DISSERTATION PROSPECTUS:
Essays on Determinants and Outcomes of Collaborative Governance in the Field of Environmental Management

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Contents

Abstract

To collaborate, or to not collaborate, that is the fundamental question for human society. Many natural resources across multiple political jurisdictions that cannot be easily managed by single organization, often need collective efforts from governments at different levels and organizations from different sectors. Therefore, the network literature is surrounded by two core research questions: (1) How to overcome political self-interests and motivate public organizations to establish collaborative networks? (2) How to measure the effectiveness of collaborations and apply networks as policy tools to achieve desirable social and environmental outcomes? To answer both questions, network researchers should study networks as a dependent variable and explore "why do these patterns emerge?"; and also study networks as independent variable and examine "what differences do they make for outcomes and processes?" (O'Toole Jr 2015, 364).

Although scholarship on collaborative governance has been "treating networks seriously" for more than two decades (O'Toole Jr 1997, 45), some theoretical gaps still remain. When studying networks as a dependent variable, we often focus on network ties between organizations and collect data after the networks have been formed. This approach is either "too late" or "too aggregated" to explain organizational leaders' individual motivation for network formation. And we lack analytical tools to distinguish and compare the causal mechanisms from overlapping network theories. When studying networks as an independent variable, we often measure the overall effects of networks, but rarely discuss the effectiveness of different network structures. Moreover, many classical network theories are grounded in the United States, which need to be tested internationally under different institutional environments. To fill these gaps and advance network theories, I designed and conducted a series of studies concerning the determinants and outcomes of collaborative governance in comparative contexts, with both experimental and panel data methods.

The first chapter studies the determinants of intergovernmental network formation.

Berry et al.'s (2004, 543) seminal framework categorizes network research traditions into political science, sociology, and public management. I revise this framework by breaking down the political science tradition into neo-institutional economics and political psychology, based on their different assumptions of human behaviors. I further apply a nationwide conjoint survey experiment of American municipal officials to test and compare three fundamental network theories from these research traditions: rational choice (neo-institutional economics), ideological homophily (political psychology), and relational trust (sociology). The results indicate that municipal officials' collaboration decisions are jointly driven by all three theories, but ideological homophily contributes relatively smaller explanation power than do the other two theories. In addition, the subgroup analysis of Democrat and Republican respondents further discusses the complex interaction effects between fair sharing of cost and ideological homophily. This experimental approach of network analysis advances network theories and provides new opportunities to study collaborative governance.

The second chapter studies the outcomes of network administrative organizations (NAOs), which are special cases of intergovernmental networks. In the existing literature, collaborative outcomes are often measured at either the organization (network node) or the entire network level. However, we lack "edge level" outcomes to evaluate structured interactions among network actors, especially for natural resources across political jurisdictional boundaries. Therefore, I evaluate collaborative outcomes of an inter-jurisdictional river, which reflects collaborative efforts between two neighboring municipal governments. At the beginning of 2018, Guangdong Province in China enacted the River Chief System (RCS), which is a top-down NAO reform to coordinate inter-city rivers' management. I employ the synthetic control method using monthly water quality data from 14 river monitoring sites to assess how well the reform worked to reduce water pollution. I find that the reform effectively reduced the inter-jurisdictional river site's pollution level, which suggests that the NAO model outplays the jurisdictional fragmentation in China's river governance.

The third chapter studies the outcomes of the bottom-up citizen-government coproduc-

tion model on fighting climate change in the United States. Comparing to the traditional federal led top-down environmental policy solution, local environmental programs may have better capacity to promote environmental consensus with residents and interest groups. However, how great an impact these bottom-up collaborative programs can achieve is still empirically unknown. To answer this research question, I plan to conduct a nationwide state level policy analysis on the Community Choice Aggregation Programs (CCAs), which allows local governments to purchase renewable energy generation for all residents within the jurisdiction. These programs have been launched in seven states, including California, Illinois, Massachusetts, New Jersey, New York, Ohio, and Rhode Island. I will employ both the difference-in-difference design in multiple time periods and the generalized synthetic control method to measure the CCA treatment effects on state energy consumption and air quality.

Overall, my dissertation covers a wide range of topics and methods in collaborative governance. First, I compare multiple network theories to explain network formations at the level of individual officials. Second, I evaluate the environmental outcomes of both top-down and bottom-up network structures. These studies contribute to the theory of collaborative governance in comparative perspectives.

CHAPTER 1
Micro Foundations of Network Formation: Experimental Evidence from American Municipal Governments

Abstract

By focusing on organizational or network level analysis, the earlier research agenda on intergovernmental collaboration is either "too late" or "too aggregated" to explain public officials' individual motivation of network formation. Existing literature relies on observational data to discuss governments' collaborative decisions from a rear-view mirror perspective; after networks have formed. To help us get a proactive worldview, this study examines three fundamental network formation theories at individual official level. These theories include rational choice, ideological homophily, and relational trust. A conjoint survey experiment of U.S. municipal officials, including elected officials and city managers, was conducted to test the hypotheses. The results indicate that municipal officials' collaboration decisions are jointly driven by all three theories, but ideological homophily contributes relatively smaller explanation power than the other two. In addition, the subgroup analysis of Democrat and Republican respondents further discusses the complex interaction effects between fair sharing of cost and ideological homophily. This experimental approach of network analysis advances network theories and provides new opportunities to study collaborative governance.

