a decade ago, Koontz and Thomas (2006) wrote about what we knew and needed to know about the environmental outcomes of collaborative management. They called for empirical work that demonstrates whether "collaboration improves environmental conditions more than traditional processes and newer market-based processes" (Koontz & Thomas, 2006). Still, as of today, not much emphasis has been placed on matching the expected CEM outcomes with actual empirical evidence.

My Overall Research Setup

This section gives an overview of my chosen policy context, explains the relevance of my research, and justifies the appropriateness of my selected cases.

<u>The added value of city cluster development in promoting CEM</u>

China's urbanization rate is projected to reach a whopping rate of 70 percent (Seto, 2015). In an effort to handle the increasing migration from rural areas to the major cities, the Chinese government is proactively thinking of ways to integrate resources and maximize resource utilization. It introduced its National New-Type Urbanization Scheme (2014-2010) a few years ago, in which it mentioned its plans to develop the so-called national-level city clusters. The main logic behind forming such urban agglomeration is that it ensures economic competitiveness and resource-use efficiency in the long run. As of March 2018, nine such city clusters were approved by the State Council. These city clusters are mostly situated along the country's eastern border or from the central China region. Together, they span a total area of 1.76 million kilometer square, which represents about 18 percent of China's total area.

Prior to the release of the New-Type Urbanization Scheme, there were three major urban agglomerations in China. These include the very well-known Beijing-Tianjin-Hebei region, the Yangtze River Delta, and the Pearl River Delta. These regions were strategically formed for economic development purposes, and they have served as China's three economic pillars in recent decades. As of 2015, these regions accounted for 39.4 percent of China's national GDP.

Unlike the development of these earlier-formed urban agglomerations, the new wave of city cluster formation since 2015 appears to have a much broader goal for collaborative development. Apart from using these city clusters to support economic development, the Chinese government also aims to promote industrial upgrading, transportation interconnectedness, integrated social service network, and collaborative environmental management through these regional integration plans.

However, the implementation strategies of these regional development plans are not clear. It is also not clear why city cluster formation is the best way to achieve the above-mentioned goals on integrated development and collaborative governance. Many speculate that: 1) the formation of the city cluster brings economies of scale. 2) The more constant interaction among different localities' officials and the relationship that grows among them will become a layer of cushion that minimizes inter-jurisdictional conflict when there is a transboundary dispute. 3) The process of city cluster formation will likely provide a conducive environment for resource integration and resource use maximization. 4) Regional integration plans allow involved cities to strategically line up their development strategies and prioritize in such a way that the region's total strength is maximized. However, there is minimal research on whether these are the ways how things work in practice.

Moreover, why did cities and provinces engage in such big-scale policy experiments? Why is the State Council seemingly pushing the traditional provincial economy and independent administrative region economy to an urban agglomeration economy, which has intertwined jointly-administered regional economy? One widely speculated reason is that cities within strategically-developed regions tend to be the "first ones in line" to receive special funding or budgetary transfer from the central government. However, is this reason alone enough to hold members of the city clusters accountable within this construct, and make this whole complicated new governance model work? This remains a big puzzle because the goal of having these city clusters is by no means formally creating a new administrative layer that sits between the local government and the central government.

So, why shall we take these city clusters seriously? Is it really adding any value to collaborative environmental management? Is it, as Heilmann formally put it in his policy experimentation theory, an experiment put in place simply because environmental management is a sector in which political elites would benefit from supporting new types of activity (Heilmann, 2008)? Or is it a genuine trial of facilitating institutional innovation by injecting bottom-up initiative and local knowledge into the national policy process? It is for these reasons that I used the Central China Triangle region as a case study for China's city cluster development, looking at how its air pollution management practices changed before and after the formation of this city clusters, and whether there are significant differences when we compare cities within this city cluster with their outside-cluster counterparts.

The formation of the "Central China Triangle" and its progress on CEM

Among these newly formed national-level city clusters is the Central China Triangle. In April 2015, the State Council of China officially approved a regional development plan, which integrates three city clusters along the middle reaches of the Yangtze River. This city cluster consists of forty-one cities in total (See Appendix 0-1 for a complete list of cities that are involved in this city cluster). It centers on the three provincial capital cities of Wuhan, Changsha, and Nanchang, and spans a total area of 317,000 square kilometers in Hubei, Hunan and Jiangxi provinces. This is the first national-level city cluster approved by the State Council after the introduction of the National New-Type Urbanization Plan (2014-2020). This is also part of China's national strategy to turn central China into the fourth pillar of economic development, and part of the central government's plan to promote the development of the Yangtze River Economic Belt.

According to this regional development plan (The State Council, 2015), there are six broad goals that the involved cities and provinces are supposed to achieve as a group: 1) a coordinated rural-urban development scheme, 2) an interconnected infrastructural support system, 3) a harmonized industrial upgrade, 4) a collaborative effort towards ecological civilization and environmental management, 5) a borderless public service network, and 6) a more conducive environment for knowledge sharing and future cooperation. By framing these goals the way they are, the Chinese government seems to have suggested that collaboration is the key to tackling all of its regional development challenges. Also, by setting the same timeline for all six goals, the State Council seems to be making the claim that these different pieces of the regional development plan should in principle get along with each other, and have the opportunity of being achieved altogether.

Based on various news and reports that are available on the involved regions' EPB websites, Hunan, Hubei, and Jiangxi Province have shown a very positive attitude towards this regional integration plan's development. Each of these three provinces came up with a policy document that helps its cities to digest the details in the Central China Triangle plan. The capital cities of these three provinces got together a few times a year to sign memorandums of understanding (MOUs) on economic development, high-tech advancement, industrial cooperation, and infrastructural connectivity.

As for actual progress in the area of collaborative environmental management, first, a few inter-jurisdictional MOUs on cross-boundary dispute settlement were signed. Second, several inter-city synchronized spot-checks were conducted on watersheds and industrial polluters. Third, quite a number of joint meetings were held among the clustered cities to discuss the joint pathway to a low carbon future.

However, neither the government's official progress report on the Central China Triangle's development nor the existing academic research discusses whether the formation of the national-level city cluster has added unique values to the involved regions' CEM practices.

My three-pronged approach

Bearing in mind the research gaps that I have discussed in the previous sections, this dissertation takes a **three-pronged approach** to study how China's development of national-level city clusters has brought unique opportunities and challenges for collaborative environmental management (CEM), and more specifically, in the area of air pollution control.

This research **first** looks at the city clusters along the Middle Reaches of the Yangtze River, also known as the Central China Triangle, and answers whether this regional integration plan and its embedded call for CEM have brought observable process changes to the involved cities' air quality management system. It **then** looks at how the venture capital investors, an increasingly important type of private capital provider, have perceived this policy, and whether a more collaborative environmental governance framework has any influence on how these investors make their cleantech investment decisions. **Lastly**, this research creates an original dataset containing 137 Chinese cities' information on their local environmental protection bureaus' (EPBs') resource adequacy and regulatory enforcement power, industrial polluters' degree of compliance, and these cities' average air quality outcomes for the Year 2017, and uses Structural Equation Modeling method to analyze whether clustered cities and their un-clustered counterparts exhibit observable variations, both in terms of how the enforcement-compliance mechanism functions, and how this mechanism influences the environmental outcomes.

These three essays are more exploratory than theory-testing in nature. Together, they systematically evaluate the added value of city cluster formation in promoting collaborative environmental management, and not just whether CEM is working in China's city clusters. They also demonstrate a way to systematically evaluate CEM's actual procedural outcomes and environmental outcomes based on empirical data.

The appropriateness of my chosen case to Study

There are many CEM experiments in China. This section explains why I pick air pollution control as my studied policy challenge, why I analyze CEM in the context of city cluster formation, and why the Central China Triangle is selected from all the existing city clusters as the candidate for my study.

Air pollution control

According to the existing literature, air pollution abatement is one of the focus areas that are most frequently targeted by CEM experiments. For example, a study that was done by Yi and co-authors found that 25 percent of China's inter-jurisdictional agreements in urban regions focus solely on air pollution abatement (Yi et al., 2016).

CEM experiments' heavy focus on air pollution control is not a surprise because of the following reasons. First, air pollution can be traced back to many economic sectors and responsible parties, and in recent years, air pollution in urban China is increasingly attributed to dispersed sources such as motor vehicles and construction sites, over which local environmental protection bureaus (EPBs) do not have the sole jurisdiction power (Li & Chan, 2009). Second, air pollution has very strong regional characteristics, given how easily air pollutants floating around regardless of boundaries. According to a study that was done by the China Council for International Cooperation on Environment and Development (CCICED, 2012), the eruption of heavy smog is always simultaneous in neighboring cities, and cities that are frequently hit by severe air pollution are highly clustered geographically. This is supported by other studies, which shows that there are strong inter-regional and sectoral linkages of air pollutant emissions (Wang, Liu, Mao, Zuo, & Ma, 2017).

Moreover, air pollution is an interesting environmental problem to study because it is amongst the most difficult policy challenges in China (IEA, 2014), and has spurred a lot of public concerns and complaints. According to a recent study, which monitored the daily average air quality of 190 cities in China for the entire year of 2013, only 25 of these cities were able to meet China's National Ambient Air Quality Standard (Zhang & Cao, 2015). This is not even to mention the fact that China's national standards for PM2.5, one of the most hazardous local air pollutants, is already way higher than the World Health Organization's suggested values, which indicates that the actual scale of China's air pollution problem may be even bigger than what we see.

The national-level city clusters

National-level city clusters have played an important role in China's socio-economic development. The Beijing-Tianjin-Hebei Metropolitan Region is the nation's political and economic center. The Pearl River Delta Region and the Yangtze River Delta region are two important poles of the nation's economic growth. According to China's National Bureau of Statistics, in 2015, these three city clusters host 23 percent of its national population and contribute to 39.4 percent of the national GDP.

Meanwhile, these national-level city clusters have been important testing beds for collaborative governance in China. Existing literature finds that the major urban agglomerations (namely: the Beijing-Tianjin-Hebei Metropolitan Regions, Yangtze River Delta, Pearl River Delta, Mid-China region, and Chengdu Plain) are regions that most frequently practice inter-local collaboration (Ye, 2009; Feiock, 2016). More importantly, the roles played by national-level city clusters are expected to expand in the future, especially in facilitating inter-jurisdictional collaborations. Starting with the 12th Five Year Plan, the central government's intention to use city-clusters to provide the impetus for collaborative regional development was made very clear. In China's national New-Type Urbanization Plan, the need to promote coordinated regional development through the formation of city clusters was mentioned 47 times.

The map below highlights China's major urban agglomerations in shaded blue and the officially-approved national-level city clusters in red circles (Baidu Baike, 2018). It is clear that the formation of national-level city clusters is reshaping China's development landscape.

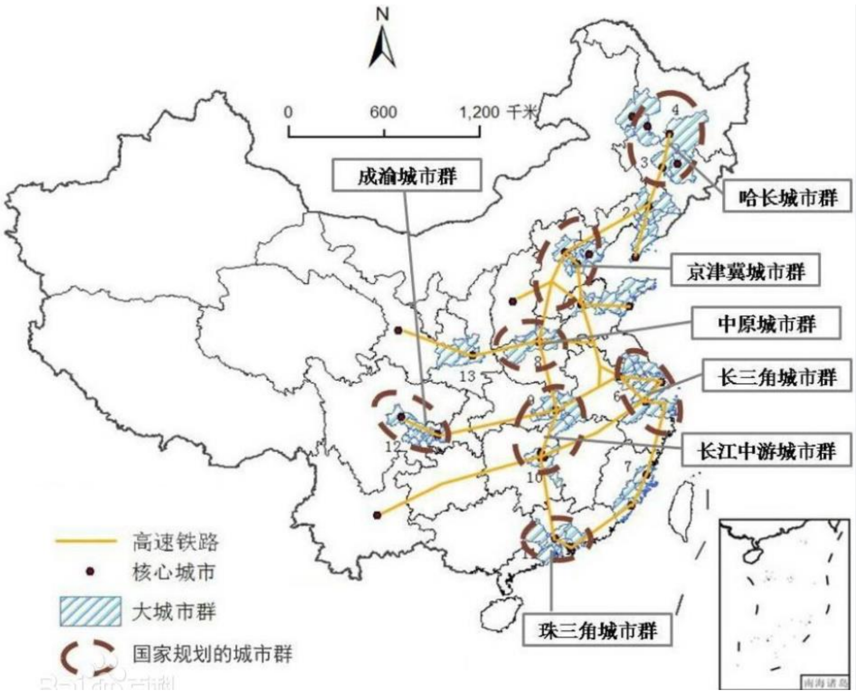


Figure 0-1: China's major urban agglomeration and city clusters

The Central China Triangle

The Central China Triangle spans a total area of 317,000 square kilometers in Hubei, Hunan and Jiangxi provinces, and it centers on the three provincial capital cities of Wuhan, Changsha, and Nanchang.

I used this region as a case study for China's city cluster development for the following reasons. First, it was the first formally approved national-level city cluster after China announced its New Type Urbanization Scheme, and hence gives the longest time for this rather-new regional integration construct to bring out its full effect. Second, the State Council is planning to turn this region into the fourth economic pillar of the nation, so it is a region of strategic importance to study. Third, this region does not enjoy a unique geographic location (e.g., facing the sea and being close to Hong Kong in the case of the Pearl Delta) or contains a city that has a special administrative status (e.g., in the case of the Beijing-Tianjin-Hebei region and the Yangtze River Delta). The lack of uniqueness in this region's geographic location makes it easier to establish external validity for the potential findings, that is, applying potential takeaways from this study to other city clusters. The involved regions' comparable geopolitical importance is a desirable feature for CEM experiments because "large gaps in administrative level among collaboration participants produce asymmetries of influence that have the potential to make collaboration efforts more difficult" (Sun, 2013; Yi et al. 2015).

In addition, this region has suffered severe air pollution in recent years partly due to its own industrial structure, and partly due to its geographic location of being the "downwind" locations of the heavy-polluting Northern provinces. Bounded by high mountains, this region does not enjoy the best topography and climate conditions when it comes to local air pollutants dissipation, which makes it more pertinent to look at air pollution control strategies.

Moreover, environmental management practices in Hunan, Hubei, and Jiangxi have received much attention nationwide even before the formation of the Central China Triangle. All three provinces were indeed used as testing beds for innovative constructs of environmental management practices previously. Hunan Province and Hubei Province were the pilot-testing sites for "Liang Xing She Hui" (i.e., resource-conserving and environmental-friendly society) since 2007. Jiangxi Province was chosen to be an experimental site for "green financing mechanisms" in 2017. These prior experiences make this region a good fit for my CEM studies because local governments in this region are more likely to be already convinced with the importance of environmental management. This provides the ideal foundation for successful CEM experiments.

Having said that, this is by no means suggesting that CEM will be easy to achieve in this region. Hunan, Hubei, and Jiangxi have relatively similar industrial structure and are all facing challenges of supply-side structural reform. Some conflicts of interests may likely arise while this region embarks on collaborative development. Moreover, the involved cities' pre-existing air pollution management capacities and practices also appear to be highly heterogeneous, which makes it even more difficult to bring different participants to the same page. These challenges are the realities that involved localities have to tackle when dealing with regional integration and inter-jurisdictional collaboration, and it is vital to investigate how CEM works in practice despite these potential conflicts of interest.

Chapter 1

Has the formation of the Central China Triangle, and the embedded call for Collaborative Environmental Management (CEM), brought observable changes to the involved regions' air quality management system?

Introduction and Motivation

<u>China's air pollution challenge and the government's call for collaborative environmental management (CEM)</u>

China's impressive economic growth in the past decades comes with environmental costs, and "the increasingly widespread and frequent outbreak of severe air pollution is amongst the most difficult policy challenges" that the country faces (IEA, 2014). In 2013 alone, long-lasting and large-scale hay weather affected 600 million people living in 17 provinces across China (Zhao, 2014).

To tackle this policy challenge, China has looked into various options, including: restructuring its industrial sectors, developing alternative sources of energy, shutting down some coal-fired power plants, encouraging the use of public transportation, and so on. To support the implementation of these air pollution control measures, it has also come up with a wide range of laws, regulations, and action plans, for example: the Law on the Prevention and Control of Air Pollution, the 12th Five Year Plan on Air Pollution Prevention and Control in Key Regions, and the Action Plan on the Prevention and Control of Atmospheric Pollution, which was adopted in 2013. This Action Plan set 2017 as the achievement year for two major goals: a 10 percent reduction in concentrations of large particulate matters in major cities; and up to a 25 percent decrease in concentrations of fine particulate matter in targeted regions (CAAC, 2015; CCICED, 2014). Many believe that this Action Plan represents the strictest air pollution control measure ever adopted in China. In June 2018, China again set a three-year action plan aimed at cleaning the nation's air, which is called the "Blue Sky Battle", hoping to further bring down the total emissions of sulfur dioxide, nitrogen oxide, and PM2.5 so that cities will enjoy "good" quality air days for about 80 percent of the year (CGTN, 2018).

Interestingly, "joint prevention and control of air pollution" is a popular phrase that frequently appears in all the above-mentioned major policy documents. Realizing that air pollution often brings with it negative spillovers, and cannot be effectively managed unless different stakeholders take concerted effort towards a common goal, China started promoting this collaborative environmental management model since the early 2000s, experimenting this new tool to stamp out air pollution. In fact, air pollution abatement is one of the focus areas that are most frequently targeted by CEM experiments. According to the existing literature, 25 percent of China's inter-jurisdictional agreements in urban regions focus solely on air pollution abatement (Yi et al., 2016).

China's promotion of CEM was surprising to the rest of the world, for multi-stakeholder governance is not the first thing that the western scholars would associate with an authoritarian regime. However Chinese CEM experiments' heavy focus on air pollution control is not unexpected because of the following reasons. First, air pollution can be traced back to many economic sectors and responsible parties, and in recent years, air pollution in urban China is increasingly attributed to dispersed sources such as motor vehicles and construction sites, over which local environmental protection bureaus (EPBs) do not have the sole jurisdiction power (Li & Chan, 2009). Second, air pollution has very strong regional characteristics, given how easily air pollutants floating around regardless of boundaries. According to a study that was done by the China Council for International Cooperation on Environment and Development (CCICED, 2012), the eruption of heavy smog is always simultaneous in neighboring cities, and cities that are frequently hit by severe air pollution are highly clustered geographically. This is supported by other studies, which shows that there are strong inter-regional and sectoral linkages of air pollutant emissions (Wang, Liu, Mao, Zuo, & Ma, 2017; Li, Liu, & Tang, 2013).

Collaboration is important for the governance of transboundary environmental issues, from local-level air pollution reduction to international climate action. Fragmentation issues present great challenges for local governments in effectively managing their environment (Yi, Suo, Shen, Zhang, Ramaswami, & Feiock, 2017). Negative environmental externalities and policy spillovers across jurisdictions make it sensible, if not necessary, for local governments to look beyond policy instruments that coordinate resources and management efforts within their governed domain, and seek collaboration with their neighboring jurisdictions (Feiock & Scholz, 2010; Durant, Fiorino, & O'Leary, 2004). There is general agreement that "achieving the next level of environmental improvement and sustainable communities" will not only require guidance from the central government, but also depend on the joint efforts made by the local communities, industries, non-profit organizations, and others" (Randolph, 2004).

The added value of city cluster development in promoting CEM

China has experienced unprecedented urbanization rate in recent years. In an effort to handle the increasing migration from rural areas to the major cities, the Chinese government is proactively thinking of ways to integrate resources and maximize resource utilization. It introduced its National New-Type Urbanization Scheme (2014-2010) a few years ago, in which it mentioned its plans to develop the so-called national-level city clusters. The main logic behind forming such urban agglomeration is that it ensures economic competitiveness and resource-use efficiency in the long run. As of March 2018, nine such city clusters were approved by the State Council. These city clusters are mostly situated along the country's eastern border or from the central China region. Together, they span a total area of 1.76 million kilometer square, which represents about 18 percent of China's total area.

Prior to the release of the New-Type Urbanization Scheme, there were three major urban agglomerations in China. These include the very well-known Beijing-Tianjin-Hebei region, the Yangtze River Delta, and the Pearl River Delta. These regions were strategically formed for economic development purposes, and they have served as China's three economic pillars in recent decades. As of 2015, these regions accounted for 39.4 percent of China's national GDP.

Unlike the development of these earlier-formed urban agglomerations, the new wave of city cluster formation since 2015 appears to have a much broader goal for collaborative development. Apart from using these city clusters to support economic development, the Chinese government also aims to promote industrial upgrading, transportation interconnectedness, integrated social service network, and collaborative environmental management through these regional integration plans.

However, the implementation strategies of these regional development plans are not clear. It is also not clear why city cluster formation is the best way to achieve the above-mentioned goals on integrated development and collaborative governance. Many speculate that: 1) the formation of the city cluster brings economies of scale. 2) The more constant interaction among different localities' officials and the relationship that grows among them will become a layer of cushion that minimizes inter-jurisdictional conflict when there is a transboundary dispute. 3) The process of city cluster formation will likely provide a conducive environment for resource integration and resource use maximization. 4) Regional integration plans allow involved cities to strategically line up their development strategies and prioritize in such a way that the region's total strength is maximized. However, there is minimal research on whether these are the ways how things work in practice.

Moreover, why did cities and provinces engage in such big-scale policy experiments? Why is the State Council seemingly pushing the traditional provincial economy and independent administrative region economy to an urban agglomeration economy, which has intertwined jointly-administered regional economy? One widely speculated reason is that cities within strategically-developed regions tend to be the "first ones in line" to receive special funding or budgetary transfer from the central government. However, is this reason alone enough to hold members of the city clusters accountable within this construct, and make this whole complicated new governance model work? This remains a big puzzle because the goal of having these city clusters is by no means formally creating a new administrative layer that sits between the local government and the central government.

So, why shall we take these city clusters seriously? Is it really adding any value to collaborative environmental management? Is it, as Heilmann formally put it in his policy experimentation theory, an experiment put in place simply because environmental management is a sector in which political elites would benefit from supporting new types of activity (Heilmann, 2008)? Or is it a genuine trial of facilitating institutional innovation by injecting bottom-up initiative and local knowledge into the national policy process? It is for these reasons that I used the Central China Triangle region as a case study for China's city cluster development, looking at how its air pollution management practices changed before and after the formation of this city clusters, and whether there are significant differences when we compare cities within this city cluster with their outside-cluster counterparts.

The use of the Central China Triangle as a case study for China's city cluster development

Among these newly formed national-level city clusters is the Central China Triangle. In April 2015, the State Council of China officially approved a regional development plan, which integrates three city clusters along the middle reaches of the

Yangtze River. This city cluster consists of forty-one cities in total. It centers on the three provincial capital cities of Wuhan, Changsha, and Nanchang, and spans a total area of 317,000 square kilometers in Hubei, Hunan and Jiangxi provinces.

I used this region as a case study for China's city cluster development for the following reasons. First, it was the first formally approved national-level city cluster after China announced its New Type Urbanization Scheme, and hence gives the longest time for this rather-new regional integration construct to bring out its full effect. Second, the State Council is planning to turn this region into the fourth economic pillar of the nation, so it is a region of strategic importance to study. Third, this region does not enjoy a unique geographic location (e.g., facing the sea and being close to Hong Kong in the case of the Pearl Delta) or contains a city that has a special administrative status (e.g., in the case of the Beijing-Tianjin-Hebei region and the Yangtze River Delta). The lack of uniqueness in this region's geographic location makes it easier to establish external validity for the potential findings, that is, applying potential takeaways from this study to other city clusters. The involved regions' comparable geopolitical importance is a desirable feature for CEM experiments because "large gaps in administrative level among collaboration participants produce asymmetries of influence that have the potential to make collaboration efforts more difficult" (Sun, 2013; Yi et al. 2015).

In addition, this region has suffered severe air pollution in recent years partly due to its own industrial structure, and partly due to its geographic location of being the "downwind" locations of the heavy-polluting Northern provinces. Bounded by high mountains, this region does not enjoy the best topography and climate conditions when it comes to local air pollutants dissipation, which makes it more pertinent to look at air pollution control strategies.

Moreover, environmental management practices in Hunan, Hubei, and Jiangxi have received much attention nationwide even before the formation of the Central China Triangle. All three provinces were indeed used as testing beds for innovative constructs of environmental management practices previously. Hunan Province and Hubei Province were the pilot-testing sites for "Liang Xing She Hui" (i.e., resource-conserving and environmental-friendly society) since 2007. Jiangxi Province was chosen to be an experimental site for "green financing mechanisms" in 2017. These prior experiences make this region a good fit for my CEM studies because local governments in this region are more likely to be already convinced with the importance of environmental management. This provides the ideal foundation for successful CEM experiments.

Central China Triangle's progress on CEM

According to the Central China Triangle formation plan (The State Council, 2015), there are six broad goals that the involved cities and provinces are supposed to achieve as a group: 1) a coordinated rural-urban development scheme, 2) an interconnected infrastructural support system, 3) a harmonized industrial upgrade, 4) a collaborative effort towards ecological civilization and environmental management, 5) a borderless public service network, and 6) a more conducive environment for knowledge sharing and future cooperation. By framing these goals the way they are, the Chinese government seems to have suggested that collaboration is the key to tackling all of its regional development challenges. Also, by setting the same timeline for all six goals, the State Council seems to be making the claim that these different pieces of the regional development plan should in principle get along with each other, and have the opportunity of being achieved altogether.

Based on various news and reports that are available on the involved regions' EPB websites, Hunan, Hubei, and Jiangxi Province have shown a very positive attitude towards this regional integration plan's development. Each of these three provinces came up with a policy document that helps its cities to digest the details in the Central China Triangle plan. The capital cities of these three provinces got together a few times a year to sign memorandums of understanding (MOUs) on economic development, high-tech advancement, industrial cooperation, and infrastructural connectivity.

As for actual progress in the area of collaborative environmental management, first, a few inter-jurisdictional MOUs on cross-boundary dispute settlement were signed. Second, several inter-city synchronized spot-checks were conducted on watersheds and industrial polluters. Third, quite a number of joint meetings were held among the clustered cities to discuss the joint pathway to a low carbon future.

However, neither the government's official progress report on the Central China Triangle's development nor the existing academic research discusses whether the formation of the national-level city cluster has added unique values to the involved regions' CEM practices.

<u>The central-local power dynamics in China, and why this makes it difficult for CEM to work</u>

It is difficult to claim, based on these current observations, that CEM is expected to flourish in the Central China Triangle. China's decentralized environmental governance structure and its complicated central-local power dynamics are some of the important reasons behind my modest optimism regarding CEM's actual success.

For almost any top-down orders on environmental management, such as the call for CEM in this case, local implementation effort is highly heterogeneous in China. In some cases, certain regions' lack of resources and insufficient regulatory capacity are the reasons why these places are lagging behind in their environmental management effort. In other cases, this boils down to the complicated central-local power dynamics in China, where local governments have certain degrees of autonomy in designing policies that cater to their own needs and having their own interpretations of the central government's directives (Mei & Pearson, 2014; Oi, 1999; Huang, 2004). This is further complicated by the government's perpetual dilemma in balancing the pursuit of economic growth with the need to attain other socioeconomic objectives (Qi & Zhang, 2014). As a result, some heavy-polluting firms from pillar industries enjoy protection from both the central and local government (Eaton & Kostka, 2017) because they are the major contributors of local tax revenues. In some cases, instead of using its regulatory power to enforce compliance behavior, some local governments are found to purposely provide inadequate disclosure of environmental data, intentionally distort monitoring information, and as a result, obstructing public participation and supervision and helping the polluting firms to evade the potential punishment for environmental non-compliance (Qi & Zhang, 2014). In other cases, neighboring governments' very different needs and priorities even lead them to reckless pursuit of economic profit and race-to-the-bottom competitions over development opportunities, which then required central government's intervention (Tsai, 2004; O'Brien & Li, 1999; Cai & Treisman, 2004).

To hold the local officials accountable for implementing the central government's requested orders, in the area of environmental management, Beijing has adopted several instruments to exert greater vertical-level direct control over the local jurisdictions' government agencies and their policy implantation effort. This includes, but is not limited to, linking local cadres' promotion evaluation with achievement of pre-set KPI and conducting central-government-led inspection tours to check for defiance behavior on the ground. And more recently, the central government started to make use of "deterrence signals" to deter specific discretionary behaviors. According to Mei and Pearson (2014), the first scholars who studied this phenomenon in depth, all top-down orders are essentially viewed as deterrence signals in the eyes of local officials, and the decision of whether or not to comply with the center's directives is made based on local officials' evaluation of the "selectiveness, severity, and retractability of sanctions, and the reputation of the center" (Mei & Pearson, 2014). In other words, punishing selected local officials for their wrongdoings and making such effort publicly known is central government's way of establishing its regulatory reputation and its way to influence the incentive structure of local officials

(Mei & Pearson, 2014). Having said that, these instruments of course have their limitations.

As a result, for scholars who studied China's collaborative air pollution management, some found that China's decentralized EMS administrative structure and the uncoordinated local-level fiscal management practices have led to further fragmentation of power, which makes it difficult to practice collaborative reduction of air pollution (Liu et al. 2016). Others found that "experimental programs largely failed in generating an effective provision of social goods which would require a combination of active provision of social goods which would require a combination of active societal supervision and strict central government enforcement" (Heilmann, 2008). In a recent study by Eaton and Kostka (Eaton & Kostka, 2018), which did an in-depth case study of interjurisdictional ecological protection redline zones, it is shown that although inter-jurisdictional collaboration is ideal, "the implementation challenges facing all these efforts to build out China's environmental state in the horizontal plane are considerable".

The use of Institutional Collective Action (ICA) framework in studying CEM

Despite China's many years of attempts to address regional governance of environmental issues, researchers paid limited theoretical attention to China's CEM practices until recently. Feiock and colleagues were the first ones, who used the Institutional Collective Action (ICA) framework to rigorously examine the potential roles of voluntary agreements in local environmental governance. They even modified the ICA framework to fit the Chinese context (Feiock, 2009; Feiock, 2013; Feiock & Scholz, 2010).

More researchers have followed their paths since then. Some of them focus on describing the mechanisms of corporation among local authorities and analyzing factors that could explain the choices of environmental collaboration agreements among Chinese cities (Yi et al., 2015; Feiock, 2016; Mandell & Steelman, 2003; Wondolleck & Yaffee, 2000; Heikkila & Gerlak, 2016; Siddiki & Goel, 2017). Others talk about the characteristics of an ideal CEM framework and the barriers that confront effective inter-local collaboration on environmental management (Gong & Zhang, 2015; Liu, Yi, & Li, 2013; Lu, 2014; Gong et al., 2014). To highlight a few key findings from these research: first, pre-existing differences in economic, social, political, and environmental conditions complicate local governments' decision-making process when they choose the type of inter-local agreements to participate in and the partners to form alliance with (Suo & Li, 2015; Yi et al. 2017). Second, the practices of institutional collection action is further jeopardized when the involved regions are of different geopolitical importance (Yi et al. 2017). Third, for a CEM experiment to work, contractural schemes and multi-stakeholder coordination efforts must be carefully managed to avoid ambiguous allocation of regulatory responsibilities and funding (Silvestre, Marques, & Gomes, 2017; Ling, 2002; Kim, 2011). A well-designed national framework that takes into account the role and mandates of all levels of government should also exist (GIZ, 2017).

However, given how difficult it is to provide these above-mentioned pre-requisites for a CEM experiment to work, good intentions to collaborate often end up with ICA dilemmas. Moreover, does CEM lead to improvements in the overall environmental management system? Does CEM lead to better environmental outcomes? The excitement over CEM has not been matched by empirical evidence that this environmental governance model really improves environmental management practices and environmental conditions more than traditional processes and newer market-based processes" (Koontz & Thomas, 2006). This is especially the case in China. Huang et al. (2015) and Li et al. (2017) were among the handful of scholars who examined CEM's impact on air quality outcomes. Their studies found suggestive evidence that CEM efforts during the APEC summit did alleviate the air pollution problem for the involved region. However, the policy context that they studied was a short-term one-off event, which makes it hard to use these findings to inform CEM practices in other contexts.

Similarly, the empirical evidence has lagged behind practice in understanding the extent to which China's city clusters have promoted joint prevention and control of air pollution. Most of China's research on regional air pollution management focuses on the Beijing-Tianjin-Hebei region (Gong & Zhang, 2015; Lu, 2014; Gong et al., 2014). Very few studies (Feiock, 2016; Yi et al., 2017; Zhong et al., 2013) have paid attention to CEM experiences from the rest of China and discussed the actual outcomes of such practices.

The evaluation of a system-level change for an environmental management system

Throughout the analysis, the ICA framework is used as a theoretical lens to "view the structural patterns and participants in the collaboration efforts" (Chen & Thurmaier, 2009; Feiock, 2013; Feiock 2016; LeRoux & Carr, 2007). I also borrow Lovei and Weiss' (1997) framework to tease out meaningful process changes from the one-off events.

In Lovei and Weiss' (1997) famous book on environmental management and institutions in OECD countries, they defined environmental management as a process that involves "the recognition of environmental problems, the emergence of public awareness and political commitment to address these problems, the formulation of environmental policies, the expression of policies in regulation and legislation, and the implementation and enforcement of policies".

They also defined what a system-level change in the environmental management system looks like. To them, if such changes happen, differences should be observed in one or more of the following areas: 1) the environmental policy making process, 2) the legal and regulatory framework, and the 3) administrative and institutional framework. To elaborate, the first area covers things like political commitment making, priority setting, consensus building, cross-sectoral integration of environmental policy, and the designing of policy implementation approaches. The second area consists of environmental regulations and legislation and the distribution of political and administrative authority in shaping these rules. The third area is related to the evolution of the administrative agencies (in China's case, from the Ministry of Ecology and Environment to the state- and local- level environmental protection bureaus), the administrative control of these agencies, and the organizational structure of the relevant environmental authorities.

Although the administrative and institutional framework, to a certain extent, covers also the human capacity that is related to these administrative apparatus, I think that the three areas of environmental management system that Lovei and Weiss' proposed does not capture the function aspect of the system, for example, how people within the environmental protection bureaus are making use of their limited resources for environmental management, or improving their knowledge of doing things through trainings. For this reason, I propose to add a fourth category called the "other system drivers", and will be using all of these four categories in determining whether any system-level changes have happened since the formation of the Central China Triangle in the involved regions.

The present study

This research looks at the city clusters along the Middle Reaches of the Yangtze River, also known as the Central China Triangle, and answers whether this regional integration plan and its embedded call for CEM have brought observable changes to the involved cities' air quality management system. My hypothesis is that this city cluster's formation has added minimal value to the involved regions' CEM practices.

This research is the first that rigorously studied Central China Triangle's contribution to collaborative environmental management. It is also the first that systematically evaluated CEM's impact on the different aspects of air quality management system.

Many western scholars' first reactions to China's city cluster formation plan is that it is a way for the central government to take back some of the power that it has previously delegated to the local government. These reactions are in line with the literature, which "frequently ascribes blame for China's environmental problems to sub-national governments' lax environmental enforcement" (Kostka and Nahm, 2017; Mei & Pearson, 2014; Oi, 1999; Huang, 2004) and argues for the needs for re-centralization of power.

While it is difficult to figure out the genuine motivations behind this type of regional integration plan, it is worthwhile to check if the central government's call for CEM is truly having some impact on the central-local power dynamics in environmental management. In fact, scholars like Hensengerth (2015) has articulated the needs to "map power relationships in the making and implementation of policies in order to reach analytical depth", and has pointed out that "China's authoritarian regimes can be analyzed in terms of multiple levels as authoritarianism no longer automatically implies strict top-down entities."

Moreover, recent China studies show that, in some cases, "regulatory pluralism happens without the retreat of party-state control" (Van Rooij et al. 2016), and "re-centralization does not necessarily improve outcomes in every case" (Kostka & Nahm, 2017). Assuming that the formation of the Central China Triangle was indeed partially driven by the central government's motives to re-centralize some of its management power, understanding CEM's potential impact on the central-local power dynamics is all the more imperative.

Methods and Data

Research Design

Evaluating the outcomes of policy intervention is easier said than done. This is especially true for a policy concept like CEM that has many potential interpretations and various areas of application. To minimize the risks of finding no observable system-level changes as a result of me interpreting CEM differently from the way that the policy makers designed it for, I looked for governmental reports and official news that talked about the actual practices of CEM in the area of air quality control since the formation of the Central China Triangle. However, most of the publicly-accessible reports on Central China Triangle's CEM progress discuss the intended ways of doing collaborative air pollution control, not at all what happened in practice.

In the end, I found three concrete goals that the Central China Triangle has set for the joint prevention and control of air pollution. These goals are: 1) coordinating on the management of heavy-polluting vehicles, 2) establishing compatible environmental impact assessment (EIA) procedures and criteria, and 3) practicing joint monitoring, information sharing, and collaborative law enforcement (Hunan DRC, 2017). I looked for CEM-related system-level changes in these three areas to see if there were noticeable differences between the clustered cities and the un-clustered cities before and after the formation of the Central China Triangle. More importantly, I analyzed whether any of these differences was potentially due to the formation of the Central China Triangle. Besides, I conducted additional analyses to see if there were other CEM-related system-level changes happening in the involved regions' air quality management system outside of these three expected testing fields for CEM. The overall goal of this research is not only to see if there are CEM-related system-level changes happening in the Central China Triangle's air quality management system, but also to assess the added value of this city cluster development plan in promoting joint prevention and control of air pollution.

Data

Existing literature was first used to derive a list of the common examples of CEM in air pollution management (Appendix 1-1). These examples were then used as search terms to explore China's CyberMedia Network database, local governments' environmental protection bureaus' (EPB) websites, and China's primary search engine Baidu to get relevant CEM events that have happened in the studied regions over the last five years (i.e. mostly from 2013 to 2017).

More than 1000 sources entered my final database, covering all cities in the Hunan, Hubei, and Jiangxi Province (not just the 31 cities that fall within the Central China Triangle). Two rounds of manual quality control were done to make sure that the sources were value-adding and not repetitive before they got included in my dataset. Rigorous source categorization and coding procedures were followed to prepare the data for later analysis. These sources were then evaluated using a mixed-method approach with the help of NVivo (for coding and content analysis) and Gephi (for network analysis).

Method of analysis

Overall speaking, the institutional collective action framework was used as a theoretical lens to "view the structural patterns and participants in the collaboration efforts" (Chen & Thurmaier, 2009; Feiock, 2013; Feiock 2016; LeRoux & Carr, 2007). I also borrowed Lovei and Weiss' (1997) framework to tease out meaningful system-level changes from the one-off events.

Most of the analysis was directly performed in Chinese to preserve the nuance in the original language. In some cases, I translated selected content to English for results' presentation purposes.

In total, five sub-analyses were performed. The first three analyses fact-check whether the involved regions have met the three goals that they have set for the joint prevention and control of air pollution and if the clustered cities are doing significantly better than the un-clustered counterparts as a result of the city cluster formation. The fourth analysis looks at the evolvement of policy focus, stakeholders, and the context in which CEM has been discussed in air quality control, for all cities in Hunan, Hubei, and Jiangxi provinces. The fifth analysis looks for other CEM-related system-level changes outside of the three areas that are the expected testing beds for CEM experiments. Together, these five sections systematically evaluate the added value of the Central China Triangle formation in promoting joint prevention and control of air pollution, and not just whether CEM is positively shaping the Central China Triangle's air management system.

The management of the heavy-polluting vehicles

For this part of the analysis, I developed a policy timeline for each city based on all the policies and regulations that are relevant to its heavy-polluting vehicles' management (between 2010 and 2018).

The following three tools are the most commonly used measures across all cities: fiscal penalty and reward, restricted road access, and tailpipe emissions tests. So, I looked at how cities' policies and management practices have evolved over the years in each of these three areas. Besides, I also paid special attention to cities' policies and performances regarding the inspection of vehicles that were registered elsewhere, second-hand vehicle relocation, and polluter tracking database' connectivity, because CEM practices are highly relevant to these areas' proper functioning and success.

All cities' information was piled up together in one excel workbook so that I have the capacity to filter all of the records by province, city, cluster, and policy type. The goal is to see if the evolvement of cities' policies and performances in the different aspects of heavy-polluting vehicles management over time implies more extensive practices of CEM in the Central China Triangle since 2015. Appendix 1-2 shows a snapshot (i.e., the top few rows) of this constructed database.

Notice that, to facilitate the analysis, I erased the specific contexts of the different policies, using 1 or 0 to capture the presence or absence of a particular policy element for any given year. I then calculated helpful summary statistics such as "the percentage of cities that made use of restricted road access" based on the newly created dummy variables. Lastly, I compared the trends of the clustered group with that of the non-clustered group to see if there is any meaningful difference.

The compatibility of the Environmental Impact Assessment (EIA) process

One important thing to clarify before I go into the method of analysis for this section is that the original wording that the local government used for what I am calling the “compatibility of the EIA process” was “the establishment of a uniform market admission requirement” (Hunan DRC, 2017).

The term “market admission requirement” is very vague, and there is no standard definition that academic researchers or the policymakers have used to define it. However, my preliminary research shows that this term mostly refers to the environmental impact assessment process, especially how it is used to keep some of the heavy polluters out of the market. Following this definition, cities within the clustered construct should have more similar standards set for key pollutants in order to establish a uniform market admission requirement.

For this part of the analysis, I analyzed 77 EIA-related guidelines and policies (announced between 2013 to 2018) for the clustered cities and 28 corresponding documents for the un-clustered cities. Although the total number of policies that I studied for the un-clustered group is a lot smaller than that of the clustered group, the un-clustered group is by no means under-represented in my study. This is because the total number of cities falling under the un-clustered group is also significantly smaller than that of the clustered group (i.e., ten versus thirty-one).

I used NVivo to query key terms such as "total emissions control," "coal-fired power plants," and "pollution control" to look at the contexts in which these things were mentioned and analyze whether there are interesting differences regarding key pollutants' standards across the two groups. I also searched for the word "downward delegation of responsibility" after realizing that this is a major national trend that has happened in the EIA process in recent years.

I lumped the policies from different years together when doing these contextual analyses for the following reasons: first, EIA procedures and criteria do not change much from one year to another. Second, not every city has a new EIA policy announced in each of the years (2013 to 2018) that I looked at, making the yearly subsets of these policies less representative of the general characteristics of the whole group.

Joint monitoring, information sharing, and collaborative law enforcement

This is the single area where most of the actual CEM activities have been happening. Based on the actual contexts of these events, I translated each CEM activity into a relationship between two parties. These relationships can be directed, from an initiator to a target, but they can also be undirected. The year in which these CEM activities happen is recorded, so is the weight (i.e., the cumulative frequency) of connection for each unique pair of partners. The table below demonstrates how CEM activities get coded into relationships in practice. I kept the type of relationship (i.e., the actual context in which CEM is happening) in my raw data file to help determine how many relationships were implied per CEM activity and what were the directions of these relationships.

year	initiator	target	type of relationship	Directionality	Frequency
2015	citygov	cityEPB	gave instruction on CEM target	directed	1
2015	cityEPB	countyEPB	joint inspection of point-source polluters	directed	1
2015	citygov	citydir	joint meetings on CEM action plan	directed	1
2015	citygov	countygov	joint meetings on CEM action plan	directed	1
2015	citygov	citylaw	joint meetings on CEM action plan	directed	1
2015	cityEPB	countyEPB	joint inspection of point-source polluters	directed	6
2015	countyEPB	countydir	issued joint statement on future CEM plan	directed	1
2015	countyEPB	countylaw	issued joint statement on future CEM plan	directed	1
2015	cityEPB	citylaw	joint training on law enforcement	directed	1
2015	cityEPB	countyEPB	joint training on law enforcement	directed	1
2016	citygov	cityEPB	gave instruction on CEM target	directed	1
2016	cityEPB	countygov	supervised CEM action	directed	16
2016	cityEPB	countydir	supervised CEM action	directed	16
2016	cityEPB	countyEPB	supervised CEM action	directed	16
2016	cityEPB	countylaw	supervised CEM action	directed	16
2016	cityEPB	media	invited media coverage of CEM effort	directed	16

Table 1-1: A table of relationships that I created based on CEM events

To give a concrete example, let us assume a hypothetical case that a city-level EPB called for a meeting, which was attended by both the city's law enforcement agency and representatives from the mayor's office. I will code three relationships out of this one event: a directed relationship from EPB to the law enforcement agency, a directed relationship from EPB to the mayor's office, and an undirected relationship between the law enforcement agency and the mayor's office. Appendix 1-3 has a list of abbreviations that I used to code the relevant parties involved in these CEM events. I later used these same abbreviations when I plotted the results from network analysis. Moreover, in my raw data file, I made notes on whether a pair of relationships involved inter-jurisdictional collaboration, inter-cluster collaboration (i.e., between cities within the Central China Triangle and cities that are outside of this city cluster construct), or inter-provincial collaboration.