Keywords: Network formation, Collaborative governance, Conjoint experiment, Municipal governments

1.1 Introduction

What drives governments to collaborate with each other? This is one of the most long-standing research questions in the field of public administration. The basic theoretical rationale for developing scholarship on collaborative network is straightforward: many intergovernmental problems cannot be solved or solved easily, by single organizations (Agranoff and McGuire 2001, 296). The increasing complexities of interorganizational actions facilitate our need to investigate the process of network emergence in public organizations (O'Toole Jr 1997). With this consideration, the ways public organizations connect with each other and the motivations they reach collaborative decisions are pre-conditions for scholars to further study other network activities and outcomes.

In this vein, public policy and management literature integrates diverse theoretical approaches to explain network formation (e.g., Berry et al. 2004; Henry et al. 2011; Provan and Kenis 2008; Scott and Thomas 2017; Yi et al. 2018). Two areas of study, however, need further investigation. The first one is mechanism confusion, which means that multiple theories and hypotheses can explain the same network phenomenon (Siciliano et al. 2021). For example, many scholars agreed that collaboration agreements are functions of risk aversion from network actors: Public organizations seek to bridge with new collaborators when they perceive low risk; and they seek to bond with existing collaborators under high risk (Berardo and Scholz 2010). However, risk is difficult to measure and often inferred by hindsight. Network actors' risk perceptions toward partnerships may result from cost-benefit calculations, attribute-based homophily, relational trust, or other possible factors. Therefore, multiple competing hypotheses may simultaneously contribute to one positive or negative effect of risk on network formation. This issue of mechanism confusion creates barriers for scholars to identify which theories are the ones at work and compare their explanation powers, since many of them have overlapping functions that need to be isolated (Siciliano et al. 2021).

Second, network scholars develop abundant evidence about intergovernmental network at organizational or network levels, but we paid relatively sparse attention to network the-

ories at individual-level. By way of definition, the most fundamental elements in networks are individuals who managing organizations within networks, because they "... as actors can be seen simultaneously as occupants of positions within a public administrative organization and as components of one or more multiorganizational web(s) of action built in one way or another around functions or public problems" (O'Toole Jr 2015, 362). However, the previous research agenda is either "too late" or "too aggregated" to explain individual officials' incentives of network activities. By focusing on meso or macro levels, existing literature discusses public organizations' collaborative behaviors from a rear-view mirror perspective; after networks have formed. Public managers' initial motivation to trigger collaborative decision is empirically unknown.

To help us get a proactive worldview, I propose an experimental approach to study network formation. Experimental method is useful to solve the above two problems in network research. Randomization techniques in experiments are effective to achieve mechanism isolation, so researchers can compare effects between different theories in a common standard. Moreover, most experiments are situated at individual-level, which allow researchers to closely observe willingness to collaborate from organizational decision-makers. Based on these premises, this study asks: What micro-level mechanisms motivate public managers to make collaborative decisions in an intergovernmental world?

Specifically, this study compares the relative explanatory power of three fundamental but competing network theories. These theories are rational choice, ideological homophily, and social capital. In rational choice, collaborative partnerships are functions of costs-benefits calculation between network members (Ostrom 1990). This approach assumes that collaboration is largely based on participants' self-interests. However, ideological homophily argues that collaborations are determined by participants who share similar ideological beliefs, which are not always generated from rational considerations (Jenkins-Smith and Sabatier 1993). The theory of social capital is in the middle ground between the above two approaches, which argues that self-interests and ideological beliefs are respectively under- and

over-socialized concepts (Granovetter 1985). In alternative, collaborations are established on the relational trust that comes from prior interactions. Although these three theories are influential to explain network formation, the direct comparison between them is encountered by mechanism isolation issue in observational studies' posterior analyses.

Therefore, I examined causal mechanism directly from each of these theories in a survey based conjoint experiment of municipal officials (elected officials and city managers) across the United States. As part of the survey, I provided a vignette about implementing a sustainable development program. Municipal officials were then asked to choose program proposals suggested by potential collaborator cities. The three network theories are manipulated as attribute components in the program proposals, and respondents need to trade off among attributes to make collaborative decisions. Using this strategy, I simultaneously compared treatment effects from the three theories on officials' partner selection choices.

The findings indicate that all three theories contribute significant effects on municipal officials' collaborative decisions. Interestingly, rational choice and social capital theories share similar and stronger effects than ideological homophily. In particular, low costs, high benefits, and good collaborative experiences are major reasons for partnerships. In addition, fair distribution of program costs between collaborators is also important, but it is conditional on officials' party affiliations. Although municipal officials have tendencies to collaborate with cities that share the same partisanship, this effect is less critical in our model. Overall, collaborative decisions of municipal officials are not solely determined by a single theory. Conversely, multi-dimensional considerations drive public officials to achieve collaborative decisions in reality.

This article sheds new light on network formation theories at individual-level analysis, and especially on interlocal collaborative decisions of municipal leaders. The establishments of rational choice, ideological homophily, and social capital theories in the conjoint experiment bridge solid connections with existing literature. Combining the findings from this study and other levels' (meso and macro) network research, scholars can translate collab-

orative motivations of public managers before networks happened to actual organizational process after networks have formed. From this perspective, we can further advance network theories conceptually and methodologically.

1.2 Competing Network Theories

Before proceeding, I wish to clarify at the outset about the definition of network and network theory in this article. Network is a complex concept, which has multiple definitions and types in public policy and management literature. This article follows the classic definition from Agranoff and McGuire (2001, 296):

> "Networks, as the term is used in the literature, typically refers to multiorganizational arrangements for solving problems that cannot be achieved, or achieved easily, by single organizations. Public management networks are led or managed by government representatives. Simply put, networks constitute emergent phenomena that are distinctive managerial vehicles and that offer challenges for the single organization and its management."

This definition not only provides a clear demonstration about the purpose of intergovernmental network, but also indicates the necessity of studying network activities of government representatives. Based on this insight, this article specifies network formation at individual officials' collaborative decision.

For network theories, the literature distinguishes networks by multiple types given their different functions, such as learning networks (Nisar and Maroulis 2017; Siciliano 2015), service networks (Romzek et al. 2014), and policy networks (Ingold and Leifeld 2016; Yi et al. 2018). However, network members in any of these networks have demands to find new collaborative partners for achieving organizational goals. Regarding this feature, using collaborative decision as a potential network outcome is generalizable to different institutional contexts. The literature also investigates network activities by different structures, such as

nodes, dyads, triads, and multi-layer relationships (Berardo and Scholz 2010). As a micro level study to examine the fundamental theories of collaborative behaviors, this article only emphasizes on the most basic network activity: collaborative willingness from one actor to another. I recognize that this simplistic two-actor mode is limited to describe many multi-dimensional network activities embedding in complex network structures, but it serves well as an outcome measurement to isolate interdependency of other confounding factors in the institutional environment. Therefore, it fits with the research purpose of this study.

1.2.1 Revising the Three Traditions of Network Research

Scholarship on interorganizational collaboration has been "treating networks seriously" for more than two decades (O'Toole Jr 2015). As an applied science, the field of public administration incorporates interdisciplinary traditions into the network research agenda (Berry et al. 2004). Berry and her colleagues sort network research traditions into sociology, political science, and public management. These authors categorize network traditions by different assumptions about human behaviors: social embeddedness in sociology, rational choice in political science, and instrumentalism in public management. The sociology tradition assumes that human behaviors are embedded in structural social contexts. Therefore, network formations are related to norms, ongoing social relations, and institutional trust. Unlike sociology, the political science tradition assumes that human behaviors are economic self-interest, so public network activities are rationally instrumental in both policy process and governance issues (Berry et al. 2004). The public management tradition integrates assumptions from both sociology and political science tradition to manage public program implementation process. Every tradition provides theories to explain network formations, and these theories remain influential today and help network scholars to progressively study public networks in different institutional contexts.

However, after almost 20 years evolution, social science research has developed more plentiful theories to explain human behaviors, which cannot always be categorized by either

rational choice or social embeddedness. For example, the fast-growing field of political motivated reasoning challenges the rational choice theory in political science. Rather than using accuracy goals to motivate rational decision-making, individuals often use partisan goals to justify their actions (Bisgaard and Slothuus 2018; Graham and Svolik 2020; James and Van Ryzin 2017; Taber and Lodge 2006). So, network activities are not necessary products of rational choice, but products of political alignments. This stream suggests that public officials' ideological views strongly shape their affinity of policy actions (Butler et al. 2017). Combining this theoretical development and Berry et al.'s seminal article of network categorization, I revise intellectual traditions in network research and break down the political science tradition into neo-institutional economics with rational choice assumption (Ostrom 1990; Williamson 1981) and political psychology with motivated reasoning assumption. In addition, this revision aligns with Berry et al.'s (2004, 543) opinion on public management in the network tradition category, which integrates diverse traditions into the public network research agenda and "...geared toward instrumental concerns." Table 1.1 summarizes Berry et al.'s (2004) categorized network traditions and the current revision as well as their corresponding assumptions about behavior.

Table 1.1: The Network Traditions

Berry et al. (2004)	**Current Revision**	**Assumptions About Behavior**
Sociology	Sociology	Social embeddedness
Political science	Neo-institutional economics	Rational choice
	Political psychology	Political motivated reasoning
↓	↓	↓
Public management	Public management	Integration and instrumentalism

The following parts in this section introduce each of the three network research perspectives and their representing theories. In particular, this study investigates cost-benefit analysis from neo-institutional economics, ideological homophily from political psychology, and relational trust from sociology. These theories are competing with each other, because

their basic assumptions about human behaviors are different: Cost-benefit analysis is built on rational choice assumption, ideological homophily is based on motivated reasoning assumption, and relational trust is developed by social capital assumption. Although these theories offer unique explanations of network formation, they are not mutually exclusive, because network decisions are often combinations of multi-dimensional considerations in complex information environments (Silvia 2018). Therefore, the purpose of this study is not to choose an optimal network solution for public managers, but rather to compare the relative explanation power between different theories in public officials' collaborative decisions.