Notice that I did not do this exercise for all forty-one cities from the three involved provinces. Instead, I looked at nine selected cities for this analysis' purpose. First, I selected three control-treatment city pairs, one pair from each province. All of these six cities sit along the provincial borders. Within each comparison group, cities are neighbors with each other, one falling within the Central China Triangle and the other one outside, but they are comparable in most of the socioeconomic characteristics. On top of this, I picked the three capital cities from each province, under the assumption that if changes were to happen, these capital cities would have higher chances of hosting these changes.

The evolvement of policy focus, stakeholders, and the context in which CEM is discussed

This section involves a straight-forward contextual analysis of all the major policies (136 in total) with the main focus on air pollution control, announced between 2014 and 2017. I removed policies from 2013 and 2018 because I did not have a representative sample size for those years. Also, I removed macro-scale five-year long term plans that cover every aspect of environmental management. Appendix 1-4 shows the average number of air pollution management policies announced between 2014 and 2017. Based on these figures, there are no significant differences between the clustered group and the non-clustered group in this aspect, providing a reasonable foundation for contextual analysis later on.

With the help of NVivo, I was able to calculate, for each city, the share of policies that mentions the following key stakeholders as essential players in air pollution management: NDRC (the National Reform and Development Commission), law enforcement agencies, governmental agencies that are more focused on economic development, EPB (Environmental Protection Bureau), other environmental services agencies excluding the EPB, court and the judiciary branch, as well as the top officials in power (e.g. the mayors, governors, or their representatives). Then, with these summary statistics from NVivo, I graphed each of these stakeholders' expected involvement in air pollution management over time, for the two groups, to see if there are interesting differences.

Moreover, I did a text query in the way similar to what I explained in the EIA policy analysis section, looking at word trees formed around the word "joint effort" to see changes in the contexts in which CEM has been mentioned.

Other CEM-related system-level changes

In this part of the analysis, I looked for other CEM-related system-level changes outside of the three areas that are the expected testing beds for CEM experiments. I read and coded all the relevant sources, which mentioned additional aspects of CEM practices that have happened in the studied region since 2015. The goal was to figure out whether there were CEM events that could be potentially categorized under the four categories of system-level changes: namely, policy making process, institutional setup and administrative apparatus, legislative and regulatory tools, and other system drivers.

Results

The management of the heavy-polluting vehicles

Results show that improvements in the management of the heavy-polluting vehicles have been made in all cities in recent years, and a similar set of policy tools have been used in both the clustered cities and the non-clustered cities. There are no significant differences between the two groups that can be directly attributed to the city cluster formation. Appendix 1-6 contains graphical summary statistics that support my conclusion.

The compatibility of the Environmental Impact Assessment (EIA) process

EIA regulations and rules do not change much from one year to another. While there are a few distinct differences between the clustered cities and the non-clustered cities, there is hardly any evidence that these differences are related to the establishment of a uniform market admission requirement. In other words, there is a lack of evidence to conclude that the inter-group differences were due to the formation of the Central China Triangle or its embedded call for CEM.

The two illustrations below represent all the contexts in which “coking coke” is mentioned in the searched documents (Illustration 1-1 was created using the clustered cities’ EIA policies, while Illustration 1-2 was created using the non-clustered cities’ EIA policies). While the volume of the texts does tell us about how frequent this phrase is mentioned in all of the searched documents, it is more than just a frequency count. Instead, these illustrations are showing us the 20 words before “coking coal” and 20 words after “coking coal,” organized around word stems (i.e., common themes) that NVivo automatically detected.

The main observations from looking at the two illustrations below are as follows. First, the two groups of cities are entirely consistent with each other regarding the types of coal-fired power plants that they wish to retire (i.e., plants that have a stand-alone capacity of 100 MW or less, which have operated for 20 years or longer). Second, both the clustered cities and the non-clustered cities emphasize the importance of coal-to-gas or coal-to-electricity transition and have both set the future minimum efficiency standards for the coal-fired boiler at 80% (and gas-fired boiler at 92%).

Having said that, there are distinct differences as well. While the un-clustered groups tend to very broadly talk about the need for greater use of renewable energy in place of fossil fuels, with the target year of 2020, the clustered cities have more concrete and near-term work plans specified. For example, the clustered cities have spelled out much more specific emissions control guidelines for their coal-fired power plants, mandating the needs to retrofit selected self-use fleet and enforcing the use of desulphurization scrubber.

However, none of these differences seems to be a result of the formation of the Central China Triangle or its embedded call for CEM. I ended up with similar conclusions when I look at word trees for the other key terms such as “total emissions control” and “pollution control”. As for the “downward delegation of power,” it is a phenomenon that is so common everywhere, which hardly has any association with the formation of the Central China Triangle or CEM.

Figure 1-1: the word tree around "coking coke" based on the clustered group's EIA policies

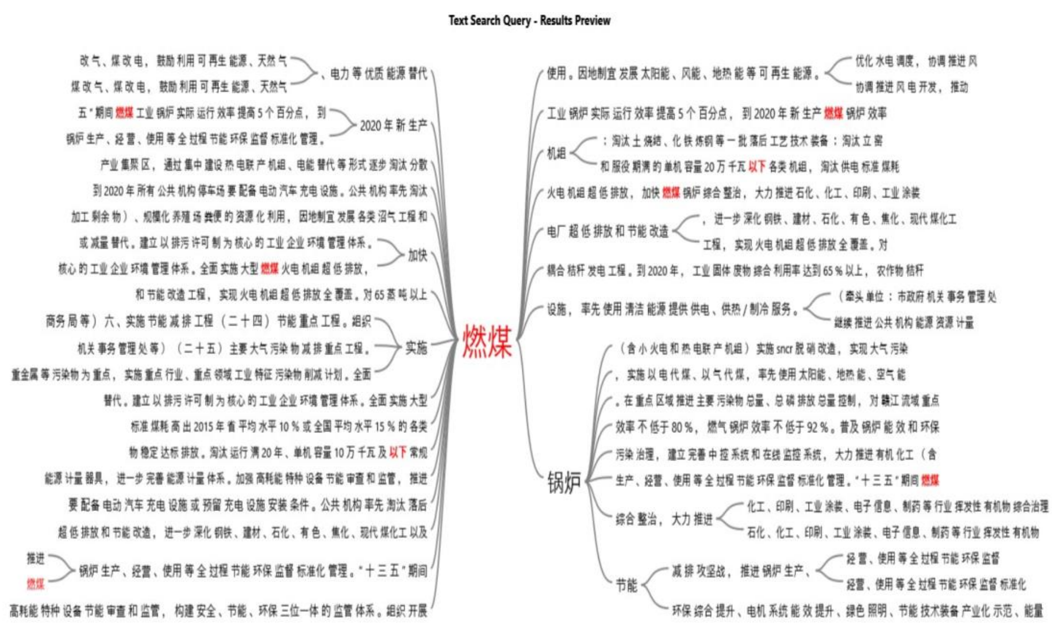


Figure 1-2: the word tree around "coking coke" based on the un-clustered group's EIA policies

Joint monitoring, information sharing, and collaborative law enforcement

In this section, I used network analysis to see how the dynamics of air quality management (especially in the area of joint monitoring, information sharing, and collaborative law enforcement) have evolved over the years, for nine cities that I selected. As I described in the methods of analysis section, I selected three control-treatment city pairs, one pair from each province. On top of that, I picked the three capital cities from each province, under the assumption that if changes were to happen, these capital cities would have higher chances of hosting these changes.

Unlike what I did for the EIA policy analysis, where I lumped all the clustered cities' policies as one group and all the un-clustered cities' policies as the other group, for the network analysis, it is essential to observe the detailed collaborative effort that is going within each city. This nuanced analysis allows me to examine: who are the typical players involved? What is the share of directed collaboration versus undirected ones? How strong are the relationships? How have these relationships evolved over the years?

Notice that the reporting styles of different cities are hugely different, making it difficult to compare the number and strength of connections in absolute values across cities. To give a hypothetical example, assuming both City A and City B conduct seasonal joint monitoring of industrial polluters in the winter months, but A counts every different day with such collaboration effort happening as a unique CEM record, while B has only one record that says "collaboration has happened in the winter months." Here, a direct comparison of "connection strength" between these two cities will be misleading.

The graph below captures this phenomenon. This graph tallies the total number of unique pair-wise relationships by year, for each of the nine cities that I looked at (see Appendix 1-5 for the table behind this graph). My data collection process told me that the City of Changsha ended up having many more records than all of the other cities because of its different reporting style. However, these inconsistent reporting styles do not adversely affect our interpretations of cities' CEM changes over time because the reporting style in each city has stayed consistent from one year to another.

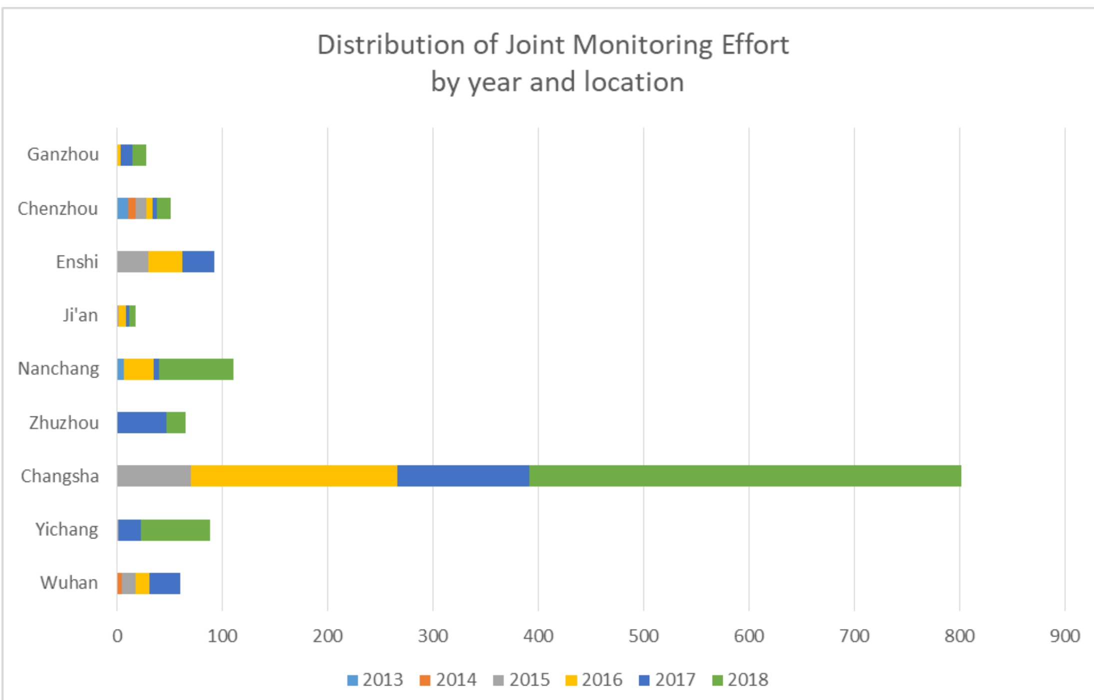


Figure 1-3: Distribution of joint monitoring effort by year and location

Another important observation from this graph is that it is very difficult to conclude whether the formation of the Central China Triangle or its embedded call for CEM has had a significant influence on the collaboration networks for the involved region. On the one hand, there is evidence that support this claim because for cities in the clustered group (the bottom six cities on the vertical axis), most of the CEM events were observed since 2015, whereas for the un-clustered group (the top three cities on the vertical axis), the share of CEM events observed pre- and post-2015 is not that much different at least for two out of the three cities. On the other hand, there is evidence that this regional integration plan's impact on CEM is minimal because: first, the inter-jurisdictional collaboration effort is an extremely small portion of the total amount of the CEM effort analyzed. Second, these inter-jurisdictional efforts are not exclusive to cities that fall within the Central China Triangle. Third, such efforts existed even before the formation of the Central China Triangle. Notice that a caveat in this analysis is that it is impossible to tease out the changes in CEM effort from changes in cities' data availability and reporting capacity.

Province	Type	City	inter-jurisdictional	inter-cluster	inter-provincial
Hubei	Hubei_capital	Wuhan	2	0	2
Hubei	Hubei_clustered	Yichang	4	2	2
Hunan	Hunan_capital	Changsha	0	0	0
Hunan	Hunan_clustered	Zhuzhou	4	0	0
Jiangxi	Jiangxi_capital	Nanchang	0	0	0
Jiangxi	Jiangxi_clustered	Ji'an	0	0	0
Hubei	Hubei_unclustered	Enshi	1	0	1
Hunan	Hunan_unclustered	Chenzhou	17	13	3
Jiangxi	Jiangxi_unclustered	Ganzhou	3	3	0

Table 1-2: Summary of inter-jurisdictional CEM effort by city

Year	inter-jurisdictional	inter-cluster	inter-provincial
2013	3	3	0
2014	3	3	0
2015	4	4	0
2016	9	4	4
2017	7	1	2
2018	5	3	2

Table 1-3: Summary of inter-jurisdictional CEM effort by year

Next, I highlight a few key findings from the network analysis. Instead of showing the results from all nine cities, I highlight findings from 5 of them. These five cities are the ones that have CEM records available both before and after the formation of the Central China Triangle.

The two graphs below represent the network of stakeholders that is involved in air quality joint monitoring and collaborative law enforcement in the City of Changsha, before and after the Central China Triangle formation (the Year 2015 vs. the Year 2018). Each involved party is represented as a node. I positioned these nodes in such a way that the nodes on top are parties of higher hierarchy (e.g., the state-level EPB in this example), and the nodes at the bottom are parties of relatively lower administrative levels (e.g., the county-level agencies). Notice that in China, the definition of city and county is the opposite to that of the United States. Directed relationships are drawn in red, undirected ones are drawn in green, and the thickness of the lines denotes the strength of the connection.

As shown in the figures below, for the City of Changsha, i.e., the capital city of the Hunan Province, the main change in the air quality management network is the strengthening of the connections among city-level EPB and the various county-level agencies in conducting these collaborative environmental management efforts. The city-level EPB is the main leader among these involved actors.

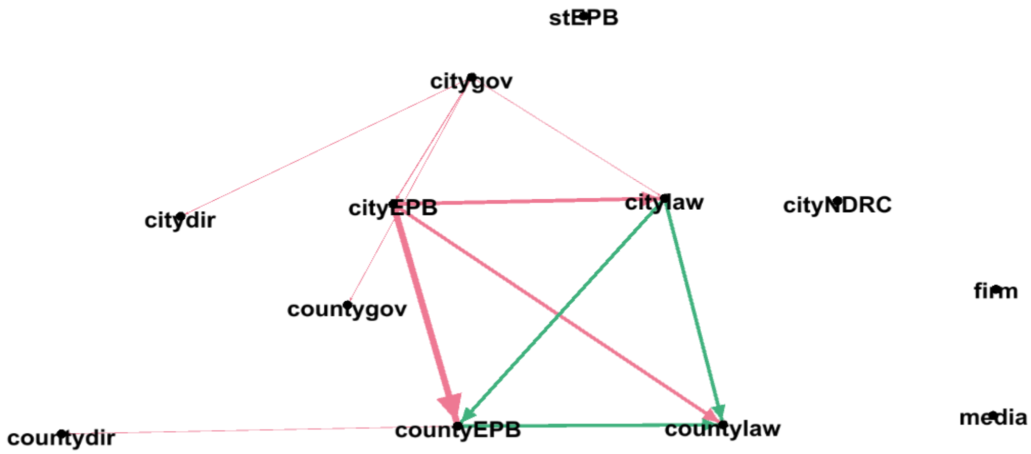


Figure 1-4: representations of Changsha's CEM network before the Central China Triangle formation

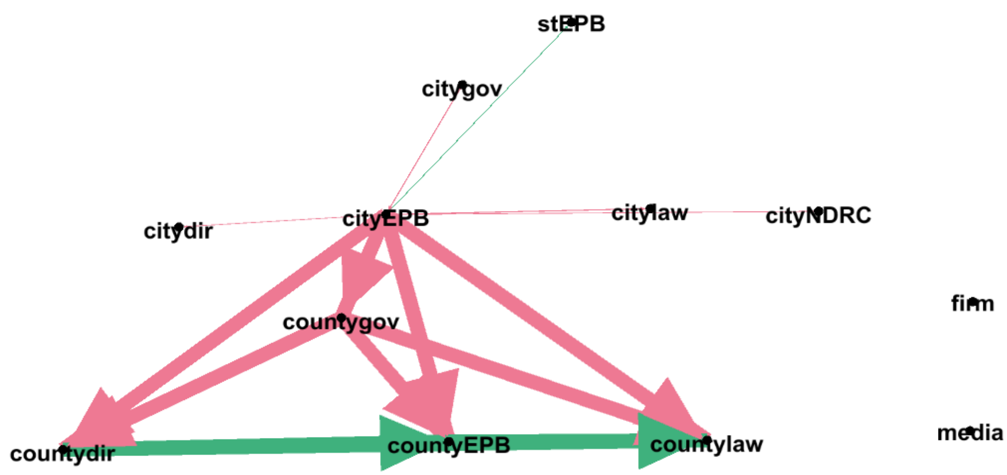


Figure 1-5: representation of Changsha's CEM network after the Central China Triangle formation

The actors involved in the joint prevention and control of air pollution looks very different for the City of Wuhan, the capital city of Hubei Province. In this case, a lot more actors from a lot more administrative levels are involved (for example, the Ministry of Ecology and Environment and the regional supervision centers are being part of this network), and inter-jurisdictional collaborations emerge after the formation of the Central China Triangle. Looking at the power dynamics among the stakeholders who are involved in Wuhan's air quality management, before and after this regional integration plan was formalized, the main difference is the big boom in the variety of the partnerships that have been formed among different stakeholders. Not much can be commented about the durability or the strength of these newly formed connections yet, but the strong connections between the city-level EPB and the county-level EPB have persisted over the years. In fact, the EPBs (i.e., the state-level EPB, city-level EPB, and the county-level EPB) are important pillars of Wuhan's air management network.

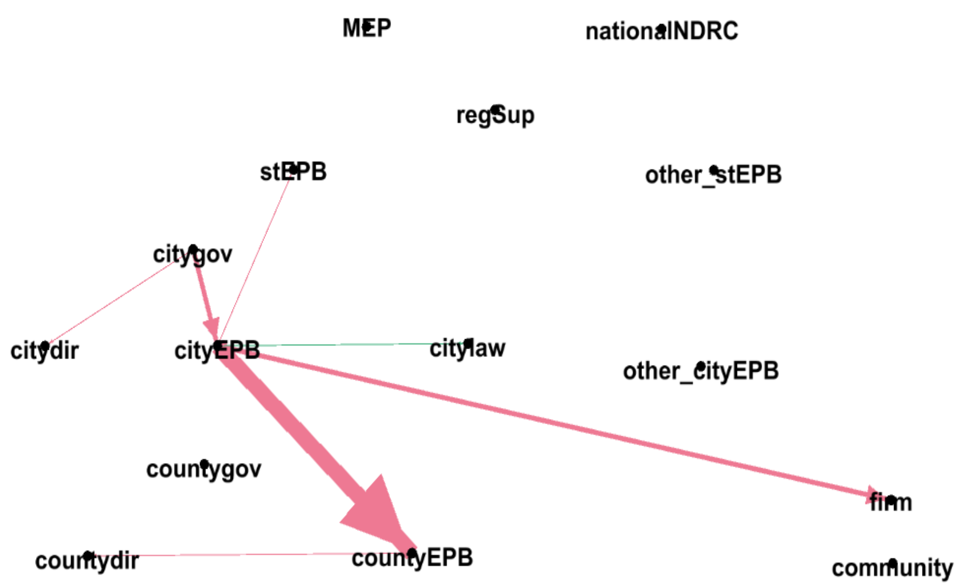


Figure 1-6 representations of Wuhan's CEM network before the Central China Triangle formation

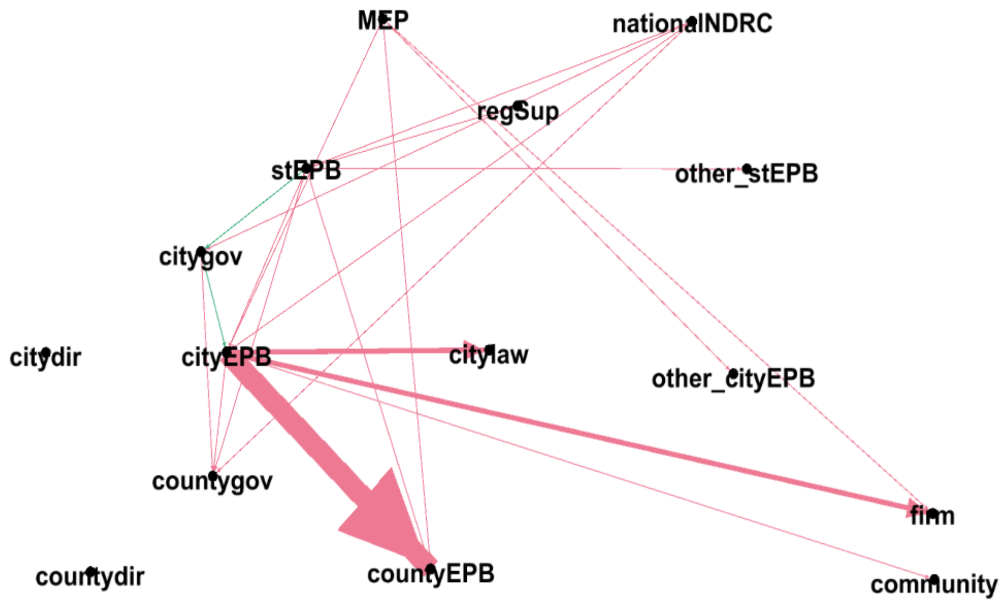


Figure 1-7: representations of Wuhan's CEM network after the Central China Triangle formation

Moving to the city of Nanchang, the capital city of the Jiangxi Province, the main observation is again different. In this case, there is clearly a change in the power dynamics among the involved stakeholders. Before the Central China Triangle formation, most of the collaborations were vertically imposed or initiated by the Ministry of Ecology and the Environment. After this city cluster was formed, the different levels of EPBs (i.e. the state-level EPB, the city-level EPB, and the county-level EPB), the mayor's office and its directly controlled subsidiary agencies, and the county-level government officials have formed a stable connection among themselves that sustained the joint prevention and control of air pollution in this region, even without much enforcement from the central government.

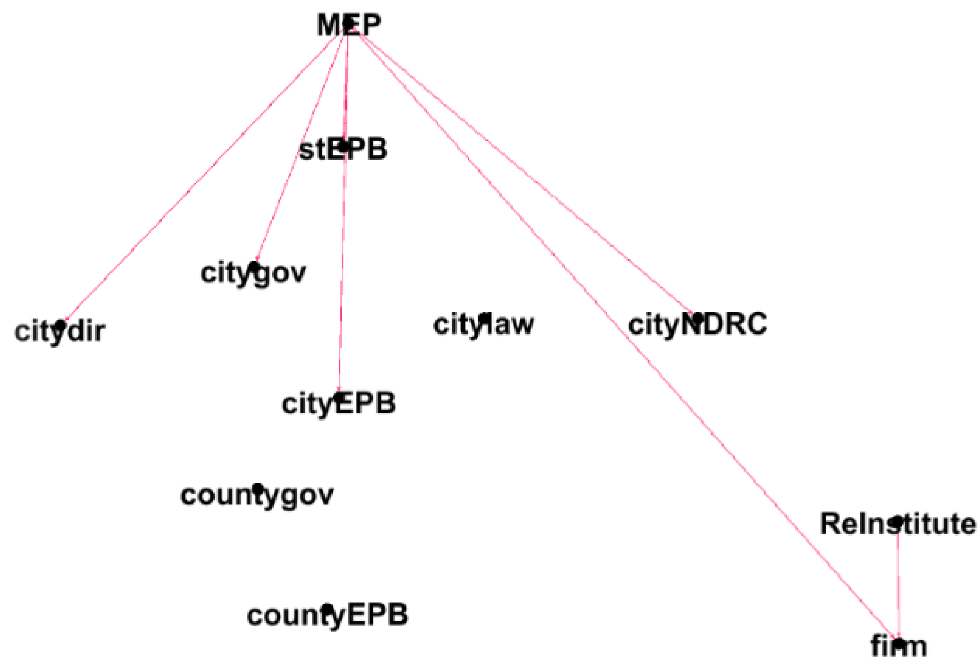


Figure 1-8: representations of Nanchang's CEM network before the Central China Triangle formation

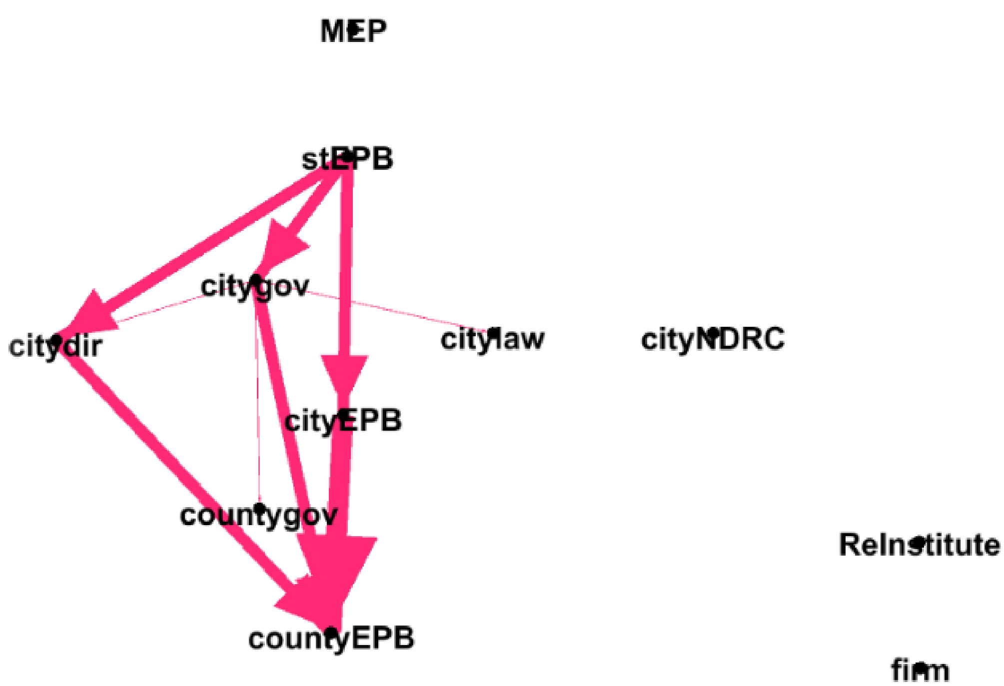


Figure 1-9: representations of Nanchang's CEM network after the Central China Triangle formation

Next, we look at two cities from the un-clustered group to see if the story is similar or different from that of the three capital cities.

For the City of Chenzhou, inter-jurisdictional collaborations happened even before the formation of the Central China Triangle. These collaborations were mostly coordinated by the state-level EPB. There were also a fair amount of intra-jurisdictional collaborations among different stakeholders. Most of these collaborations were horizontal ones that happened among agencies of the same administrative level, across different functions.

As time evolved, the City of Chenzhou experimented with newer types of horizontal and vertical collaboration partnerships to deal with the joint prevention and control of air pollution. City-level EPB, county-level EPB, and administrative agencies that are directly controlled by the mayor's office are critical players that jointly supported the new collaboration dynamics among the different stakeholders as of 2017.

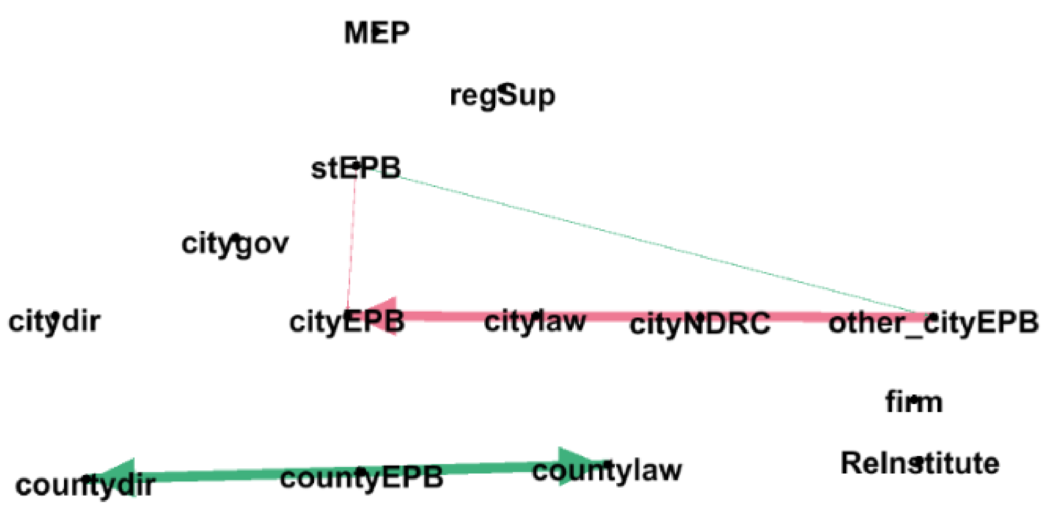


Figure 1-10: representations of Chenzhou's CEM network before the Central China Triangle formation

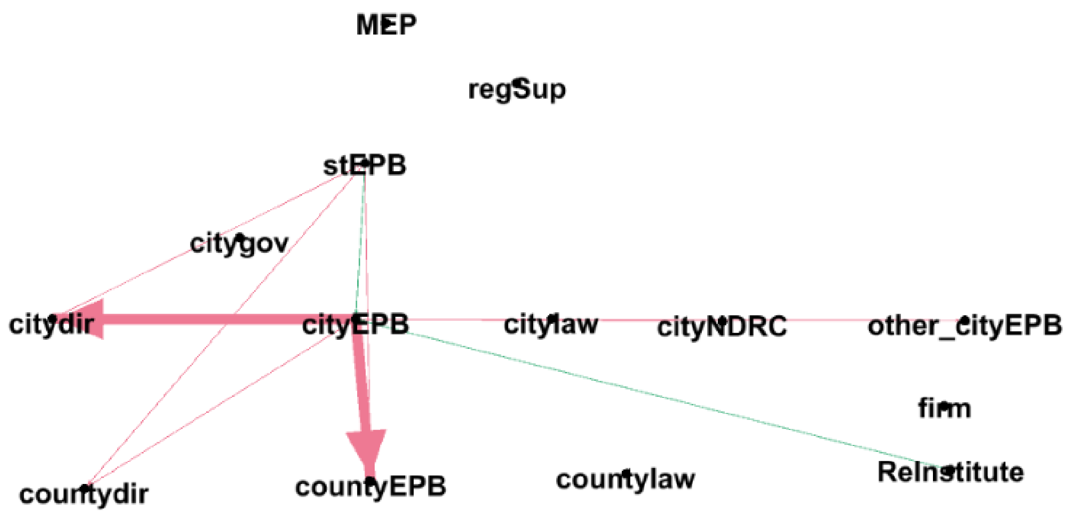


Figure 1-11: representations of Chenzhou's CEM network after the Central China Triangle formation

As for the last city, Enshi, the main story is the simultaneous improvements made by the state-level EPB and city-level government (i.e., mostly the mayor's office) in trying to establish more alliances with its subsidiary-level government agencies over the years in joint prevention and control of air pollution. Enshi is the only one, out of the five cities that we have looked at, where city-level EPB is not the most central player in the joint monitoring of air polluters or the collaborative law enforcement practices regarding air pollution control.

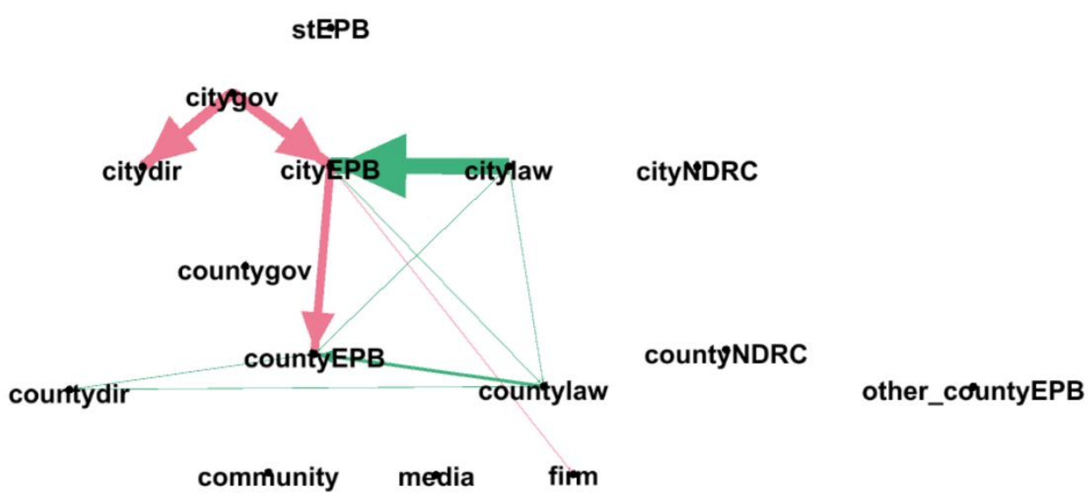


Figure 1-12: Representation of Enshi's CEM network before the Central China Triangle formation

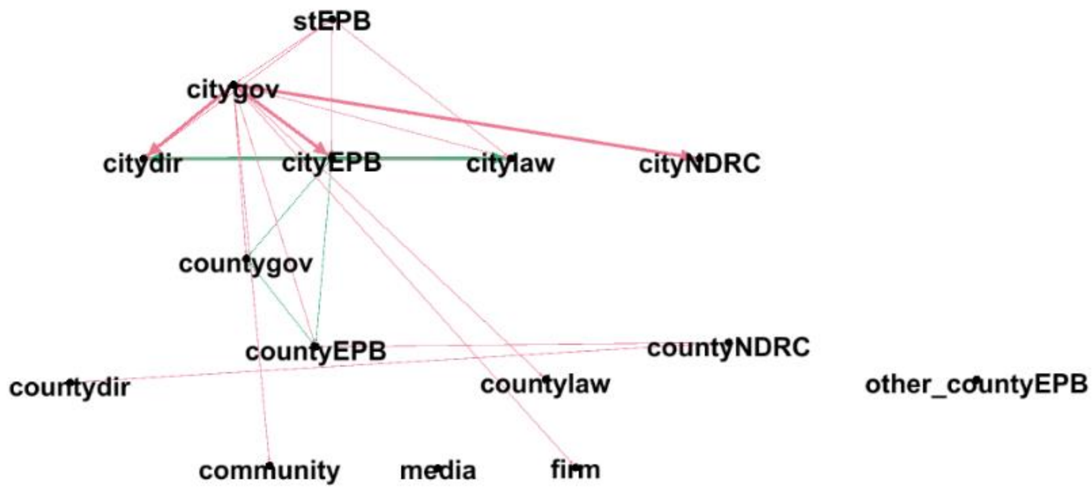


Figure 1-13: representations of Enshi's CEM network after the Central China Triangle formation

All in all, there is a quite consistent observation that the power dynamics within the CEM networks have changed quite noticeably for both the clustered cities and the non-clustered ones, in the area of air pollution control. However, the added value of the Central China Triangle in promoting inter-jurisdictional joint monitoring of air pollutants and collaborative law enforcement has been minimal.

Moreover, this section's results suggest that this city cluster development plan is very unlikely to have been originated from the central government's intention to take away some power from the local-level governments, at least in the air quality management sphere. On the contrary, there is increasing engagement of non-governmental stakeholders such as media and firms in these CEM efforts, and increasing participation of ground-level effort (i.e., the involvement of county-level agencies and local community). Critics may say that this general conclusion does not explain the findings of Wuhan, in which case the Ministry of Ecology and Environment and the national-level Reform and Development Commission appear to have a much stronger appearance in the CEM network after the formation of the Central China Triangle. However, a deeper dive into the context behind these graphical representations of CEM networks shows that in Wuhan's case, the higher-hierarchy governmental agencies got involved mainly because of some occasional training or research and inspection effort. There was no evidence of them taking power away from the local-level agencies either.

<u>The evolvement of policy focus, stakeholders, and the context in which CEM is discussed</u>

The graphs below show changes in the expected involvement of the different stakeholders in air quality management, as suggested by all the analyzed policies that are relevant to air pollution control. The way to interpret this is that, for all the air pollution management policies that are newly-released in a particular year, what is the share of policies that mention the following stakeholder as an important player?

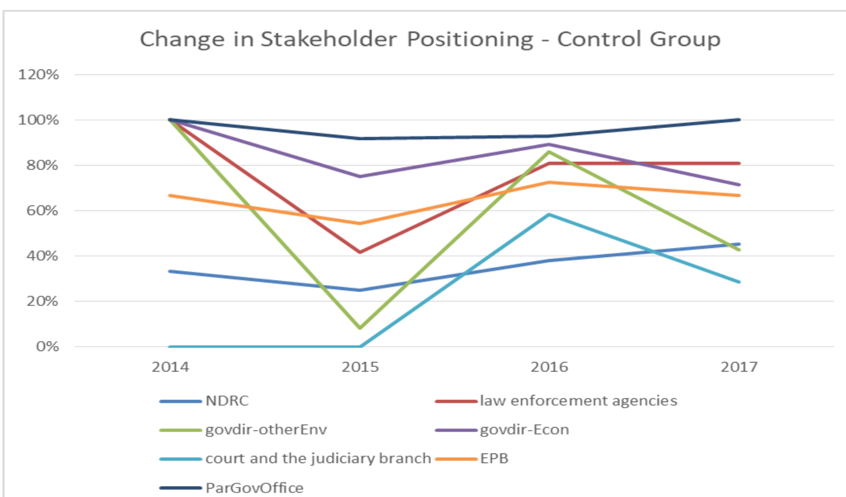


Figure 1-14: Changes in stakeholder positioning in air pollution management – Unclustered cities

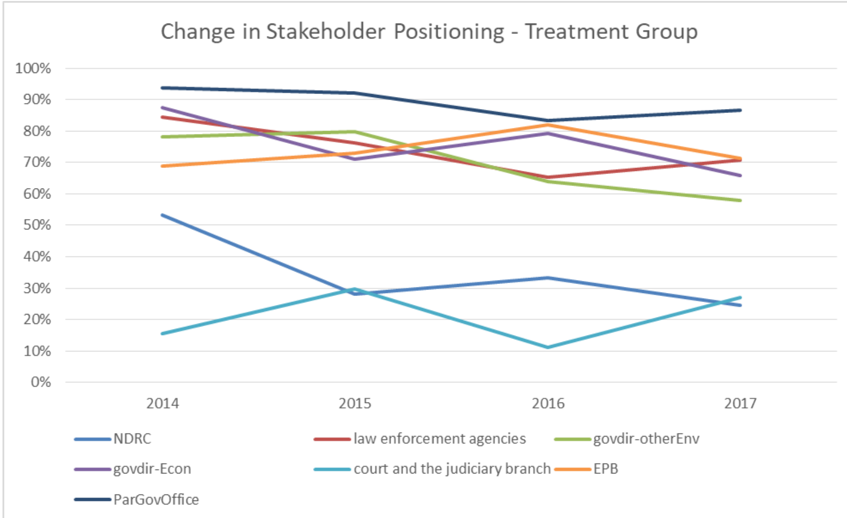


Figure 1-15: Changes in stakeholder positioning in air pollution management- Clustered cities

The main observation was that, similar trends were observed for EPB, law enforcement agencies, and the governmental agencies that are conventionally more focused on economic development (labelled as “govdir-Econ” in the figures below), across the clustered group and the non-clustered group. Different trends were observed for the other stakeholders

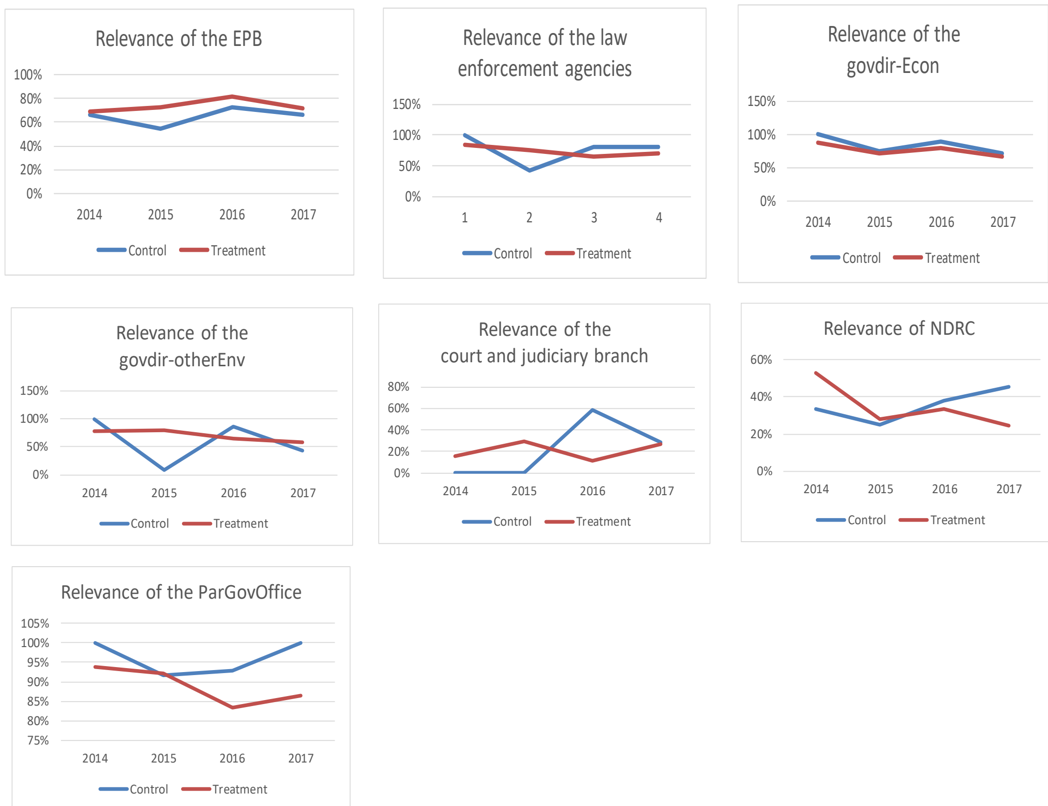


Figure 1-16: Comparison of expected involvement, by stakeholder group

Besides, for both groups, a full range of policy tools and targeted areas of improvement have been mentioned since 2014. These include, but are not limited to, the management of point sources and mobile sources of pollution, the need for long-term energy system structural reform, and the promotion of market-based incentivizing mechanisms. There is no evidence indicating a difference between the policy focus of the clustered cities and that of the non-clustered group.

As for the evolvement of context in which CEM has been mentioned before and after the formation of the Central China Triangle, the contextual expansion related to the joint prevention and control of air pollution is much greater in the clustered city group, at first glance (see Appendix 1-7 for the actual word trees). However, a detailed look at these contexts shows that the added value of the Central China Triangle formation to inter-jurisdictional air pollution management is negligible (see Appendix 1-8 for the evolvement of context in which inter-jurisdictional joint prevention and control of air pollution is mentioned for the two city groups).

<u>Other CEM-related system-level changes</u>

A summary of results is provided below. The main conclusion is that there have been CEM-related system-level changes happening in the clustered cities since the formation of the Central China Triangle. More importantly, all four categories of system-level changes are observed. However, there is little evidence that these developments can be directly attributed to the formation of the Central China Triangle because outside-clustered cities had similar progress in many of these areas too.

Type of CEM-related Progress	Policy-making process	Institutional setup and admin. apparatus	Legislative and regulatory tools	Other system drivers
Joint research	X			
Common guidelines			X	
CEM roadmap	X		X	
Clarification of collaborators' roles	X		X	X
Joint meetings	X			
Performance Evaluation	X		X	X
Mutual acceptance of standards	X		X	
Policy agreements	X		X	
Preparation of a common tracking system		X		
Joint monitoring and law enforcement	X	X		X
CEM working groups	X	X		

Table 1-4: Other evidence of system-level changes brought by CEM, for the clustered cities

Discussion and Conclusion

Results show that, while all four types of system-level changes (changes in: the policy-making processes, the regulatory tools, the institutional setup, and other system drivers) are somewhat observed in the studied region since 2015, most of these changes are found in both the clustered cities and the un-clustered cities, so there is lack of evidence to attribute these CEM-related system-level changes to the formation of the Central China Triangle alone.

Even though a few cities have engaged in more inter-local collaborations on air pollution management since 2015, most of these system-level changes support vertical or cross-functional collaborations among governmental agencies within the same city or province, and these collaborative effort focus almost exclusively on keeping the point-source polluters compliant, leaving quite a bit of wiggle room for mobile sources of air pollution. This corroborates the very recent findings by Eaton and Kostka, which shows that “the implementation challenges facing all these efforts to build out China’s environmental state in the horizontal plane are considerable” (Eaton & Kostka, 2018).

The most relevant political theory to potentially explain why there is similar improvements observed in the un-clustered cities is Mei and Pearson’s theory on “deterrence signaling” (Mei & Pearson, 2014). To apply their theory in CEM’s context, first, the central government’s repetitive emphasis on collaborative development and regional integration in the recent years have sent a very clear message to the local officials regarding its policy priorities. More importantly, such messages are accompanied by strong deterrence signals such as: rounds of high-pressure nation-wide inspection tours, harsh punishment of selected local officials for environmental management wrongdoing, and public shaming of agencies and personnel involved in such incidence. All of these persevered disciplinary effort on the one hand establishes the central government's reputation in defiance correction, and on the other hand could have altered the incentive structure of un-clustered cities' local officials in such a way that they now perceive a higher likelihood of being a target of sanction in the event of non-compliance, see a larger penalty attached to such sanctions, and hence feel the need to be proactive regarding the calls for CEM.

This explanation appears to explain my findings better than other alternative theories, such as policy learning through spillover, because existing research shows that, while technical and conceptual forms of policy leaning have taken place in China, there is very limited amount of social learning taking place in the environment and energy policy field (Mah & Hills, 2014), and CEM happens to be a governance framework that is hugely dependent on social construct such as trust and reciprocity.

There are some caveats in my research designs. First, even though the commonly discussed forms of collaborative governance in the literature include public-private partnerships (Jing & Savas, 2009), inter-jurisdiction agreements (Chen, Suo & Ma, 2015; Wu et al. 2016; Yi & Liu, 2015), and government-nonprofit partnerships (Jing & Chen, 2012), for this research, the scope is limited to studying how government agencies at different administrative levels collaborate with each other and across jurisdictions. As a result, this may be underestimating the true level of CEM-related activities and CEM-related system-level changes that have happened.

Second, existing literature has found that the principal participants of inter-governmental agreements are governments and public agencies who put an emphasis on voluntary adoption. “These agreements more likely take the form of policy documents, rather than legal documents, and their effects depend on trust and reciprocity among participating government leaders, which is very hard to measure” (Feiock, 2016).

Having said that, this research is the first study that demonstrates the complex decision-making processes that can arise during processes of joint prevention and control of air pollution, even when pre-existing socioeconomic differences are largely controlled for. It is also the first study that rigorously showed whether a regional integration plan, a commonly touted instrument to promote collaboration among involved regions, actually promotes collaborative environmental management. Moreover, it was able to capture the changing power dynamics among stakeholders that are involved in air pollution management, before and after the Central China Triangle was formed, for selected cities. All in all, this study not only demonstrates how policy practitioners can study CEM’s actual impacts on environmental governance, structurally and functionally, but also shows how future scholars can evaluate a giant policy package’s impact on environmental management by systematically tracing its process outcomes (i.e. its related system-level changes).

Chapter 2

Does the formation of the Central China Triangle, and the embedded call for Collaborative Environmental Management (CEM), change venture capital firms' perceived risks of investing in the cleantech SMEs in the involved regions?

Introduction and Motivation

The importance of private capital participation in China's environmental management industry

Environmental management and environmental service provision is an industry that heavily depends on policy pulls and government support to function, for its nature of being a public good. This is especially the case in China where many believe that "one way to characterize its economy today is that it is an economic system rooted in state capitalism" (Huang, 2015). In a so-called state capitalism market, the government owns many big firms and maneuvers the future of these firms by controlling the subsidies and favorable loans that are available to them.

China's overall investment in pollution control grew exponentially from 2005 to 2013, with the growth rate at around 18.1% per year. However, the share of these investments out of the national GDP actually did not change much, staying at below 1.7 percent in these years (Guo et al., 2015). Moreover, most of this financial burden is carried by the local government. Based on data from China's statistical yearbook in 2014, roughly 97 percent of government's expenditures on environmental protection came from the local government. This cost bearing structure makes it very challenging for localities to practice any kind of inter-jurisdictional collaborative environmental management because participants are very likely to weigh their individual interests over the regional collective goals. This is part of the reasons why I want to investigate private capital investors' perceptions of the Central China Triangle formation and its embedded call for CEM because, without greater private capital participation, collaborative development goals will at most stay as beautiful but unrealistic ideals.

Moreover, depending on the resource endowment and the standard of living a local jurisdiction has, the need to take care of the environmental issues is sometimes believed to be in conflict with the attainment of other development objectives such as economic growth, and hence there is a perpetual "tug-of-war" for funding support between environmental management needs and other socioeconomic development goals if actors from different government units do not coordinate with each other in pursuing their policy objectives. This budget constraint is another reason why it is important to encourage private capital participation in environmental management.

In an attempt to promote greener economic growth and to alleviate the financing hurdles faced by the local governments, China has gradually diversified the investment and financing channels for the environmental management and cleantech industry in the recent years. Traditional commercial banks, which covers more than 90 percent of the total financing needs in the country (Guo et al., 2015), started to develop green loans for small and medium enterprises that operate in this industry. Other innovative financing models were used to attract private investment. This includes a range of public-private partnership models, green securities, green insurance, environmental protection industry fund, government-led venture capital fund, and so on (Guo et al., 2015).

The reality of private capital participation in China's environmental management industry

Despite the good effort China has made to encourage private capital participation in its environmental management industry, SMEs in this field still has a lot of difficulties getting themselves financed, just like SMEs in other parts of the world (Claessens & Tzioumis, 2006; Guo et al., 2015; Schmukler, 2017; Statista, 2019), and there were challenges in mobilizing private capital through the other financing mechanisms as well.

To elaborate, although the traditional commercial banks started to develop green loans since 2007, due to the lack of sufficient supervision guidelines and performance evaluation standards, the implementation of these programs was chaotic, and the commercial banks ended up having little enthusiasm in rolling out a long-term plan for these mechanisms (Fang, 2016). Meanwhile, the Ministry of Finance released its Notice on Regulating the Management of the Public-Private-Partnership (PPP) Integrated Information Platform Project Database (also known as Notice No. 92) in 2017, which resulted in the abrupt cancellation of many ongoing

PPP projects all over China, cutting off many participating cleantech SMEs' money supply and leaving them in limbo.

As for the other innovative financing channels – such as the World Bank's Program-for-Results Financing and the so-called "yin-zheng-tou" model (i.e. a new financing model under which the commercial banks, the government, and the institutional investors jointly share the investment risks) – all of them are still at their experimental stages.

Venture capital and its potential roles in supporting environmental management

Given the current financing and investment environment, more and more cleantech SMEs have turned to venture capital (VC) firms for financing needs nowadays, not only for the immediate cash line that VC investors offered, but also for the potential opportunity of having a successful IPO in the stock market later.

Venture capital is a critical type of private finance that investors provide to startup companies or small-and-medium enterprises that are believed to have cutting-edge technologies or superior long-term growth potential (Saha & Muro, 2017; Gosh & Nanda, 2010). Venture capital investors typically intervene a target firm at an early stage. Besides offering its investment in exchange for ownership stake, it offers investment target firms with strategic advice on its business models, marketing strategies, and ways to stay compliant with the accounting rules and legal requirements that is required for an initial public offering (IPO) or a merger and acquisition (M&A). The eventual goal of the venture capital investors is to exit an investment deal with a return-on-investment multiple that is so high that outweighs all of the risks it has undertaken in this deal. Having said that, because startups and SMEs face high uncertainty, VC investments do have high rates of failure.

The western world has had much richer experiences with venture capital, and has offered important lessons for the rest of the world. VC investment has been essential to the survival and growth of many well-known cleantech SMEs in the energy production, energy efficiency, transportation, and energy storage realms (Saha & Muro, 2017; Marcus et al., 2013), however, VC deals seem to be biased toward later-stage mature technologies and are heavily concentrated in a few metropolitan areas.

In China, between 2000 and 2018, private equity investors participated in a total of 829 cleantech-specific investment activities, and injected about 61.5 billion of Chinese Yuan (CNY) into China's cleantech market. A significant share of these investments involved funds that are controlled by venture capital firms.

However, VC firms are believed to function somewhat differently given the nation's special political regime. Research shows that, unlike VCs in the developed countries. First, there is quite a significant number of governmental venture capital firms Chinese VCs (GVCs), which had the power of granting their investees priority of getting listed on the domestic stock market (Zhang et al., 2018). Second, political ties with the central or local government are crucial for VCs to exit via Chines mainland stock markets and M&As (Anderson et al., 2017). Third, due to the lack of appropriate exit channels and the absence of an open and stable equity-driven capital market, there is low mobilization efficiency in the venture capital market in China

(Zhao & Chen, 2007). Fourth, government policy is the most important factor that influences the venture capital market in China, compared to a whole range of other factors including macroeconomic environment, target investment firms' R&D expenditure, and regional factors such as the presence of a high-tech industry cluster (Tu & Liu, 2011).

In fact, government policy's impact on VCs' investment is clearly reflected in the real market data (QingKe Zeto-to-IPO database, 2019). Looking at Figure 2-1 and Figure 2-2, there is an obvious dip in both the investment activities and the investment amount in 2018.

This is very much related to "China's market-roiling crackdown on financial leverage" in the last two years (Bloomberg News, 2019). Starting in 2017, China's central government has rolled out a series of "deleveraging pushes" (including Notice No. 92 on PPP regulation, which was mentioned in the previous section), in an attempt to curb the sharp increases in short-term debt, slow down the unsustainable credit growth, and create a healthier mix of financing options for the private sector. This two-year anti-leverage drive "sank Chinese stocks, restrained economic growth, triggered record bond defaults, and pummeled the nation's gargantuan shadow-banking industry" (Bloomberg News, 2019), leaving many cleantech firms on the verge of bankruptcy as the capital pool all of a sudden shrank and the cost of financing skyrocketed.

Yet, a report published by the People's Bank of China in 2019 seemed to signal that the Central government would not continue with its original deleveraging activities at full speed out of its consideration to "support the economy".

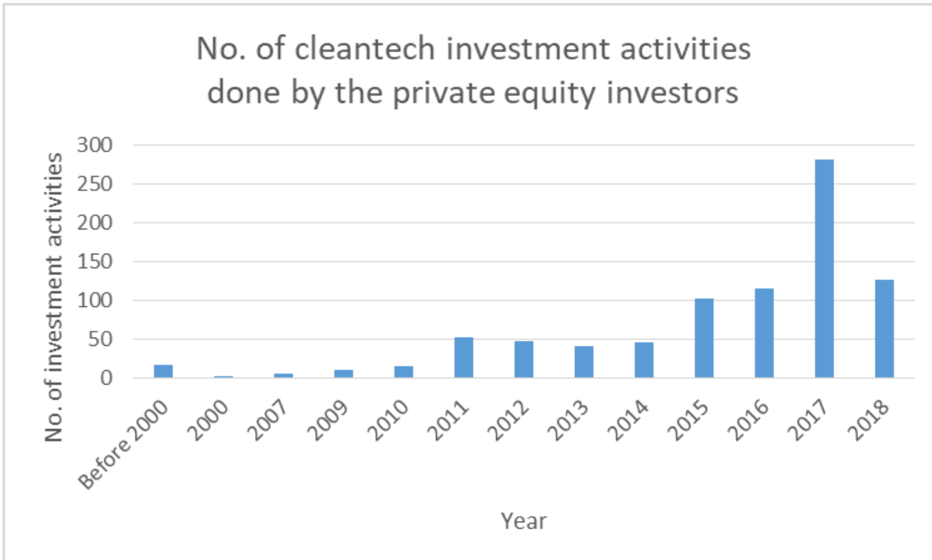


Figure 2-1: Number of cleantech investment activities done by the private equity investors, 2000-2018 (source: QingKe Zeto-to-IPO database, 2019)

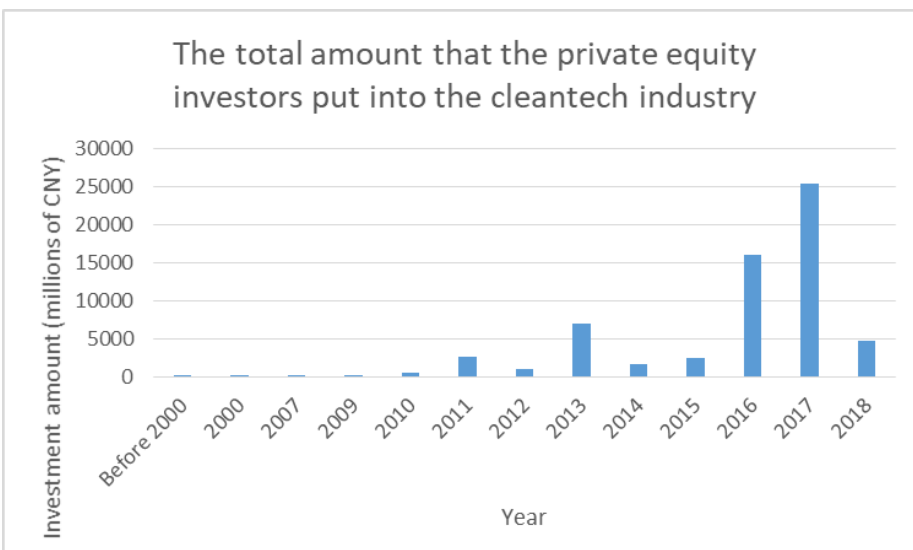


Figure 2-2: The total amount that the private equity investors put into the cleantech industry, 2000-2018 (Source: QingKe Zeto-to-IPO database, 2019)

Public policy's roles in mobilizing private finance

Existing research has formally looked at public policy's roles in mobilizing private finance, talking about the effects of policy and financial derisking on investor risk mitigation, and emphasizing the need to supplement policy derisking and financial derisking with direct financial incentives (UNDP, 2013). However, the discussions focus only on the roles of direct financial incentives, not a broader category of policies, and the narrative around how public policy mobilizes private finance is very much lop-sided, attributing private investors' perceived market uncertainty, political risks, and regulatory risks, which is associated with the policy environment, as the main determinant of investment decisions and neglecting the return side of the equation (Bergek et al., 2013; Chassot et al., 2014; Polzin et al., 2015). It is not until very recently that researchers have explicitly mentioned that for a policy to effectively mobilize private finance, it needs to address risk and return simultaneously (Polzin et al., 2019). Moreover, all of these studies almost exclusively focus on investors' perspective regarding renewable energy development, and not any other area of the environmental management.

These gaps in the existing resaerch led me to the research question, which looks at the potential impact of a regional integration plan, and its embedded call for CEM, on private finance mobilization.

The present study

Existing literature suggests that perceived market uncertainty and perceived risks caused by policies are the main determinants of institutional investors' decisions in the renewable energy sphere (Bergek et al., 2013; Chassot et al., 2014; Polzin et al., 2015). To elaborate, using panel data (2003-2011) from the OECD countries, these scholars find that renewable energy related long-term policy commitment and strategic planning signal greater stability, reliability, and predictability of the general renewable energy investment environment. This lowers institutional investors' perceived general market uncertainty, political risks, and regulatory risks, which in turn positively influences their evaluation of the cost of capital and the stability of cash flows over the duration of their investment, and eventually makes a difference in their renewable energy investment decisions.

Inspired by this strand of literatures, this essay asks whether the formation of the Central China Triangle, and the embedded call for Collaborative Environmental Management (CEM), changes the venture capital firms' perceived risks of investing in the cleantech SMEs in the involved regions. To phrase it slightly differently, my research analyzes whether CEM among local Environmental Protection Bureaus has the potential of bringing some co-benefits to the involved regions' cleantech development, apart from having direct impacts on the involved localities' environmental management systems.

The private sector has a big potential role to play in China's environmental services management and cleantech industry. According to an analysis done by the

Portuguese Chinese Chamber of Commerce and Industry (CCILC, 2017), even though some cleantech sectors – wind, solar, municipal waste water treatment, green vehicles, and smart grids – are mainly controlled by the State Owned Enterprises (SOEs), other sectors – for example, biomass, waste-to-energy and sewage treatment – have a market that is yet to be exploited. This presents national and international SMEs with a broad range of opportunities.

This is especially true for the central provinces of China, where the Central China Triangle is based. Summary statistics provided by China's SOE Supervision and Management Yearbook indicate that, as of 2016, the market share of the SOEs (measured in terms of percentage share of the total number of firms, percentage share of the total number of employees, and percentage share of their year-end fixed assets) in the Central China region is much lower than that of the Eastern coastal region (Table 2-1).

The share of State-Owned Enterprises (SOEs)	Number of firms (%)	Number of employees (%)	Year-end fixed assets (%)
The Eastern coastal region	55.31	46.57	63.63
The Central China region	20.22	26.91	16.00
The Western provinces	24.47	26.52	20.37

Table 2-1: The market share of the SOEs as of Year 2016 (Ma, 2016)

The hypothesis of this study is that CEM's impact on cleantech investment is minimum, meaning that local EPB's more collaborative environmental governance framework is unlikely to affect how VC investors perceives the general cleantech market environment, or affect how they make actual cleantech investment decision at the project level.

The main potential contributions of this essay to the existing literatures are the following: first, institutional investors' experiences with and perceptions of government policies are seldom looked at in China, so this fills some important gaps in this area. Second, most of the existing literatures on VC investors' decision-making process focuses on their experiences with only the renewable energy industry. However, renewable energy is only a section of the environmental management and service industry, and its capital structure and return portfolio is hugely different from that of a pollution control business or a cleantech firm that does not focus on renewable energy development. Hence, this research investigated VC investors' experiences with the broader cleantech industry, and paid special attention to their involvement with the pollution control related businesses.

This piece is coherent to the dissertation's overarching topic of examining how city cluster formation contributes to joint prevention and control of air pollution, because as what was shown earlier, most of the government's expenditures on environmental protection currently comes from the local government. This cost bearing structure makes it very challenging for localities to practice any kind of inter-jurisdictional collaborative environmental management because participants are very likely to weigh their individual interests over the regional collective goals. This then makes it very interesting to look at private capital investors' perceptions of the Central China Triangle formation and its embedded call for CEM because, without greater private capital participation, collaborative development goals will at most stay as beautiful but unrealistic ideals.

Methods and data

Research design

This essay asks whether the formation of the Central China Triangle, and the embedded call for Collaborative Environmental Management (CEM), changes venture capital firms' perceived risks of investing in cleantech SMEs based in the involved regions.

To answer this question, between August and October of 2018, semi-structured interviews were conducted in Shenzhen, one of the venture capital hubs in China. The interviewee recruitment process did not involve any kind of advertisement. I first approached the firm that I had personal connection with, one of the top five venture capital firms in China. I then used the snowballing method to establish connections with managers from a few other leading venture capital firms. With the support and authorization from these managers, I then gained access to my actual participants, who have the most relevant background and experiences in cleantech investment.

In terms of the actual format of my studies, my preferred approach was conducting on-site one-on-one interviews. However, in the event that my interviewees were not based in Shenzhen or happened to be travelling during my data collection period, I sent my questionnaire to them beforehand, and followed up with them over the phone with additional inquiries if needed when I received their written responses.

To ensure the quality of the responses that I get, I prepared a brief introduction about me and my project, and sent it to all of my potential participants about one week before our scheduled interview time to let them familiarize with the issues that we would be discussing. Although many of my contacted investors did not find my topic to be something that has high relevance to what they do or what they care when evaluating investment opportunities, after they took a quick glance at my study's introduction, they were willing to open-mindedly participate in my study regardless, and were very generous with their time. In total, 15 representatives from 3 leading VC firms were interviewed either in person or over the phone. Each interview took between 30 minutes to 2 hours to complete. All of the participating firms offered me a private office on-site, where I could have easy access to my interviewees and conduct my interviews in a conducive environment.

In addition, to truly understand the financing and investment environment of the cleantech industry from all angles, I asked 3 cleantech industry chief analysts from 3 securities companies to offer their opinions at a more macro level, and I talked to CEOs and CFOs of two cleantech firms, which have businesses in the Central China Triangle, to gain their first-hand experiences with the regional integration plan, actual CEM practices on the ground, and changes in the financing environment if there is any. All of these interviews were conducted over the phone.

Appendix 2-4 provides a full list of the twenty-one interviews that were conducted for this study, with personal and company identifier removed. They are numbered in the order that they were conducted and will be cited accordingly in the results section.

Two set of interview questions were prepared (Appendix 2-1 & Appendix 2-2), one for the institutional investors (including the venture capital investors and analysts from the securities companies), and one for the cleantech firm representatives. The questionnaires had a section right at the beginning to gauge the participants' familiarity with the city cluster formation plan that I was interested in, and the interview protocol was carefully designed in a way that allowed me to tease out respondents' perception of CEM from their perception of the Central China Triangle plan as a whole.

Notice that the word "cleantech" refers to an investment category that consists of products, services, and processes that are designed to "improve the productive and responsive use of natural resources, reduce or eliminate negative ecological impacts". Following this definition, both renewables and end-of-pipe emissions mitigation technologies are examples of "cleantech" that are directly relevant to air pollution control. Other non-exclusive examples of "cleantech" include: emissions monitoring system, waste treatment process, and energy-efficient products. Though being broad and vague, "cleantech" is a commonly used term in the venture capital industry. This is why I stayed with this term in designing and conducting my interviews.

This research design received approval from (Appendix 2-3) the University of Maryland Institutional Review Board in July 2019, before the fieldwork started. Appropriate enrollment procedures and consent process were followed to keep the risks of participating in my research study minimum. All possible measures were taken to minimize any potential loss of participants' confidentiality. It was also made clear to the participants that their participation was completely voluntary, and they have the option of stop participating or withdraw their participation at any time.

Data

In total, 15 representatives from 3 leading VC firms were interviewed. These 3 firms have consistently made it to the nation's "Top 15 VC List" (Appendix 2-5) in recent years, based on real market data on investment activities and investment volume.   More importantly, all 3 of them have a significant portfolio in the cleantech industry, and are among the VC firms that are most responsive to government's call for "private capital participation", joining many investment activities that were led by government-sponsored industrial development fund (QingKe Zero-to-IPO Database, 2019).

Below are two tables that show the distribution of this study's participants by firms, and the share of participants by their managerial levels. As shown from Table 2-2, one of the firms (labelled as VC1) contributed the most number of interviewees. This is because I had the privilege of talking to not only investment managers at its headquarter in Shenzhen, but also the investment team that is based in the Central China Triangle, under one of its subsidiary branch locations (labelled as VC1-subsidiary). In fact, for this firm, I even had the opportunity to access its confidential archive of past projects in the areas of environmental management and cleantech development, from 2010 onwards, to get a feel of VC investors' decision-making process in real life. Also, as shown by Table 2-3, I spoke to investors from different managerial levels to get a broad spectrum of views, but all of them were truly experienced investors who were at least at the rank of regional investment managers. Having access to this group of knowledgeable experts was extremely helpful for my study because these people are the powerful gatekeepers in the venture capital firms, controlling the fate of potential investment deals, and they are the ones who are most likely to be well acquainted with macro-level strategic planning (for example, the city cluster formations) that potentially have an impact on the general investment environment, because where you stand determines what you see.

Distribution of interviewees by VC firm

VC1	8
VC1-subsidiary	3
VC2	2
VC3	2

Table 2-2: Distribution of interviewees by VC firm

Share of interviewees by managerial level

Director	1
CEO	1
VP	6
Chief Financial Risk Manager	1
Senior investment manager	3
regional investment manager	3

Table 2-3: Share of interviewees by managerial leve

In addition to these 15 interviews, as previously noted, I talked to 3 cleantech industry chief analysts from several securities companies and 3 leaders from selected cleantech firms to gain a cohesive understanding of what the cleantech industry's investment and financing environment looks like, and how it has evolved in recent years.

Together, these 21 interviews provided a reasonable basis for reliable and interesting findings, because even though this is not a large number per se, the importance of my selected firms, the powerful voice that my interviewees have in actual investment decision-making, and the wide range of views that are on offer all provide the basis for interesting findings.

At the same time, this study's sample does have its own limitations. For example, even though more than 90 percent of interviewees were at least somewhat familiar with the formation of the Central China Triangle, about 30 percent of them were not really familiar with the concept of Collaborative Environmental Management (CEM) when it was initially mentioned to them, and only 40 percent of the investors have either made actual cleantech investments or investigated high-potential cleantech firms in the Central China Triangle since 2015. Critics may find this low level of CEM familiarity and actual investments among interview participants worrisome, and question the relevance of their views in answering my research question.

In my opinion, respondents' limited knowledge with CEM was not an overly alarming issue because when I went beyond the broad concept of CEM to provide actual illustrations of CEM in practice, all of my respondents immediately knew what I was talking about, and were able to give examples of CEM on their own based on their past experiences. And, as for the respondents who have not been investigating or investing in the Central China Triangle's cleantech businesses since 2015, they prompted me to understand what the reasons were behind their "inaction". For example, did other regions offer more promising cleantech deals? Or, has the cleantech industry underperformed as a whole in recent years? Moreover, this group of respondents makes my sample mix more interesting and diverse, and allows me to say that any potential findings (on CEM's impact on investors' perceived risks of investing in the cleantech industry) is not only drawn from investors' past experiences, but also reflect how they could be making investment decisions in the future.

Method of analysis

Handwritten notes were taken while interviews took place. These notes were transcribed into fuller scripts, which were then used for thematic exploration. I first followed the structure of my interview protocol to lay out my findings, and then re-organized them around the following themes:

- What areas of "joined-up governance" do VC investors mostly associate with the Central China Triangle formation?
- How do VC investors view CEM both within and without the context of city cluster formation?

- Does the formation of the Central China Triangle, and other similar regional integration efforts, change VC investors' perceived risks of investing in the involved region's cleantech market?

- Do CEM practices change VC investors' perceived risks of investing in the involved region's cleantech market?

I cross-referenced the archive that contains information on past cleantech project investments, when applicable, to see if interviewees' responses could have been influenced by past experiences. I also analyzed my interviews with the cleantech industry analysts and cleantech firms' leaders to see if they offer any additional insights on what I was studying.

Results

<u>Central China Triangle, CEM, and other goals for joined-up governance</u>

According to the Central China Triangle Plan, there are six broad goals that the involved cities and provinces are supposed to achieve as a group: 1) a coordinated rural-urban development scheme, 2) an interconnected infrastructural support system, 3) a harmonized industrial upgrade, 4) a collaborative effort towards ecological civilization and environmental management (what I have called CEM so far), 5) a borderless public service network, and 6) a more conducive environment for knowledge sharing and future cooperation.

I asked 13 out of the 15 VC investors to choose in which of these six areas of joined-up governance they would expect to see improvements, with the formation of the Central China Triangle. Their responses are summarized in the bar chart below (Figure 2-3). The other two investors did not have time to answer this question due to their tight schedule.

The most important takeaway is that, other than the almost-unanimous agreement on the potential impact of regional integration on the development of an interconnected infrastructural system, there is no consensus among the venture capital investors on the other proposed relationships. The respondents are either not aware of these other goals also being priorities of the Central China Triangle plans, or do not see the potential linkage between city cluster formation and improvement in these other areas of joined-up governance. My respondents' different familiarity with the different pieces of the Central China Triangle plan and their different expectations regarding the realization of these different collaborative governance goals reflect the very common but inconvenient truth that there are always some gaps between the intended policy goals and the perceived policy priorities. Their responses on this may also be related to the fact that most of the inter-jurisdictional collaboration that has happened in the Central China Triangle so far is in the area of infrastructural development.

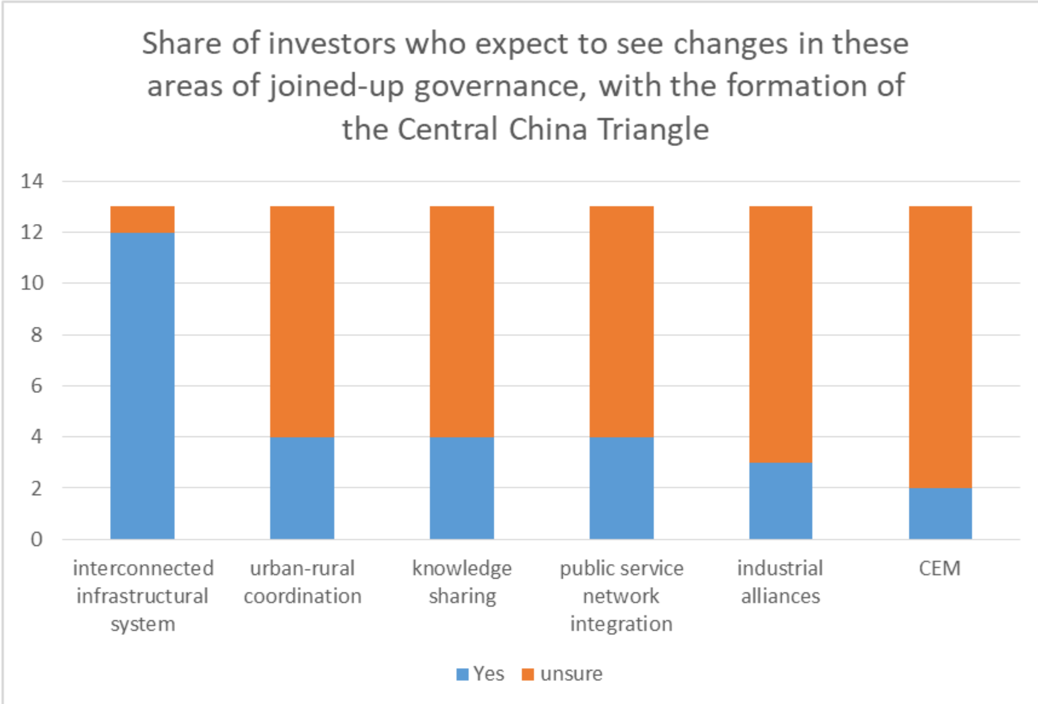


Figure 2-3: Share of investors who expect to see changes in these areas of joined-up governance, with the formation of the Central China Triangle

A few of the respondents mentioned that, in their view, the biggest motivation behind the development of the city clusters was cities' common challenges in dealing with issues such as rapid urbanization, persistent urban-rural inequality, and inefficient resource management (Interview No. 4, No. 6, No. 8, & No. 10). This is why they are more optimistic about the potential impact of city cluster formation on some of the above-mentioned areas of joined-up governance, but not all. To quote one of the investment managers, "things like industrial alliances may sound very good on paper, and may make a lot of economic sense in theory, but are simply not likely to succeed in practice. With issues like inter-jurisdictional competitions, I do not see how regional integration plans can simply enforce industrial alliances" (Interview No. 6). In other words, to this group of respondents, each city's industrial structure is heavily shaped by its resource endowment, historical strategic focus, as well as other socio-economic capacities. These things are not likely to change quickly, if changing at all, with the city cluster formation and its call for integrated development.

Meanwhile, some investors expressed a more positive view about the potential influence of regional integration on industrial alliance formation. To quote one of these respondents, the "city cluster's heavy focus on pollution management and efficient resource utilization gives a strong push for the involved regions to relocate their heavy polluters and eliminate excess production capacity. This process will unavoidably involve inter-jurisdictional conversations on industrial restructuring" (Interview No. 11). However, these more optimistic views represent that of the minority. As shown in Figure 2-3, the majority of the respondents were unsure about how the formation of the Central China Triangle would influence the different areas of joined-up governance.

Collaborative environmental management (CEM) is not one of the first things that VC investors tend to associate with city cluster development. However, somewhat surprisingly, all of the respondents were immediately receptive to the fact that CEM was one of the six critical goals set by the Central China Triangle Plan after being informed about it. In other words, they did not find it unnatural to see this environmental-management-focused target bundled up with a plan that seems otherwise more economically-oriented. This is very different from the first reactions of the western scholars, whom I talked to during my preliminary research, and demonstrates the fact that it seems easier for the government to establish legitimacy for what it does in an authoritarian regime (Xu, 2018).

To elaborate on the respondents' perceived associations between regional integration and CEM, a few of them believe that a city cluster construct could help "amplify the importance of CEM and establish CEM's credential in actual practices" (Interview No. 4, No. 5 & No. 8). At the same time, other investors remained more reserved regarding the additional value brought to CEM by the discussed regional integration plan. They pointed out correctly that "city cluster formation is not a pre-requisite for CEM," (Interview No. 10) and brought up the fact that "government's calls for CEM were also found in other strategic long-term plans that were unrelated to city cluster formation" (Interview No. 9).

Investing in China's cleantech SMEs

All of the respondents mentioned the fact that China's environmental management services are not privatized, and Cleantech SMEs almost certainly need a stable connection with the government, which brings market demand for their products and services, to survive and thrive. This government-led and policy-driven nature of the cleantech business is not desirable at all in the eyes of VC investors, because it makes it very difficult to forecast future market demand and earnings potential for an investment target firm in this industry. A few investors provided specific instances where a seemingly plausible investment deal fell apart after they realized that even the much-touted public-private-partnership (PPP) might not guarantee a stable cash flow (Interview No. 1 & No. 6). In a few other cases, investors mentioned that while some high-potential cleantech SMEs had accounts receivable that looked healthy on financial statements, their actual cash flows were very problematic mainly because their customer (in this case: the government) were very tardy with their payments (Interview No. 3, No. 4, No. 5, & No. 8). In fact, in recent years, more and more originally-promising PPP projects have been in dire straits, causing some cleantech firms to be on the verge of bankruptcy, because some local governments found themselves running out of their budget and being unable to reimburse project developers, after cleantech SMEs already completing the projects and pre-paying lots of the expenses (Interview No. 1, No. 3, No. 4, No. 5, No. 6, & No. 8).

To further complicate the decision-making behind cleantech investment, the natural resources and energy sectors have been rife with corruption. Since the 18th Party Congress in November 2012, large numbers of senior executives in coal, petroleum, natural gas, and electricity have faced corruption allegations (Figure 2-4). Given the intertwined relationship between the cleantech industry and these sectors, a few high-level investment managers told the truth that they have chosen to shrink their cleantech investment portfolio in recent years, despite understanding the potential benefits that these investments would bring to the environment and the general society (Interview No. 1, No. 3, No. 4, No. 5, & No. 8).

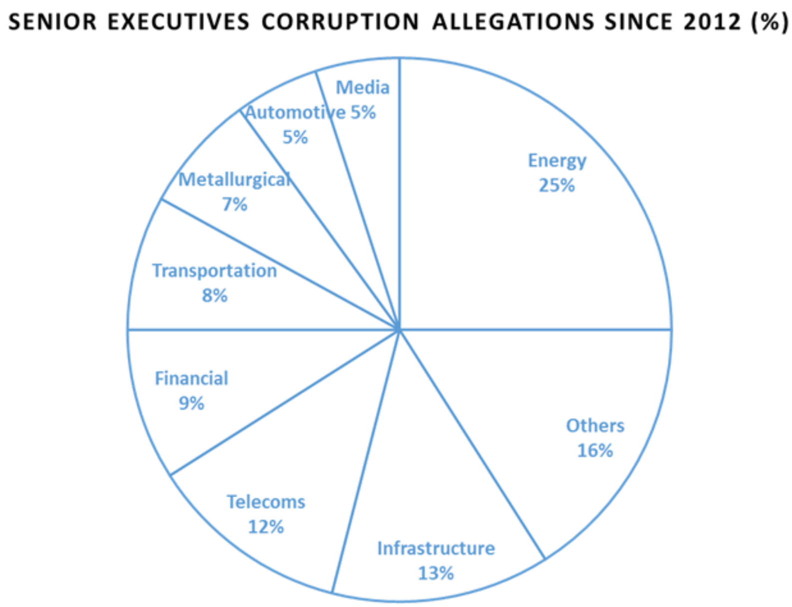


Figure 2-4: Senior executives corruption allegations since 2012 (source: China News Service)

The announcement of Clean Air Act, Clean Water Act, and Clean Land Act (in the Year 2013, 2015, and 2016 respectively) in China and the promotion of PPP have brought excitement to the cleantech industry and their investors in recent years (Interview No. 1, No. 3, No. 4, No. 6, No. 8, No. 10, & No. 14), but this excitement has not sustained VC investors' increasing interests in making cleantech investments for the following reasons. First, the nature of many cleantech SMEs' businesses does not precisely match with VC investors' preferences (Interview No. 1, No. 4, No. 6, No. 8, No. 9, & No. 10). Many firms in the cleantech industry are asset-heavy firms that do not adapt quickly to market changes. It takes very long for the return on investment to set in, and it is an industry that has relatively low average revenue multiple (or in layman terms: little chance to gain abnormally high returns). To quote one of the very senior-level investors, "we always keep our radar on for interesting cleantech projects, but in what area to invest? We simply do not find enough firms with truly cutting-edge technologies or innovative capacity that appeal to us" (Interview No. 3).

Second, due to the lack of guidelines on project eligibility and lack of performance evaluation matrix for projects that involve government-industry collaborations, PPP has been over-exploited for environmental service provision in recent years. Sometimes, out of their urgent needs to alleviate financial stress through private capital mobilization, local governments recklessly market some environmental services requests as PPP projects. What ended up happening in such PPP projects was that, the investors realized later that they were expected to bear with risks of dealing with bad debt or the possibility of a sudden withdrawal of government participation (Interview No. 1, No. 6, No. 8, No. 9, No. 10, & No. 14). In the eyes of the VC investors, the government seems to have a misunderstanding of what kind of risks that the venture capital firms are “venturous” with when calling for greater VC capital engagement.

Besides, the central government’s two-year anti-leverage pushes, an issue that I discussed earlier, and the more stringent requirement on shareholding reduction have made venture capital investors all the more cautious when looking at the cleantech SMEs (Interview No. 3, No. 4 & No. 8).

<u>City cluster development's influence on cleantech investments</u>

VC investors expressed mixed views regarding whether or not regional integration plans, such as the formation of the Central China Triangle, were significant policy changes that would influence their overall evaluation of the cleantech industry's investment opportunity and investment environment. A few of my interviewees explicitly mentioned that the formation of the Central China Triangle would probably encourage them to pay more attention to this region's cleantech industry (Interview No. 3, No. 5, & No. 15). A few others provided examples of increasing cleantech market demand that was directly driven by the formation of the Central China Triangle (Interview No. 6, No. 11 & No. 16). However, the majority of the respondents did not see an obvious connection between city cluster development and their perceived cleantech market environment. Also, even for those respondents who were more positive about the potential influence of city cluster formation on cleantech development, they all pointed out that such influence is not unique to the cleantech market (Interview No. 3, No. 5, No. 6, No. 11, No. 15, No. 16). In other words, the same cause-effect relationship may apply to the other industries as well, for instance, telecommunications and healthcare, to name just a few. In their view, the process of city cluster formation will likely provide a conducive environment for resource integration, and create more favorable conditions for technological innovation and industrial upgrading. These positive changes, if realized, will be beneficial for the development of all industries.

Besides, a few of the respondents raised their concerns that these regional integration plans may exacerbate inter-regional inequality rather than reducing it. In their views, these regional integration plans may inevitably result in the resources (both human and capital) flowing from rural areas to urban areas, and from smaller cities to larger cities, defeating its original goal of lifting the left-behind regions (Interview No. 3, No. 4, No. 6, No. 9, No. 11, No. 17).

More importantly, there was unanimous agreement among the VC investors that these city cluster development plans have minimal influence on their project-level decision-making in cleantech investments. The figure below presents the two main points that resonated among all respondents. First, firm-level characteristics are what matter the most to investors' project-level decisions, outweighing all other factors. Second, to the majority of VC investors, cleantech SMEs face a national market to start with, so changes in regional-level policies do not necessarily affect their risk and return evaluations regarding cleantech investment. It is true that the figure below implies only the fact that regional-level policy is a much less important determinant of investors' decisions as compared to the other two alternative factors, and not that city cluster formation is not important at all. My overall feeling after having in-depth discussions with the investors was that they agreed with the potential cause-effect relationship between regional integration policies and their investment choices in a ritual sense, but nothing beyond that.

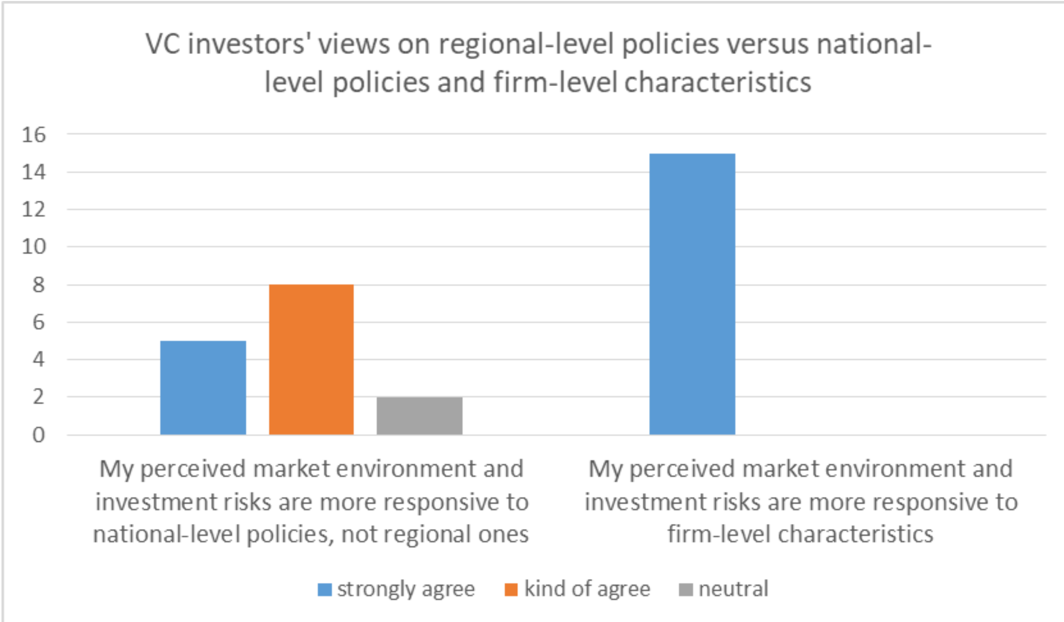


Figure 2-5: VC investors' views on regional-level policies versus national-level policies and firm-level characteristics

CEM's influence on cleantech investments

Investors' views on CEM's influence on the overall cleantech market mostly follow the findings that I discussed in the previous section. They view CEM as something that provides a conducive environment for resource integration and creates more favorable conditions for technological innovation and industrial upgrading. This improvement in the overall market environment would then potentially benefit all industries, including cleantech businesses. Besides, most of the respondents agreed in general with a causal mechanism that some existing literature suggested (De Jager et al., 2011; Bergek et al., 2013; Chassot et al., 2014; Polzin et al., 2015). Following these researchers' lines of argument, the government's call for CEM may serve as a long-term policy commitment, and may potentially reduce institutional investors' perceived market uncertainty, political risks, and regulatory risks in the cleantech industry.

However, while these researchers found that institutional investors' actual cleantech investment would likely to increase, because their favorable perceptions of the market stability, reliability, and predictability will positively influence their evaluation of the cost of capital and the stability of cash flows, my findings did not support these arguments. Instead, the respondents' answers showed that reduced risks in the general market environment alone do not guarantee a favorable change in their return-on-investment evaluation or an increase in the actual cleantech investment (Interview No. 1, No. 3, No. 4, No. 10, No. 12, No. 13, & No. 14). To quote a vice president who had more than 15 years of experience investing in the cleantech market, "the general environment matters, but what really drives our decisions are: how we feel when talking to a potential target firm's business leaders, what we find in their financial statements, and how many loopholes there are when a due diligence investigation is performed" (Interview No. 3).