1.2.2 Rational Choice Assumption and Cost-Benefit Analysis

Williamson (1981) and other neo-institutional economics scholars assume that human behaviors are generally rational. Therefore, network members' self-interested utility maximization should predict their decisions, and rational factors should explain the major variations of network activities. Collaborative behaviors are functions of costs and benefits between network actors, so network actors' decisions should depend on their expectations of economic gains in the actions they involved.

The rational choice theory and cost-benefit analysis are powerful in network literature. Finishing intergovernmental tasks in collaboration is an attractive strategy for network actors, because they can complement each other in works (Olson 1965). Through effective communication and coordination, each network actor learns from each other, and eventually achieve costs reduction and benefits maximization in an ideal condition. The rational choice theory is immense in the context of polycentric governance. For example, Lubell et al. (2002) investigate American watershed management and argue that partnerships are more likely to emerge when organizations need to offset costs associated with severe environmental problems. Similarly, other authors find that organizations join partnership to access knowledge for policy solutions (Berardo and Lubell 2016; Hileman and Bodin 2019). The rational choice theory also fits with individual level (Ostrom 1990). In studying networks of frontline

bureaucrats, individuals like to build connections with peers with strong expertise, so they can maximize their own benefits (Nisar and Maroulis 2017; Siciliano 2015). In addition, frontline bureaucrats also search advises from peers who are most accessible to reduce social costs (Siciliano 2017).

On the other side, social scientists not always agree with the pure rational model, even if they consider the importance of costs and benefits in making collaborative decisions. (Ostrom 1998) suggests that the cost-benefit calculus should condition on fairness of cost allocation between collaboration parties, and sharing the costs unequally between parties can reduce the levels of cooperation. Abbink et al. (2001, 5) call this argument as "punishment hypothesis", in which "...punishment attributes a motive to the second mover's rejection of an unequal division asserting that it is done to punish the first mover for unfair treatment." Therefore, cost fairness is important in a partnership, otherwise actors may reject the collaboration proposal regardless how much utility they can gain from it. For example, Shrestha (2012) find that conflicts about fair sharing critically affect success of collaborative public programs. Nonetheless, cost fairness has not been popularly examined yet in network literature. Thus, this study integrates both the pure rational model and a cost fairness assumption into the hypothesis testing.

H1a: Municipal officials are more likely to form collaborations with partners that offer lower costs.

H1b: Municipal officials are more likely to form collaborations with partners that offer fair sharing of costs.

H2: Municipal officials are more likely to form collaborations with partners that offer larger benefits.

1.2.3 Motivated Reasoning Assumption and Ideological Homophily

Political psychology offers a different view about human behaviors rather than the conventional rational model. It suggests that "all reasoning is motivated" (Taber and Lodge

2006, 756). People "... generate theories that view their own attributes as more predictive of desirable outcomes" (Kunda 1987, 636). When this assumption applied to political life, people process information by their partisan goals rather than accuracy, which means that people no longer make decisions by actual evidence they observe but by prior ideological beliefs they defend (Taber and Lodge 2006).

The theory of political motivated reasoning is widely used in political science and public administration. It affects citizens' policy judgements and voting decisions (e.g., Bisgaard and Slothuus 2018; Graham and Svolik 2020; James and Van Ryzin 2017). Compared to citizens, some authors suggest that the effect of motivated reasoning is even stronger among public officials (Baekgaard et al. 2019; Christensen and Moynihan 2020). Christensen and Moynihan (2020) provide an exploratory analysis about this phenomenon: unlike general citizens, elected officials are trained to stay consistent with their political identities, if else they would be punished by voters and other political stakeholders. Therefore, the professional role of public officials may lead them to prioritize political considerations in intergovernmental actions, which will eventually affect network outcomes.

In network literature, the impact of prior ideological beliefs on collaborative decisions has been introduced by the Advocacy Coalition Framework (ACF), which argues that network actors with similar beliefs comprise coalitions and they learn policy knowledge within the coalitions (Jenkins-Smith et al. 2018). Different from rational choice, the ACF assumes that network activities are boundedly rational, because network actors have limited ability to access information, allocate time, and learn relevant knowledge before they make decisions (Simon 1957). Therefore, cost-benefit analysis cannot fully predict public officials' collaboration choices. In alternative, "individuals simplify the world through their belief system and are, therefore, prone to biased assimilation of stimuli" (Jenkins-Smith et al. 2018, 108). The ACF suggests a three-tiered belief system (deep core beliefs, policy beliefs, and secondary beliefs) to predict network formation. Deep core beliefs are fundamental normative values, which are often measured by individuals' cultural and ideological identities (Ripberger

et al. 2014). Policy beliefs are network actors' value priorities in the policy subsystem. Secondary beliefs are specific instrumental means for achieving policy goals of the policy beliefs (Jenkins-Smith et al. 2018). Among these beliefs, deep core beliefs underpin policy beliefs and secondary beliefs in network activities, so it is crucial for scholarship development in investigating how deep core beliefs (e.g., ideology) motivate collaborative decisions. Comparing the effect of political motivated reasoning and other theories will advance our theoretical understanding of network formation.