Interestingly, investors' perceived CEM's influence on cleantech investments was quite different from what I just highlighted when they were provided with specific examples of CEM practices. In other words, VC investors' perception of CEM in theory (as a broad concept) turned out to be very different from their perception of CEM in practice (as specific illustrations). More importantly, they viewed some aspects of CEM as being more relevant to their decision-making than others. To elaborate, when I asked my respondents to rate "how do the following examples of CEM affect your perceived investment risks in the involved regions' cleantech industry on a scale of 1 to 5 (from least likely to the most likely)", all of them gave at least a "3" to Bullet A, B and F, and forty percent of them independently brought up the same point that these three aspects of CEM could potentially influence not only their perceived market risks but also their actual project-level investment decisions. This is because, in their views, these selected CEM practices may help to establish the reliability of cleantech SMEs' market demand in the involved regions, and hence give them more confidence in making risk and return projections (Interview No. 4, No. 6, No. 8, No. 11, No. 13, No. 14).

A. Information-sharing among neighboring cities (including e.g. key polluters' emissions behavior, cleantech firms' credit history, environmental impact assessment (EIA) information, etc.)

B. Harmonization of the environmental standards and regulations with the neighboring cities (e.g. pollutant emissions standards and EIA evaluation criteria)

C. Joint-establishment of cleantech industrial park

D. Knowledge sharing and talent exchange among government agencies and research institutions, collaborative research on energy efficiency, renewable energy deployment and pollution remediation

E. Public-private partnership in building better investment/financing platforms for the cleantech firms

F. Local environmental protection bureaus' joint monitoring of pollutants, joint response to environmental hazard mitigation, and joint enforcement of environmental standards and regulations.

Although no quantitative analysis can be performed to check the "statistical significance" of my findings, my results are quite robust because of the followings: first, the results from my other six interviews, i.e., the ones with cleantech industry analysts and cleantech firm leaders, corroborated with VC investors' views regarding CEM's potential influence on cleantech investments. One of these cleantech firms that I spoke to was a major supplier of air pollutant monitoring equipment in China. Its CFO explicitly mentioned the significant improvement in local-level regulatory enforcement and polluters' compliance in recent years, after the central government and local environmental protection bureaus collaborated on conducting nation-wide inspection tours (Interview No. 19). Besides, two of the interviewed cleantech market analysts pointed out that cities' CEM effort, if resulting in stronger regulatory enforcement power, may inspire technological advancement and innovation in the area of pollution control technology and attract additional institutional investors' attention to this field (Interview No. 7 & No. 10).

Second, I looked through one VC firm's archive of past projects and was able to find instances where collaborative environmental management effort across jurisdictions had affected investors' decisions. For instance, in one of the investment proposals, a reason why the investment managers made the recommendation to invest in a firm doing water pollution control was that the local jurisdictions in which this business was operating were diligently practicing the "river-master system" (or "He

Zhang Zhi" in Chinese). This river management framework is an experimental CEM practice that was recently adopted in some parts of China. Designated persons are in charge of specific sections of a shared river, and the allocation of responsibility is done collaboratively.

Third, I looked at other elements from the Central China Triangle Plan, which were designed to speak directly to the venture capital investors (for example, the call for creating a government-led investment fund for cleantech businesses), and I asked the respondents to compare the potential influence of these policy elements on their cleantech investment decisions with that of CEM. There was unanimous agreement that these other elements were not new and additional to what was already happening in the cleantech market. In other words, investors did not see how any of these directly-relevant policy elements would change their evaluation of the general cleantech market environment or their project-level investment decisions.

Discussion and Conclusion

This study echoes the existing literature, which shows that environmental-related long-term policy commitment appears to allow institutional investors to perceive greater market stability, less political risks, and less regulatory risks. It also corroborates with the very recent study on how policies mobilize private finance, showing that effective policies should address risk and return simultaneously.

On top of that, my research brings unique contribution to the existing literatures in the following ways:

First, it shows that information sharing, uniform standard setting, and joint monitoring and law enforcement are specific elements of collaborative environmental management practices that could potentially boost investors' perceived return on cleantech investment, because these aspects of CEM help establishing the reliability of cleantech SMEs' market demand in the involved region, giving VC investors more confidence in making projections when doing risk and return evaluations for a potential target firm. This enriches the existing literature in this realm, which has mainly focused on the risk side of the equation and shows that "generic instrument design features, such as credibility and predictability (e.g. continuous evaluation and monitoring) considerably impact investment risk" (Polzin et al., 2019).

Second, this study showed that it is worthwhile to look beyond just the direct financial derisking measures or fiscal incentives provision when trying to influence private investors' perceived risks or returns, because other policies (in this case, effective practices of the collaborative environmental management model) also appear to positively influence private investors' perceived return on investment. These findings shed some light on some of the prospective channels that policy makers may use to mobilize private finance in the future.

Moreover, while most of the existing literatures on VCs' investment decision-making focuses on their experiences with the renewable energy industry, this research filled in this gap by investigating VC investors' perceptions of investment risks and opportunities in the broader cleantech industry, and also paid special attention to their involvement with the pollution control related businesses. This adds values to the existing knowledge because renewable energy industry's capital structure and return portfolio is hugely different from that of a pollution control business or a cleantech firm that does not focus on renewable energy development.

Last but not least, two other observations came out of my findings. One of them is the need to build up supportive mechanisms for CEM implementations, because many of the interviewed investors raised their concerns on the difficulties of implementing inter-jurisdictional CEM in practice. To them, it would be unlikely for different jurisdictions (especially across provinces) to truly collaborate on environmental management on all fronts given how difficult it is for each city to balance the perpetual push-and-pull between environmental management and other socioeconomic development goals on its own. Having said that, some of these same participants also said that a key determinant behind these potential compliance/defiance behavior for CEM is the strength of the central government's enforcement power. They elaborated this point by referring to the observable improvements in local-level environmental management practices, which resulted from the recent rounds of nation-wide environmental management inspection tour, an effort that was led by the Ministry of Ecology and Environment and coordinated among the local governments and EPBs.

The other takeaway is the need for the government to be more explicit and elaborative in their language when writing long-term strategic plans. Chinese policy makers have had the tendency of being really vague in defining goals and laying out implementation roadmaps, which is not helpful for the targeted audience.

Chapter 3

Did cities within major clusters have better average air quality in 2017 than their outside-cluster counterparts? Can differences among cities' air quality be explained by differences in their local EPBs' resource adequacy and their capacity to enforce regulatory compliance?

Introduction and Motivation

The enforcement-compliance mechanism is believed to be one of the most important channels through which government authorities can reduce the impact of economic activities on the environment (OECD, 2009a). Compared to voluntary compliance, which stems from social norms and intrinsic motivation to "do good", enforcement tools have the ability to forcefully alter the probability of offence detection, the probability of sanctions if offences are not corrected, and the severity of sanctions, and hence tend to be more efficient in driving compliance (OECD, 2006).

This research aims to answer whether cities' "membership" to regional economic integration plans are likely to affect their local environmental protection bureaus' regulatory enforcement capacity, and as a result influence these cities' average air quality outcome. My hypotheses are: the two city groups should exhibit observable variations, both in terms of how the enforcement-compliance mechanism functions, and how this mechanism is influencing environmental outcomes.

China's environmental governance structure and the role of environmental protection bureaus

China's environmental administration is a multi-layered institutional structure with territorial divisions at the central, provincial, city, county, township, and village levels (OECD, 2006). At the top, the Ministry of Ecology and Environmental Protection, directly under the State Council, is empowered and required by law to design environmental policies and enforce environmental laws and regulations. Then, to take forward the vision of MEP on ground level, the different Environmental Protection Bureaus (EPBs) interpret the environmental protection plans and integrate them into the local economic and social development plans. The local EPBs respond to environmental complaints and coordinate with different units of local governments in endorsing environmental regulations. In addition, they are also in charge of environmental quality monitoring, environmental reporting and initiating enforcement activities against firms that fail to meet environmental requirements.

In air pollution management, the local EPBs often collaborate with other governmental agencies (for example, agencies under the economic development branches and law enforcement agencies) for strategic planning and law enforcement, but it remains the backbone of this environmental management service.

Notice that although local EPBs are structurally a direct subordinate of the Ministry of Ecology and Environmental Protection, "they are institutionally and financially subordinate to provincial and local governments" (OECD, 2006), and hence their decisions and actions are not at all independent of the preferences and priorities of the local governors. This poses significant challenge for environmental management at the local level because different government units may not necessarily agree with each other in setting their policy objectives, and end up with a perpetual "push-and-pull" between prioritizing environmental management and emphasizing other socioeconomic development goals.

Having said that, the Chinese government is aware of the exact conflict of interest that is potentially associated with its decentralized multi-layered environmental governance structure, and has taken important measures in recent years to improve the situations. For example, many provinces and cities in China have started to include environmental performance related indicators in evaluating local cadre's performance since the 2000s (Zheng et al., 2014), and in recent years, China's Ministry of Ecology and Environmental Protection has put greater emphasis on "direct and vertical control" over the local EPBs.

The enforcement-compliance mechanism's role in environmental management

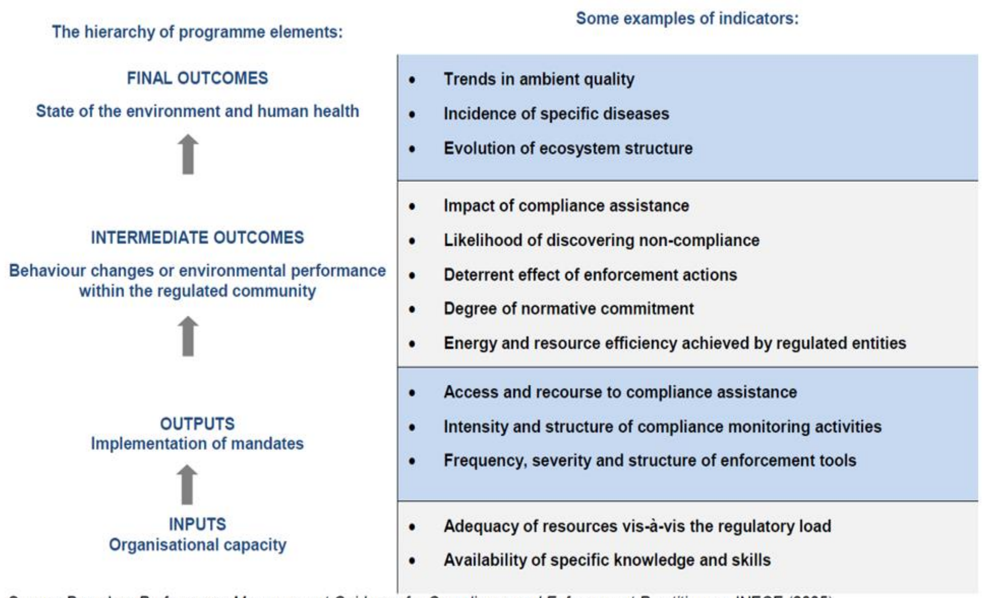
In many countries, the current environmental management regulatory environment sometimes leads to a less than socially optimal level of management outcome (Burnett and Mothorpe, 2018), and as a result, monitoring, control, and surveillance actions are believed to be important measures that promote effective environmental management (Miller et al., 2013; Gottinger, 2001). Enforcement-compliance is a critical part of the international environmental regime, including the European Union's Emission Trading Scheme (EU-ETS), the US SO2 emission trading program, and the Kyoto Protocol (Aakre and Hovi, 2010). It is also a mechanism that is commonly applied around the world for domestic environmental management (El-Zayat et al., 2006; Tallberg, 2002; Smith, 1999; Estrada, 2017; Boakye, 2015; Yasamis, 2007; El-Zayat et al., 2006), and has broad applications in many areas including marine ecosystem services and biodiversity protection (Tonin, 2018), air pollution management, stormwater management (Burnett and Mothorpe, 2018), mineral mining (Sajwani & Nielsen, 2017), and hazardous waste treatment (Stafford, 2016; Cookey et al., 2016).

Theoretically, enforcement-compliance is a policy tools that emphasizes “the deterrence of noncompliance through inflexibly imposed sanctions” (Earnhart and Glicksman, 2015), and it works the best when enforcement tools are supported by management mechanisms that engage the regulators and regulatees in a collaborative problem-solving approach (Tallberg, 2002; Earnhart and Glicksman, 2015) However, this mechanism has had various degrees of success based on empirical studies. Some shows no statistically significant relations between environmental enforcement and inspection activities and compliance outcomes (Smith, 1999; Cookey et al., 2016), others find supportive evidence that local enforcement activities encourage adoption of environmental management systems and environmental compliances behavior (Stafford, 2016). In countries where the institution of law is weak, firms’ decisions of adopting basic and proactive environmental management practices are heavily driven by their perceived strength of the regulatory environment and their evaluation of the potential punishments that come with regulation violations (Yee et al., 2016). Very often, the penalties for non-compliance are not a credible threat for the violators, and regulatees simply refused to comply without feeling any consequence (Hovi et al., 2012).

In addition to answering whether enforcement measures drive compliance behavior, some recent literatures have also started to understand how enforcement measures influence compliance behavior (Gray & Deily, 1996; Lee & Alm, 2004; Ruhl, 2000; Jackson-Morris et al., 2016; Walters et al., 2015). Meanwhile, other scholars have discovered some important reasons behind the very heterogeneous regulatory stringency level and degree of compliance when it comes to environmental management. They show that: enforcement activity is often targeted towards frequent violators and larger firms with business operations in poor and dense municipalities, but not the more profitable firms (Escobar & Chavez, 2013). They also find that plants with high abatement costs and those that are new comply less frequently (Gupta et al, 2019; Duflo, Greenstone, Pande, & Ryan, 2018), and enterprises with different ownership styles and different political influence tend to have different environmental compliance costs (Xu et al., 2019). However, in these studies, the unit of assessment is often individual polluters or firms, and not cities; and the measure of enforcement or compliance is often single-dimensional. More importantly, the enforcement-compliance mechanism's impact on final environmental outcome is also unclear.

Evaluating the effectiveness of the enforcement-compliance mechanism

Performance measurement guidance for compliance and enforcement practitioners have existed for years (INECE, 2005; OECD 2009a), the lack of universal performance evaluation rubrics and the limited data transparency have made it almost impossible to conduct such studies in actual practice. Evaluating the effectiveness of the enforcement-compliance mechanism is easier said than done because it poses subsequent questions on how to capture the progress in capacity building and how to conduct performance evaluation for environmental management in general. None of these questions has an obvious solution.



Source: Based on *Performance Measurement Guidance for Compliance and Enforcement Practitioners*, INECE (2005).

Figure 3-1: Indicators that could measure elements of the enforcement-compliance mechanism, source: (INECE, 2005)

"Environmental management capacity building" has been a popular buzzword in the policy making world for the last two decades. While the focus of many of these capacity building projects has catered to the needs of the developing countries, environmental management capacity building is an issue of upmost interest to more developed countries as well. In fact, it is one of the areas that draws the most attention and resources from international organizations as well as local governments. To give just a few examples, the Sustainable Development Goals Partnerships Platform established a special initiative that aimed to build capacity at the local government level "for implementation and application of Environmental Management Systems

(EMS) as effective and strategic tools for improving the environment" almost two decades ago, in 2002. The recently adopted Paris Agreement has languages that specifically discussed its plans on "addressing gaps and needs, both current and emerging, in implementing capacity building" in participating country Parties. The World Bank also has programs, like the Partnership for Market Readiness, which help major economies and key market players to improve their capacity in designing market-based approaches that will help them more effectively achieve the climate change mitigation objectives. There is general consensus that developing countries' challenges with environmental management capacity building are much greater than that of the developed countries.

Having said that, if we were to take one step back and ask the following two questions: what do we mean by "capacity building"? How to define "capacity"? Answers to these questions remain vague despite the time and resources that have been spent in this area of research. Very often, researchers and practitioners proceed to discussing "the objectives of environmental management capacity building" without providing a definition for capacity or capacity building. For those that do discuss these terms in greater detail, the definitions they provide are always different from one another (see Appendix 3-1 for typical components of an environmental management capacity building program), and very few of them mention what can be used as potential indicators or evaluation matrix to measure capacity building programs' progress or development.

The vagueness and ambiguity that is in its definitions has much to do with the complicated and multi-faceted nature of capacity building. First, many stakeholders can get involved in this process, for example: government agencies, NGOs, local communities, and research institutions, and capacity building means different things to these different participants. Second, capacity building could happen at multiple levels - internationally, nationally, or locally- simultaneously or consequentially. Moreover, definitions for capacity building change depending on the context in which it is being discussed. For example, capacity building in water resource management may not be the same as capacity building in air pollution management (see Appendix 3-2 for the different areas of environmental management where capacity building could be relevant). Consequently, many details regarding capacity building remain hidden in a black box, waiting for researchers to explore.

As for environmental management performance evaluation, Dr. Metzenbaum's study in 1998, titled "Making Measurement Matter", was one of the first to comprehensively explore the challenges and potentials of building a performance-focused environmental protection system. A lot of her guidelines – for example, the need for a performer-specific measures, the need for user-focused performance measures, and the need for user-friendly measures in selecting performance measures – are still useful and relevant in today's context. Many of the potential tensions and challenges that she mentioned 20 years ago– such as the resistance to reporting and the uncertainty of performance targets – are some of the very challenges that researchers still encounter today in environmental management performance evaluation.

This is not to say that environmental management performance evaluation has not made any progress over the years. For example, the United States Environmental

Protection Agency (EPA) started regularly producing evaluation reports for its commissioned programs since the early 2000s. These programs cover a wide variety of areas (ranging from air, waste, and water, to enforcement and compliance assurance and environmental justice), and their evaluation reports are accessible to the general public. In addition, to help the EPA work efficiently, the Government Accountability Office regularly checks in with the EPA to offer recommendations on how to better manage its workload, workforce, budget, and so on. As for China, in an effort to promote greener economic growth, many provinces and cities have started to include environmental performance related indicators in evaluating local cadre's performance since the 2000s (Zheng et al., 2014).

There is broad consensus internationally that evidence-based performance evaluation drives better policy and policy making process, yet substantiation remains thin due to various challenges to designing and implementing relevant studies . So, as what was mentioned previously, even though guidelines for key performance indicators' design and selection have existed for years, for many aspects of environmental management, the lack of universal performance evaluation rubrics and the lack of data transparency have made it almost impossible to conduct such studies in actual practice, especially in the context of developing countries.

City cluster formation's potential influence on enforcement-compliance and environmental outcome

Not enough attention has been paid to the true logic behind China's city cluster formation, or the exact causal chain through which such regional integration plans could bring better environmental management practices and improved environmental outcome, but it is widely speculated that cities within the strategically developed clusters receive greater attention from the central government and tend to be the “first in lines” when the central government designate special funding or provide general budgetary support, and it is also believed that members of the city clusters are more likely to have a conducive environment for resource integration and regulatory enforcement (through collaborative environmental management practices such as uniform standard setting, and joint monitoring and law enforcement). This gives me reasonable confidence to suspect that the enforcement-compliance mechanism, a salient channel that captures the influence of capacity changes on enforcement-compliance and environmental outcome as illustrated by the INECE (2005), could be a reasonable causal chain that helps us understand the impact of this city cluster formation experiment on environmental management.

Having said that, there is not enough empirical studies on CEM’s impact on actual environmental outcomes. Ample literature touts the benefits of CEM, but the most crucial questions often remain unanswered or unasked: to what extent does CEM work? Does CEM lead to improved environmental outcomes (Koontz & Thomas, 2006)? Huang et al. (2015) and Li et al. (2017) were among the handful of scholars who examined CEM’s impact on air quality outcomes. Their studies found suggestive evidence that CEM efforts during the APEC summit did alleviate the air pollution problem for the involved region; however the policy context that they studied was a short-term one-off event that makes it hard to establish external validity for its findings or use these findings to inform CEM practices in other contexts.

Zhong et al.'s study (2013) on the impact of Pearl River Delta Regional Air Quality Monitoring Network remains the closest research, which used air quality trends to demonstrate the importance of regional collaboration in addressing air pollution problems.

The present study

This research aims to answer whether cities' "membership" to regional economic integration plans are likely to affect their local environmental protection bureaus' regulatory enforcement capacity, and as a result influence these cities' average air quality outcome. In other words, the construction of city cluster can be viewed as an experiment that has the potential of bringing positive institutional and functional changes to environmental management, and use empirical evidence to test whether this hypothesis is true. It is important to look at the actual environmental outcomes on top of the process outcomes because "if compliance is achieved without environmental improvements, it gives a clear indication that the regulatory requirements should be revised" (OECD, 2009a).

To tie it to the overall theme of the dissertation, since it is believed that members of the city clusters are more likely to have a conducive environment for resource integration and regulatory enforcement (through collaborative environmental management practices such as uniform standard setting, and joint monitoring and law enforcement), in this study, I am using the enforcement-compliance mechanism as a proxy that somewhat reflects cities' degree of CEM practices, and I am looking at whether cities' "membership" to regional economic integration plans is likely to affect how this mechanism functions, and as a result influence these cities' average air quality outcome.

Since I analyze not only whether cities within major clusters have better average air quality outcomes than their outside-cluster counterparts, but also whether differences among cities' air quality can be explained by differences in local EPBs' enforcement and compliance mechanisms between these two studied groups, a combination of ordinary least square regression and structural equation modeling (SEM) is used for quantitative analysis.

OLS regressions are powerful in estimating the mean of the dependent variable given specific values of the independent variable(s), and hence are used to analyze the cumulative influence of city-cluster-membership has, directly or indirectly, on environmental outcomes.

Meanwhile, given the fact that there are multiple categories of variables involved in the mechanism that is suggested by the International Network for Environmental Compliance and Enforcement (INECE, 2005), and these variables are related to each other sequentially (either directly or indirectly) in a linked system, I use Structural Equation Modeling (SEM) tools to study how the variables vary and co-vary with each other because SEM allows modelers to analyze the impact of city cluster formation and compliance assurance at each stage and at the end of the regulatory chain, and allows simultaneous analysis of all the variables of interest (Fornell & Larcker, 1981; Chin, 1998).

It is important to mention the fact that despite the great promises that SEM presents to study direct and indirect structural linkages among a large number of variables in a holistic approach, very few studies have used this powerful methodology to explore the very many mechanisms that are part of the complicated environmental management system. The application of this method, closest to the realm of environmental studies focuses on answering questions such as indoor air problems and the perceived social climate in schools or workspace (Finell et al., 2018) So, this study is one of the first that makes use of SEM tools to look at the mechanisms through which a policy change or a new experiment in governance model could be exerting its influence on environmental management system and environmental outcome.

Methods and Data

<u>The model (as represented by the path diagram)</u>

Based on the enforcement-compliance mechanism that the International Network for Environmental Compliance and Enforcement proposed (see Figure 3-1), I designed a model (see Figure 3-2 below) that captures how local EPB's resource adequacy may affect its enforcement power, which then influences industrial polluters' compliance behavior within the regulated community and makes a difference in the locality's average air quality outcome. Notice that while the INECE-suggested theoretical model uses the very generic term "organizations" as the agency behind its causal chain, in my empirical model construction, the causal chain is formed around the local environmental protection bureaus. This is because local EPBs are the most important players in cities' air quality management practices. Similarly, instead of talking in terms of "regulated community" in general, I narrow the scope of regulatees to mean just the air-polluting industrial enterprises that are located within the regulated jurisdiction. This is partly due to data feasibility issues, and partly due to the fact that they are the main contributors of many local air pollutants, including dust, SO2, and PM2.5.

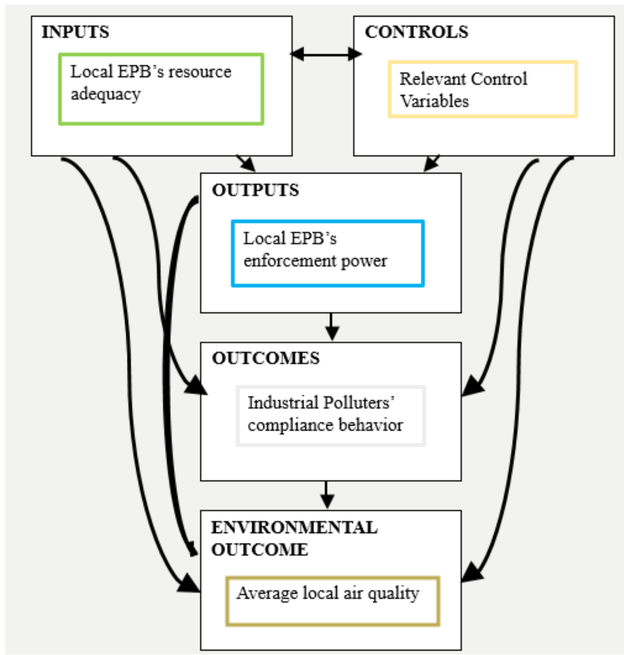


Figure 3-2: the empirical model behind my statistical analysis

To elaborate on my empirical model's setup: first, the five rectangles that I use in Figure 3-2 represent blocks of measured variables that underlie the theoretical priori (i.e. the enforcement-compliance mechanism) under study. In total, my model has six measures of EPB's resource adequacy, six measures of EPB's enforcement strength, four measures of industrial polluters' degree of compliance, and seven measures of air quality outcomes. These variables were selected mainly based on existing literatures' guidelines (OECD, 2009a; INECE, 2005), but were tailored based on the nature of air pollution control and Chinese cities' actual data availability. In addition, since research shows that it is important to control for cities' socioeconomic characteristics when analyzing the potential impact of policy changes or environmental governance capacity on air quality management (Zheng et al., 2014; Zhang & Wu, 2018; Liang & Langbein, 2015; Zhang et al., 2017), I incorporated nine linear control variables directly into my model and made sure that whatever parameter estimates that I would get from this modeling exercise have been purged of the linear effects of the control variables.

Second, this model assumes the form of a measured variable path analysis (MVPA), and does not categorize the measured variables into unobserved factors or latent variables. This is because, when a Confirmatory Factor Analysis was attempted, using the observed data as indicator variables of latent factors along the enforcement-compliance causal chain (namely: resource adequacy, enforcement strength, degree of compliance, and air quality), construct validity tests and construct reliability tests suggest that only the air quality factor is stable, replicable, and represents what it purports to measure (Fornell & Larcker, 1981; Hancock & Mueller, 2001; Hancock & Mueller, 2003).

Third, each of the arrows in this path diagram represents my hypothesized structural or non-structural linkages (i.e. sources of correlations) between any pair of the measured variables. For instance, the single-headed arrow flowing from "local EPB's resource adequacy" to "local EPB's enforcement power" means that it is hypothesized that there is a cause-to-effect relationship between each and every measured variable within the resource adequacy block and all the different indicators of enforcement power. Notice that "resource adequacy" measures and "enforcement power" measures not only have hypothesized causal paths that lead to "air quality" measures indirectly, but also have arrows that flow to "air quality" measures directly. This represents my assumptions that, these variables that are positioned near the top of the causal chain may have a direct influence on the environmental outcomes, above and beyond the influences that they bring to environmental outcomes through the enforcement-compliance mechanism. In addition, all of the control variables are allowed to co-vary as exogenous predictors within the model, as depicted by the double-headed arrow between "resource adequacy" measures and "control variables", and each of these control variables has a hypothesized causal path leading to all endogenous variables within the model, which allows me to purge their linear effects when examining parameters of main interest. Meanwhile, intermediate variables' (i.e. "enforcement power" measures and "degree of compliance" measures) error terms are allowed to co-vary within their respective groups because there are reasons to believe that these measured variables have additional associations among themselves other than the fact that they are indicators from the same group.

All in all, I created a just-identified model that has the same number of parameters to be estimated as pieces of unique information in the variance-covariance matrix. Although the lack of degree of freedom in this model is not ideal with respect to model parsimony, this model was designed in this way to avoid model misspecification caused by omitted variable relations.

Sample and Data

Our sample contains 137 cities, geographically spread over 17 of China's 32 provinces. The number of cities that was picked from each of these 17 provinces varies, and the full details of sampled cities' geographical distribution are provided in Appendix 3-3.

To elaborate on my sampling methodology: for the "treatment group", all cities that are part of the following three major city clusters - the Central China Triangle, the Yangtze River Delta, and the Pearl River Delta- are selected. Central China Triangle is the first city cluster approved by the State Council after China rolled out its New Type Urbanization Scheme in 2014, and there is currently a lack of empirical research on this policy experiment's actual procedural outcomes (i.e. the positive institutional and functional changes it brings to the involved localities' environmental management) or its impact on environmental quality. As for the Yangtze River Delta and the Pearl River Delta, they are older city clusters in China that supposedly have had more extensive experiences with collaborative environmental management. Including cities from these two older clusters not only increases my overall sample size of the treatment group (i.e. the clustered cities), but also minimizes the chances of me observing no policy effect as a result of the Central China Triangle being too new. In total, 69 cities fall under this treatment group.

As for the "control group", two types of control cities – internal controls and external controls – were included in my study. The internal controls include 33 cities that come from the same regions as those cities under the treatment group, but were not part of those city clusters. The external controls consist of 35 cities from selected regions that had no formally-approved national-level city cluster as of 2017.

While the assignment of "treatment group" versus "internal controls" follows directly from the policy packages that guided the formation of my studied city clusters, the sampling of "external controls" is a bit more subjective. To summarize the rules that were followed in selecting this group of cities: first and foremost, candidate cities need to be somewhat comparable with cities under the treatment group in terms of their administrative level, development status, and economic structure. Second, candidate cities are preferably those that receive comparable amount of outside pressure for environmental management, and so, loosely speaking, more likely to have comparable extrinsic motivations for pollution control. Third, candidate cities should perform reasonably well in terms of their pollution information disclosure.

Several sources helped me determine whether a city has met the above-mentioned eligibility criteria. This includes the China City Statistical Yearbooks, the Ministry of Ecology and Environment's "Frequently Monitored Cities for Air Quality Management", and the Pollution Information Transparency Index (PITI), an index developed by the Chinese NGO called the Institute of Public and Environmental Affair (IPE) in 2009 for an annual ranking of 133 Chinese cities by their level of environmental pollution information disclosure.

In addition, my study did not include cities from the very well-known Beijing-Tianjin-Hebei city cluster because of the following reasons. First, all the cities in Hebei are involved in this regional integration plan, offering no internal controls.

Second, the remaining two cities (i.e. Beijing and Tianjin) are two of the four so-called "directly-governed cities" in China that have a higher administrative status than that of the cities in my sample, and existing research shows that gaps in administrative level among collaboration participants tend to complicate collaboration efforts (Yi et al., 2017).

Moving on to introduce this study's data collection process: first, the existing literatures was used as a guideline, looking at suggested indicators for the different blocks of variables along the enforcement-compliance mechanism (OECD, 2009a; INECE, 2005; Zheng et al., 2014; Zhang & Wu, 2018; Liang & Langbein, 2015; Zhang et al., 2017). I then explored whether there is actually high-quality data that would allow me to construct such indicators in the sampled cities that I have chosen.

Many different data sources were used to develop the measured variables for my structural equation modeling exercises. Information for the socioeconomic variables were taken directly from China's City Statistical Yearbook and each city's statistical bureau. Measures on local EPB's resource adequacy, enforcement power, and industrial polluters' compliance behavior were constructed independently by ourselves based on budgetary reports, listings of EIA processing status, polluters' inspection reports, emissions fee filing ledger, and violation tickets issuance records. The information on violation tickets was accessed through IPE's online portal. The rest of the information was gathered from each city's EPB website. As for the air quality indicators, I thank the Shanghai Qingyue Environmental Protection Center for heavily subsidizing the cost of gaining access to the daily-level air quality data for all the different cities that I studied.

In addition, it is important to highlight that most of these data, except for a few socioeconomic variables, was collected for the Year 2017. At the time of this study, 2017 was the latest year where a full 12 months of information was available. Also, given that the Central China Triangle was formed in 2015 and had its most immediate goals set for 2020, the Year 2017 gives me just-long-enough time to conduct a legitimate mid-term evaluation for this policy experiment's impact. I also need to clarify that, my model was run on a cross-sectional dataset, which consists of yearly aggregated or yearly average measures, and not a longitudinal one that lays out the different months or quarters as different time periods.

While I definitely had the capacity to create more granular measures (i.e. quarterly or monthly indicators) for air quality, there was major issues dealing with missing data when trying to create quarterly or monthly measures for variables that are under the other categories. In fact, missing data was still a major issue even after using a coarser model that runs on yearly aggregated or yearly average values. For measures such as "the average number of days taken to approve an EIA", some cities had information missing at random for the whole year of 2017. For other measures like "the total number of penalty tickets the nationally-monitored polluters received in 2017", I had to first be able to tell the "real missing data" apart from situations where there is actually "no violation behavior being recorded" before proceeding with statistical analysis with the assumption that whatever remains missing is missing at random. After taking all the appropriate measures to deal with the missing data, in my final dataset (which contains 32 measured variables in total), the two measures related to penalty tickets issuance have a percentage of missing values that is slightly below

30 percent, 10 variables have a percentage of missing values that is somewhere between 3 percent and 14 percent, and the remaining 20 variables (i.e. 62.5 percent of the total number of measured variables) had almost full information (See Appendix 3-4 for full information on variables' percentage of missing values).

It is true that this cross-sectional study does not allow me to attribute any potentially observed policy impact to the formation of the national-level city clusters, but it allows me to observe whether there are meaningful differences, both in terms of how the enforcement-compliance mechanism functions, and how this mechanism is influencing environmental outcomes, between clustered cities and the un-clustered ones. Understanding these differences is in itself an interesting and important research question, and is the goal of this study.

All in all, 32 measured variables entered my OLS analysis and subsequent structural equation modeling exercises. The full summary statistics of these variables are provided in Appendix 3-5. Given the big differences in variances and the problems of convergence this caused to the solution of maximum likelihood iterative equations, a few variables were rescaled for modeling purposes, by dividing or multiplying the original values by a constant of ten. Rescaling details are provided in Appendix 3-6.

The tables below summarize, by category, my measured variables' abbreviated names, their exact definitions, and their units of measurement. Following each table, additional information is provided to explain how these variables were constructed, if necessary.

Inputs – Local EPB's Resource Adequacy

Abbreviated Name	Meaning	Unit of Measurement
EPB_2017_TBE	EPB's total budgeted expenditure in 2017	millions of CNY
EPB_2017_PBE	EPB's project-related budgeted expenditure in 2017	millions of CNY
EPB_2017ratio	EPB_2017_PBE / EPB_2017_TBE	percentage
EPB_2016_TAE	EPB's total actual expenditure in 2016	millions of CNY
EPB_2016_PAE	EPB's project-related actual expenditure in 2016	millions of CNY
EPB_2016ratio	EPB_2016_PAE / EPB_2016_TAE	percentage

Table 3-1: Table of Input variables

All of the resource adequacy measures were created using local EPBs' budgetary reports, which seem to be the only credible sources of information on EPBs' financial capacity that are commonly available across most of the cities. Having said that, each city's reporting style is slightly different from the others', which makes cross-comparison of budgetary items difficult. For this reason, I selected only two total aggregate measures that almost have the same definitions in all budgetary reports, namely: the total budgeted expenditure and the total project-related budgeted expenditure, and calculated the share of the project-related expenditure out of the total expenditure budgeted.

It is important to look at not only EPB's total budget but also its designated budget just for the project-related matters because the total budget covers many things – such as administrative expenses in keeping the office running, expected expenditures on employees' welfare programs, and so on – that are unrelated to project implementation. In other words, the project-related budget numbers give a more accurate representation of the amount of financial resources potentially available for actual environmental management practices such as air pollution control.

In addition, I included corresponding budgetary totals from the previous year (i.e. Year 2016) because research shows that it takes time for air pollution measures to take effect, and it is important to take into consideration pollution control investment in the previous year when evaluating current year's air quality management practices and air quality outcome (Liang & Langbein, 2015; Zhang et al. 2017; Zheng et al., 2014).

It would have been ideal to have a measure or two that measures the human resource capacity within each EPB, for example, the number of staff involved in air pollution management, the amount of relevant knowledge and previous work experiences that staff members brought to their current job, and the availability of training opportunities that aim to equip them with new skills and tools. However, there was simply no high quality data on any of these.

Outputs – Local EPB's Enforcement Power

Abbreviated Name	Meaning	Unit of Measurement
EIA_num	Total number of Environmental Impact Assessment (EIA) approved in 2017 by EPB	count
EIA_eff	Average number of days taken to approve an EIA by EPB	number of days
SupMonitor_C	Average number of nationally-monitored air polluting industrial firms that receive regular inspections from the EPB throughout 2017	count
SupMonitor_P	Average percentage of nationally-monitored air polluting industrial firms that receive regular inspections from the EPB throughout 2017	percentage
Spotcheck	EPB's regulatory stringency measured in terms of the overall quality of the spot-check it has conducted in 2017 on daily polluters	on a scale of 0-3
PercCharged	Percentage of nationally-monitored polluting firms (based within the local jurisdiction) that submitted emissions fee as required, in 2017, out of all polluting firms that did not receive a governmental overwrite on this	percentage

Table 3-2: Table of Output variables

Most of these indicators were selected following the suggestions made by the existing literatures (OECD, 2009a; INECE, 2005), but were tailored based on the nature of air pollution control and Chinese cities' actual data availability. In China, the local EPBs are in charge of most of the environmental management responsibilities on the ground. In the area of air pollution control, this ranges from approving EIA reports, conducting spot checks on daily polluters, carrying out supervisory inspections on industrial polluters, keeping track of firms' emissions compliance behavior (for example: their utilization of pollutant monitoring equipment and their emissions fee payment), and participating in a range of law enforcement and emergency control events. These practices are directly supported by EPBs' budgeted expenditure, especially the project-related budgeted expenditures, so it is legitimate to hypothesize that EPBs' enforcement power in performing these above-mentioned roles are influenced by their budgetary measures.

However, it was a huge challenge constructing reliable and replicable measured variables that could be used as the Key Performance Indicators (KPIs) for local EPBs' air pollution control enforcement power. In most cases, sampled cities' unstandardized reporting styles were the main issues. For example, some cities provide quarterly summary statistics on the supervisory inspections and spot checks carried out by the EPBs, others simply list the firms that received inspections. To give another example, some cities allow the public to track their EIA approval process using a friendly online portal, others upload a scanned image of monthly update that contains a long list of project names. This is further complicated by the issue of missing values, which was mentioned earlier.

In the end, I created six indicators to measure EPBs' enforcement power. "EIA_num" refers to the total number of EIA report that EPB has approved in 2017. "EIA_eff" refers to the average number of days taken to approve an EIA by EPB. To remove unwanted noise brought by outliers, I did not include projects that took less than 5 business days or longer than 90 days to approve in my database because China's Ministry of Ecology and Environmental Protection actually required most of the EIA approvals to be done within 60 days. "SupMonitor_C" and "SupMonitor_P" are both measures that evaluate the coverage of EPB's supervisory inspections on nationally-monitored polluters. I calculated not only the average number of firms but also the average percentage of firms that receives regular inspections, because each city may have very different amount of nationally-monitored polluters to start with. In addition, I created a measure called "Spotcheck" to measure the overall quality of the spot check EPB has conducted in 2017 on its daily polluters, and a measure called "PercCharged" to represent the percentage of nationally-monitored polluting firms that submitted emissions fee as required. The variable "Spotcheck" is a categorical variable. I rated each city's spot check performance on a scale of 0 to 3, where 0=no information is publicly available at all, 1= some indirectly relevant information is available (for example, an inspector's manual is available for the Year 2017, or spot check records for a different year can be found), 2= a full year of information is available on total number of daily polluters inspected, 3= a full year of information is available, and both inspectors' and inspected firms' information are fully available. As for the calculation of "PercCharged", I removed firms that received special overwrite from the EPB from my samples because these firms do not have to submit emissions fees to start with.

Outcomes – Industrial Polluters' Degree of Compliance

Abbreviated Name	Meaning	Unit of Measurement
PercCollected	Percentage of nationally-monitored polluting firms (based within the local jurisdiction) that submitted emissions fee as required, in 2017, out of all polluting firms	percentage
PollutionFee	Amount of pollution fees filed for and submitted by polluting firms based within the local jurisdiction	millions of CNY
PR	Total number of penalty ticket the nationally-monitored polluters (based within the local jurisdiction) received from the local EPB regarding their pollution behavior, in 2017	count
AvgPR	Average number of penalty ticket that the nationally-monitored polluters (based within the local jurisdiction) received from the local EPB regarding their pollution behavior per quarter, in 2017	count

Table 3-3: Table of Outcome variables

There is very limited data on polluters' degree of compliance. In June 2017, China's Ministry of Ecology and Environmental Management published a document that contained a list of heavy polluters across all provinces, which had frequently violated the local emissions limits in the first quarter of 2017. However, a thorough examination of this report shows that the list of firms provided is by no means exhaustive, and moreover, no similar report was available for the other three quarters. Similarly, even though all provinces had established online self-reporting portals for the nationally-monitored polluters, and made it compulsory for them, at least on paper, to keep their pollutant monitoring device running at all times, reality suggested that there were many loopholes in the actual enforcement of these rules, and the actual rate of spontaneous self-reporting and the effective data transfer rate remain hard to be determined, according to a governmental official who works at the Ministry of Ecology and Environmental Management and prefers to be unnamed.

Given such data limitations, I created two measures around the concept of emission fee submission, one capturing the percentage of nationally-monitored polluting firms that actually submitted payments (i.e. PercCollected), and the other one calculating the total amount of emissions fee submitted by them. In China, although the emissions standards are set up by the local governments, based on guidelines provided by the central government, the determination of how much fees to pay is actually mostly in the hands of polluting firms themselves. Polluters first make quarterly estimates on how much they expect to emit, based on their expected production levels. These numbers are then reported to the local EPBs for verification and becomes the expected amount of payment if being approved.

In addition, I created two more measures for polluters' degree of compliance using IPE's online portal that contains industrial firms' pollution violation ticketing records. Using big data techniques for web scraping, IPE was able to find supporting evidence for 70 percent of the penalty tickets the local EPBs claimed to have issued in 2017. Despite the remaining missing data gap, IPE's data on violation records is already one of the most extensive and trustworthy sources of information for degree of compliance evaluation. In my model, "PR" stands for total number of penalty ticket the nationally-monitored polluters received from the local EPB regarding their pollution behavior. "AvgPR" represents the average number of penalty ticket that the nationally-monitored polluters received from the local EPB regarding their pollution behavior per quarter.

Environmental Outcomes – Average Air Quality

Abbreviated Name	Meaning	Unit of Measurement
aqi	Air Quality Index	index point
so2_24h	Average yearly concentration of SO2 (calculated using daily moving average concentration of SO2)	microgram/cubic meter
no2_24h	Average yearly concentration of NO2 (calculated using daily moving average concentration of NO2)	microgram/cubic meter
co_24h	Average yearly concentration of CO (calculated using daily moving average concentration of CO)	milligram/cubic meter
o3_8h_24h	Average yearly concentration of O3 (calculated using daily moving average concentration of O3)	microgram/cubic meter
pm2_5_24h	Average yearly concentration of PM2.5 (calculated using daily moving average concentration of PM2.5)	microgram/cubic meter
Pm10_24h	Average yearly concentration of PM2.5 (calculated using daily moving average concentration of PM10)	microgram/cubic meter

Table 3-4: Table of Environmental Outcome Variables

China's Ministry of Ecology and Environment has issued specific guidelines on air quality outcome indicators and their measurement (see Appendix 3-7). Following these guidelines, I created seven measures of average air quality outcome at the yearly level, using the daily air quality information provided by the Shanghai Qingyue Environmental Protection Center. They cover the yearly concentration of Sulphur dioxide, nitrogen dioxide, carbon monoxide, ground-level ozone, particulate matter 2.5, and particulate matter 10.

Socioeconomic Controls

Abbreviated Name	Meaning	Unit of Measurement
pfrev_2017	local government's public finance revenue in 2017	billions of CNY
Expcity_2016	local government's expenditure on infrastructural maintenance and city development in 2016	billions of CNY
pfexp_2016	local government's public finance expenditure in 2016	billions of CNY
GRP_2017	Gross regional product in 2017	10s of billions of CNY
GRPPC_2016	Gross regional product per capita in 2016	10,000s of CNY
share2nd_16	Share of the secondary industry in its overall economy (in terms of % of GRP contributed) in 2016	percentage
noairp_2017	Number of nationally-monitored air polluting industrial firms in 2017	count
Pop	Population	millions of people
popdensity	Population density	hundreds of people per km-square

Table 3-5: Table of Control variables

Existing research shows that it is important to control for cities' socioeconomic characteristics when analyzing the potential impact of policy changes or environmental governance capacity on air quality management (Zheng et al., 2014; Zhang & Wu, 2018; Liang & Langbein, 2015; Zhang et al., 2017), I hence incorporated nine linear control variables directly into my model and made sure that whatever parameter estimates that I would get from this modeling exercise have been purged of the linear effects of the control variables.

One thing to mention is that, I did not include a variable that captures the mayor's or the local governor's political ambition level (i.e. their desire to enter the central politburo), even though this has proven to be an important factor that influences city's level of commitment in environmental management. This is partially due to limited time and resources, but also as a result of my consideration that Year 2017 happened to be the year of politburo transition in China. I assume that local governors would have relatively lower motivations to make drastic environmental management style changes this year for promotion-related reasons, because the next transition will not happen until five years later.

Method of analysis

Given that in this study, the goal is to analyze not only whether cities within major clusters have better average air quality outcomes than their outside-cluster counterparts, but also whether differences among cities' air quality can be explained by differences in local EPBs' enforcement and compliance mechanisms between these two studied groups, a combination of ordinary least square regression and structural equation modeling (SEM) is used for statistical analysis.

I started with the simple OLS linear regression model, looking at the differences in the means of average air quality outcome between the clustered and the un-clustered cities by just controlling for their socioeconomic characteristics. I then controlled for the impacts of EPB resource adequacy, EPB regulatory enforcement capacity, and industrial polluters' compliance, step by step, trying to see if the potential impact that city cluster formation has on the average air quality outcome changes significantly after its parameter estimate is purged of the linear effects of these variables along the enforcement-compliance mechanism. All of these regression analysis were done with the assumption that: 1) all the regressors are exogenous, 2) there is no perfect multicollinearity, 3) errors are homoscedastic and serially uncorrelated, and 4) endogeneity is controlled for to the best of my knowledge.

However, with an OLS design, it is not possible to meaningfully represent the fact that these measured variables along the enforcement-compliance mechanism, which I later added to my linear regression model as control variables, may be influenced by the socioeconomic control variables to start with, and may have a causal bearing on each other directly and indirectly according to the orders that they are placed in my proposed enforcement-compliance causal chain. In other words, the OLS analysis allows me to answer whether cities within major clusters turned out to have better average air quality outcomes than their outside-cluster counterparts in 2017, but it does not help me understand whether differences among cities' air quality can be explained by differences in local EPBs' enforcement and compliance mechanisms That is why I need structural equation modeling to complement my studies.

The Structural Equation model used for this study assumes the form of a measured variable path analysis (MVPA), as previously explained. To estimate the model that was set up, MPlus Version 8.1 is used as the software package (Muthen & Muthen, 1998). A robust maximum likelihood estimator (MLR) is used to rescale the standard errors because my measured variables did not fulfill the multi-variate normality assumption, and there were missing values in my final dataset. Similar to the Full Information Maximum Likelihood estimator (FIML), MLR deals with the missing data that is present in the measured variables by estimating the unbiased values of population parameters that maximizes the likelihood function based on the sample data that is available, instead of imputing the values of missing data.

First, I tested the model fit of my MVPA model for both the clustered cities and the un-clustered cities, using the Standardized Root Mean Square Residual (SRMR), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA) as fit indices. Given the fact that my model is a just-identified model with no degree of freedom, a goodness of fit is guaranteed, with SRMR<0.08, CFI>0.95, and RMSEA<0.06 (Hu & Bentler, 1999). I then compared the corresponding structural paths between the clustered cities group and the un-clustered cities group and evaluated whether they were statistically significantly different or invariant.

Our approach was inspired by Mann, Rutstein, & Hancock (2009), who proposed a different method of doing inter-group difference that addressed the challenges in identifying non-invariances in the structural equation. To elaborate, I used an asymptotic approximation to the parameter difference test and coded the difference test to be estimated directly within the maximum likelihood framework. I created additional parameters that represents the differences between each corresponding pair of theoretically-interesting paths. The benefit of doing this, versus the conventional way of doing this (which involves constraining all interesting paths to be equal across groups, and slowly releasing these constraints with the help of modification indices), is that it does not impose any constraint on the model that causes the more traditional strategies to have problems.

Results

In this section, I first present takeaways from the OLS regression analysis because, despite its limitations, it serves as a good starting point, helping us understand whether there is statistically significant differences between the studied two groups before I try to explain the mechanisms behind any potential differences.

I then summarized the main findings from the structural equation modeling exercises, presenting key findings on the following two questions: 1) How are the main variables along the enforcement-compliance mechanism (namely: the indicators for EPB resource adequacy, EPB enforcement power, and industrial polluters' degree of compliance) related to each other? And, what are the total effects, direct effects, and indirect effects that these variables have on the average air quality outcome? 2) Are the theoretically interesting causal bearings that I observed in Part 1 different across the two studied city groups, or are they invariant?

I report, in text, the unstandardized estimates (i.e. when the predictor increases by one unit of measurement, how much change is expected to be observed in the respondent variable in its own unit of measurement) provided by Mplus (Muthén & Muthén, 1998). I also use tables to group the theoretically interesting and statistically significant causal paths together to see if there is any pattern to be discussed.

Did cities within major clusters have better average air quality in 2017 than their outside- cluster counterparts?

Based on the OLS results, after controlling for the covariates, cities inside the major clusters did appear to enjoy lower yearly average Sulphur dioxide level as compared to their outside-cluster counterparts. However, there is no significant differences between the two studied groups when looking at the other air quality measures, namely: the yearly average concentration of nitrogen dioxide, ozone, carbon monoxide, PM2.5, PM10, or the Average Air Quality Index. Appendix 3-8 shows the details of the regression results.

Our findings stayed mostly the same when I added measures of EPB resource adequacy, EPB enforcement capacity, and industrial polluters' compliance behavior as the model's control variables. The differences (or similarities) in average air quality between the clustered city group and the un-clustered city group remain mostly the same after I purge the potential linear effects that could be brought by the variables along the enforcement-compliance mechanism. Having said that, there is limited value in over-interpreting these OLS results and trying to conclude at this point whether the enforcement-compliance channel is a legitimate mechanism through which a "membership" to a national-level city cluster could bring differences to cities' environmental outcomes. This is because: first, these OLS models do not capture the fact that these measured variables along the enforcement-compliance mechanism, which I later included as control variables, may be influenced by the socioeconomic control variables to start with. Second, these OLS models do not reflect the fact that these variables may have a causal bearing on each other.

For these reasons, I complement the OLS analysis with structural equation modeling exercise to study the direct and indirect structural linkages among my variables of interest in a holistic approach.

<u>Can differences among cities' air quality be explained by differences in their local EPBs' resource adequacy and differences in their capacity to drive polluters' compliance behavior?</u>

Overall finding:

Our overall finding was that the enforcement-compliance mechanism had limited ability in explaining cities' differences in air quality in 2017, both within and across the two studied groups. Having said that, on average, this hypothesized theoretical priori was better at predicting differences in cities' air quality outcomes for the un-clustered cities than for the clustered ones, and there were interesting differences in how this mechanism functions within these two different groups.

These conclusions were made based on my structural equation modeling exercises, which looked at not only the total effect that each variable at the start of the enforcement-compliance mechanism (i.e. each of the 6 resource adequacy measures) has on each of the air quality measures, but also the specific channels (i.e. the direct effect, total indirect effect, and specific indirect effect) through which these resource adequacy measures exert their influence on air quality outcomes.

With the model that I have set up for path analysis (Figure 3-2), each "total effect" that is observed between a resource adequacy measure and an air quality indicator may happen through 35 potential causal channels (Appendix 3-9). 34 of these are “specific indirect effect” paths that connect a resource adequacy measure to an air quality measure through other intermediate variables, such as enforcement power measures and/or measures that gauge polluters’ degree of compliance, the remaining 1 path captures the “direct effect” a resource adequacy measure has on an air quality measure, above and beyond its “total indirect effect” that is already discussed.

The enforcement-compliance mechanism’s overall performance in explaining differences in cities’ air quality outcomes:

For cities within the city clusters, there were 16 statistically significant causal paths that connect the resource adequacy measures to air quality outcome indicators. This includes 4 total effect, 2 total indirect effect, 2 direct effect, and 8 specific indirect effect. Since there are 42 such total effect, 42 such total indirect effect, 42 such direct effect, and 1428 such specific indirect effect computed and analyzed in total (because I have 6 measures for EPB’s resource adequacy and 7 possible ways of measuring air quality outcomes in my model), the observed number of statistically significant paths is a very small portion of the entire number of paths that I have analyzed, suggesting that the hypothesized enforcement-compliance mechanism did very poor in predicting the differences in cities’ air quality outcomes.

The table below summarizes the number of these significant paths observed when different indicators of air quality outcomes are used in the modeling exercises, for the clustered cities. Notice that when Sulphur dioxide and Nitrogen dioxide are used as the environmental outcome variables, there is no statistically significant path being observed at all. This is striking because the regulatees that are discussed in my model are point-source industrial polluters, which are very important contributors of Sulphur dioxide and Nitrogen dioxide.

Number of statistically significant causal paths by category	Total Effect	Total Indirect	Specific Indirect	Direct
AQI as the environmental outcome	1			
SO2 as the environmental outcome				
NO2 as the environmental outcome				
CO as the environmental outcome	1	1	1	2
O3 as the environmental outcome			1	
PM2.5 as the environmental outcome	1	1	3	
PM10 as the environmental outcome	1		3	
Total no. of statistically significant causal paths across all 7 measures of environmental outcomes	4	2	8	2
Total no. of such causal paths in my model across all 7 measures of environmental outcomes	42	42	1428	42
% share of statistically significant causal paths across all 7 measures of environmental outcomes	9.52%	4.76%	0.56%	4.76%

Table 3-6: Summary of statistical significant causal paths for the clustered city group

The picture looks quite different when looking at cities that are not part of a national-level city cluster. There were 71 statistically significant causal paths that connect the resource adequacy measures to air quality outcome indicators. This includes 9 total indirect effect, 15 direct effect, and 47 specific indirect effect. Although this is still a small portion of the overall number of causal paths that I analyzed in the model, the total number of statistically significant paths under three of the four cause-effect categories (namely: total indirect effect, specific indirect effect, and direct effect) are all much larger than that of the clustered group, suggesting that the enforcement-compliance mechanism was better at predicting differences in cities' air quality outcomes for the un-clustered cities than for the clustered ones.

Similarly, the table below tallies the number of these significant paths observed when different indicators of air quality outcomes are used, for the un-clustered cities. Notice that, for this group, there is no statistically significant total effect being observed at all between the EPB resource adequacy measures and the air quality outcome indicators, despite the fact that quite a number of the total indirect effect, specific indirect effect, and direct effect between these variables are found to be statistically significant. Moreover, it appears that this enforcement-compliance mechanism's ability to explain the differences in un-clustered cities' air quality outcomes is different when different measures of air quality outcomes are being used, performing much better in models that used AQI, Nitrogen dioxide, or PM2.5 as the air quality indicators.

Number of statistically significant causal paths by category	Total Effect	Total Indirect	Specific Indirect	Direct
AQI as the environmental outcome		2	9	5
SO2 as the environmental outcome				
NO2 as the environmental outcome		1	15	2
CO as the environmental outcome		1		1
O3 as the environmental outcome		1	4	1
PM2.5 as the environmental outcome		2	14	4
PM10 as the environmental outcome		2	5	2
Total no. of statistically significant causal paths across all 7 measures of environmental outcomes	0	9	47	15
Total no. of such causal paths in my model across all 7 measures of environmental outcomes	42	42	1428	42
% share of statistically significant causal paths across all 7 measures of environmental outcomes	0.00%	21.43%	3.29%	35.71%

Table 3-7: Summary of statistical significant causal paths for the un-clustered city group

A closer look at the 9 significant total indirect effect and 15 significant direct effect reveal the potential reasons behind the total effect's lack of significance. As shown in Appendix 3-10, in almost half of the cases, these significant paths are found "in duo", that is, their paths share the same "start" variable and the "end" variable, and they jointly explain the total relationship between this pair of variables. These duo-paths' estimated value are comparable in scale, but have the opposite direction of influence, and hence, the combined total effect gets very small in its absolute value, and its statistical significance tends to get "cancelled out" as well. In the other half of the cases (Appendix 3-11), the story is a little different. The statistical significance of either the total indirect effect or the direct effect is simply outweighed by the non-significance of the remaining sub-component of the total effect, resulting in a non-significant total effect overall.

In fact, looking at all the cause-effect pairs that connect a resource adequacy measure to an environmental outcome measure, where at least one of the two sub-components of total effect (i.e. the total indirect effect and the direct effect) is statistically significant (Appendix 3-10 and Appendix 3-11): in about a third of these cases, the direction of influence a resource adequacy measure has on an air quality measure, above and beyond the total indirect effect it exerts on this environmental outcome through the enforcement-compliance channel, is opposite to that of the total effect between this pair of variables. This suggests that, the enforcement-compliance channel serves as an important mediator, which is partially explaining the effect of EPBs' resource adequacy on cities' average air quality outcome.

EPB budgetary measures' impact on air quality outcomes:

For the clustered cities, my main finding was that, a larger share of EPB's budgeted expenditure for project-related purposes is likely to bring a lower yearly average of air pollution level in cities. Having said that, it is not clear whether this potential positive influence on air quality outcomes is exerted through the enforcement-compliance mechanism.

Table 3-8 lists all the statistically significant total effect, total indirect effect, and direct effect that are found for the clustered cities. The first 4 rows of data provide the supporting statistics behind the above-mentioned finding, because they are all effects from the share of project-related budget in EPB's total budget to different measures of air quality outcomes, and their estimates are all negative. Having said that, since these total effect's sub-components (i.e. the total indirect effect and the direct effect) are all statistically insignificant, there is lack of evidence to conclude whether the resource adequacy measure that I am discussing exerts its potential influence on air quality outcomes through the theoretical priori that I tested in my model.

Meanwhile, the impact of total budget size or total project-related budget size on air quality outcome is also unclear for these clustered cities. Only 4 statistically significant paths were observed in support of these cause-effect relationship (Table 3-8, Row 5-8), and the estimates do not provide any basis for a generalizable finding.

Row Number	Cause-effect Relationship	Effect type	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	Statistically Significant?
1	**Effects from** the share of project-related budget in EPB's total budget in 2017 **to** average yearly concentration of AQI	Total	-0.208	0.083	-2.515	0.012	**YES**
2	**Effects from** the share of project-related budget in EPB's total budget in 2017 **to** average yearly concentration of CO	Total	-0.037	0.015	-2.483	0.013	**YES**
3	**Effects from** the share of project-related budget in EPB's total budget in 2017 **to** average yearly concentration of PM2.5	Total	-0.153	0.062	-2.47	0.014	**YES**
4	**Effects from** the share of project-related budget in EPB's total budget in 2017 **to** average yearly concentration of PM10	Total	-0.247	0.094	-2.613	0.009	**YES**
5	**Effects from** EPB's total budget in 2017 **to** average yearly concentration of CO	Direct	-0.929	0.388	-2.398	0.016	**YES**
6	**Effects from** EPB's total project-related budget in 2017 **to** average yearly concentration of CO	Direct	1.131	0.451	2.506	0.012	**YES**
7	**Effects from** EPB's total budget in 2016 **to** average yearly concentration of CO	Total indirect	-0.364	0.169	-2.16	0.031	**YES**
8	**Effects from** the share of project-related budget in EPB's total budget in 2016 **to** average yearly concentration of PM2.5	Total indirect	0.134	0.059	2.259	0.024	**YES**

Table 3-8: Summary of statistical significant causal paths that highlight EPB budgetary measures' impact on air quality outcomes, for the clustered cities

As for the control group, there were some promising evidence, which suggested that a larger project-related budget from the EPB (both in terms of its absolute value and its share in EPB's total budget) could be contributing to a city's better average air quality outcome through the enforcement-compliance mechanism. As shown in Table 3-9 (Row 4-9), the estimates for the total indirect effect from "EPB's project-related budget in 2017" to a variety of different air quality indicators are consistently negative and statistically significant. So are the estimates for the total indirect effect from "the share of project-related budget in EPB's total budget in 2017" to the air quality indicators.

On the contrary, "EPB's total budget in 2017" did not seem to exert its influence on air quality outcome in the same way that its project-related counterpart measures did. As shown from Table 3-9's first three rows of results, the total indirect effect from EPB's total budget in 2017 to a few different measures of average air quality in that year turn out to be positive, indicating that a larger total budget would predict a higher pollutant level. One possible explanation for this could be the fact, which I brought up earlier in the data section, that the total budget covers many things – such as administrative expenses in keeping the office running, expected expenditures on employees' welfare programs, and so on – that are unrelated to project implementation and do not contribute to the effort of air pollution control.

Row Number	Cause-effect Relationship	Effect type	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	Statistically Significant?
1	**Effects from** EPB's total budget in 2017 **to** average yearly concentration of AQI	Total indirect	14.115	4.208	3.355	0.001	**YES**
2	**Effects from** EPB's total budget in 2017 **to** average yearly concentration of PM2.5	Total indirect	9.358	3.108	3.011	0.003	**YES**
3	**Effects from** EPB's total budget in 2017 **to** average yearly concentration of PM10	Total indirect	12.669	5.145	2.463	0.014	**YES**
4	**Effects from** EPB's total project-related budget in 2017 **to** average yearly concentration of AQI	Total indirect	-14.15	4.237	-3.339	0.001	**YES**
5	**Effects from** EPB's total project-related budget in 2017 **to** average yearly concentration of O3	Total indirect	-7.221	3.706	-1.948	0.051	**YES**
6	**Effects from** EPB's total project-related budget in 2017 **to** average yearly concentration of PM2.5	Total indirect	-9.283	3.137	-2.959	0.003	**YES**
7	**Effects from** EPB's total project-related budget in 2017 **to** average yearly concentration of PM10	Total indirect	-12.886	5.274	-2.443	0.015	**YES**
8	**Effects from** the share of project-related budget in EPB's total budget in 2017 **to** average yearly concentration of NO2	Total indirect	-0.224	0.064	-3.498	0.000	**YES**
9	**Effects from** the share of project-related budget in EPB's total budget in 2017 **to** average yearly concentration of CO	Total indirect	-0.065	0.029	-2.216	0.027	**YES**

Table 3-9: Summary of statistical significant causal paths that highlight EPB budgetary measures' impact on air quality outcomes, for the un-clustered cities

Specific indirect causal paths at work:

In the model that I have set up, there are 34 specific indirect effects tested for every possible cause-effect relationship that connects a variable that is at the start of the enforcement-compliance mechanism (i.e. a resource adequacy measure) and a variable that is at the end of this causal chain (i.e. an air quality indicator). In other words, there are 34 different indirect paths that connect a resource adequacy measure to an air quality indicator. This includes 6 paths that flow through the different measures of enforcement power, 4 paths that flow through the different measures of polluters' degree of compliance, and 24 paths that pass through both of these two intermediate-stage variables.

In total, there were 2856 specific indirect effects tested in my study, half for the clustered cities and the other half for the un-clustered ones. Only 55 of them (i.e. about 1.9%) are statistically significant, and surprisingly, only 4 intermediate-stage measured variables underlie all of these 55 paths. Three of these mediating variables are measures of EPB's enforcement power (namely: total number of Environmental Impact Assessment (EIA) approved in 2017, average number of nationally-monitored air polluting industrial firms that received regular inspections from the EPB throughout 2017, and the overall quality of EPB's spot-check on daily polluters), and the remaining one is an indicator of industrial polluters' degree of compliance, measured in terms of the average number of penalty tickets that the nationally-monitored polluters received from the local EPB regarding their pollution behavior per quarter. This tells us that although the enforcement-compliance mechanism as a whole, consisting of 32 measured variables, has limited power in explaining the differences in cities' air quality outcomes in 2017, there are specific parts of this complicated system that is partially responsible for why cities' average air quality outcomes and their local EPBs' environmental management capacity vary and co-vary the way they do.

The Figure below shows the 6 different cause-effect paths that these 55 statistically significant specific indirect effects represent, and the distribution of these indirect effects by path type. For simplification purposes, I do not show the specific resource adequacy measure and the actual air quality outcome indicator that mark the start and the end of each of these paths. And, for presentation purposes, I single out these 6 types of cause-effect paths, as if they exist by themselves independently.

However, in reality, they are all elements of the same enforcement-compliance mechanism, and can exist in conjunction with each other simultaneously to explain the effect from a resource adequacy measure to an air quality outcome.

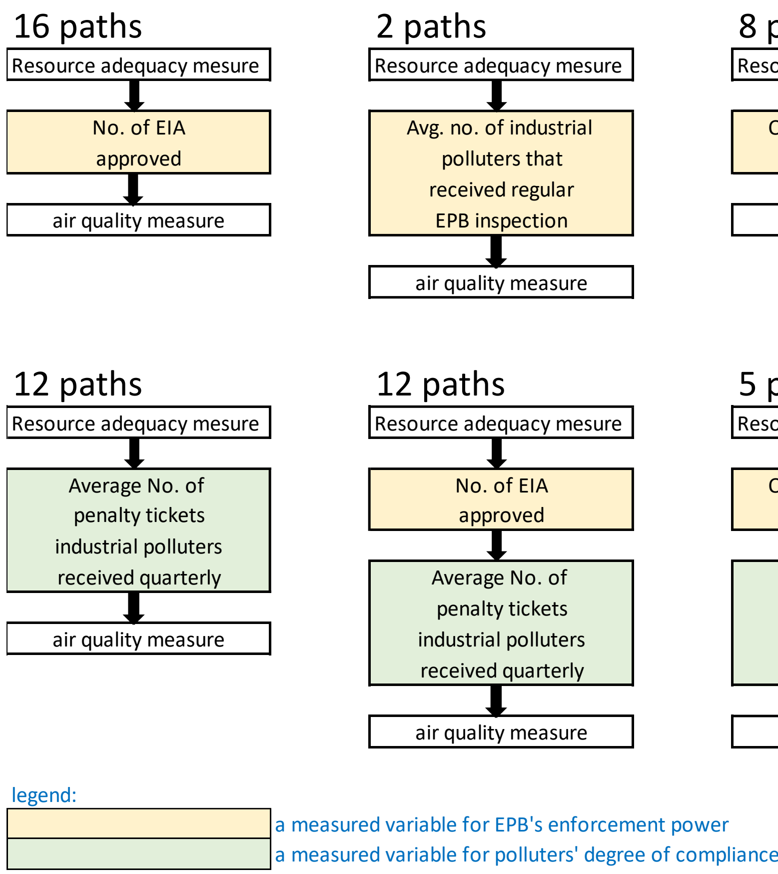
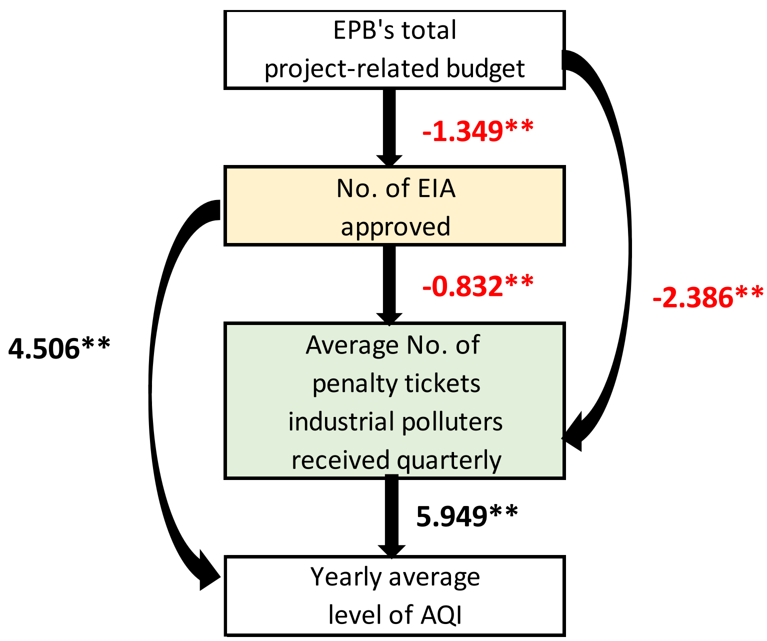


Figure 3-3: Distribution of statistically significant specific indirect path by type

Examples of these statistically significant specific indirect paths co-existing and jointly explaining a cause-effect relationship can be found when looking at the un-clustered cities. For example, the total indirect effects from "EPBs' total project-related budget in 2017" to "cities' yearly average level of AQI" were partially, and simultaneously, explained by 3 of the 6 cause-effect paths that I discussed above.

To elaborate using the path diagram below (Figure 3-4), a one million Chinese Yuan (CNY) increase in EPBs' total project-related budget is likely to bring a lower average level of Air Quality Index (i.e. a sign of better air quality) through the following mediating channel: 1) by decreasing EPBs' permitted number of new construction projects by 1.349 unit per year, or 2) directly increasing polluters' degree of compliance, as reflected by the 0.2386 unit decrease in the average number of penalty tickets industrial polluters receive quarterly. These changes are, in turn, likely to bring an improvement to the air quality outcome because: 1) one less new construction project approved by the EPB is likely to be associated with a 0.4506 point decrease in the yearly average level of Air Quality Index. 2) One less penalty ticket industrial polluters receive quarterly is likely to be associated with a 5.949 point decrease in the yearly average level of Air Quality Index.



negative values are colored in red
** signifies a 1% statistical significance level

Figure 3-4: statistically significant specific indirect causal paths that partially explain the total indirect effects from EPBs' total project-related budget in 2017 to cities' yearly average level of AQI

Having said that, the two mediating mechanisms that I have discussed above may also cross path with each other, and as a result reduce the potential positive impact that a larger project-related budget may bring to the air quality outcome. This is because, as shown in Figure 3-4, one less new construction project approved by the EPB is likely to be associated with a 0.083 unit more average number of penalty tickets that industrial polluters received quarterly, reflecting the reality that the EPB has limited time and resources to spend, and focusing on one type of air pollution control practice may inevitably draw its attention away from an alternative emissions reduction enforcement effort.

Also, it is important to highlight the fact that the numbers shown on the path diagram do not always match with what I used in the above-shown results interpretation. This is because the numbers shown in Figure 3-4 are unstandardized parameter estimates taken directly from the modeling exercises, which rescaled a few of the variables to keep their variances in a comparable range. However, in my interpretation, I adjusted these parameter estimates in such a way that the rescaling effect is reverted, and so that the cause-effect relationship can be interpreted in variables' original unit of measurement.

No similar story was found for the clustered cities. For the 8 specific indirect paths, which were found to be statistically significant, none of them start or end with the same measured variable. That said, 5 of these 8 paths pass through a common mediating variable, which is the overall quality of EPB's spot-check on daily polluters. Although the direction of this variable's influence on air quality outcome is not always clear, judging from these 5 cases, this still suggests that the quality of

EPB's spot-check on daily polluters is an important measure of enforcement power that helps to explain, and connect, the observed differences in local EPBs' resource adequacy and cities' air quality outcomes.

Even though the results that I have discussed so far suggest that the enforcement-compliance mechanism was better at predicting differences in cities' air quality outcomes for the un-clustered cities than for the clustered ones. This is by no means indicating that the clustered cities are performing worse in environmental management compliance assurance. In fact, a possible explanation behind the two groups' data-model fit could be very counter-intuitive, that is, due to the very effective environmental governance model that the local EPBs have put in place, the industrial polluters are self-motivated to comply with the emissions standard, which made the enforcement-compliance mechanism obsolete. However, I will not spend more time figuring out whether this possible explanation matches with the reality, because in order to test the validity of this possible explanation, a means model will be needed to look at EPBs' average enforcement power and polluters' average compliance behavior, among doing other analysis.

The mediating variables' direct effect on air quality outcomes:

Last but not least, I highlight some interesting findings on: 1) the direct associations between EPBs' enforcement power and air quality outcomes, above and beyond the indirect relationship between them that is mediated by polluters' compliance behavior. 2) The direct associations between industrial polluters' compliance behavior and air quality outcomes.

First, EPBs' quality of spot-check on daily polluters is positively related to cities' air quality for the clustered cities, but not for their outside-cluster counterparts, suggesting that these spot-checks may be conducted very differently in different places. Second, increasing the 'average percentage of air polluting firms that receives regular inspections from the local EPB' is a potential way of bringing air quality improvement to the un-clustered cities, but not for the clustered ones. Third, with the exception of the model on Sulphur dioxide and the model on carbon monoxide, a decrease in the number of penalty tickets polluters receive per quarter brings a statistically significant larger improvement to average air quality for the un-clustered group than for the clustered group. The detailed statistics behind these findings are provided in Appendix 3-12.

Discussion and Conclusion

To conclude (refer to Appendix 3-13 for a full summary of full SEM analysis): first, for 2017, clustered cities' average air quality was not significantly different from that of the un-clustered cities, even though there were interesting differences in how this mechanism functions within these two different groups.

Second, for the un-clustered cities, I found important elements of the enforcement-compliance mechanism that could potentially explain differences in cities' air quality outcomes. However, for the clustered cities, the enforcement-compliance mechanism had limited ability in explaining cities' different air quality in 2017. Notice though, this is by no means indicating that the clustered cities are performing worse in environmental management compliance assurance. In fact, a possible explanation behind the two groups' data-model fit could be very counter-intuitive, that is, due to the very effective environmental governance model that the local EPBs have put in place, the industrial polluters are self-motivated to comply with the emissions standard, which made the enforcement-compliance mechanism obsolete.

Third, overall speaking, only a small percentage of the total estimated cause-effect structural paths was statistically significant. On the one hand, this seems to suggest that the enforcement-compliance channel is not a legitimate mechanism through which a "membership" to a national-level city cluster could bring differences to cities' environmental outcomes, on the other hand, it is also possible that this study's results are pointing to the fact that the studied model had limited power in detecting the true effect that the enforcement-compliance mechanism has on the air quality outcomes.

The potential reasons behind the studied model's limited power are as follows. First, although the sample size in my study is not small, covering more than half of China's prefectural-level cities, the number of parameters I estimated in my model is comparable to the size of my sample, diminishing the model's power for testing these parameters. Second, the missing data in my model could have yielded biased parameter estimates, and even the available data in my dataset could have been subjected to certain degree of measurement error. This is because the reporting of such data is a complicated process that involves many people's collaborative effort, and there is no common standard for data monitoring, reporting and verification.

Third, even though I followed the guidelines from International Network for Environmental Compliance and Enforcement when I designed my own indicators to measure EPBs' regulatory stringency and industrial polluters' degree of compliance, I tailored the design of these variables based on the nature of air pollution control and Chinese cities' actual data availability, and this could have made my variable selection process a subjective one.

Having said that, a major contribution made by this study is exactly the fact that I independently constructed legitimate measures on local EPB's resource adequacy, enforcement power, and industrial polluters' compliance behavior despite the above-mentioned data limitations. In constructing this original database, I demonstrated one innovative way of substantively measuring environmental management capacity building, and I showed that capacity building can indeed influence environmental outcome. This is a topic that is of great interest to a wide variety of audience, and the method that I developed can be applied to other areas of environmental management as well.

More importantly, this unique dataset allowed me to establish a complete enforcement-compliance causal mechanism, which then made it possible for me to answer not only whether or not differences in environmental management capacity and implementation effort bring changes to environmental outcomes, but also how these changes are made throughout the environmental management process using an structural equation modeling approach. This is a big improvement to the conventional practice, which evaluates a policy intervention's impact on an end product without necessarily understanding the process through which this has happened.

In addition, this research is the first one that uses structural equation modeling (SEM) tools to study Chinese cities' differences in resource adequacy and regulatory strength in air pollution control, and how these differences contribute to their different average air quality outcomes.

Last but not least, this study is also the first one that uses empirical evidence to study whether the enforcement-compliance channel is a legitimate mechanism through which a "membership" to a national-level city cluster could bring differences to cities' air quality outcomes.

Chapter 4 - Conclusion

China has been actively developing its city clusters in recent years, hoping to use them as levers for both integrated economic development and the attainment of other goals such as collaborative environmental management (CEM). According to the existing literatures, air pollution abatement is one of the focus areas of China's CEM experiments. However, to what extent have China's city clusters promoted joint prevention and control of air pollution? The empirical evidence has lagged behind practice. Most of the research on China's regional air pollution management either focuses on just the Beijing-Tianjin-Hebei region, or discusses very broadly the characteristics of an ideal CEM framework and the challenges that are encountered. Very few have paid attention to CEM experiences from the rest of China or discussed the actual outcomes of such practices.

Essay 1 of my dissertation asks whether the central government's call for CEM, as part of the Central China Triangle development plan, has driven observable changes in the Central China Triangle's air quality management system. I found limited support for this claim. while all four types of system-level changes (changes in: the policy-making processes, the regulatory tools, the institutional setup, and other system drivers) are somewhat observed in the studied region since 2015, most of these changes are found in both the clustered cities and the un-clustered cities, so there is lack of evidence to attribute these CEM-related system-level changes to the formation of the Central China Triangle alone.

Moreover, even though a few cities have engaged in more inter-local collaborations on air pollution management since 2015, most of these system-level changes support vertical or cross-functional collaborations among governmental agencies within the same city or province, and these collaborative effort focus almost exclusively on keeping the point-source polluters compliant, leaving quite a bit of wiggle room for mobile sources of air pollution.

Essay 2 asks whether the formation of the Central China Triangle, and presumably a more conducive environment for CEM in this region, changes VC investors' perceived risks of investing in the cleantech SMEs in the involved region. I found that, for a policy to effectively mobilize private finance, it should be able to influence private investors' perceived risk and return simultaneously. More specifically, I found that, information sharing, uniform standard setting, and joint monitoring and law enforcement are specific elements of collaborative environmental management practices that could potentially boost investors' perceived return on cleantech investment, because these aspects of CEM help establishing the reliability of cleantech SMEs' market demand in the involved region, giving VC investors more confidence in making projections when doing risk and return evaluations for a potential target firm. These findings showed that it is worthwhile to look beyond just the direct financial derisking measures or fiscal incentives provision when trying to influence private investors' perceived risks or returns, shedding some light on some of the prospective channels that policy makers may use to mobilize private finance in the future.

Essay 3 looks at the relationship between local Environmental Protection Bureaus' (EPB) resource adequacy, enforcement capacity, polluters' degree of compliance, and cities' air quality outcomes in not only the Central China Triangle but also some other cities in China, and analyzes whether differences among cities' air quality can be explained by differences in their environmental enforcement and compliance capacity between these two groups. It is clear so far that, for the Year 2017, clustered cities' average air quality was not significantly different from that of the un-clustered cities, even though there were interesting differences in how this mechanism functions within these two different groups. In addition, for the un-clustered cities, I found important elements of the enforcement-compliance mechanism that could potentially explain differences in cities' air quality outcomes. However, for the clustered cities, the enforcement-compliance mechanism had limited ability in explaining cities' different air quality in 2017.

Overall speaking, only a small percentage of the total estimated cause-effect structural paths was statistically significant, suggesting that the limited data on polluters' compliance could have affected the predicting power of the studied model, to a certain extent, but these issues are not solvable by researchers alone. Government agencies should continue to work on improving data consistency, reliability, and transparency.

All in all, since there were improvements in joint prevention and control of air pollution in both the clustered cities and their un-clustered counterparts, since the formation of the Central China Triangle. There is lack of evidence to conclude whether these CEM improvements can be attributed to this regional integration policy experiment alone. While on the one hand, this seems to suggest that the city cluster formation does not add special value to collaborative environmental management practices, on the other hand, this could be a case where the central government's repetitive emphasis on collaborative environmental management and regional integration have been very effective and have altered the incentive structure of un-clustered cities' local officials in such a way that they now perceive a higher likelihood of being a target of sanction in the event of non-practice of CEM, see a larger penalty attached to such violation, and hence feel the need to be proactive regarding the calls for CEM even though they are not officially part of the city clusters.

Urban agglomeration is an important form of city planning and urban development internationally. Through better resource integration and utilization, this trend of urbanization is believed to have positive influence on technological innovation, industrial upgrading, social services provision, and so on. In recent years, national-level city cluster formation has become the main spatial form of regional development in China, and is continuing to reshape the nation's future development landscape.

This research is the first that rigorously studied Central China Triangle's contribution to collaborative environmental management, and also the first that systematically evaluated CEM's actual procedural and environmental outcomes in air quality management.

Together, the three essays in this dissertation analyzed the potential impact of a major policy package on environmental management by systematically tracing its process outcomes (i.e. its resultant system-level changes), assessing its potential impact on the private sector, and understanding the exact mechanism through which the process outcomes can be translated into improvements in actual environmental outcomes. This challenges the conventional practice of studying a policy's impact by just focusing on differences in an end product, and shows that there is great value in understanding the behavioral, institutional, and functional changes that may be happening along the way.

This study has contributed to a few areas of existing literature, both substantively and methodologically. These areas include, institutional collective action framework, Chinese governments' central-local power dynamics, collaborative environmental management, environmental management performance evaluation, environmental management capacity building, private capital mobilization, and so on. The innovative methods that I used for enforcement-compliance diagnosis can be applied to the other areas of environmental management, so does the rigorous contextual analysis framework that I used for system-level changes.

Appendices

Appendix 0-1: The list of cities that are involved (or not involved) in the Central China Triangle, from Hunan, Hubei, and Jiangxi Province

Clustered-cities:
Wuhan, Huangshi, Ezhou, Huanggang, Xiaogan, Xianning, Xiantao, Qianjiang, Tianmen, Xiangyang, Yichang, Jingzhou, Jingmen, Changsha, Zhuzhou, Xiangtan, Yueyang, Yiyang, Changde, Hengyang, Loudi, Nanchang, Jiujiang, Jingdezhen, Yingtan, Xinyu, Yichun, Pingxiang, Shangshao, Fuzhou, and Ji'an.