Following this stream, Leach and Sabatier (2005) find that when considering network actors' political deep core beliefs and policy beliefs, rational choice variables are no longer significant to determine partnership. And the deep core beliefs (measured by the respondent's conservatism) contribute strongest effects. Similarly, Henry (2011) investigates policy networks in California regional planning system, he finds that political elites tend to collaborate with ideology similar actors and avoid connecting with ideology dissimilar actors. Some network scholars classify ideological belief coalition into attribute based homophily, which argues that network actors create ties with those who share similar attributes (Siciliano et al. 2021). Although network formation may be affected by multiple attributes (such as gender and ethnicity), ideological homophily is the prominent one since partisanship is one of the strongest predictors in analyzing interlocal politics (Butler et al. 2017; Gerber and Hopkins 2011). For example, Rabovsky and Rutherford (2016) find that presidential and state policy makers' ideologies affect American universities' external networking efforts. Song et al. (2018) also discover the ideological homophily effect among Korean municipal council members in interlocal collaborations. Accordingly, I assume that municipal officials will select collaborators who match with their ideological beliefs.

H3: Municipal officials are more likely to form collaborations with partners that share the similar ideology beliefs.

1.2.4 Social Capital Assumption and Relational Trust

Sociologists study human behaviors by structural social contexts (Burt 1997). Granovetter (1985, 481) argue that "behavior and institutions are affected by social relations." He criticizes both the over- and under-socialized concepts in understanding economic actions: under-socialized account is too narrow to explain behaviors from utilitarian self-interest; over-socialized account over internalizes behaviors, so ongoing social relations are omitted in analysis. Under this argument, the rational choice assumption is an under-socialized account, because it analyzes network formation by the economic self-interest tool: cost-benefit analysis. On the other hand, the political motivated reasoning assumption is an over-socialized account, because it indicates a determined social system that behaviors are guided by social identities such as class and ideology (Granovetter 1985). Therefore, network analysis should not only emphasize on cost-benefit analysis or ideological homophily, but also the relational trust created by interactions between people (Burt 1997).

The theory of social capital assumes that prior interactions between network actors are likely to build relational trust, and relational trust will lead network actors to extend collaborations (Granovetter 1985; Krackhardt et al. 2003). For example, Metz et al. (2019) study interconnectedness in environmental policy networks and find that prior interactions create trust and social capital, which further build joint policy preferences. In addition, Bunger (2013) find that interorganizational trust boost administrative coordination among nonprofit organizations. Scott and Thomas (2015) also observe social capital effect from environmental collaboration. Their results indicate that the probability of tie formation increases if two organizations both participate in the same collaborative group.

Although the effect of social capital on collaboration has been repeatedly tested, some limitations remain. Siciliano et al. (2021) points out that the theoretical direction between trust and collaboration is unclear. Collaboration builds trust, but trust can also result further collaboration. This reverse causality issue hinders scholars to confirm the internal mechanisms between these two variables. Some authors like Metz et al. (2019) argue that

prior interactions boost relational trust, but some other authors like Scott and Thomas (2015) and Bunger (2013) suggest that relational trust results collaboration. Including longitudinal analysis in network research to study the coevolution of trust and collaboration is a remedy of this problem, but data availability issue hinders more authors to use this method (Berardo et al. 2020; Isett and Provan 2005). Rather than longitudinal analysis, I purpose an experimental method to solve the theoretical direction problem. Through manipulating information about past collaborative experience, I examine municipal officials' collaborative decisions in a hypothetical experimental scenario. I expect that good collaborative experiences (rather than bad experiences or no experience) reflect relational trust between network actors and further increase the likelihood of future collaborations. This expectation stays aligned with Huang's (2014) correlational results, which indicate that intense interaction increases the likelihood of information sharing, but this effect is only conditional on actors' perceived trustworthiness between each other. Although my experimental design cannot observe the coevolution of trust and collaboration that requires longitudinal data, this study still moves a little step forward to improve causality in network analysis.

H4: Municipal officials are more likely to form collaborations with partners that they shared good collaborative experiences in history.

1.3 Testing the Determinants of Network Formation

Recently, public policy and management scholars have achieved significant progress in studying public networks by embracing new methods, such as agent-based simulation (Scott et al. 2019), longitudinal analysis (Siciliano et al. 2020), and coded meeting records (Berardo et al. 2014). However, we still face some obstacles. For example, it is difficult to isolate mechanisms of the above theories from each other and simultaneously compare their effects. In addition, dyadic connections often arise dependently with other surrounding connections in the network (Scott and Ulibarri 2019). Therefore, it is challenging to exclude confounding factors of collaborative decisions among public organizations.