Unclustered cities:
Shaoyang, Chenzhou, Zhangjiajie, Yongzhou, Huaihua, Xiangxi, Shiyan, Suizhou, Enshi, Ganzhou

Appendix 1-1: A selected list of literature-inspired search term on CEM

Regional air pollution control emergency control mechanism	**Joint evaluation of the regional air pollution control effort**	**Environmental management talent exchange**	**Joint prevention of NOx, SO2, and soot**
Joint prevention and control of air pollution	Joint meetings on air pollution control	Information sharing on air quality	Consistent emissions standards for the key pollutants

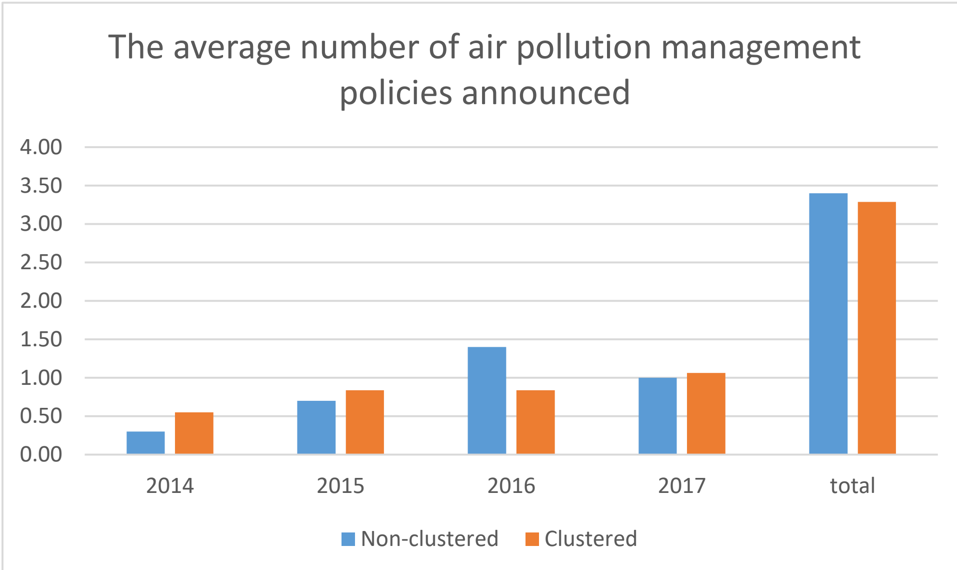
Appendix 1-2: an abstract of the policy timeline database (for the management of the heavy-polluting vehicles)

Location	province	clustered	Type of Policies	2010	2011	2012	2013	2014	2015	2016	2017	2018
上饶	jiangxi	1	penaltyreward						1	1	1	
九江	jiangxi	1	data connectivity and joint monitoring	1	1	1	1	1	1	1	1	1
九江	jiangxi	1	penaltyreward	1	1	1	1	1	1	1	1	
九江	jiangxi	1	road	1	1	1	1	1	1	1	1	
九江	jiangxi	1	second-hand vehicle relocation	1	1	1	1	1	1	1	1	
仙桃	hubei	1	data connectivity and joint monitoring							1	1	1
仙桃	hubei	1	environmental compliance sticker							1	1	1
仙桃	hubei	1	penaltyreward					1	1	1	1	
仙桃	hubei	1	road							1	1	
仙桃	hubei	1	second-hand vehicle relocation					1	1	1	1	
十堰	hubei	0	data connectivity and joint monitoring				1	1	1	1	1	1
十堰	hubei	0	penaltyreward						1	1	1	
十堰	hubei	0	road							1	1	
南昌	jiangxi	1	environmental compliance sticker						1	1	1	1
南昌	jiangxi	1	penaltyreward						1	1	1	
南昌	jiangxi	1	road						1	1	1	

Appendix 1-3:

abbreviation	Actor Represented
stEPB	state-level environmental protection bureau
citydir	city-level public agencies that are cirectly controlled by the local government
cityEPB	city-level environmental protection bureau
citygov	city-level government (mayor's office)
citylaw	city-level law enforcement agency
cityNDRC	city-level National Development and Reform Commission Branch
countydir	county-level public agencies that are directly controlled by the local governmen
countyEPB	county-level environmental protection bureaus
countygov	county-level government (county office)
countylaw	county-level law enforcement agency
countyNDRC	county-level NDRC
other_cityEPB	other city's environmental protection bureau
other_citylaw	other city's law enforcement agency
other_countyEPB	other county's environmental protection bureau
other_stEPB	other state's environmental protection bureau
community	community
firm	private company
media	media
MEP	Ministry of Ecology and Environment
nationalNDRC	National-level NDRC
regSup	regional supervision center
ReInstitute	research institute

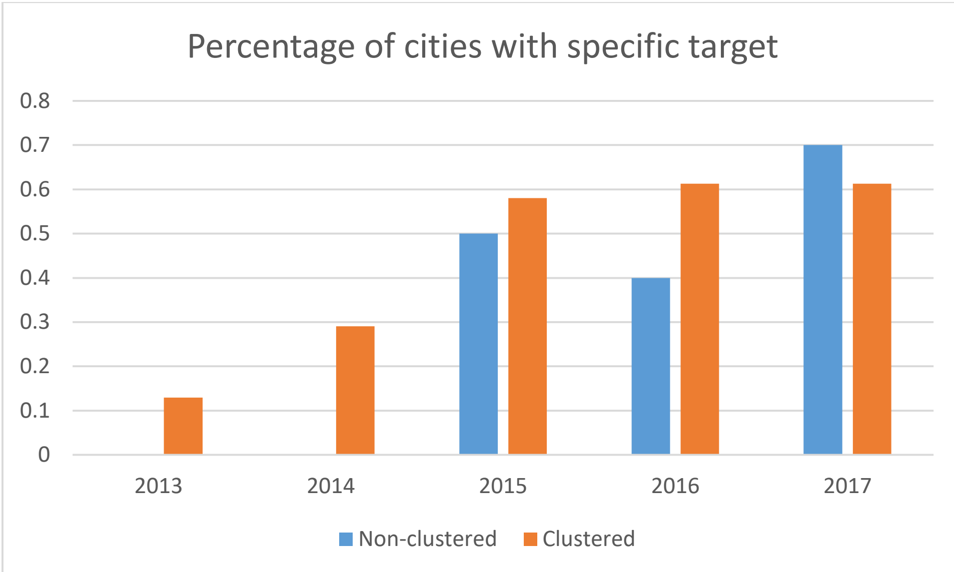
Appendix 1-4: the average number of air pollution management policies announced over years for the clustered group and the non-clustered group

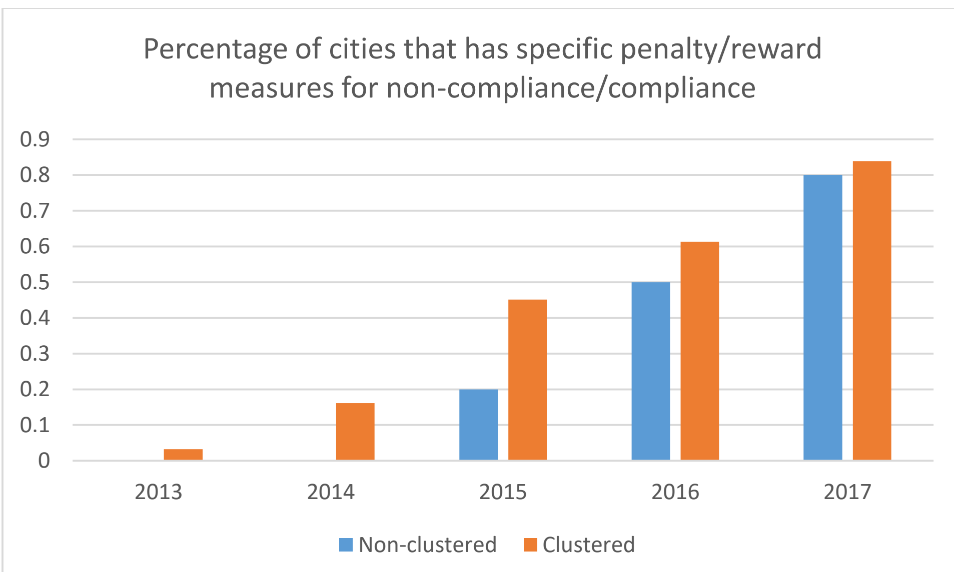


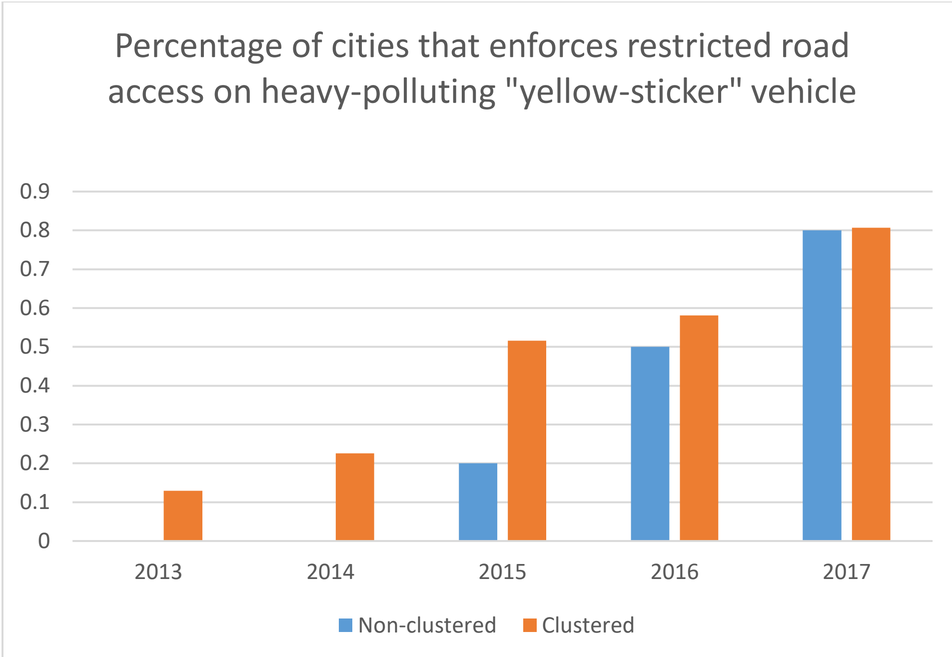
Appendix 1-5: total number of unique pair-wise CEM relationship by year and location

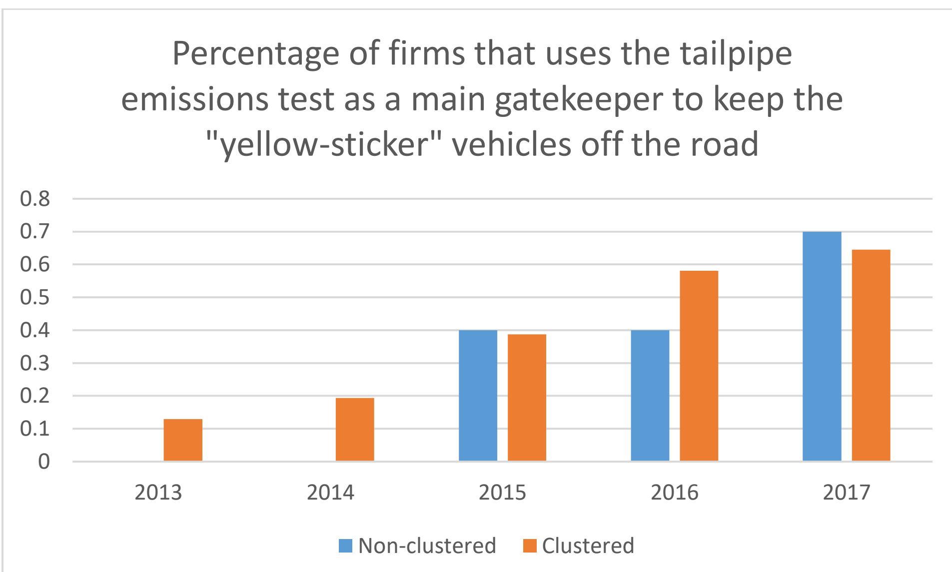
Province	Type	City	2013	2014	2015	2016	2017	2018
Hubei	Hubei_capital	Wuhan	0	4	14	13	29	0
Hubei	Hubei_clustered	Yichang	0	0	1	0	22	65
Hunan	Hunan_capital	Changsha	0	0	70	196	126	410
Hunan	Hunan_clustered	Zhuzhou	0	0	0	0	47	18
Jiangxi	Jiangxi_capital	Nanchang	7	0	0	28	5	71
Jiangxi	Jiangxi_clustered	Ji'an	0	0	1	8	3	6
Hubei	Hubei_unclustered	Enshi	0	0	30	32	30	0
Hunan	Hunan_unclustered	Chenzhou	11	7	10	6	4	13
Jiangxi	Jiangxi_unclustered	Ganzhou	0	0	0	3	12	13

Appendix 1-6:


Percentage of cities with specific target
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
Non-clustered
Clustered

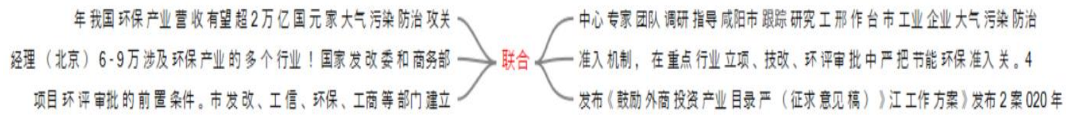

Percentage of cities that has specific penalty/reward measures for non-compliance/compliance
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
Non-clustered
Clustered


Percentage of cities that enforces restricted road access on heavy-polluting "yellow-sticker" vehicle
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
Non-clustered
Clustered

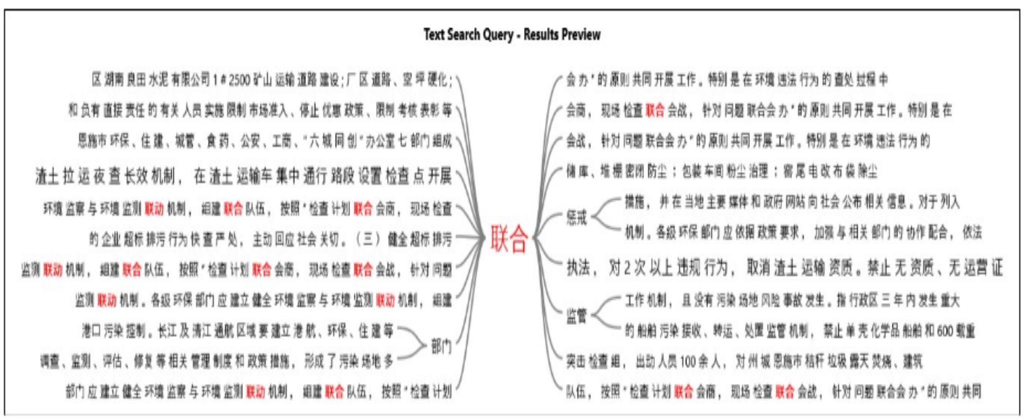

Percentage of firms that uses the tailpipe emissions test as a main gatekeeper to keep the "yellow-sticker" vehicles off the road
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
Non-clustered
Clustered

Appendix 1-7: evolvement of context in which CEM is mentioned

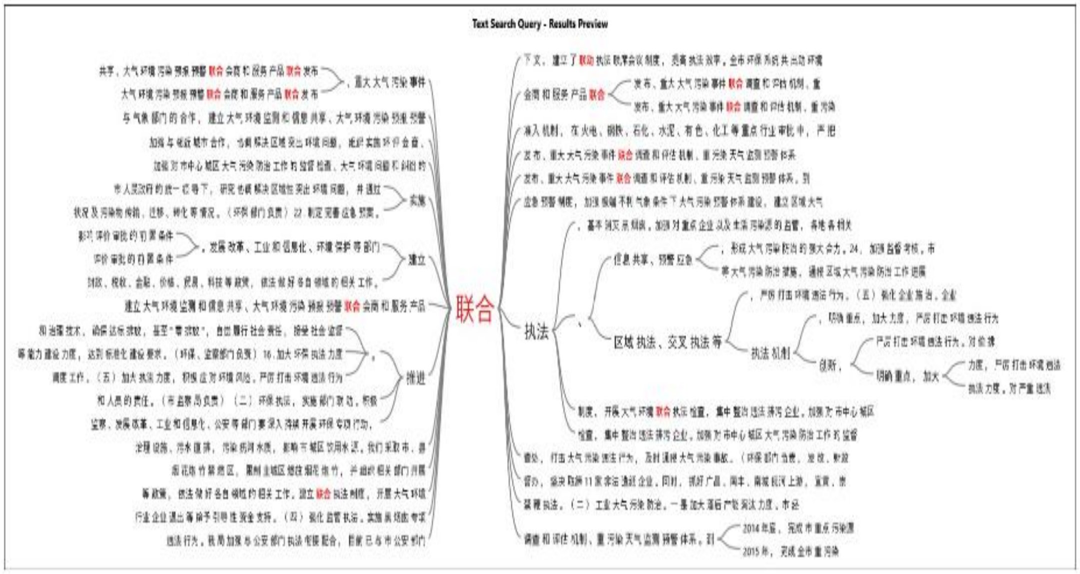
For non-clustered cities, in Year 2014:



For non-clustered cities, in Year 2017:



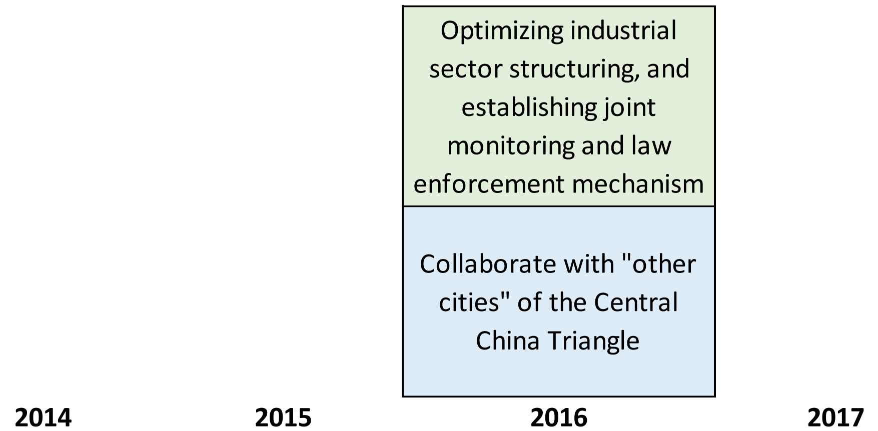
For clustered cities, in Year 2014:



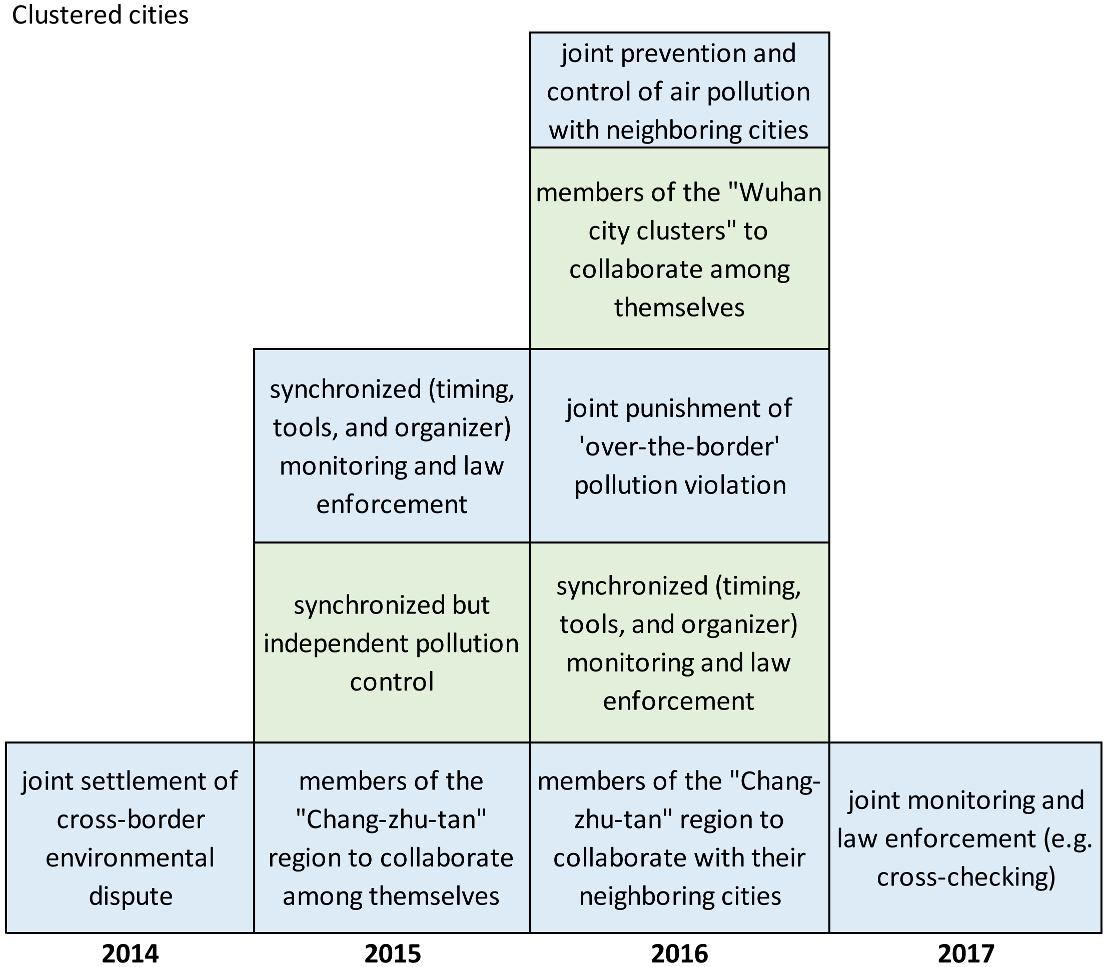
For clustered cities, in Year 2017:

Appendix 1-8: the evolvement of context in which inter-jurisdictional joint prevention and control of air pollution is mentioned for the two city groups

Unclustered cities



Clustered cities



Appendix 2-1: Interview questions for the institutional investors

My interviews will follow a semi-structured format, and will be focused on the following topics:

Section 1: - General Questions

1a-1. How much do you know about the State Council's decision to form the city clusters along the Middle Reaches of the Yangtze River (hereinafter referred to as "the Central China Triangle Plan") and their recent approvals of several other national-level city clusters?

- A lot / Some/ A little

1a-2. If the answer to 1a-1 is somewhat affirmative, ask the followings: how did you know about it? (news/work-related research?) In the eyes of VC investors, what may be the biggest impacts of such policy decisions on your investment decisions?

1b. How do you understand the concept of "joined-up governance"?

2. Do you think these regional integration plans have the potential of promoting the so-called "joined-up governance" (i.e. coordinating activities across organizational boundaries without removing the boundaries themselves, these boundaries may be inter-departmental, central-local, and cross-sectoral (Ling, 2002))? How would you rate these regional integration plans' potential contribution to the followings, for the involved regions? (from the least likely to the most likely, 1 to 5) A coordinated rural-urban development scheme

- An interconnected infrastructural support system
- A harmonious industrial upgrade
- A collaborative effort towards ecological civilization and environmental management
- A borderless public service network
- A more conducive environment for knowledge sharing and future corporation

3a. If not "joined-up governance", what other potential benefits would you possibly associate with "national-level city clusters" development?

3b. **If no response from 3a**, ask the following instead:

Some people seem to associate the development of “national-level city clusters” more with things that don’t have much to do with “joined-up governance”. How much do you agree with the following potential benefits that they identified?

- Economies of scale
- Greater attention and favorable policies from the central government?

4a: Were there any instances when you invested in a project that might have been considered as a rather risky project (from pure commercial sense) for “policy support” reasons, such as:

- a clear long-term strategy (strategic plan)
- a stable regulation / a long-term vision for the regulatory environment
- reliable regulatory instruments support (such as: codes, standards, and obligation schemes)

4b. Please rank the following factors (from 1 to 5, based on the likelihood of them affecting how you perceive investment projects’ market environment and investment risks?

- Regulatory environment;
- firm-level characteristics;
- economic and fiscal incentives;

5. Has the formation of the national-level city clusters influenced **how you perceive the market environment and/or investment risks** (and as a result, affected your willingness to investigate/invest) in the involved regions because: (strongly agree, agree, neutral, disagree, or strongly disagree)

- Cities in the cluster tend to have a long-term strategic framework and long-term policy commitment (enforced by the central and local government), which means that there are less unforeseeable changes to regulations and greater policy consistency , which hence gives you more confidence in the stability of investees’ cash flows over the duration of your investments.

- Cities in the cluster tend to have more harmonized/similar regulatory standards and a streamlined administration process, which could potentially reduce your overall or portfolio cost.

- Cities in the cluster are more likely to have supportive financial incentives for firms and investors, and a more transparent policy making environment, which could lower your perceived investment risks.

- Not really. Cities that form the national-level city clusters are more vibrant cities with more investment opportunities to start with. I would have paid more attention to them anyway.

- Not really. My perceived market environment and investment risks are more responsive to national-level policies, not regional ones.

- Not really. My perceived market environment and investment risks are more responsive to firm-level characteristics.

- Not really. My and/or my peers' past experiences seem to suggest that cities in the national-level city clusters don't appear to be much different from the other cities in terms of their policy environment and the investment opportunities that they offer.

- Anything I didn't say that is important to you?

Section 2 – Cleantech-specific questions

6a. Have you worked on a cleantech project/proposal since 2015? If yes, please elaborate a little bit on what type of cleantech business it is/was. Where is this investee/potential investee firm located?

6b. **If the answer for "location" from 6a happens to be somewhere in the Central China Triangle,** ask if they felt "any change in the broad policy environment" since 2015.

7. Speaking from your own experiences (as a VC investor), what have been the main barriers to cleantech investment and financing in recent years? (**For those that had specific experiences in the cleantech industry, also ask:** can you give any examples on how you made decisions when you rejected an investment ideas? (Background information that may be used as prompts: existing literatures suggest that, in the eyes of institutional investors, high upfront costs, risks, and uncertainty regarding long-term viability of the technology, long payback periods, high regulatory and infrastructural dependency as well as social acceptance of policy among the local communities are some of the top barriers to cleantech investment.)

8. In your opinion, **how responsive is VC's interest to invest/actual investment in the cleantech industry to the followings** (on a scale of 1 to 5, least responsive to most responsive):

- Changes in the overall macroeconomic environment (e.g. changes in the involved localities' GDP growth rate, unemployment rate, and inflation)
- Changes in the broad regulatory framework (e.g. the Central China Triangle's goal of having supply-side structural reform, cities and provinces' long-term policy commitment / strategic planning for energy system transformation)
- Changes in the specific fiscal and financial incentives that speak directly to the cleantech industry (e.g. the State Council's recent announcement to cut down solar subsidies, aka the "531 Plan", grants, government loans, etc.)
- Changes in the local governments' environmental management practices (e.g. local environmental protection bureaus' efficiency in conducting environmental impact analysis, their frequency of spot-checking polluting firms, etc.)

9. Which of the following examples of "joined-up governance" may influence **how you perceive the investment risks** in the involved regions' cleantech industry (on a scale of 1 to 5, least likely to most likely)?

- Information-sharing among neighboring cities (including e.g. key polluters' emissions behavior, cleantech firms' credit history, environmental impact assessment (EIA) information, etc.)
- Harmonization of the environmental standards and regulations with the neighboring cities (e.g. pollutant emissions standards and EIA evaluation criteria)
- Joint-establishment of cleantech industrial park
- Knowledge sharing and talent exchange among government agencies and research institutions, collaborative research on energy efficiency, renewable energy deployment and pollution remediation
- Public-private partnership in building better investment/financing platforms for the cleantech firms
- Local environmental protection bureaus' joint monitoring of pollutants, joint response to environmental hazard mitigation, and joint enforcement of environmental standards and regulations.

- Specific environmental management style/practices (i.e. joint-governance or not) don't really affect my perceived investment risk or my investment decision.
- Anything I didn't say that is important to you?

Appendix 2-2: Interview questions for the cleantech firms

1. How much do you know about the State Council's decision to form the city clusters along the Middle Reaches of the Yangtze River (hereinafter referred to as "the Central China Triangle Plan") and their recent approvals of several other national-level city clusters?

    - A lot / Some/ A little

2. Do you feel that the regional integration plans have created opportunities for your company's business development/expansion in the involved regions? (probably as a result of harmonization of the environmental standards, which creates greater demand for environmental management services?)

3. Has the financing environment changed noticeably in the Central China Triangle in recent years? If yes, in what way has it changed?

4. Since the formation of city clusters, has your firm participated in any kind of strategic alliance that collaboratively work towards innovation and technological development?

5. Does regulatory strength of the local environmental protection bureaus have a potential influence on how you view your business' growth prospect?

6. Which of the following examples of "joined-up governance" **may help local EPBs improve their environmental management capacity and regulatory strength** (on a scale of 1 to 5, least likely to most likely)?

    - Information-sharing among neighboring cities (including e.g. key polluters' emissions behavior, cleantech firms' credit history, environmental impact assessment (EIA) information, etc.)
    - Harmonization of the environmental standards and regulations with the neighboring cities (e.g. pollutant emissions standards and EIA evaluation criteria)
    - Public-private partnership in building better investment/financing platforms for the cleantech firms

- Local environmental protection bureaus' joint monitoring of pollutants, joint response to environmental hazard mitigation, and joint enforcement of environmental standards and regulations.

7. Can you give an example of local government's collaborative environmental management (CEM) practices that you have come across, if any? Do you see city cluster formation (e.g. the formation of the Central China Triangle) as a construct that promotes CEM?

Appendix 2-3: A copy of IRB's approval letter

UNIVERSITY OF MARYLAND

INSTITUTIONAL REVIEW BOARD

1204 Marie Mount Hall
College Park, MD 20742-5125
TEL 301.405.4212
FAX 301.314.1475
irb@umd.edu
www.umresearch.umd.edu/IRB

DATE:	July 16, 2018
TO:	Linlang He
FROM:	University of Maryland College Park (UMCP) IRB
PROJECT TITLE:	[1259599-1] Do Regional Integration Plans Promote Joint Prevention and Control of Air Pollution?
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	APPROVED
APPROVAL DATE:	July 16, 2018
EXPIRATION DATE:	July 15, 2019
REVIEW TYPE:	Expedited Review
REVIEW CATEGORY:	Expedited review category # 7

Thank you for your submission of New Project materials for this project. The University of Maryland College Park (UMCP) IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a project design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

Prior to submission to the IRB Office, this project received scientific review from the departmental IRB Liaison.

This submission has received Expedited Review based on the applicable federal regulations.

This project has been determined to be a Minimal Risk project. Based on the risks, this project requires continuing review by this committee on an annual basis. Please use the appropriate forms for this procedure. Your documentation for continuing review must be received with sufficient time for review and continued approval before the expiration date of July 15, 2019.

Please remember that informed consent is a process beginning with a description of the project and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the project via a dialogue between the researcher and research participant. Unless a consent waiver or alteration has been approved, Federal regulations require that each participant receives a copy of the consent document.

Please note that any revision to previously approved materials must be approved by this committee prior to initiation. Please use the appropriate revision forms for this procedure.

All UNANTICIPATED PROBLEMS involving risks to subjects or others (UPIRSOs) and SERIOUS and UNEXPECTED adverse events must be reported promptly to this office. Please use the appropriate reporting forms for this procedure. All FDA and sponsor reporting requirements should also be followed.

All NON-COMPLIANCE issues or COMPLAINTS regarding this project must be reported promptly to this office.

Generated on IRBNet

Please note that all research records must be retained for a minimum of seven years after the completion of the project.

If you have any questions, please contact the IRB Office at 301-405-4212 or irb@umd.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Maryland College Park (UMCP) IRB's records.

Appendix 2-4: A list of the twenty-one interviews conducted

Interivew Reference Number	Type of Firm	Interviewees' managerial level
Interview 1	VC1	Senior investment manager
Interview 2	VC1	VP
Interview 3	VC1	CEO
Interview 4	VC1	VP-exit strategy
Interview 5	VC1-subsidiary	regional investment manager
Interview 6	VC1-subsidiary	regional investment manager, ex-SECand new third-board experience
Interview 7	Security1	Chief analyst
Interview 8	VC2	Senior investment manager
Interview 9	VC1	Director, (also the chairperson of China's Venture Capital Association)
Interview 10	Security2	Chief analyst
Interview 11	VC1	VP-cleantech investment
Interview 12	VC1	VP
Interview 13	VC2	VP
Interview 14	VC3	VP
Interview 15	VC3	Senior investment manager
Interview 16	VC1-subsidiary	regional investment manager
Interview 17	VC1	Chief Financial Risk Manager
Interview 18	Security3	Chief analyst
Interview 19	Cleantech1	CFO
Interview 20	Cleantech2	Founder and CEO
Interview 21	Cleantech2	CFO

Appendix 2-5: list of Top 15 VC firms in China as of Year 2019 (Source: QingKe Zero-to-IPO Database)

(million CNY)

VC/PE Name	Chinese Name	Invested Cases / Invested Companies	% share of total Invested Cases / % share of total Invested Companies	Invested Amount	% share of the total invested amount made by VCs
Shen Chuang Tou	深创投	1456 / 941	0.93% / 1.74%	49,909.98	0.50%
IDG Capital	IDG资本	1400 / 918	0.89% / 1.7%	42,084.73	0.42%
Zhen Ge	真格基金	1240 / 952	0.79% / 1.76%	7,082.31	0.07%
Sequoia China	红杉中国	1190 / 877	0.76% / 1.63%	104,314.57	1.04%
Jiu Ding Investment	九鼎投资	825 / 513	0.53% / 0.95%	54,299.75	0.54%
Fortune Venture Capital	达晨创投	803 / 544	0.51% / 1.01%	20,628.09	0.21%
Jun Lian Capital	君联资本	775 / 585	0.49% / 1.08%	33,473.81	0.34%
Jing Wei China	经纬中国	765 / 510	0.49% / 0.95%	18,156.12	0.18%
Tian Xing Capital	天星资本	678 / 567	0.43% / 1.05%	8,193.28	0.08%
Dong Fang Fu Hai	东方富海	644 / 446	0.41% / 0.83%	20,277.40	0.20%
Tong Chuang Wei Ye	同创伟业资管	626 / 451	0.4% / 0.84%	15,156.24	0.15%
Tencent Investment	腾讯投资	618 / 479	0.39% / 0.89%	184,933.24	1.85%
Yi Da Capital	毅达资本	582 / 410	0.37% / 0.76%	17,596.35	0.18%
Shi Dai Bo Le	时代伯乐	581 / 263	0.37% / 0.49%	10,153.72	0.10%
Shanghai Yong Xuan	上海永宣	568 / 457	0.36% / 0.85%	15,291.78	0.15%
All Others (60,204 as of Feb. 2019)	其他	144050 / 50867	91.87% / 94.26%	9,387,364.04	93.97%

Appendix 3-1: typical components of an environmental management capacity building program

- Assist institutions in strengthening their legal, technical, research, analytical, program implementation capacity, and policies and procedures for more effective governance through the exchange of expert knowledge, information, strategies, and tools.

Appendix 3-2: Areas of environmental management where capacity building could be relevant

- Environmental policy planning
- Environmental administration
- Decentralization of environmental management
- Environmental law implementation
- Monitoring and compliance in high priority environmental problem areas
- Harmonization of the environmental legislative framework
- Water resource management
- Solid waste management
- Air quality management
- Greenhouse gases management

- Environmental impact assessment
- Public participation/ social inclusion
- Environmental enforcement and compliance

Appendix 3-3: sampled cities' geographical distribution

Guangdong	广东	21
Anhui	安徽	16
Jiangsu	江苏	13
Zhejiang	浙江	11
Hubei	湖北	16
Hunan	湖南	14
Jiangxi	江西	11
Yunnan	云南	3
Shandong	山东	9
Shanxi	山西	4
Guangxi	广西	2
Xinjiang	新疆	1
Gansu	甘肃	2
Fujian	福建	2
Guizhou	贵州	1
Liaoning	辽宁	5
Shanxi	陕西	6

Appendix 3-4: measured variables' percentages of missing values

variable label	al sample s	No. of missing variable	Percentage of missing variable
EPB_2017_TBE	137	4	2.9%
EPB_2017_PBE	137	9	6.6%
EPB_2017ratio	137	9	6.6%
EPB_2016_TAE	137	6	4.4%
EPB_2016_PAE	137	13	9.5%
EPB_2016ratio	137	13	9.5%
pfrev_2017	137	0	0.0%
expcitymd_2016	137	0	0.0%
pfexp_2016	137	0	0.0%
GRP_2017?	137	0	0.0%
GRPPC_2016	137	0	0.0%
share2nd_1716	137	0	0.0%
noairp_2017	137	0	0.0%
pop	137	0	0.0%
popdensity	137	0	0.0%
EIA_num	137	14	10.2%
EIA_eff	137	19	13.9%
SupMonitor_C	137	9	6.6%
SupMonitor_P	137	9	6.6%
Spotcheck	137	0	0.0%
PercCharged	137	1	0.7%
PercCollected	137	0	0.0%
Pollution Fee	137	0	0.0%
PR	137	42	30.7%
AvgPR	137	42	30.7%
aqi	137	3	2.2%
so2_24h	137	3	2.2%
no2_24h	137	3	2.2%
co_24h	137	3	2.2%
o3_8h_24h	137	3	2.2%
pm2_5_24h	137	3	2.2%
pm10_24h	137	3	2.2%

Appendix 3-5: summary statistics of the variables.

Control group variables

Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Control	68	0	0	0	0
EPB_2017_TBE	65	75.463	134.952	7.111	923.318
EPB_2017_PBE	63	48.85	116.022	1.55	786.143
EPB_2017ra~o	63	47.717	22.302	6.085	88.784
EPB_2016_TAE	64	94.683	164.479	5.634	1037.315
EPB_2016_PAE	60	64.638	143.318	2.357	864.169
EPB_2016ra~o	60	54.712	19.398	6.388	91.746
pfrev_2017	68	20.963	20.972	2.006	115.711
expcity~2016	68	3.588	6.977	.018	51.779
pfexp_2016	68	16.525	16.93	1.02	94.522
GRP_2017	68	24.308	21.567	2.243	110.373
GRPPC_2016	68	6.012	2.53	1.939	13.179
share2n~1716	68	45.088	10.596	15.89	68.41
noairp_2017	68	9.765	8.344	0	42
pop	68	1.632	1.294	.21	6.29
popdensity	68	9.063	5.723	.696	26.475
EIA_num	63	43.619	43.398	0	192
EIA_eff	57	29.346	10.23	6.58	53.39
SupMonitor_C	64	6.78	6.354	1	31
SupMonitor_P	64	69.833	23.563	11.25	100
Spotcheck	68	1.882	1.09	0	3
PercCharged	67	44.011	16.1	13	75.25
PercCollec~d	68	68.239	20.733	23.5	100
PollutionFee	68	23.568	25.911	.128	125.509
Selfmon	39	15.436	4.957	0	20

Selfinf	39	.938	1.153	0	3.6
PR	42	19.524	21.795	0	107
AvgPR	42	6.688	8.869	0	52
aqi	68	81.839	21.377	52.298	130.272
so2_24h	68	20.189	12.667	4.634	79.512
no2_24h	68	32.67	11.339	12.842	58.938
co_24h	68	1.023	.293	.534	2.069
o3_8h_24h	68	94.96	12.372	66.576	117.342
pm2_5_24h	68	47.182	15.119	22.96	82.436
pm10_24h	68	82.718	27.234	43.784	135.653

Treatment group variables:

Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
Control	68	0	0	0	0
EPB_2017_TBE	65	75.463	134.952	7.111	923.318
EPB_2017_PBE	63	48.85	116.022	1.55	786.143
EPB_2017ra~o	63	47.717	22.302	6.085	88.784
EPB_2016_TAE	64	94.683	164.479	5.634	1037.315
EPB_2016_PAE	60	64.638	143.318	2.357	864.169
EPB_2016ra~o	60	54.712	19.398	6.388	91.746
pfrev_2017	68	20.963	20.972	2.006	115.711
expcity~2016	68	3.588	6.977	.018	51.779
pfexp_2016	68	16.525	16.93	1.02	94.522
GRP_2017	68	24.308	21.567	2.243	110.373
GRPPC_2016	68	6.012	2.53	1.939	13.179
share2n~1716	68	45.088	10.596	15.89	68.41
noairp_2017	68	9.765	8.344	0	42

pop	68	1.632	1.294	.21	6.29
popdensity	68	9.063	5.723	.696	26.475
EIA_num	63	43.619	43.398	0	192
EIA_eff	57	29.346	10.23	6.58	53.39
SupMonitor_C	64	6.78	6.354	1	31
SupMonitor_P	64	69.833	23.563	11.25	100
Spotcheck	68	1.882	1.09	0	3
PercCharged	67	44.011	16.1	13	75.25
PercCollec~d	68	68.239	20.733	23.5	100
PollutionFee	68	23.568	25.911	.128	125.509
Selfmon	39	15.436	4.957	0	20
Selfinf	39	.938	1.153	0	3.6
PR	42	19.524	21.795	0	107
AvgPR	42	6.688	8.869	0	52
aqi	68	81.839	21.377	52.298	130.272
so2_24h	68	20.189	12.667	4.634	79.512
no2_24h	68	32.67	11.339	12.842	58.938
co_24h	68	1.023	.293	.534	2.069
o3_8h_24h	68	94.96	12.372	66.576	117.342
pm2_5_24h	68	47.182	15.119	22.96	82.436
pm10_24h	68	82.718	27.234	43.784	135.653

Appendix 3-6: rescaling factors used for model runs

```
DEFINE:

input1=input1/10;
input2=input2/10;
input4=input4/10;
input5=input5/10;
cont1=cont1/10;
cont3=cont3/10;
output1=output1/10;
outcome2=outcome2/10;
outcome5=outcome5/10;
envout4=envout4*10;
```

Appendix 3-7:

Below is the guidelines on air quality outcome measurement provided by China's Ministry of Ecology and Environment

2. 环境空气质量标准（GB3095-2012）中六项污染物浓度限值如下表所示:

环境空气污染物基本项目浓度限值

污染物项目	平均时间	浓度限值		单位
		一级	二级	
SO_2	年平均	20	60	μg/m³
	24 小时平均	50	150	
	1 小时平均	150	500	
NO_2	年平均	40	40	
	24 小时平均	80	80	
	1 小时平均	200	200	
CO	24 小时平均	4	4	mg/m ³
	1 小时平均	10	10	
O_3	8 小时平均	100	160	μg/m³
	1 小时平均	160	200	
PM_{10}	年平均	40	70	
	24 小时平均	50	150	
$PM_{2.5}$	年平均	15	35	
	24 小时平均	35	75	

Appendix 3-8: Regression results:

SO2:

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	-1.6691	-2.8122*	-4.7854**	-3.8812**	-5.4000**	-4.4479**	-4.3204	-3.0552
	(1.3472)	(1.4656)	(1.9570)	(1.8277)	(2.0329)	(2.0381)	(3.3183)	(3.3784)
pfrev_2017	-0.6605	-0.8794	-0.6023	-1.4508	-0.5419	-1.8565*	-1.6727	-2.5837
	(0.7164)	(0.7163)	(0.8649)	(0.9566)	(0.9352)	(1.0029)	(1.3705)	(1.8165)
expcitymd_2016	-0.0220	-0.0186	0.0052	0.0109	0.0430	0.0360	0.0492	0.1771
	(0.0613)	(0.0663)	(0.1011)	(0.0674)	(0.1298)	(0.0812)	(0.1795)	(0.2416)
pfexp_2016	0.4850	0.6625	0.4212	1.1032	0.5075	1.4565**	1.1302	1.8915**
	(0.5130)	(0.4908)	(0.5737)	(0.6835)	(0.5540)	(0.6702)	(0.8470)	(0.9053)
GRP_2017	-0.0725	-0.0495	-0.0542	-0.0878	-0.0594	-0.0404	-0.0043	0.0506
	(0.0593)	(0.0683)	(0.0579)	(0.0923)	(0.0751)	(0.0964)	(0.1297)	(0.1557)
GRPPC_2016	-0.1955*	-0.1573	-0.1516	-0.2039	-0.1000	-0.4401	-1.0281	-1.5775
	(0.1106)	(0.0983)	(0.1015)	(0.5693)	(0.0872)	(0.5869)	(1.0269)	(1.1108)
share2nd_1716	-0.2082	-0.2262	-0.1274	-0.3123	-0.2400	-0.4166	-0.1401	-0.3517
	(0.1553)	(0.1912)	(0.2026)	(0.2267)	(0.2624)	(0.2702)	(0.2397)	(0.2660)
noairp_2017	0.5545**	0.5141**	0.3808	0.3964**	0.2249	0.3606*	0.3788	0.1154
	(0.1925)	(0.2237)	(0.4443)	(0.1839)	(0.4596)	(0.2064)	(0.5809)	(0.5513)
pop	0.0435	-0.9966	0.7977	0.3694	-0.2746	-1.3730	1.1879	-0.8978
	(1.2342)	(1.2586)	(1.2130)	(1.9345)	(1.2853)	(1.9213)	(1.7745)	(2.2296)
popdensity	0.4034**	0.3730**	0.3276**	0.5389**	0.2658*	0.5167**	0.5242**	0.5672**
	(0.1447)	(0.1686)	(0.1487)	(0.1706)	(0.1463)	(0.1895)	(0.2133)	(0.2174)
EPB_2017_TBE		0.3025			0.1550	0.5583		-0.6722
		(0.9586)			(1.2649)	(1.3662)		(2.3126)
EPB_2017_PBE		-0.4982			-0.4338	-0.7102		0.3438
		(1.0672)			(1.3862)	(1.4468)		(2.4283)
EPB_2017ratio		-0.0148			-0.0002	-0.0324		0.0150
		(0.0617)			(0.0780)	(0.0735)		(0.0973)
EPB_2016_TAE		-0.5744			-0.2619	-0.9453		0.1819
		(0.5151)			(0.7670)	(0.8472)		(1.5135)
EPB_2016_PAE		1.0309*			0.6620	1.4441		0.3272
		(0.6088)			(0.8643)	(0.9165)		(1.5723)
EPB_2016ratio		-0.0850			-0.0623	-0.1534		-0.2135
		(0.0694)			(0.0823)	(0.1046)		(0.1350)
EIA_num			-0.1222		-0.0971		-0.1648	-0.0474
			(0.1117)		(0.1487)		(0.1593)	(0.2328)
EIA_eff			0.0762		0.1326*		0.0592	0.0745
			(0.0677)		(0.0796)		(0.0858)	(0.0958)
SupMonitor_C			0.0514		0.2399		-0.4926	-0.1806
			(0.4392)		(0.4172)		(0.8045)	(0.7191)
SupMonitor_P			-0.0886*		-0.0972**		-0.0775	-0.1070
			(0.0533)		(0.0476)		(0.0725)	(0.0680)
Spotcheck			-3.1221**		-2.8142**		-3.1473**	-2.7712*
			(0.9030)		(0.9622)		(1.2180)	(1.3969)
PercCharged			0.1433**		0.1908**		0.0795	0.0277
			(0.0595)		(0.0740)		(0.1466)	(0.1611)
PercCollected				0.0812		0.1406*	0.0866	0.1888
				(0.0616)		(0.0784)	(0.1462)	(0.1812)
PollutionFee				0.1948		0.1895	0.2167	0.1972
				(0.2103)		(0.2193)	(0.2829)	(0.3316)
PR				-0.0710		0.1083	1.2475	1.0238
				(0.3694)		(0.5552)	(1.6029)	(1.4400)
AvgPR				0.1134		0.1385	0.2902	0.8465
				(0.1530)		(0.2337)	(0.5257)	(0.5843)
N	134	121	106	93	98	84	74	68
R-sq	0.288	0.349	0.442	0.365	0.505	0.478	0.497	0.617
adj. R-sq	0.230	0.249	0.342	0.251	0.360	0.313	0.307	0.374
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.0	*** p<0.01"						

NO2:

	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	0.8164	0.3834	-0.8250	-0.3423	-1.3396	0.3130	-1.3592	-0.9099
	(1.6865)	(1.7392)	(2.1263)	(1.8638)	(2.1749)	(2.1199)	(2.6761)	(2.6028)
pfrev_2017	0.8513	0.5522	0.8158	0.3824	0.3516	0.0940	-0.2961	-0.5488
	(0.6110)	(0.6821)	(0.7874)	(0.7823)	(0.8080)	(1.0308)	(0.9239)	(1.6544)
expcitymd_2016	0.1587**	0.1476**	0.3479**	0.1210**	0.2497*	0.0803	0.2054	0.0197
	(0.0616)	(0.0662)	(0.1358)	(0.0553)	(0.1386)	(0.0758)	(0.1893)	(0.2241)
pfexp_2016	-0.7298**	-0.6911*	-0.9542**	-0.4628	-0.8995**	-0.4141	-0.2831	-0.1315
	(0.3597)	(0.3529)	(0.4425)	(0.5171)	(0.4107)	(0.5611)	(0.6214)	(0.7931)
GRP_2017	-0.0014	-0.0051	0.0484	-0.0057	0.0686	-0.0054	0.0648	0.0726
	(0.0632)	(0.0750)	(0.0734)	(0.0712)	(0.0920)	(0.0738)	(0.0968)	(0.1274)
GRPPC_2016	-0.1374	-0.1740	-0.1898	0.0102	-0.1590	-0.0600	-0.0415	-0.1649
	(0.1764)	(0.1721)	(0.1539)	(0.4787)	(0.2003)	(0.5167)	(0.7364)	(0.7567)
share2nd_1716	-0.0049	0.0141	-0.0525	-0.1715	-0.0833	-0.1890	-0.1048	-0.1309
	(0.1094)	(0.1165)	(0.1097)	(0.1455)	(0.1324)	(0.1816)	(0.1561)	(0.2190)
noairp_2017	0.2825**	0.2158*	0.0295	0.1019	-0.0317	0.0981	-0.3759	-0.4089
	(0.1099)	(0.1252)	(0.2838)	(0.1165)	(0.2876)	(0.1357)	(0.3901)	(0.4519)
pop	1.6198	0.3320	0.2829	1.9936**	-0.8922	1.2447	0.9955	0.4402
	(1.0859)	(1.3490)	(1.1712)	(0.9983)	(1.4847)	(1.5154)	(1.1380)	(2.0141)
popdensity	0.1372	0.2376	0.2522	0.2223	0.2224	0.3594**	0.2499	0.2495
	(0.1361)	(0.1535)	(0.1552)	(0.1450)	(0.1716)	(0.1552)	(0.1887)	(0.2076)
EPB_2017_TBE		0.8340			1.9927**	-0.3220		1.5546
		(1.0514)			(0.8956)	(1.2274)		(1.4291)
EPB_2017_PBE		-1.0086			-2.1570**	0.1236		-1.7994
		(1.1580)			(1.0114)	(1.3282)		(1.5345)
EPB_2017ratio		0.0165			0.0664	0.0054		0.0230
		(0.0564)			(0.0668)	(0.0661)		(0.0824)
EPB_2016_TAE		0.2580			-0.5609	0.8296		-0.6861
		(0.7982)			(0.5864)	(0.8588)		(1.1084)
EPB_2016_PAE		-0.1724			0.6051	-0.7447		0.8275
		(0.8720)			(0.6623)	(0.9689)		(1.2270)
EPB_2016ratio		0.0604			0.0928	0.0955		0.0953
		(0.0606)			(0.0677)	(0.0842)		(0.1058)
EIA_num			0.0979		0.0079		0.1491	0.0453
			(0.1124)		(0.1278)		(0.1479)	(0.1694)
EIA_eff			-0.0490		-0.0209		-0.1014	-0.0914
			(0.0956)		(0.0944)		(0.1181)	(0.1392)
SupMonitor_C			0.2840		0.1662		0.3289	0.1744
			(0.3926)		(0.4020)		(0.5668)	(0.6494)
SupMonitor_P			-0.0013		0.0315		-0.0106	0.0043
			(0.0496)		(0.0619)		(0.0697)	(0.0909)
Spotcheck			-1.4382*		-1.2618		-0.4990	-0.0986
			(0.7764)		(0.8364)		(1.0131)	(1.0545)
PercCharged			0.1390**		0.1735**		0.2373	0.2349
			(0.0578)		(0.0685)		(0.1467)	(0.1720)
PercCollected				0.1089**		0.0940*	-0.0664	-0.0748
				(0.0453)		(0.0519)	(0.1082)	(0.1292)
PollutionFee				0.0779		0.1093	0.0444	0.1455
				(0.2097)		(0.2580)	(0.2408)	(0.3799)
PR				-1.0323**		-0.7738	0.8389	1.0804
				(0.4051)		(0.6104)	(1.2999)	(1.3759)
AvgPR				0.5387***		0.3991*	0.3456	0.2409
				(0.1186)		(0.2008)	(0.4385)	(0.3538)
N	134	121	106	93	98	84	74	68
R-sq	0.314	0.360	0.383	0.393	0.446	0.422	0.428	0.489
adj. R-sq	0.259	0.261	0.272	0.284	0.284	0.239	0.212	0.165
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.05	*** p<0.01"						

PM10:

	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	-1.1234	-4.0307	-5.4816	-4.5577	-8.7079	-5.8467	-7.6244	-11.0499*
	(4.0242)	(4.3677)	(4.7198)	(4.8388)	(5.2630)	(5.3016)	(5.8538)	(6.1265)
pfrev_2017	0.4682	0.1726	1.6781	-0.5231	2.1028	0.0556	-2.1588	-1.2215
	(1.4467)	(1.6216)	(1.7858)	(1.7117)	(2.0571)	(2.0698)	(2.5751)	(3.8211)
expcitymd_2016	-0.0280	-0.0259	0.1061	-0.1397	0.0399	-0.2356	-0.6552	-0.6753
	(0.1928)	(0.2132)	(0.4317)	(0.1878)	(0.4385)	(0.1979)	(0.4594)	(0.5756)
pfexp_2016	-0.0784	0.1303	-1.5755	0.8953	-1.5230	0.8975	0.5352	0.6987
	(0.8598)	(0.8280)	(1.0578)	(1.1049)	(1.1195)	(1.2003)	(1.5122)	(1.9007)
GRP_2017	-0.2996*	-0.2936	-0.2033	-0.2709	-0.2289	-0.3023	0.0683	-0.0249
	(0.1563)	(0.1888)	(0.1958)	(0.1675)	(0.2446)	(0.1832)	(0.2768)	(0.3781)
GRPPC_2016	-0.3786	-0.3216	-0.2806	-1.4186	-0.1032	-2.0956*	-1.3550	-1.4475
	(0.2724)	(0.2877)	(0.2707)	(1.0956)	(0.2324)	(1.0598)	(1.6885)	(1.8777)
share2nd_1716	-0.1042	-0.1287	-0.2837	-0.2878	-0.3110	-0.2954	-0.0607	-0.0312
	(0.2360)	(0.2733)	(0.2070)	(0.2986)	(0.2409)	(0.3410)	(0.3167)	(0.4221)
noairp_2017	1.2264***	1.1267***	-0.3070	0.9016***	-0.6850	0.9970***	-0.7360	-1.0095
	(0.3018)	(0.3288)	(0.5872)	(0.3102)	(0.6217)	(0.3476)	(0.8618)	(0.9352)
pop	4.4746	2.5673	3.3922	4.4542	2.1007	5.7944	4.1702	3.6717
	(2.9186)	(3.8662)	(3.0962)	(2.7111)	(3.9416)	(3.5250)	(3.0714)	(5.3915)
popdensity	0.3060	0.7334*	0.5400*	0.7331**	0.5281	1.5531***	0.9036**	1.1190**
	(0.2998)	(0.4141)	(0.3182)	(0.3488)	(0.3701)	(0.5181)	(0.3897)	(0.4254)
EPB_2017_TBE		1.5103			3.6976	-2.3225		2.0213
		(2.5561)			(2.5710)	(2.8829)		(4.6878)
EPB_2017_PBE		-1.6282			-3.8273	1.8705		-2.4127
		(2.7817)			(2.8568)	(3.1181)		(4.9606)
EPB_2017ratio		-0.0932			0.0013	-0.1971		-0.1475
		(0.1373)			(0.1501)	(0.1606)		(0.1932)
EPB_2016_TAE		-0.7926			-2.4960*	1.0604		-1.9246
		(1.6670)			(1.3284)	(1.8119)		(3.0800)
EPB_2016_PAE		0.9543			2.5068	-0.6749		2.3280
		(1.9026)			(1.6386)	(2.0683)		(3.2628)
EPB_2016ratio		0.0150			0.0431	-0.0082		-0.0299
		(0.1514)			(0.1571)	(0.2077)		(0.2364)
EIA_num			0.1771		-0.0003		0.0086	-0.0262
			(0.2300)		(0.2747)		(0.3010)	(0.3984)
EIA_eff			0.1429		0.1758		0.0167	0.0205
			(0.1878)		(0.2053)		(0.2341)	(0.2845)
SupMonitor_C			1.9715**		2.3200**		2.4398**	2.5761**
			(0.8617)		(0.9308)		(1.1183)	(1.2230)
SupMonitor_P			-0.1620		-0.1753		-0.2147	-0.2043
			(0.1051)		(0.1150)		(0.1427)	(0.1652)
Spotcheck			-6.6853**		-6.2552**		-6.4676**	-5.2480*
			(1.8325)		(2.0621)		(2.3870)	(2.7017)
PercCharged			0.2943**		0.2942*		0.3216	0.3610
			(0.1305)		(0.1529)		(0.2883)	(0.3973)
PercCollected				0.2487**		0.1822	0.0810	-0.0091
				(0.1068)		(0.1249)	(0.2247)	(0.2908)
PollutionFee				0.5820		0.3462	0.7757	0.5598
				(0.6514)		(0.7246)	(0.6792)	(0.8561)
PR				-2.4780**		-1.7376	-2.0385	-0.9274
				(0.9769)		(1.3332)	(2.9771)	(3.5685)
AvgPR				1.2873***		1.0579**	1.0053	0.8472
				(0.2874)		(0.4312)	(1.0718)	(1.2343)
N	134	121	106	93	98	84	74	68
R-sq	0.243	0.279	0.437	0.399	0.458	0.493	0.539	0.578
adj. R-sq	0.182	0.168	0.335	0.291	0.299	0.332	0.365	0.310
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.05	*** p<0.01"						

PM2.5:

	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	2.6040	0.1922	0.3844	2.2337	-1.7575	0.5660	0.7276	-1.4066
	(2.3629)	(2.5629)	(2.5346)	(2.6317)	(2.8200)	(2.9498)	(3.1421)	(3.2998)
pfrev_2017	0.7103	0.6437	1.3681	-0.3097	1.9523	0.4227	-1.2163	-0.3522
	(0.7851)	(0.8741)	(0.9890)	(0.9245)	(1.1863)	(1.1301)	(1.2707)	(1.8537)
expcitymd_2016	0.0135	0.0310	0.1019	-0.0112	0.0841	-0.0683	-0.1830	-0.0927
	(0.1019)	(0.1195)	(0.2357)	(0.0906)	(0.2566)	(0.1094)	(0.2156)	(0.2916)
pfexp_2016	-0.3599	-0.1214	-1.1302*	0.4444	-1.0972*	0.3880	0.2144	0.3024
	(0.4630)	(0.4461)	(0.6081)	(0.5959)	(0.6349)	(0.6422)	(0.7929)	(0.9846)
GRP_2017	-0.1832**	-0.1792	-0.1374	-0.1333	-0.1661	-0.1502	0.0849	0.0139
	(0.0915)	(0.1107)	(0.1143)	(0.1007)	(0.1507)	(0.1126)	(0.1408)	(0.1909)
GRPPC_2016	-0.2104	-0.2117	-0.1824	-1.0144	-0.0856	-1.4555**	-1.2921	-1.4052
	(0.2179)	(0.2436)	(0.2178)	(0.6879)	(0.1793)	(0.6526)	(0.9471)	(1.0609)
share2nd_1716	-0.0346	0.0447	-0.0986	-0.2159	-0.0500	-0.1172	0.0014	0.0382
	(0.1586)	(0.1875)	(0.1447)	(0.1845)	(0.1881)	(0.2034)	(0.1899)	(0.2406)
noairp_2017	0.4506**	0.4309**	-0.1324	0.3840**	-0.3976	0.5020***	-0.1000	-0.2898
	(0.1735)	(0.1934)	(0.3986)	(0.1623)	(0.4291)	(0.1806)	(0.5840)	(0.6110)
pop	2.2344	1.5928	1.4076	1.9008	1.1057	3.0494	0.8914	1.1249
	(1.6624)	(2.2827)	(1.6789)	(1.4519)	(2.2536)	(2.0839)	(1.4585)	(2.7484)
popdensity	0.1931	0.3490	0.2678	0.5299**	0.2330	0.9476***	0.6148***	0.7647***
	(0.1840)	(0.2387)	(0.1872)	(0.2249)	(0.2164)	(0.2678)	(0.2050)	(0.2246)
EPB_2017_TBE		0.2856			1.7732	-2.5036		-0.3252
		(1.5380)			(1.4509)	(1.6956)		(2.5638)
EPB_2017_PBE		-0.4012			-1.8898	2.2205		0.0877
		(1.6151)			(1.5683)	(1.7440)		(2.6991)
EPB_2017ratio		-0.0418			0.0006	-0.1753**		-0.1322
		(0.0786)			(0.0826)	(0.0814)		(0.1029)
EPB_2016_TAE		-0.5790			-1.7563**	0.7903		-0.6802
		(0.9841)			(0.6921)	(1.0325)		(1.5890)
EPB_2016_PAE		0.7916			1.8917**	-0.4256		1.0465
		(1.0314)			(0.7871)	(1.0398)		(1.6183)
EPB_2016ratio		-0.0692			-0.0474	-0.0485		-0.0816
		(0.0826)			(0.0829)	(0.0996)		(0.1148)
EIA_num			0.1284		-0.0141		0.0446	0.0779
			(0.1341)		(0.1526)		(0.1806)	(0.2239)
EIA_eff			0.1335		0.1410		0.0297	0.0034
			(0.1137)		(0.1263)		(0.1304)	(0.1628)
SupMonitor_C			0.7581		1.0622*		0.8881	1.0393
			(0.5166)		(0.5425)		(0.7128)	(0.7187)
SupMonitor_P			-0.0525		-0.0627		-0.0967	-0.0949
			(0.0681)		(0.0699)		(0.0869)	(0.0921)
Spotcheck			-3.4071**		-2.8894**		-3.4406**	-2.5378*
			(1.0825)		(1.1847)		(1.2916)	(1.4362)
PercCharged			0.1304*		0.1047		-0.0033	0.0137
			(0.0749)		(0.0848)		(0.1673)	(0.2215)
PercCollected				0.1767***		0.1165	0.1963	0.1434
				(0.0663)		(0.0731)	(0.1418)	(0.1799)
PollutionFee				0.0969		-0.0864	0.2218	-0.0526
				(0.3184)		(0.3635)	(0.3479)	(0.4032)
PR				-1.7225**		-1.1582	-1.6172	-0.6970
				(0.5227)		(0.7391)	(1.9281)	(2.1224)
AvgPR				0.8801***		0.7125***	0.7941	0.7546
				(0.1623)		(0.2454)	(0.6250)	(0.7210)
N	134	121	106	93	98	84	74	68
R-sq	0.144	0.177	0.327	0.340	0.349	0.476	0.453	0.524
adj. R-sq	0.075	0.050	0.205	0.221	0.158	0.310	0.247	0.222
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.05	*** p<0.01"						

Ozone:

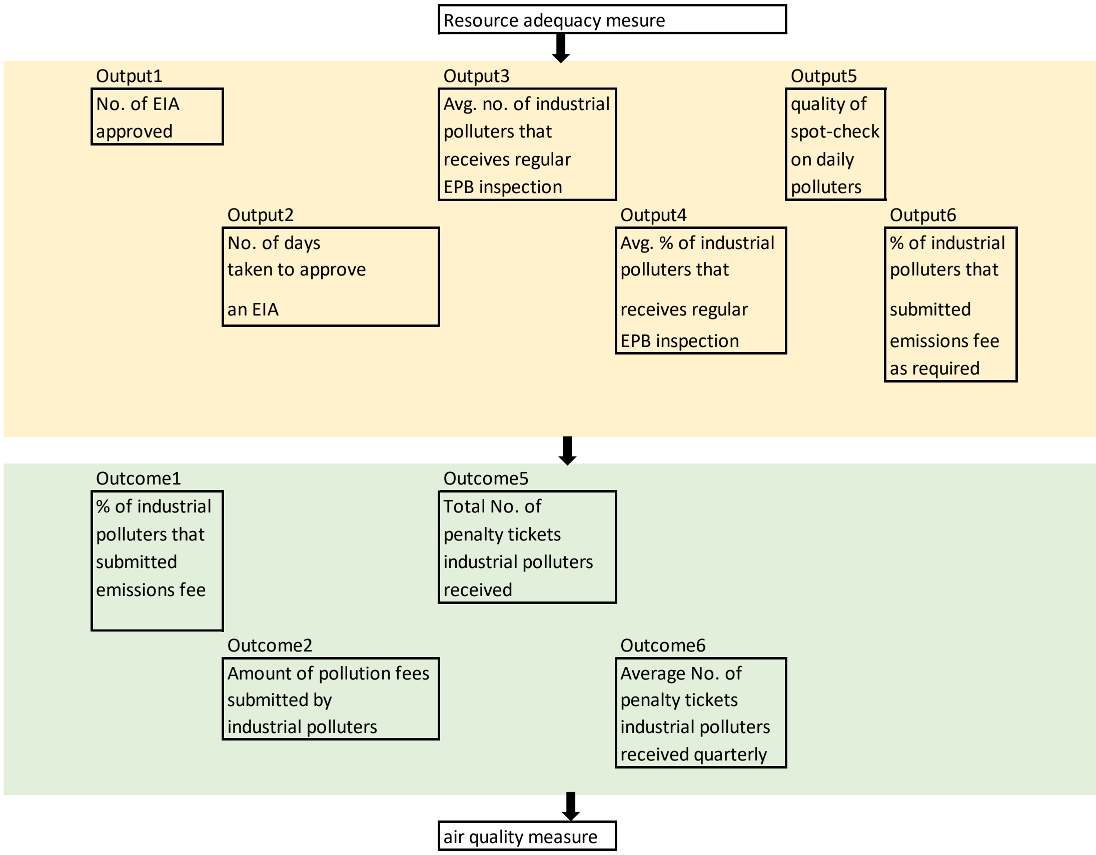
	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	1.4411	3.0325	1.3034	-1.3769	1.6166	0.8633	-0.1378	0.4588
	(2.0595)	(2.2466)	(2.6406)	(2.7227)	(2.7587)	(3.0316)	(3.7364)	(4.1087)
pfrev_2017	1.0742	1.0687	2.2781**	0.5291	2.3855**	0.2552	1.2038	2.3624
	(0.8462)	(0.8917)	(0.9494)	(0.9702)	(1.0749)	(1.2510)	(1.1890)	(2.0092)
expcitymd_2016	-0.1338	-0.1713**	-0.1515	-0.0866	-0.1537	-0.1429	-0.1058	-0.0929
	(0.0817)	(0.0766)	(0.1183)	(0.0976)	(0.1316)	(0.1116)	(0.2424)	(0.2914)
pfexp_2016	-1.2596**	-1.3484**	-2.0626**	-1.0189	-2.0504**	-1.0391	-1.4363*	-1.7626*
	(0.5422)	(0.5663)	(0.5363)	(0.7044)	(0.5323)	(0.7467)	(0.7892)	(0.8779)
GRP_2017	0.0131	0.0285	-0.0089	0.1389	-0.0182	0.1719	0.0868	0.0001
	(0.0769)	(0.0823)	(0.0893)	(0.0914)	(0.1001)	(0.1064)	(0.1201)	(0.1710)
GRPPC_2016	0.0239	-0.0139	0.1517	-1.2894*	0.1955	-1.1672	-0.7702	-0.6588
	(0.1438)	(0.1461)	(0.1434)	(0.6852)	(0.1801)	(0.7671)	(0.9656)	(1.1599)
share2nd_1716	0.0537	-0.0369	-0.0173	0.1312	-0.1153	-0.0461	0.0650	0.0153
	(0.1277)	(0.1553)	(0.1635)	(0.1517)	(0.2029)	(0.1916)	(0.2088)	(0.2652)
noairp_2017	0.1713	0.1937	-0.4394	0.0184	-0.5113	0.0710	-0.4971	-0.4660
	(0.1642)	(0.1824)	(0.2962)	(0.1517)	(0.3311)	(0.1791)	(0.3878)	(0.4542)
pop	1.9764*	1.9148	1.5571	0.6748	1.5201	0.2681	0.7699	1.7701
	(1.0651)	(1.2166)	(1.1247)	(1.2468)	(1.3776)	(1.8853)	(1.4195)	(2.3749)
popdensity	-0.0486	0.0843	-0.0132	0.0867	-0.0565	0.2629	0.0888	0.0403
	(0.1655)	(0.2489)	(0.1928)	(0.2031)	(0.2023)	(0.3086)	(0.2544)	(0.2755)
EPB_2017_TBE		-0.8108			-0.1705	-0.6193		0.2319
		(1.2072)			(1.3070)	(1.7394)		(1.8352)
EPB_2017_PBE		0.8220			0.1392	0.8054		-0.3345
		(1.2771)			(1.3856)	(1.7202)		(1.8398)
EPB_2017ratio		-0.0029			-0.0319	-0.0808		-0.0413
		(0.0769)			(0.0871)	(0.0930)		(0.1113)
EPB_2016_TAE		0.5719			0.2416	0.2695		-0.2457
		(0.8304)			(0.8264)	(1.1712)		(1.1851)
EPB_2016_PAE		-0.7371			-0.3672	-0.4723		0.1246
		(0.8522)			(0.8520)	(1.1529)		(1.1993)
EPB_2016ratio		0.1758**			0.1923**	0.2209**		0.2005
		(0.0757)			(0.0868)	(0.0976)		(0.1252)
EIA_num			-0.4458**		-0.4428**		-0.4318*	-0.5060*
			(0.1736)		(0.1907)		(0.2482)	(0.2523)
EIA_eff			0.1199		0.1576		0.0428	0.0886
			(0.0955)		(0.1161)		(0.1497)	(0.1671)
SupMonitor_C			0.8236**		0.8507**		0.3253	0.1894
			(0.3417)		(0.4152)		(0.5438)	(0.6308)
SupMonitor_P			0.0414		-0.0038		0.0486	-0.0148
			(0.0593)		(0.0679)		(0.0776)	(0.0898)
Spotcheck			-0.8758		-1.3249		-0.7679	-1.0693
			(1.0111)		(1.0350)		(1.2150)	(1.2997)
PercCharged			0.1117		0.1812**		0.0859	0.1481
			(0.0797)		(0.0859)		(0.1515)	(0.1838)
PercCollected				0.1775**		0.2168***	0.0680	0.0733
				(0.0687)		(0.0753)	(0.1351)	(0.1507)
PollutionFee				0.2944*		0.2084	0.3149	0.0646
				(0.1591)		(0.2073)	(0.2334)	(0.3437)
PR				0.7337		0.4011	2.2298	2.5380
				(0.6322)		(0.8033)	(2.5620)	(2.4837)
AvgPR				0.0028		0.0770	-0.0835	-0.1890
				(0.1843)		(0.2538)	(0.9149)	(0.9388)
N	134	121	106	93	98	84	74	68
R-sq	0.108	0.161	0.274	0.225	0.359	0.321	0.320	0.450
adj. R-sq	0.035	0.032	0.143	0.086	0.171	0.106	0.063	0.102
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.05	*** p<0.01"						

Carbon monoxide:

	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	-0.1825	-0.4435	-0.6644	0.0795	-0.6084	-0.0978	0.1053	0.2594
	(0.4477)	(0.4676)	(0.5142)	(0.5556)	(0.5299)	(0.6127)	(0.6691)	(0.7436)
pfrev_2017	-0.5249**	-0.5435**	-0.7840**	-0.6017**	-0.8177**	-0.5447**	-1.2284**	-1.2998**
	(0.1688)	(0.1876)	(0.1838)	(0.1953)	(0.1881)	(0.2237)	(0.2204)	(0.3634)
expcitymd_2016	0.0310	0.0385*	0.0472	0.0239	0.0557	0.0278	-0.0017	0.0487
	(0.0199)	(0.0221)	(0.0390)	(0.0181)	(0.0398)	(0.0216)	(0.0398)	(0.0539)
pfexp_2016	0.3866***	0.3943***	0.5424***	0.5084***	0.4953***	0.4946***	0.7762***	0.7930***
	(0.1211)	(0.1271)	(0.1195)	(0.1387)	(0.1168)	(0.1480)	(0.1469)	(0.1634)
GRP_2017	-0.0088	-0.0087	-0.0014	-0.0108	0.0046	-0.0128	0.0540**	0.0521
	(0.0145)	(0.0171)	(0.0162)	(0.0173)	(0.0174)	(0.0208)	(0.0221)	(0.0313)
GRPPC_2016	0.0155	0.0283	0.0315	-0.1372	0.0473	-0.1484	-0.4347**	-0.4239**
	(0.0477)	(0.0442)	(0.0448)	(0.1386)	(0.0389)	(0.1573)	(0.1687)	(0.1931)
share2nd_1716	-0.0415	-0.0197	-0.0454	-0.0777**	-0.0587	-0.0502	-0.0257	-0.0517
	(0.0311)	(0.0360)	(0.0323)	(0.0389)	(0.0412)	(0.0550)	(0.0317)	(0.0446)
noairp_2017	0.1598***	0.1588***	0.2999***	0.1359***	0.3245***	0.1545**	0.2596**	0.3240***
	(0.0439)	(0.0519)	(0.0902)	(0.0485)	(0.0944)	(0.0589)	(0.0987)	(0.1038)
pop	-0.1374	-0.2994	-0.0577	-0.2115	-0.1511	-0.1872	-0.4019	-0.3667
	(0.2410)	(0.2926)	(0.2626)	(0.3106)	(0.3080)	(0.4694)	(0.3009)	(0.5338)
popdensity	0.0354	0.0231	0.0312	0.0435	0.0396	0.0532	0.0524	0.0931*
	(0.0286)	(0.0374)	(0.0363)	(0.0370)	(0.0446)	(0.0530)	(0.0470)	(0.0544)
EPB_2017_TBE		0.1018			-0.1846	-0.3195		-0.7291**
		(0.2584)			(0.2832)	(0.2753)		(0.3182)
EPB_2017_PBE		-0.0874			0.2348	0.2925		0.7200**
		(0.2772)			(0.3009)	(0.2865)		(0.3355)
EPB_2017ratio		-0.0104			-0.0216	-0.0133		-0.0107
		(0.0182)			(0.0182)	(0.0245)		(0.0254)
EPB_2016_TAE		-0.0258			0.1992	0.1943		0.5458**
		(0.1627)			(0.1999)	(0.1499)		(0.2349)
EPB_2016_PAE		0.0381			-0.2426	-0.1488		-0.5368**
		(0.1824)			(0.2217)	(0.1657)		(0.2589)
EPB_2016ratio		-0.0086			0.0123	-0.0173		-0.0125
		(0.0177)			(0.0184)	(0.0246)		(0.0259)
EIA_num			0.0780***		0.0981***		0.0570	0.0969**
			(0.0295)		(0.0313)		(0.0344)	(0.0427)
EIA_eff			-0.0195		-0.0107		-0.0384	-0.0414
			(0.0211)		(0.0223)		(0.0306)	(0.0348)
SupMonitor_C			-0.2027**		-0.2269**		-0.3304**	-0.3663**
			(0.0978)		(0.1037)		(0.1292)	(0.1392)
SupMonitor_P			-0.0147		-0.0083		-0.0217	-0.0159
			(0.0114)		(0.0123)		(0.0139)	(0.0178)
Spotcheck			-0.4621**		-0.5045**		-0.4446*	-0.5467**
			(0.1884)		(0.2040)		(0.2409)	(0.2631)
PercCharged			0.0121		0.0187		-0.0146	-0.0240
			(0.0154)		(0.0185)		(0.0322)	(0.0386)
PercCollected				0.0005		-0.0070	0.0267	0.0388
				(0.0152)		(0.0185)	(0.0230)	(0.0277)
PollutionFee				0.0565		0.0518	0.1291**	0.0876
				(0.0485)		(0.0711)	(0.0539)	(0.0929)
PR				-0.2898**		-0.2098	0.3965	0.2967
				(0.1029)		(0.1492)	(0.3418)	(0.3525)
AvgPR				0.1435***		0.1170**	0.1662*	0.2291**
				(0.0317)		(0.0511)	(0.0976)	(0.0896)
N	134	121	106	93	98	84	74	68
R-sq	0.250	0.286	0.467	0.387	0.482	0.423	0.641	0.678
adj. R-sq	0.189	0.176	0.371	0.277	0.330	0.239	0.506	0.474
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.05	*** p<0.01"						

AQI:	eq1	eq2	eq3	eq4	eq5	eq6	eq7	eq8
Control	1.6457	0.3126	-0.517	-0.34	-2.4317	-0.4399	-0.9147	-3.3243
	-3.1717	-3.5256	-3.7037	-3.7886	-4.0562	-4.2673	-4.7237	-4.9619
pfrev_2017	0.9325	0.7027	2.0772	-0.0483	2.3368	0.4778	-1.2428	-0.0001
	-1.1064	-1.2328	-1.2827	-1.3472	-1.529	-1.7641	-1.7565	-2.7719
expcitymd_2016	0.0204	0.0141	0.1765	-0.0395	0.1355	-0.1502	-0.2396	-0.1982
	-0.1343	-0.1589	-0.3062	-0.1338	-0.3352	-0.1581	-0.3289	-0.4411
pfexp_2016	-0.7629	-0.6708	-2.0000**	0.028	-1.9818**	-0.1266	-0.2185	-0.3251
	-0.6341	-0.6159	-0.747	-0.8373	-0.7903	-0.9076	-1.0516	-1.3279
GRP_2017	-0.1709	-0.1508	-0.1164	-0.0975	-0.1198	-0.0895	0.1574	0.0574
	-0.12	-0.1434	-0.1466	-0.129	-0.1906	-0.1518	-0.1947	-0.2671
GRPPC_2016	-0.1751	-0.1797	-0.0865	-1.4167	0.0397	-1.7903**	-1.652	-1.4766
	-0.2059	-0.2295	-0.1995	-0.8768	-0.1696	-0.8936	-1.3106	-1.4808
share2nd_1716	-0.0543	-0.0562	-0.2402	-0.243	-0.2711	-0.2811	-0.089	-0.1194
	-0.2031	-0.2414	-0.1908	-0.2376	-0.2425	-0.2629	-0.2689	-0.35
noairp_2017	0.7786***	0.7243***	-0.1653	0.5187**	-0.418	0.6736**	-0.3911	-0.5154
	-0.2389	-0.2682	-0.5023	-0.2302	-0.5257	-0.2605	-0.7151	-0.7362
pop	3.5973	2.1816	2.1885	3.0511	1.0173	3.7941	1.8898	1.928
	-2.1888	-2.9734	-2.1953	-1.9895	-2.9615	-3.0125	-2.0863	-3.8973
popdensity	0.0997	0.4246	0.306	0.4777	0.2903	1.1146***	0.6791**	0.8464**
	-0.239	-0.3299	-0.2343	-0.2919	-0.2735	-0.3734	-0.296	-0.3374
EPB_2017_TBE		0.0477			1.9145	-3.3892		-0.0389
		-1.9709			-2.0361	-2.1258		-3.3501
EPB_2017_PBE		-0.1469			-2.0158	3.0643		-0.3552
		-2.1258			-2.2253	-2.2458		-3.4926
EPB_2017ratio		-0.0864			-0.0469	-0.2318*		-0.1812
		-0.1145			-0.121	-0.1208		-0.1412
EPB_2016_TAE		0.0305			-1.4255	1.5557		-0.7146
		-1.2319			-1.0244	-1.315		-2.1993
EPB_2016_PAE		0.137			1.5253	-1.1806		1.1346
		-1.3283			-1.1718	-1.3757		-2.279
EPB_2016ratio		0.0468			0.0778	0.0886		0.0601
		-0.1146			-0.1159	-0.1324		-0.1533
EIA_num			0.0126		-0.1015		-0.0487	-0.0331
			-0.1669		-0.1991		-0.2462	-0.304
EIA_eff			0.1603		0.1997		0.0188	0.018
			-0.1466		-0.1687		-0.1745	-0.2091
SupMonitor_C			1.1948*		1.4050**		1.1074	1.1785
			-0.649		-0.683		-0.8974	-0.923
SupMonitor_P			-0.0492		-0.0544		-0.1038	-0.1041
			-0.0842		-0.0891		-0.114	-0.1194
Spotcheck			-4.2584***		-3.8959**		-3.9599**	-3.1776
			-1.3621		-1.553		-1.6887	-1.9805
PercCharged			0.2222**		0.2340*		0.1474	0.1954
			-0.1006		-0.1176		-0.219	-0.2987
PercCollected				0.2458**		0.2043*	0.1647	0.1083
				-0.0933		-0.1065	-0.1905	-0.2395
PollutionFee				0.321		0.0487	0.4614	0.0474
				-0.4134		-0.4487	-0.4422	-0.5762
PR				-1.9563**		-1.5557	-0.7698	0.1588
				-0.8288		-1.0898	-2.2491	-2.619
AvgPR				1.1519***		1.0023***	1.119	0.94
				-0.2314		-0.3424	-0.7291	-0.7669
N	134	121	106	93	98	84	74	68
R-sq	0.185	0.194	0.377	0.355	0.384	0.463	0.469	0.526
adj. R-sq	0.119	0.07	0.265	0.239	0.203	0.293	0.269	0.226
N_g								
Marginal effects; Standard errors in parentheses								
(d) for discrete change of dummy variable from 0 to 1								
="* p<0.1	** p<0.05	*** p<0.01"						

Appendix 3-9: 35 potential causal paths between resource adequacy measures and the environmental outcome measures:



- Resource adequacy → [output1/2/3/4/5/6]→ air quality measures (6 paths)
- Resource adequacy → [outcome1/2/5/6]→ air quality measures (4 paths)
- Resource adequacy → [outcome1/2/3/4/5/6]→ [outcome1/2/5/6]→ air quality measures (24 paths)
- Resource adequacy → air quality measure (1 path)

Appendix 3-10: Cases from the un-clustered cities where total effect is non-significant – Scenario A

				Two-Tailed		
Cause-effect pair of variables	**Effect type**	**Estimate**	**S.E.**	**Est./S.E.**	**P-Value**	**TRUE=statistically significant**
Effects from INPUT1 to ENVOUT1	Total	1.112	2.715	0.41	0.682	**FALSE**
Effects from INPUT1 to ENVOUT1	Total indirect	14.115	4.208	3.355	0.001	**TRUE**
Effects from INPUT1 to ENVOUT1	Direct	-13.003	3.943	-3.298	0.001	**TRUE**
Effects from INPUT2 to ENVOUT1	Total	-2.153	2.752	-0.783	0.434	**FALSE**
Effects from INPUT2 to ENVOUT1	Total indirect	-14.15	4.237	-3.339	0.001	**TRUE**
Effects from INPUT2 to ENVOUT1	Direct	11.997	3.946	3.04	0.002	**TRUE**
Effects from INPUT3 to ENVOUT3	Total	0.107	0.062	1.720	0.085	**FALSE**
Effects from INPUT3 to ENVOUT3	Total indirect	-0.224	0.064	-3.498	0.000	**TRUE**
Effects from INPUT3 to ENVOUT3	Direct	0.331	0.041	8.140	0.000	**TRUE**
Effects from INPUT3 to ENVOUT4	Total	0.021	0.026	0.797	0.425	**FALSE**
Effects from INPUT3 to ENVOUT4	Total indirect	-0.065	0.029	-2.216	0.027	**TRUE**
Effects from INPUT3 to ENVOUT4	Direct	0.085	0.026	3.273	0.001	**TRUE**
Effects from INPUT1 to ENVOUT6	Total	0.104	2.189	0.047	0.962	**FALSE**
Effects from INPUT1 to ENVOUT6	Total indirect	9.358	3.108	3.011	0.003	**TRUE**
Effects from INPUT1 to ENVOUT6	Direct	-9.255	2.784	-3.324	0.001	**TRUE**
Effects from INPUT2 to ENVOUT6	Total	-0.906	2.191	-0.413	0.679	**FALSE**
Effects from INPUT2 to ENVOUT6	Total indirect	-9.283	3.137	-2.959	0.003	**TRUE**
Effects from INPUT2 to ENVOUT6	Direct	8.377	2.809	2.982	0.003	**TRUE**
Effects from INPUT1 to ENVOUT7	Total	2.777	3.567	0.779	0.436	**FALSE**
Effects from INPUT1 to ENVOUT7	Total indirect	12.669	5.145	2.463	0.014	**TRUE**
Effects from INPUT1 to ENVOUT7	Direct	-9.893	4.935	-2.005	0.045	**TRUE**

Appendix 3-11: Cases from the un-clustered cities where total effect is non-significant – Scenario B

					Two-Tailed	
Cause-effect pair of variables	**Effect type**	**Estimate**	**S.E.**	**Est./S.E.**	**P-Value**	**TRUE=statistically significant**
Effects from INPUT4 to ENVOUT1	Total	1.906	2.181	0.874	0.382	**FALSE**
Effects from INPUT4 to ENVOUT1	Total indirect	-5.236	3.284	-1.595	0.111	**FALSE**
Effects from INPUT4 to ENVOUT1	Direct	7.142	2.916	2.449	0.014	**TRUE**
Effects from INPUT5 to ENVOUT1	Total	-1.301	2.269	-0.573	0.566	**FALSE**
Effects from INPUT5 to ENVOUT1	Total indirect	5.481	3.516	1.559	0.119	**FALSE**
Effects from INPUT5 to ENVOUT1	Direct	-6.782	3.105	-2.184	0.029	**TRUE**
Effects from INPUT6 to ENVOUT1	Total	0.144	0.182	0.794	0.427	**FALSE**
Effects from INPUT6 to ENVOUT1	Total indirect	-0.443	0.258	-1.712	0.087	**FALSE**
Effects from INPUT6 to ENVOUT1	Direct	0.587	0.225	2.605	0.009	**TRUE**
Effects from INPUT6 to ENVOUT3	Total	0.133	0.085	1.559	0.119	**FALSE**
Effects from INPUT6 to ENVOUT3	Total indirect	-0.128	0.095	-1.344	0.179	**FALSE**
Effects from INPUT6 to ENVOUT3	Direct	0.261	0.048	5.439	0.000	**TRUE**
Effects from INPUT2 to ENVOUT5	Total	-1.145	1.482	-0.773	0.44	**FALSE**
Effects from INPUT2 to ENVOUT5	Total indirect	-7.221	3.706	-1.948	0.051	**TRUE**
Effects from INPUT2 to ENVOUT5	Direct	6.076	3.548	1.712	0.087	**FALSE**
Effects from INPUT6 to ENVOUT5	Total	0.147	0.123	1.197	0.231	**FALSE**
Effects from INPUT6 to ENVOUT5	Total indirect	-0.217	0.183	-1.181	0.237	**FALSE**
Effects from INPUT6 to ENVOUT5	Direct	0.364	0.176	2.073	0.038	**TRUE**
Effects from INPUT4 to ENVOUT6	Total	1.207	1.752	0.689	0.491	**FALSE**
Effects from INPUT4 to ENVOUT6	Total indirect	-3.692	2.374	-1.555	0.12	**FALSE**
Effects from INPUT4 to ENVOUT6	Direct	4.899	2.001	2.449	0.014	**TRUE**
Effects from INPUT5 to ENVOUT6	Total	-0.665	1.806	-0.368	0.713	**FALSE**
Effects from INPUT5 to ENVOUT6	Total indirect	3.737	2.533	1.475	0.14	**FALSE**
Effects from INPUT5 to ENVOUT6	Direct	-4.401	2.135	-2.062	0.039	**TRUE**
Effects from INPUT2 to ENVOUT7	Total	-4.061	3.56	-1.141	0.254	**FALSE**
Effects from INPUT2 to ENVOUT7	Total indirect	-12.886	5.274	-2.443	0.015	**TRUE**
Effects from INPUT2 to ENVOUT7	Direct	8.825	5.041	1.751	0.080	**FALSE**
Effects from INPUT6 to ENVOUT7	Total	0.16	0.209	0.767	0.443	**FALSE**
Effects from INPUT6 to ENVOUT7	Total indirect	-0.481	0.283	-1.699	0.089	**FALSE**
Effects from INPUT6 to ENVOUT7	Direct	0.641	0.269	2.387	0.017	**TRUE**

Appendix 3-12: The mediating variables' direct effect on air quality outcomes

EPBs' quality of spot-check on daily polluters is positively related to cities' air quality for the clustered cities, but not for their outside-cluster counterparts, suggesting that these spot-checks may be conducted very differently in different places.

	MODEL RESULTS					MODEL RESULTS					MODEL RESULTS				
		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
	Group TREATMENT					Group CONTROL					Difference (TREATMENT-CONTROL)				
SO2	OUTPUT4	-0.043	0.033	-1.274	0.203	OUTPUT4	-0.448	0.878	-0.51	0.61	EO2OP4_D	0.405	0.879	0.461	0.645
NO2	OUTPUT4	0.062	0.063	0.976	0.329	OUTPUT4	-0.762	0.074	-10.339	0.000	EO3OP4_D	0.824	0.097	8.482	0.000
PM2.5	OUTPUT4	-0.11	0.04	-2.725	0.006	OUTPUT4	-0.758	0.297	-2.553	0.011	EO6OP4_D	0.648	0.3	2.162	0.031
PM10	OUTPUT4	-0.102	0.072	-1.417	0.156	OUTPUT4	-1.524	0.724	-2.106	0.035	EO7OP4_D	1.422	0.727	1.956	0.051
AQI	OUTPUT4	-0.09	0.064	-1.414	0.157	OUTPUT4	-1.305	0.476	-2.74	0.006	EO1OP4_D	1.215	0.48	2.528	0.011
CO	OUTPUT4	-0.014	0.010	-1.332	0.183	OUTPUT4	-0.202	0.046	-4.382	0.000	EO4OP4_D	0.188	0.047	3.982	0.000
ozone	OUTPUT4	0.007	0.069	0.107	0.915	OUTPUT4	-1.016	0.405	-2.510	0.012	EO5OP4_D	1.024	0.411	2.492	0.013

Increasing the 'average percentage of air polluting firms that receives regular inspections from the local EPB' is a potential way of bringing air quality improvement to the un-clustered cities, but not for the clustered ones.

	MODEL RESULTS					MODEL RESULTS					MODEL RESULTS				
		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
	Group TREATMENT					Group CONTROL					Difference (TREATMENT-CONTROL)				
SO2	OUTPUT5	-0.976	0.713	-1.368	0.171	OUTPUT5	1.902	13.172	0.144	0.885	EO2OP5_D	-2.878	13.191	-0.218	0.827
NO2	OUTPUT5	0.454	0.912	0.498	0.619	OUTPUT5	9.272	1.169	7.93	0.000	EO3OP5_D	-8.818	1.483	-5.947	0.000
PM2.5	OUTPUT5	-2.054	0.903	-2.274	0.023	OUTPUT5	12.384	3.957	3.129	0.002	EO6OP5_D	-14.438	4.059	-3.557	0.000
PM10	OUTPUT5	-5.257	1.387	-3.789	0.000	OUTPUT5	18.403	8.536	2.156	0.031	EO7OP5_D	-23.66	8.648	-2.736	0.006
AQI	OUTPUT5	-2.269	1.254	-1.81	0.070	OUTPUT5	19.316	6.198	3.116	0.002	EO1OP5_D	-21.585	6.324	-3.413	0.001
CO	OUTPUT5	-0.424	0.198	-2.145	0.032	OUTPUT5	0.678	0.887	0.765	0.444	EO4OP5_D	-1.102	0.908	-1.213	0.225
ozone	OUTPUT5	-0.781	1.377	-0.567	0.571	OUTPUT5	13.264	5.108	2.597	0.009	EO5OP5_D	-14.045	5.291	-2.655	0.008

With the exception of the model on Sulphur dioxide and the model on carbon monoxide, a decrease in the number of penalty tickets polluters receive per quarter brings a statistically significant larger improvement to average air quality for the un-clustered group than for the clustered group.