1.3.1 Conjoint Experimental Design and Identification Strategy

To overcome these difficulties and test the above hypotheses causally, I introduce a conjoint experimental approach to study network formation. The design and data analysis plan were pre-registered at [anonymous for peer-review] (see Appendix 1.A). Within a sustainable development program vignette, I constructed the above theories into four program attributes. This design (a) isolated attributes' components by randomization; (b) captured theoretical mechanisms of the hypotheses; (c) and required respondents to trade-off between multiple attributes in collaborative decision-making.

After briefly introducing the program scenario, the survey presented three pairs of hypothetical city partnership opportunities. In each pair, respondents compared two program proposals from two cities. Then, respondents were requested to indicate which city they prefer to collaborate with. The chosen proposals were coded as 1, otherwise 0. Each program proposal contains information of four attributes: program costs (own cost and partnership city's cost), job creation benefits, collaborator's partisanship (Democrats or Republicans), and previous collaborating experiences with this city. Respectively, these four attributes corresponded to the three theories we interested: costs-benefits analysis, ideological homophily, and relational trust. Table 1.2 displays detailed information of each attribute. It is worth noting that the cost attribute contains two elements for hypotheses testing. It tested whether respondents prefer the lowest cost (H1a, component (1)) or fair sharing of cost (H1b, component (2)). After the conjoint comparison tasks, respondents answered questions about their party affiliation, ideology, and position tenure. Finally, they also answered demographic questions of race, gender, age, and education. Survey instruments are reported in Appendix 1.B.

As aforementioned, every proposal was randomly assigned a component from each attribute, thus these components were independent treatments in the between and within subject design (Hainmueller et al. 2014). There were totally $54 = 3 \times 3 \times 2 \times 3$ possible combinations of attribute components in program proposals (see Table 1.2). The conjoint ex-

Table 1.2: Attributes for Collaborative Program Proposals

Attributes	Components
Cost of the program Theory: cost aversion/cost fairness (H1a, H1b)	(1) You pay: $250,000; your partner pays: $750,000 (2) You pay: $500,000; your partner pays: $500,000 (3) You pay: $750,000; your partner pays: $250,000
The program will create Theory: benefit (H2)	(1) 200 jobs in your city (2) 500 jobs in your city (3) 800 jobs in your city
The program is proposed by Theory: ideological homophily (H3)	(1) Democrats (2) Republicans
Previous working experiences with this city Theory: Relational trust (H4)	(1) Good (2) Bad (3) No experience

periment not only randomized attribute components, but also the order of attributes across respondents. This design reduced order effects, which made the results more robust[1] ((Hainmueller et al. 2014). In summary, proposal attributes were independent and identically distributed random variables. I regressed them in one linear probability model that used proposals as units of analysis (Equation 1). Standard errors were clustered at individual level to control non-independence of the within subject proposal comparison.

$$Collaboration = \beta_1 Cost + \beta_2 Benefit + \beta_3 Party + \beta_4 Trust + \mu \quad (1)$$

Testing H3 needs to measure the interaction between respondents' self-partisanship identities and the partisanship attribute components in program proposals. If respondents' self-partisanship identities match with the partisanship attribute components, for example a Democrat respondent see a Democrats proposed program proposal, the probability of she or he chooses this proposal will be increased. Therefore, the completed identification strategy shows in Equation 2.

$$Collaboration = \beta_1 Cost + \beta_2 Benefit + \beta_3 Party + \beta_4 Trust + \beta_5 Party \times SelfParty + \mu \quad (2)$$

[1]Order of attributes within respondents are fixed, which avoided the within subject confusion.

Since Hainmueller and his colleagues developed conjoint experiment (Hainmueller and Hopkins 2015; Hainmueller et al. 2014), this method has been widely used in political science and public administration (e.g., Hollibaugh Jr et al. 2020; Jankowski et al. 2020; Jilke and Tummers 2018; Michael Auerbach and Thachil 2020). The advantages of this method are threefold. First, it simultaneously tests multiple theories in one model, so effects of these theories can be compared with a common standard (Hainmueller et al. 2014). Second, it requires respondents to trade-off between different attributes by the force choice outcome measurement, which improves realism relative to traditional factorial experiments (Hainmueller et al. 2015). Finally, the multiple information environment of conjoint experiment reduces the concerns about social desirability, and the experimental purpose thereby is hard to detected by respondents (Bansak et al. 2021). Based on these characteristics, conjoint experiment is an ideal identification technique to isolate mechanisms from multiple network theories and test hypotheses on individual officials.

1.3.2 Data Collection and Sample Representativeness

The current study targets municipal officials in the United States, which include elected officials (mayors, councilors, or the equivalent) and municipal managers (city managers, assistant city managers, or the equivalent). These public officials often serve as policy makers and government representatives in managing networks, so their leadership can shape organizational collaborative actions (Butler et al. 2017; McGuire and Silvia 2010).

To build the sample pool of municipal officials, I collected information of their names, gender, and email addresses from municipalities' official websites. The sample pool included large and medium size American municipalities having population above 30,000 (1352 municipalities in total). About half of the United States' population are living in these areas. Municipalities without email addresses for public officials were removed from this study. I used Qualtrics to create the survey and sent it out to municipal officials via emails. To increase response rate, I fielded one initial invitation with two friendly reminders in two

months (from April to early June, 2021). Appendix 1.C reports the email invitation context.

Finally, 9928 emails have successfully arrived this sample pool of municipal officials[2]. For effective responses, 772 municipal officials responded at least one conjoint proposal comparison task and provided party affiliation and ideology information[3]. The overall response rate was about 8%, which was comparable with other surveys in recent that using similar samples(e.g., Lee and Stecula 2021; Malhotra et al. 2019; Shaffer et al. 2020). The final sample covered 49 states and the District of Columbia; 533 (39%) municipalities had at least one official effectively responded to the survey[4]. Appendix 1.D provides the full description of the sample characteristics.

The final sample were broadly representative of the whole sample pool. To test the sample representativeness, I collected municipal level demographic data from the U.S. Census Bureau 2019 American Community Survey, including population, median household income, home value, labor force participation, unemployment rate, and information of ethnicity distribution (Black and White population). I also calculated municipalities' female official ratio in the contact information collection process. With this information, I compared municipalities of these variables that had at least one respondent and municipalities without respondent by two sample t-tests. Although responded municipalities have slightly higher female official ratio and White population, there were few statistical differences between responded and no-response municipalities. Figure 1.1 shows the visualized results, and Table D.2 in Appendix 1.D reports more information of the sample representativeness with these variables.

[2]10288 emails were sent. Among them, 16 were failed to arrive, 344 were bounced back.
[3]Overall, 987 respondents had opened the survey and answered at least one question, so the response rate was 10%. However, 772 among them were effective response that can be used in analysis.
[4]Delaware was the only State without any effective response.

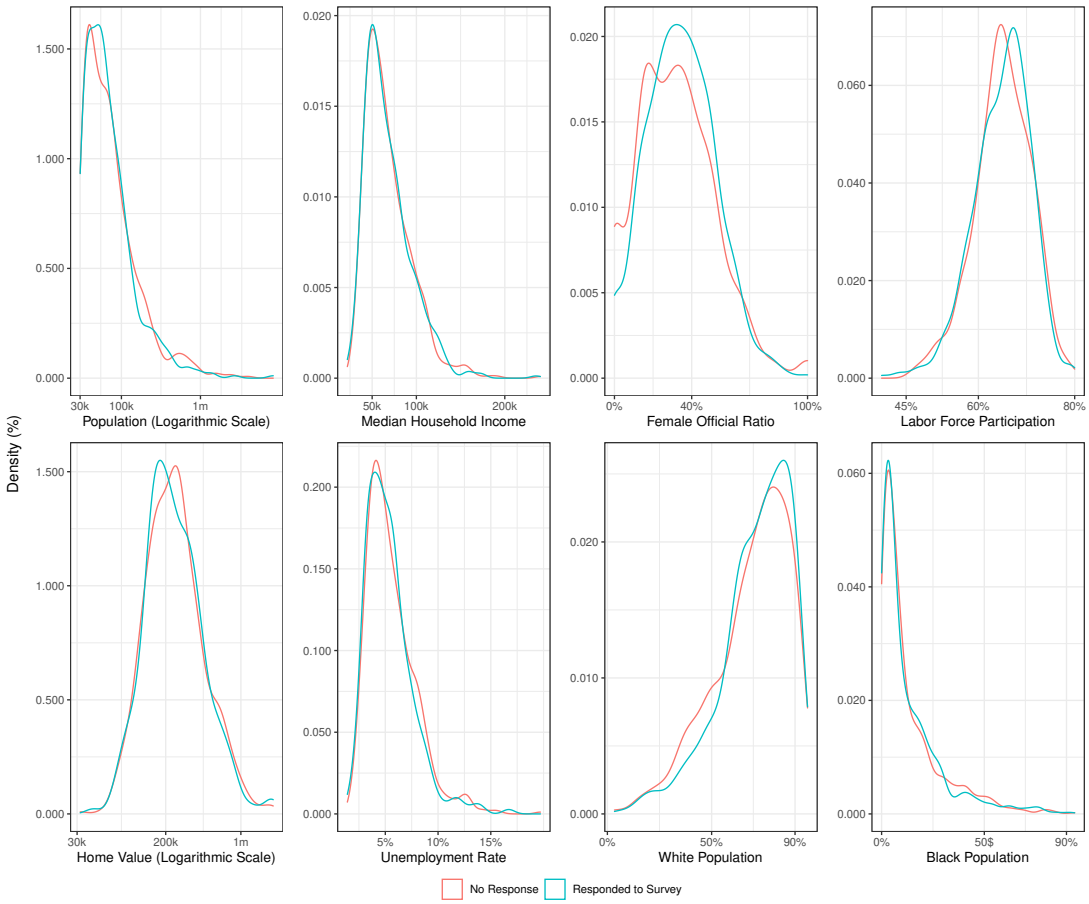

Figure 1.1: Representativeness of Municipal Officials Who Responded

1.4 Results

1.4.1 Descriptive Summary

The final sample contained 772 individual officials (39% female, 78% White, Mage = 57), 674 of them were elected officials and 98 of them were municipal managers. Among them, 363 are Democrats, 193 are Republicans, and 216 are independent or other parties. The respondents totally completed 4534 program proposal evaluations. As above mentioned, the measurement of ideological homophily effect needs to match respondents' ideology and the party affiliation showed in the program proposals, which assumes that respondents' ideology overlap with their partisanship. Figure 1.2 validates this assumption, in which most of Democrats were liberals and most of Republicans were conservatives in the sample.