	MODEL RESULTS					MODEL RESULTS					MODEL RESULTS				
		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
	Group TREATMENT					Group CONTROL					Difference (TREATMENT-CONTROL)				
SO2	OUTCOME6	0.095	0.24	0.397	0.692	OUTCOME6	1.562	4.828	0.324	0.746	EO2OC6_D	-1.467	4.834	-0.303	0.762
NO2	OUTCOME6	0.024	0.528	0.045	0.964	OUTCOME6	2.331	0.491	4.746	0.000	EO3OC6_D	-2.307	0.721	-3.198	0.001
PM2.5	OUTCOME6	0.888	0.377	2.358	0.018	OUTCOME6	3.313	1.05	3.154	0.002	EO6OC6_D	-2.424	1.116	-2.173	0.030
PM10	OUTCOME6	1.397	0.677	2.064	0.039	OUTCOME6	6.236	1.801	3.463	0.001	EO7OC6_D	-4.839	1.924	-2.515	0.012
AQI	OUTCOME6	0.991	0.574	1.726	0.084	OUTCOME6	5.949	1.422	4.184	0.000	EO1OC6_D	-4.958	1.533	-3.233	0.001
CO	OUTCOME6	0.169	0.085	2.001	0.045	OUTCOME6	0.465	0.239	1.944	0.052	EO4OC6_D	-0.295	0.254	-1.164	0.244
ozone	OUTCOME6	-0.659	0.834	-0.791	0.429	OUTCOME6	4.557	1.598	2.851	0.004	EO5OC6_D	-5.217	1.803	-2.893	0.004

Appendix 3-13: a full summary of SEM results

Treatment group:

		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	significant "=TRUE"
Effects from INPUT1 to ENVOUT1	Total	-0.733	1.527	-0.48	0.631	**FALSE**
Effects from INPUT1 to ENVOUT1	Total indirect	0.612	1.123	0.545	0.586	**FALSE**
Effects from INPUT1 to ENVOUT1	Direct	-1.345	1.318	-1.02	0.308	**FALSE**
Effects from INPUT2 to ENVOUT1	Total	1.413	1.82	0.776	0.438	**FALSE**
Effects from INPUT2 to ENVOUT1	Total indirect	-0.613	1.297	-0.472	0.637	**FALSE**

Effects from INPUT2 to ENVOUT1	Direct	2.025	1.658	1.221	0.222	**FALSE**
Effects from INPUT3 to ENVOUT1	Total	-0.208	0.083	-2.515	0.012	**TRUE**
Effects from INPUT3 to ENVOUT1	Total indirect	-0.072	0.047	-1.537	0.124	**FALSE**
Effects from INPUT3 to ENVOUT1	Direct	-0.136	0.081	-1.675	0.094	**FALSE**
Effects from INPUT4 to ENVOUT1	Total	-1.099	1.035	-1.063	0.288	**FALSE**
Effects from INPUT4 to ENVOUT1	Total indirect	-0.476	0.89	-0.535	0.593	**FALSE**
Effects from INPUT4 to ENVOUT1	Direct	-0.623	1.041	-0.599	0.549	**FALSE**
Effects from INPUT5 to ENVOUT1	Total	0.623	1.302	0.479	0.632	**FALSE**

Effects from INPUT5 to ENVOUT1	Total indirect	0.481	1.026	0.469	0.639	**FALSE**
Effects from INPUT5 to ENVOUT1	Direct	0.142	1.36	0.105	0.917	**FALSE**
Effects from INPUT6 to ENVOUT1	Total	0.099	0.082	1.21	0.226	**FALSE**
Effects from INPUT6 to ENVOUT1	Total indirect	0.112	0.064	1.746	0.081	**FALSE**
Effects from INPUT6 to ENVOUT1	Direct	-0.013	0.111	-0.114	0.909	**FALSE**
Effects from INPUT1 to ENVOUT2	Total	0.822	0.798	1.03	0.303	**FALSE**
Effects from INPUT1 to ENVOUT2	Total indirect	-0.371	0.625	-0.595	0.552	**FALSE**
Effects from INPUT1 to ENVOUT2	Direct	1.193	0.751	1.589	0.112	**FALSE**

Effects from INPUT2 to ENVOUT2	Total	-1.087	0.996	-1.091	0.275	**FALSE**
Effects from INPUT2 to ENVOUT2	Total indirect	0.039	0.785	0.049	0.961	**FALSE**
Effects from INPUT2 to ENVOUT2	Direct	-1.126	0.901	-1.25	0.211	**FALSE**
Effects from INPUT3 to ENVOUT2	Total	-0.009	0.055	-0.157	0.875	**FALSE**
Effects from INPUT3 to ENVOUT2	Total indirect	-0.026	0.034	-0.755	0.451	**FALSE**
Effects from INPUT3 to ENVOUT2	Direct	0.017	0.051	0.333	0.739	**FALSE**
Effects from INPUT4 to ENVOUT2	Total	-1.05	0.591	-1.776	0.076	**FALSE**
Effects from INPUT4 to ENVOUT2	Total indirect	-0.173	0.478	-0.361	0.718	**FALSE**

Effects from INPUT4 to ENVOUT2	Direct	-0.878	0.538	-1.633	0.103	**FALSE**
Effects from INPUT5 to ENVOUT2	Total	1.273	0.785	1.623	0.105	**FALSE**
Effects from INPUT5 to ENVOUT2	Total indirect	0.534	0.589	0.907	0.364	**FALSE**
Effects from INPUT5 to ENVOUT2	Direct	0.739	0.642	1.152	0.249	**FALSE**
Effects from INPUT6 to ENVOUT2	Total	-0.079	0.079	-0.998	0.318	**FALSE**
Effects from INPUT6 to ENVOUT2	Total indirect	0.002	0.056	0.03	0.976	**FALSE**
Effects from INPUT6 to ENVOUT2	Direct	-0.08	0.071	-1.126	0.26	**FALSE**
Effects from INPUT1 to ENVOUT3	Total	-0.023	0.952	-0.024	0.981	**FALSE**

Effects from INPUT1 to ENVOUT3	Total indirect	0.018	0.660	0.028	0.978	**FALSE**
Effects from INPUT1 to ENVOUT3	Direct	-0.041	1.015	-0.041	0.968	**FALSE**
Effects from INPUT2 to ENVOUT3	Total	0.240	1.107	0.217	0.828	**FALSE**
Effects from INPUT2 to ENVOUT3	Total indirect	0.011	0.828	0.013	0.989	**FALSE**
Effects from INPUT2 to ENVOUT3	Direct	0.229	1.199	0.191	0.848	**FALSE**
Effects from INPUT3 to ENVOUT3	Total	-0.047	0.055	-0.858	0.391	**FALSE**
Effects from INPUT3 to ENVOUT3	Total indirect	0.017	0.032	0.532	0.595	**FALSE**
Effects from INPUT3 to ENVOUT3	Direct	-0.064	0.049	-1.309	0.191	**FALSE**

Effects from INPUT4 to ENVOUT3	Total	-0.364	0.705	-0.516	0.606	**FALSE**
Effects from INPUT4 to ENVOUT3	Total indirect	0.235	0.508	0.463	0.643	**FALSE**
Effects from INPUT4 to ENVOUT3	Direct	-0.599	0.768	-0.779	0.436	**FALSE**
Effects from INPUT5 to ENVOUT3	Total	0.413	0.829	0.498	0.618	**FALSE**
Effects from INPUT5 to ENVOUT3	Total indirect	-0.314	0.622	-0.505	0.614	**FALSE**
Effects from INPUT5 to ENVOUT3	Direct	0.727	0.934	0.779	0.436	**FALSE**
Effects from INPUT6 to ENVOUT3	Total	0.035	0.061	0.566	0.571	**FALSE**
Effects from INPUT6 to ENVOUT3	Total indirect	0.008	0.053	0.147	0.883	**FALSE**

Effects from INPUT6 to ENVOUT3	Direct	0.027	0.078	0.347	0.729	**FALSE**
Effects from INPUT1 to ENVOUT4	Total	-0.55	0.395	-1.391	0.164	**FALSE**
Effects from INPUT1 to ENVOUT4	Total indirect	0.38	0.213	1.783	0.075	**FALSE**
Effects from INPUT1 to ENVOUT4	Direct	-0.929	0.388	-2.398	0.016	**TRUE**
Effects from INPUT2 to ENVOUT4	Total	0.681	0.456	1.491	0.136	**FALSE**
Effects from INPUT2 to ENVOUT4	Total indirect	-0.451	0.264	-1.709	0.087	**FALSE**
Effects from INPUT2 to ENVOUT4	Direct	1.131	0.451	2.506	0.012	**TRUE**
Effects from INPUT3 to ENVOUT4	Total	-0.037	0.015	-2.483	0.013	**TRUE**

Effects from INPUT3 to ENVOUT4	Total indirect	-0.01	0.011	-0.952	0.341	**FALSE**
Effects from INPUT3 to ENVOUT4	Direct	-0.026	0.015	-1.757	0.079	**FALSE**
Effects from INPUT4 to ENVOUT4	Total	0.139	0.283	0.49	0.624	**FALSE**
Effects from INPUT4 to ENVOUT4	Total indirect	-0.364	0.169	-2.16	0.031	**TRUE**
Effects from INPUT4 to ENVOUT4	Direct	0.503	0.299	1.68	0.093	**FALSE**
Effects from INPUT5 to ENVOUT4	Total	-0.203	0.337	-0.602	0.547	**FALSE**
Effects from INPUT5 to ENVOUT4	Total indirect	0.396	0.206	1.924	0.054	**FALSE**
Effects from INPUT5 to ENVOUT4	Direct	-0.599	0.351	-1.706	0.088	**FALSE**

Effects from INPUT6 to ENVOUT4	Total	0.009	0.019	0.491	0.624	**FALSE**
Effects from INPUT6 to ENVOUT4	Total indirect	-0.004	0.015	-0.292	0.77	**FALSE**
Effects from INPUT6 to ENVOUT4	Direct	0.014	0.02	0.688	0.492	**FALSE**
Effects from INPUT1 to ENVOUT5	Total	-0.398	1.983	-0.201	0.841	**FALSE**
Effects from INPUT1 to ENVOUT5	Total indirect	0.352	0.98	0.359	0.719	**FALSE**
Effects from INPUT1 to ENVOUT5	Direct	-0.751	1.812	-0.414	0.679	**FALSE**
Effects from INPUT2 to ENVOUT5	Total	0.588	2.347	0.251	0.802	**FALSE**
Effects from INPUT2 to ENVOUT5	Total indirect	-0.632	1.157	-0.546	0.585	**FALSE**

Effects from INPUT2 to ENVOUT5	Direct	1.22	2.226	0.548	0.584	**FALSE**
Effects from INPUT3 to ENVOUT5	Total	-0.12	0.116	-1.041	0.298	**FALSE**
Effects from INPUT3 to ENVOUT5	Total indirect	0.048	0.055	0.882	0.378	**FALSE**
Effects from INPUT3 to ENVOUT5	Direct	-0.169	0.105	-1.606	0.108	**FALSE**
Effects from INPUT4 to ENVOUT5	Total	0.026	1.304	0.02	0.984	**FALSE**
Effects from INPUT4 to ENVOUT5	Total indirect	0.172	0.766	0.225	0.822	**FALSE**
Effects from INPUT4 to ENVOUT5	Direct	-0.147	1.393	-0.105	0.916	**FALSE**
Effects from INPUT5 to ENVOUT5	Total	-0.125	1.583	-0.079	0.937	**FALSE**

Effects from INPUT5 to ENVOUT5	Total indirect	-0.26	0.918	-0.283	0.777	**FALSE**
Effects from INPUT5 to ENVOUT5	Direct	0.135	1.769	0.076	0.939	**FALSE**
Effects from INPUT6 to ENVOUT5	Total	0.146	0.106	1.372	0.17	**FALSE**
Effects from INPUT6 to ENVOUT5	Total indirect	-0.076	0.079	-0.964	0.335	**FALSE**
Effects from INPUT6 to ENVOUT5	Direct	0.222	0.14	1.585	0.113	**FALSE**
Effects from INPUT1 to ENVOUT6	Total	-0.501	1.426	-0.352	0.725	**FALSE**
Effects from INPUT1 to ENVOUT6	Total indirect	0.359	0.988	0.363	0.716	**FALSE**
Effects from INPUT1 to ENVOUT6	Direct	-0.86	1.075	-0.801	0.423	**FALSE**

Effects from INPUT2 to ENVOUT6	Total	1.171	1.706	0.686	0.493	**FALSE**
Effects from INPUT2 to ENVOUT6	Total indirect	-0.292	1.174	-0.249	0.804	**FALSE**
Effects from INPUT2 to ENVOUT6	Direct	1.463	1.328	1.102	0.271	**FALSE**
Effects from INPUT3 to ENVOUT6	Total	-0.153	0.062	-2.47	0.014	**TRUE**
Effects from INPUT3 to ENVOUT6	Total indirect	-0.088	0.049	-1.814	0.07	**FALSE**
Effects from INPUT3 to ENVOUT6	Direct	-0.065	0.062	-1.045	0.296	**FALSE**
Effects from INPUT4 to ENVOUT6	Total	-0.944	1.007	-0.937	0.349	**FALSE**
Effects from INPUT4 to ENVOUT6	Total indirect	-0.543	0.753	-0.72	0.472	**FALSE**

Effects from INPUT4 to ENVOUT6	Direct	-0.401	0.857	-0.468	0.64	**FALSE**
Effects from INPUT5 to ENVOUT6	Total	0.412	1.246	0.33	0.741	**FALSE**
Effects from INPUT5 to ENVOUT6	Total indirect	0.665	0.929	0.716	0.474	**FALSE**
Effects from INPUT5 to ENVOUT6	Direct	-0.254	1.113	-0.228	0.82	**FALSE**
Effects from INPUT6 to ENVOUT6	Total	0.023	0.074	0.305	0.761	**FALSE**
Effects from INPUT6 to ENVOUT6	Total indirect	0.134	0.059	2.259	0.024	**TRUE**
Effects from INPUT6 to ENVOUT6	Direct	-0.111	0.096	-1.152	0.25	**FALSE**
Effects from INPUT1 to ENVOUT7	Total	0.553	2.178	0.254	0.8	**FALSE**

Effects from INPUT1 to ENVOUT7	Total indirect	1.954	1.537	1.272	0.204	**FALSE**
Effects from INPUT1 to ENVOUT7	Direct	-1.401	1.713	-0.818	0.413	**FALSE**
Effects from INPUT2 to ENVOUT7	Total	0.327	2.561	0.128	0.899	**FALSE**
Effects from INPUT2 to ENVOUT7	Total indirect	-2.417	1.784	-1.355	0.176	**FALSE**
Effects from INPUT2 to ENVOUT7	Direct	2.743	2.026	1.354	0.176	**FALSE**
Effects from INPUT3 to ENVOUT7	Total	-0.247	0.094	-2.613	0.009	**TRUE**
Effects from INPUT3 to ENVOUT7	Total indirect	-0.128	0.071	-1.794	0.073	**FALSE**
Effects from INPUT3 to ENVOUT7	Direct	-0.119	0.091	-1.316	0.188	**FALSE**

Effects from INPUT4 to ENVOUT7	Total	-1.694	1.519	-1.115	0.265	**FALSE**
Effects from INPUT4 to ENVOUT7	Total indirect	-2.232	1.178	-1.894	0.058	**FALSE**
Effects from INPUT4 to ENVOUT7	Direct	0.538	1.339	0.401	0.688	**FALSE**
Effects from INPUT5 to ENVOUT7	Total	0.556	1.877	0.296	0.767	**FALSE**
Effects from INPUT5 to ENVOUT7	Total indirect	2.7	1.413	1.911	0.056	**FALSE**
Effects from INPUT5 to ENVOUT7	Direct	-2.144	1.744	-1.23	0.219	**FALSE**
Effects from INPUT6 to ENVOUT7	Total	0.159	0.127	1.251	0.211	**FALSE**
Effects from INPUT6 to ENVOUT7	Total indirect	0.138	0.096	1.439	0.15	**FALSE**

Effects from INPUT6 to ENVOUT7	Direct	0.021	0.158	0.13	0.897	**FALSE**

Control Group:

		Estimate	**S.E.**	**Est./S.E.**	**Two-Tailed P-Value**	**significant "=TRUE"**
Effects from INPUT1 to ENVOUT1	Total	1.112	2.715	0.41	0.682	**FALSE**
Effects from INPUT1 to ENVOUT1	Total indirect	14.115	4.208	3.355	0.001	**TRUE**
Effects from INPUT1 to ENVOUT1	Direct	-13.003	3.943	-3.298	0.001	**TRUE**
Effects from INPUT2 to ENVOUT1	Total	-2.153	2.752	-0.783	0.434	**FALSE**

Effects from INPUT2 to ENVOUT1	Total indirect	-14.15	4.237	-3.339	0.001	**TRUE**
Effects from INPUT2 to ENVOUT1	Direct	11.997	3.946	3.04	0.002	**TRUE**
Effects from INPUT3 to ENVOUT1	Total	0.114	0.159	0.713	0.476	**FALSE**
Effects from INPUT3 to ENVOUT1	Total indirect	-0.055	0.165	-0.334	0.738	**FALSE**
Effects from INPUT3 to ENVOUT1	Direct	0.169	0.158	1.071	0.284	**FALSE**
Effects from INPUT4 to ENVOUT1	Total	1.906	2.181	0.874	0.382	**FALSE**
Effects from INPUT4 to ENVOUT1	Total indirect	-5.236	3.284	-1.595	0.111	**FALSE**
Effects from INPUT4 to ENVOUT1	Direct	7.142	2.916	2.449	0.014	**TRUE**

Effects from INPUT5 to ENVOUT1	Total	-1.301	2.269	-0.573	0.566	**FALSE**
Effects from INPUT5 to ENVOUT1	Total indirect	5.481	3.516	1.559	0.119	**FALSE**
Effects from INPUT5 to ENVOUT1	Direct	-6.782	3.105	-2.184	0.029	**TRUE**
Effects from INPUT6 to ENVOUT1	Total	0.144	0.182	0.794	0.427	**FALSE**
Effects from INPUT6 to ENVOUT1	Total indirect	-0.443	0.258	-1.712	0.087	**FALSE**
Effects from INPUT6 to ENVOUT1	Direct	0.587	0.225	2.605	0.009	**TRUE**
Effects from INPUT1 to ENVOUT2	Total	0.423	1.79	0.236	0.813	**FALSE**
Effects from INPUT1 to ENVOUT2	Total indirect	1.307	6.823	0.192	0.848	**FALSE**

Effects from INPUT1 to ENVOUT2						
	Direct	-0.885	6.634	-0.133	0.894	**FALSE**
Effects from INPUT2 to ENVOUT2						
	Total	-0.752	1.911	-0.393	0.694	**FALSE**
Effects from INPUT2 to ENVOUT2						
	Total indirect	-1.465	7.005	-0.209	0.834	**FALSE**
Effects from INPUT2 to ENVOUT2						
	Direct	0.714	6.814	0.105	0.917	**FALSE**
Effects from INPUT3 to ENVOUT2						
	Total	0.021	0.089	0.242	0.809	**FALSE**
Effects from INPUT3 to ENVOUT2						
	Total indirect	-0.132	0.163	-0.811	0.418	**FALSE**
Effects from INPUT3 to ENVOUT2						
	Direct	0.154	0.169	0.91	0.363	**FALSE**
Effects from INPUT4 to ENVOUT2						
	Total	0.132	1.205	0.109	0.913	**FALSE**

Effects from INPUT4 to ENVOUT2	Total indirect	0.735	1.386	0.53	0.596	**FALSE**
Effects from INPUT4 to ENVOUT2	Direct	-0.603	1.388	-0.435	0.664	**FALSE**
Effects from INPUT5 to ENVOUT2	Total	0.31	1.309	0.237	0.813	**FALSE**
Effects from INPUT5 to ENVOUT2	Total indirect	-0.649	1.531	-0.424	0.672	**FALSE**
Effects from INPUT5 to ENVOUT2	Direct	0.958	1.549	0.619	0.536	**FALSE**
Effects from INPUT6 to ENVOUT2	Total	-0.02	0.11	-0.179	0.858	**FALSE**
Effects from INPUT6 to ENVOUT2	Total indirect	0.085	0.141	0.601	0.548	**FALSE**
Effects from INPUT6 to ENVOUT2	Direct	-0.104	0.155	-0.672	0.501	**FALSE**

Effects from INPUT1 to ENVOUT3	Total	1.742	1.268	1.374	0.170	**FALSE**
Effects from INPUT1 to ENVOUT3	Total indirect	1.990	1.369	1.453	0.146	**FALSE**
Effects from INPUT1 to ENVOUT3	Direct	-0.248	1.081	-0.229	0.819	**FALSE**
Effects from INPUT2 to ENVOUT3	Total	-2.118	1.277	-1.659	0.097	**FALSE**
Effects from INPUT2 to ENVOUT3	Total indirect	-2.017	1.348	-1.495	0.135	**FALSE**
Effects from INPUT2 to ENVOUT3	Direct	-0.101	1.042	-0.097	0.922	**FALSE**
Effects from INPUT3 to ENVOUT3	Total	0.107	0.062	1.720	0.085	**FALSE**
Effects from INPUT3 to ENVOUT3	Total indirect	-0.224	0.064	-3.498	0.000	**TRUE**

Effects from INPUT3 to ENVOUT3	Direct	0.331	0.041	8.140	0.000	**TRUE**
Effects from INPUT4 to ENVOUT3	Total	1.218	1.069	1.140	0.254	**FALSE**
Effects from INPUT4 to ENVOUT3	Total indirect	1.176	1.138	1.033	0.302	**FALSE**
Effects from INPUT4 to ENVOUT3	Direct	0.042	0.836	0.051	0.960	**FALSE**
Effects from INPUT5 to ENVOUT3	Total	-1.176	1.107	-1.063	0.288	**FALSE**
Effects from INPUT5 to ENVOUT3	Total indirect	-1.243	1.173	-1.060	0.289	**FALSE**
Effects from INPUT5 to ENVOUT3	Direct	0.067	0.822	0.081	0.935	**FALSE**
Effects from INPUT6 to ENVOUT3	Total	0.133	0.085	1.559	0.119	**FALSE**

Effects from INPUT6 to ENVOUT3	Total indirect	-0.128	0.095	-1.344	0.179	**FALSE**
Effects from INPUT6 to ENVOUT3	Direct	0.261	0.048	5.439	0.000	**TRUE**
Effects from INPUT1 to ENVOUT4	Total	0.225	0.339	0.665	0.506	**FALSE**
Effects from INPUT1 to ENVOUT4	Total indirect	0.658	0.592	1.112	0.266	**FALSE**
Effects from INPUT1 to ENVOUT4	Direct	-0.433	0.559	-0.774	0.439	**FALSE**
Effects from INPUT2 to ENVOUT4	Total	-0.305	0.373	-0.819	0.413	**FALSE**
Effects from INPUT2 to ENVOUT4	Total indirect	-0.571	0.611	-0.934	0.350	**FALSE**
Effects from INPUT2 to ENVOUT4	Direct	0.266	0.566	0.469	0.639	**FALSE**

Effects from INPUT3 to ENVOUT4	Total	0.021	0.026	0.797	0.425	**FALSE**
Effects from INPUT3 to ENVOUT4	Total indirect	-0.065	0.029	-2.216	0.027	**TRUE**
Effects from INPUT3 to ENVOUT4	Direct	0.085	0.026	3.273	0.001	**TRUE**
Effects from INPUT4 to ENVOUT4	Total	0.381	0.203	1.877	0.061	**FALSE**
Effects from INPUT4 to ENVOUT4	Total indirect	0.259	0.392	0.659	0.510	**FALSE**
Effects from INPUT4 to ENVOUT4	Direct	0.123	0.363	0.338	0.735	**FALSE**
Effects from INPUT5 to ENVOUT4	Total	-0.381	0.219	-1.739	0.082	**FALSE**
Effects from INPUT5 to ENVOUT4	Total indirect	-0.301	0.416	-0.724	0.469	**FALSE**

Effects from INPUT5 to ENVOUT4						
	Direct	-0.08	0.381	-0.209	0.834	**FALSE**
Effects from INPUT6 to ENVOUT4						
	Total	0.005	0.025	0.206	0.837	**FALSE**
Effects from INPUT6 to ENVOUT4						
	Total indirect	0.044	0.032	1.386	0.166	**FALSE**
Effects from INPUT6 to ENVOUT4						
	Direct	-0.039	0.026	-1.513	0.130	**FALSE**
Effects from INPUT1 to ENVOUT5						
	Total	0.879	1.41	0.623	0.533	**FALSE**
Effects from INPUT1 to ENVOUT5						
	Total indirect	6.876	3.697	1.86	0.063	**FALSE**
Effects from INPUT1 to ENVOUT5						
	Direct	-5.998	3.595	-1.668	0.095	**FALSE**
Effects from INPUT2 to ENVOUT5						
	Total	-1.145	1.482	-0.773	0.44	**FALSE**

Effects from INPUT2 to ENVOUT5	Total indirect	-7.221	3.706	-1.948	0.051	**TRUE**
Effects from INPUT2 to ENVOUT5	Direct	6.076	3.548	1.712	0.087	**FALSE**
Effects from INPUT3 to ENVOUT5	Total	0.139	0.1	1.4	0.162	**FALSE**
Effects from INPUT3 to ENVOUT5	Total indirect	-0.022	0.106	-0.212	0.832	**FALSE**
Effects from INPUT3 to ENVOUT5	Direct	0.162	0.105	1.542	0.123	**FALSE**
Effects from INPUT4 to ENVOUT5	Total	-0.161	1.137	-0.142	0.887	**FALSE**
Effects from INPUT4 to ENVOUT5	Total indirect	-1.021	2.511	-0.407	0.684	**FALSE**
Effects from INPUT4 to ENVOUT5	Direct	0.86	2.479	0.347	0.729	**FALSE**

Effects from INPUT5 to ENVOUT5	Total	0.16	1.253	0.128	0.898	**FALSE**
Effects from INPUT5 to ENVOUT5	Total indirect	1.293	2.728	0.474	0.635	**FALSE**
Effects from INPUT5 to ENVOUT5	Direct	-1.133	2.661	-0.426	0.67	**FALSE**
Effects from INPUT6 to ENVOUT5	Total	0.147	0.123	1.197	0.231	**FALSE**
Effects from INPUT6 to ENVOUT5	Total indirect	-0.217	0.183	-1.181	0.237	**FALSE**
Effects from INPUT6 to ENVOUT5	Direct	0.364	0.176	2.073	0.038	**TRUE**
Effects from INPUT1 to ENVOUT6	Total	0.104	2.189	0.047	0.962	**FALSE**
Effects from INPUT1 to ENVOUT6	Total indirect	9.358	3.108	3.011	0.003	**TRUE**

Effects from INPUT1 to ENVOUT6	Direct	-9.255	2.784	-3.324	0.001	**TRUE**
Effects from INPUT2 to ENVOUT6	Total	-0.906	2.191	-0.413	0.679	**FALSE**
Effects from INPUT2 to ENVOUT6	Total indirect	-9.283	3.137	-2.959	0.003	**TRUE**
Effects from INPUT2 to ENVOUT6	Direct	8.377	2.809	2.982	0.003	**TRUE**
Effects from INPUT3 to ENVOUT6	Total	0.08	0.113	0.704	0.481	**FALSE**
Effects from INPUT3 to ENVOUT6	Total indirect	-0.033	0.114	-0.288	0.773	**FALSE**
Effects from INPUT3 to ENVOUT6	Direct	0.112	0.097	1.156	0.247	**FALSE**
Effects from INPUT4 to ENVOUT6	Total	1.207	1.752	0.689	0.491	**FALSE**

Effects from INPUT4 to ENVOUT6	Total indirect	-3.692	2.374	-1.555	0.12	**FALSE**
Effects from INPUT4 to ENVOUT6	Direct	4.899	2.001	2.449	0.014	**TRUE**
Effects from INPUT5 to ENVOUT6	Total	-0.665	1.806	-0.368	0.713	**FALSE**
Effects from INPUT5 to ENVOUT6	Total indirect	3.737	2.533	1.475	0.14	**FALSE**
Effects from INPUT5 to ENVOUT6	Direct	-4.401	2.135	-2.062	0.039	**TRUE**
Effects from INPUT6 to ENVOUT6	Total	0.01	0.128	0.077	0.939	**FALSE**
Effects from INPUT6 to ENVOUT6	Total indirect	-0.192	0.18	-1.069	0.285	**FALSE**
Effects from INPUT6 to ENVOUT6	Direct	0.202	0.152	1.33	0.184	**FALSE**

Effects from INPUT1 to ENVOUT7	Total	2.777	3.567	0.779	0.436	**FALSE**
Effects from INPUT1 to ENVOUT7	Total indirect	12.669	5.145	2.463	0.014	**TRUE**
Effects from INPUT1 to ENVOUT7	Direct	-9.893	4.935	-2.005	0.045	**TRUE**
Effects from INPUT2 to ENVOUT7	Total	-4.061	3.56	-1.141	0.254	**FALSE**
Effects from INPUT2 to ENVOUT7	Total indirect	-12.886	5.274	-2.443	0.015	**TRUE**
Effects from INPUT2 to ENVOUT7	Direct	8.825	5.041	1.751	0.080	**FALSE**
Effects from INPUT3 to ENVOUT7	Total	0.117	0.175	0.667	0.505	**FALSE**
Effects from INPUT3 to ENVOUT7	Total indirect	-0.084	0.178	-0.472	0.637	**FALSE**

Effects from INPUT3 to ENVOUT7						
	Direct	0.201	0.172	1.168	0.243	**FALSE**
Effects from INPUT4 to ENVOUT7						
	Total	1.168	2.87	0.407	0.684	**FALSE**
Effects from INPUT4 to ENVOUT7						
	Total indirect	-4.118	3.417	-1.205	0.228	**FALSE**
Effects from INPUT4 to ENVOUT7						
	Direct	5.286	3.34	1.583	0.114	**FALSE**
Effects from INPUT5 to ENVOUT7						
	Total	-0.384	2.921	-0.131	0.895	**FALSE**
Effects from INPUT5 to ENVOUT7						
	Total indirect	4.306	3.625	1.188	0.235	**FALSE**
Effects from INPUT5 to ENVOUT7						
	Direct	-4.69	3.504	-1.338	0.181	**FALSE**
Effects from INPUT6 to ENVOUT7						
	Total	0.16	0.209	0.767	0.443	**FALSE**

Effects from INPUT6 to ENVOUT7	Total indirect	-0.481	0.283	-1.699	0.089	**FALSE**
Effects from INPUT6 to ENVOUT7	Direct	0.641	0.269	2.387	0.017	**TRUE**

Treatment-Control=Difference

					Two-Tailed	**significant**
		Estimate	**S.E.**	**Est./S.E.**	**P-Value**	**"=TRUE"**
Effects from INPUT1 to ENVOUT1	Total	-1.845	3.114957	-0.5923	0.554	**FALSE**
Effects from INPUT1 to ENVOUT1	Total indirect	-13.503	4.355272	-3.10038	0.002	**TRUE**
Effects from INPUT1 to ENVOUT1	Direct	11.658	4.157448	2.804124	0.005	**TRUE**

Effects from INPUT2 to ENVOUT1	Total	3.566	3.299379	1.080809	0.280	**FALSE**
Effects from INPUT2 to ENVOUT1	Total indirect	13.537	4.43107	3.055019	0.002	**TRUE**
Effects from INPUT2 to ENVOUT1	Direct	-9.972	4.280173	-2.32981	0.020	**TRUE**
Effects from INPUT3 to ENVOUT1	Total	-0.322	0.17936	-1.79527	0.073	**FALSE**
Effects from INPUT3 to ENVOUT1	Total indirect	-0.017	0.171563	-0.09909	0.921	**FALSE**
Effects from INPUT3 to ENVOUT1	Direct	-0.305	0.177553	-1.7178	0.086	**FALSE**
Effects from INPUT4 to ENVOUT1	Total	-3.005	2.414122	-1.24476	0.213	**FALSE**
Effects from INPUT4 to ENVOUT1	Total indirect	4.76	3.402463	1.398986	0.162	**FALSE**

Effects from INPUT4 to ENVOUT1	Direct	-7.765	3.096246	-2.50788	0.012	**TRUE**
Effects from INPUT5 to ENVOUT1	Total	1.924	2.616021	0.735468	0.462	**FALSE**
Effects from INPUT5 to ENVOUT1	Total indirect	-5	3.66264	-1.36514	0.172	**FALSE**
Effects from INPUT5 to ENVOUT1	Direct	6.924	3.389782	2.042609	0.041	**TRUE**
Effects from INPUT6 to ENVOUT1	Total	-0.045	0.19962	-0.22543	0.822	**FALSE**
Effects from INPUT6 to ENVOUT1	Total indirect	0.555	0.265819	2.087883	0.037	**TRUE**
Effects from INPUT6 to ENVOUT1	Direct	-0.6	0.25089	-2.39148	0.017	**TRUE**
Effects from INPUT1 to ENVOUT2	Total	0.399	1.959822	0.20359	0.839	**FALSE**

Effects from INPUT1 to ENVOUT2	Total indirect	-1.678	6.851566	-0.24491	0.807	**FALSE**
Effects from INPUT1 to ENVOUT2	Direct	2.078	6.676373	0.311247	0.756	**FALSE**
Effects from INPUT2 to ENVOUT2	Total	-0.335	2.15498	-0.15545	0.876	**FALSE**
Effects from INPUT2 to ENVOUT2	Total indirect	1.504	7.048847	0.213368	0.831	**FALSE**
Effects from INPUT2 to ENVOUT2	Direct	-1.84	6.87331	-0.2677	0.789	**FALSE**
Effects from INPUT3 to ENVOUT2	Total	-0.03	0.104623	-0.28674	0.774	**FALSE**
Effects from INPUT3 to ENVOUT2	Total indirect	0.106	0.166508	0.636605	0.524	**FALSE**
Effects from INPUT3 to ENVOUT2	Direct	-0.137	0.176528	-0.77608	0.438	**FALSE**

Effects from INPUT4 to ENVOUT2	Total	-1.182	1.342127	-0.88069	0.378	**FALSE**
Effects from INPUT4 to ENVOUT2	Total indirect	-0.908	1.466111	-0.61933	0.536	**FALSE**
Effects from INPUT4 to ENVOUT2	Direct	-0.275	1.488619	-0.18473	0.853	**FALSE**
Effects from INPUT5 to ENVOUT2	Total	0.963	1.526337	0.630922	0.528	**FALSE**
Effects from INPUT5 to ENVOUT2	Total indirect	1.183	1.640391	0.72117	0.471	**FALSE**
Effects from INPUT5 to ENVOUT2	Direct	-0.219	1.676772	-0.13061	0.896	**FALSE**
Effects from INPUT6 to ENVOUT2	Total	-0.059	0.135429	-0.43565	0.663	**FALSE**
Effects from INPUT6 to ENVOUT2	Total indirect	-0.083	0.151714	-0.54708	0.584	**FALSE**

Effects from INPUT6 to ENVOUT2	Direct	0.024	0.170488	0.140773	0.888	**FALSE**
Effects from INPUT1 to ENVOUT3	Total	-1.765	1.5856	-1.11314	0.266	**FALSE**
Effects from INPUT1 to ENVOUT3	Total indirect	-1.972	1.51979	-1.29755	0.194	**FALSE**
Effects from INPUT1 to ENVOUT3	Direct	0.207	1.48283	0.139598	0.889	**FALSE**
Effects from INPUT2 to ENVOUT3	Total	2.358	1.690023	1.395247	0.163	**FALSE**
Effects from INPUT2 to ENVOUT3	Total indirect	2.028	1.581989	1.281931	0.200	**FALSE**
Effects from INPUT2 to ENVOUT3	Direct	0.330	1.58851	0.207742	0.835	**FALSE**
Effects from INPUT3 to ENVOUT3	Total	-0.154	0.082879	-1.85812	0.063	**FALSE**

Effects from INPUT3 to ENVOUT3	Total indirect	0.241	0.071554	3.368077	0.001	**TRUE**
Effects from INPUT3 to ENVOUT3	Direct	-0.395	0.063891	-6.18245	0.000	**TRUE**
Effects from INPUT4 to ENVOUT3	Total	-1.582	1.280541	-1.23542	0.217	**FALSE**
Effects from INPUT4 to ENVOUT3	Total indirect	-0.941	1.246238	-0.75507	0.450	**FALSE**
Effects from INPUT4 to ENVOUT3	Direct	-0.641	1.135218	-0.56465	0.572	**FALSE**
Effects from INPUT5 to ENVOUT3	Total	1.589	1.383	1.148951	0.251	**FALSE**
Effects from INPUT5 to ENVOUT3	Total indirect	0.929	1.32771	0.699701	0.484	**FALSE**
Effects from INPUT5 to ENVOUT3	Direct	0.660	1.244203	0.53046	0.596	**FALSE**

Effects from INPUT6 to ENVOUT3	Total	-0.098	0.104623	-0.9367	0.349	**FALSE**
Effects from INPUT6 to ENVOUT3	Total indirect	0.136	0.108784	1.250182	0.211	**FALSE**
Effects from INPUT6 to ENVOUT3	Direct	-0.234	0.091586	-2.55497	0.011	**TRUE**
Effects from INPUT1 to ENVOUT4	Total	-0.775	0.520525	-1.48888	0.137	**FALSE**
Effects from INPUT1 to ENVOUT4	Total indirect	-0.278	0.629153	-0.44186	0.659	**FALSE**
Effects from INPUT1 to ENVOUT4	Direct	-0.496	0.680459	-0.72892	0.466	**FALSE**
Effects from INPUT2 to ENVOUT4	Total	0.986	0.589122	1.673676	0.094	**FALSE**
Effects from INPUT2 to ENVOUT4	Total indirect	0.12	0.665595	0.18029	0.857	**FALSE**

Effects from INPUT2 to ENVOUT4	Direct	0.865	0.723711	1.195229	0.232	**FALSE**
Effects from INPUT3 to ENVOUT4	Total	-0.058	0.030017	-1.93226	0.053	**FALSE**
Effects from INPUT3 to ENVOUT4	Total indirect	0.055	0.031016	1.773271	0.076	**FALSE**
Effects from INPUT3 to ENVOUT4	Direct	-0.111	0.030017	-3.69795	0.000	**TRUE**
Effects from INPUT4 to ENVOUT4	Total	-0.242	0.348279	-0.69485	0.487	**FALSE**
Effects from INPUT4 to ENVOUT4	Total indirect	-0.623	0.426878	-1.45943	0.144	**FALSE**
Effects from INPUT4 to ENVOUT4	Direct	0.38	0.470287	0.808017	0.419	**FALSE**
Effects from INPUT5 to ENVOUT4	Total	0.178	0.401908	0.442887	0.658	**FALSE**

Effects from INPUT5 to ENVOUT4	Total indirect	0.697	0.464211	1.501472	0.133	**FALSE**
Effects from INPUT5 to ENVOUT4	Direct	-0.519	0.518037	-1.00186	0.316	**FALSE**
Effects from INPUT6 to ENVOUT4	Total	0.004	0.031401	0.127386	0.899	**FALSE**
Effects from INPUT6 to ENVOUT4	Total indirect	-0.048	0.035341	-1.35819	0.174	**FALSE**
Effects from INPUT6 to ENVOUT4	Direct	0.053	0.032802	1.615734	0.106	**FALSE**
Effects from INPUT1 to ENVOUT5	Total	-1.277	2.433185	-0.52483	0.600	**FALSE**
Effects from INPUT1 to ENVOUT5	Total indirect	-6.524	3.824684	-1.70576	0.088	**FALSE**
Effects from INPUT1 to ENVOUT5	Direct	5.247	4.025838	1.303331	0.192	**FALSE**

Effects from INPUT2 to ENVOUT5	Total	1.733	2.77574	0.624338	0.532	**FALSE**
Effects from INPUT2 to ENVOUT5	Total indirect	6.589	3.882407	1.697143	0.090	**FALSE**
Effects from INPUT2 to ENVOUT5	Direct	-4.856	4.188482	-1.15937	0.246	**FALSE**
Effects from INPUT3 to ENVOUT5	Total	-0.259	0.153154	-1.69111	0.091	**FALSE**
Effects from INPUT3 to ENVOUT5	Total indirect	0.07	0.119419	0.586169	0.558	**FALSE**
Effects from INPUT3 to ENVOUT5	Direct	-0.331	0.148492	-2.22907	0.026	**TRUE**
Effects from INPUT4 to ENVOUT5	Total	0.187	1.730082	0.108087	0.914	**FALSE**
Effects from INPUT4 to ENVOUT5	Total indirect	1.193	2.625238	0.454435	0.650	**FALSE**

Effects from INPUT4 to ENVOUT5	Direct	-1.007	2.84357	-0.35413	0.723	**FALSE**
Effects from INPUT5 to ENVOUT5	Total	-0.285	2.018885	-0.14117	0.888	**FALSE**
Effects from INPUT5 to ENVOUT5	Total indirect	-1.553	2.878317	-0.53955	0.590	**FALSE**
Effects from INPUT5 to ENVOUT5	Direct	1.268	3.195353	0.396826	0.691	**FALSE**
Effects from INPUT6 to ENVOUT5	Total	-0.001	0.162373	-0.00616	0.995	**FALSE**
Effects from INPUT6 to ENVOUT5	Total indirect	0.141	0.199324	0.707391	0.479	**FALSE**
Effects from INPUT6 to ENVOUT5	Direct	-0.142	0.224891	-0.63142	0.528	**FALSE**
Effects from INPUT1 to ENVOUT6	Total	-0.605	2.612508	-0.23158	0.817	**FALSE**

Effects from INPUT1 to ENVOUT6	Total indirect	-8.999	3.261259	-2.75936	0.006	**TRUE**
Effects from INPUT1 to ENVOUT6	Direct	8.395	2.984339	2.813018	0.005	**TRUE**
Effects from INPUT2 to ENVOUT6	Total	2.077	2.776854	0.747969	0.454	**FALSE**
Effects from INPUT2 to ENVOUT6	Total indirect	8.991	3.349484	2.684294	0.007	**TRUE**
Effects from INPUT2 to ENVOUT6	Direct	-6.914	3.107099	-2.22523	0.026	**TRUE**
Effects from INPUT3 to ENVOUT6	Total	-0.233	0.128891	-1.80772	0.071	**FALSE**
Effects from INPUT3 to ENVOUT6	Total indirect	-0.055	0.124085	-0.44325	0.658	**FALSE**
Effects from INPUT3 to ENVOUT6	Direct	-0.177	0.115122	-1.5375	0.124	**FALSE**

Effects from INPUT4 to ENVOUT6	Total	-2.151	2.02078	-1.06444	0.287	**FALSE**
Effects from INPUT4 to ENVOUT6	Total indirect	3.149	2.490559	1.264375	0.206	**FALSE**
Effects from INPUT4 to ENVOUT6	Direct	-5.3	2.176798	-2.43477	0.015	**TRUE**
Effects from INPUT5 to ENVOUT6	Total	1.077	2.194118	0.490858	0.624	**FALSE**
Effects from INPUT5 to ENVOUT6	Total indirect	-3.072	2.697986	-1.13863	0.255	**FALSE**
Effects from INPUT5 to ENVOUT6	Direct	4.147	2.407695	1.722394	0.085	**FALSE**
Effects from INPUT6 to ENVOUT6	Total	0.013	0.147851	0.087926	0.930	**FALSE**
Effects from INPUT6 to ENVOUT6	Total indirect	0.326	0.189423	1.721018	0.085	**FALSE**

Effects from INPUT6 to ENVOUT6	Direct	-0.313	0.179778	-1.74104	0.082	**FALSE**
Effects from INPUT1 to ENVOUT7	Total	-2.224	4.179375	-0.53214	0.595	**FALSE**
Effects from INPUT1 to ENVOUT7	Total indirect	-10.715	5.369674	-1.99547	0.046	**TRUE**
Effects from INPUT1 to ENVOUT7	Direct	8.492	5.223849	1.625621	0.104	**FALSE**
Effects from INPUT2 to ENVOUT7	Total	4.388	4.385467	1.000578	0.317	**FALSE**
Effects from INPUT2 to ENVOUT7	Total indirect	10.469	5.567561	1.880357	0.060	**FALSE**
Effects from INPUT2 to ENVOUT7	Direct	-6.082	5.432896	-1.11948	0.263	**FALSE**
Effects from INPUT3 to ENVOUT7	Total	-0.364	0.198648	-1.83239	0.067	**FALSE**

Effects from INPUT3 to ENVOUT7	Total indirect	-0.044	0.191638	-0.2296	0.818	**FALSE**
Effects from INPUT3 to ENVOUT7	Direct	-0.32	0.194589	-1.64449	0.100	**FALSE**
Effects from INPUT4 to ENVOUT7	Total	-2.862	3.247193	-0.88138	0.378	**FALSE**
Effects from INPUT4 to ENVOUT7	Total indirect	1.886	3.614357	0.521808	0.602	**FALSE**
Effects from INPUT4 to ENVOUT7	Direct	-4.748	3.598405	-1.31947	0.187	**FALSE**
Effects from INPUT5 to ENVOUT7	Total	0.94	3.472084	0.270731	0.787	**FALSE**
Effects from INPUT5 to ENVOUT7	Total indirect	-1.606	3.890655	-0.41278	0.680	**FALSE**
Effects from INPUT5 to ENVOUT7	Direct	2.546	3.91402	0.650482	0.515	**FALSE**

Effects from INPUT6 to ENVOUT7	Total	-0.001	0.244561	-0.00409	0.997	**FALSE**
Effects from INPUT6 to ENVOUT7	Total indirect	0.619	0.298839	2.071347	0.038	**TRUE**
Effects from INPUT6 to ENVOUT7	Direct	-0.62	0.31197	-1.98737	0.047	**TRUE**

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