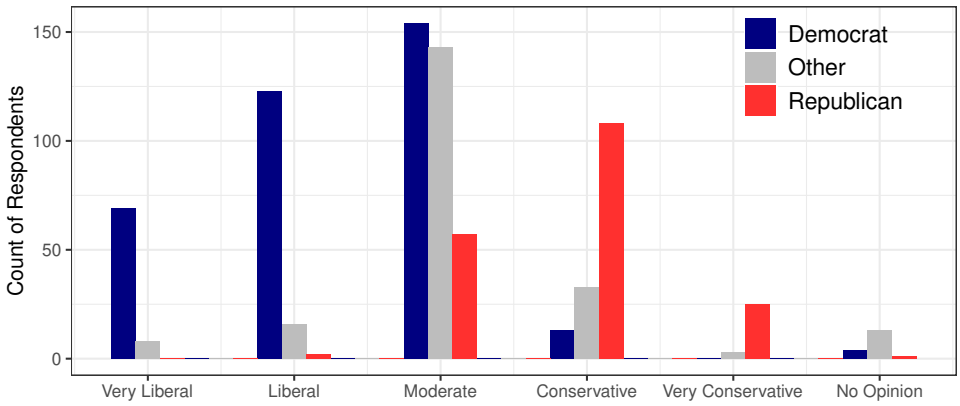

Figure 1.2: Party Affiliation and Ideology of Municipal Officials Who Responded
Note: The final sample contained 363 Democrats, 193 Republicans, and 216 respondents who identified themselves either "Independent" or "Other Party".

1.4.2 Main Findings

Average marginal component effect (AMCE) is the standard estimation strategy in conjoint experiments (Hainmueller et al. 2014). In the fully randomized context, AMCEs are identical to coefficients in a linear probability model. For example, we can compare the marginal effect on collaboration formation between "good collaborative experience" and "bad collaborative experience", holding all other possible attribute components at average levels.

Table 1.3 shows the main findings of this study. Model (1) estimates overall effects for the four attributes, and we use it to test hypotheses H1a, H1b, H2, and H4. Model (2) tests H3 by estimating the interaction effect between respondents' self-partisanship identity and the party cue attribute. Model (3) validates the results in Model (2) by interacting respondents' self-ideology with the party cue attribute. In general, these models support H1a, H2, H3, and H4.

H1a assumes that municipal officials will prefer lower cost when comparing collaborative partners. Results in Model (1) support this hypothesis. Respondents were 23% (p = 0.00) less likely to form partnership with cities that costed them $750,000, when compared to the cities that costed them $250,000. Similarly, respondents were 7% ($p = 0.00$) less likely to

Table 1.3: Probability of Intergovernmental Collaboration

	(1)	(2)	(3)
H1a & H1b: Self vs Partner's Cost (Ref: 250:750)			
750:250	$-0.230\ (0.017)^{***}$	$-0.228\ (0.017)^{***}$	$-0.228\ (0.017)^{***}$
500:500	$-0.070\ (0.017)^{***}$	$-0.069\ (0.017)^{***}$	$-0.070\ (0.017)^{***}$
H2: Benefit (Ref: 200 Jobs)			
800 Jobs	$0.343\ (0.016)^{***}$	$0.341\ (0.016)^{***}$	$0.341\ (0.016)^{***}$
500 Jobs	$0.198\ (0.016)^{***}$	$0.197\ (0.016)^{***}$	$0.197\ (0.016)^{***}$
Program Proposed by (Ref: Democrats)			
Republicans	$-0.024\ (0.014)$	$-0.120\ (0.019)^{***}$	$-0.247\ (0.040)^{***}$
H3: Ideological Homophily			
Republicans×Self Republican		$0.205\ (0.033)^{***}$	
Republicans×Self Other		$0.159\ (0.032)^{***}$	
Republicans×Conservatism			$0.077\ (0.014)^{***}$
H4: Collaborative Experience (Ref: Bad)			
Good	$0.360\ (0.017)^{***}$	$0.360\ (0.017)^{***}$	$0.361\ (0.017)^{***}$
No	$0.240\ (0.017)^{***}$	$0.239\ (0.016)^{***}$	$0.239\ (0.017)^{***}$
Self-Partisanship (Ref: Self-Democrat)			
Self Republican		$-0.098\ (0.019)^{***}$	
Self Other		$-0.099\ (0.018)^{***}$	
Conservatism			$-0.034\ (0.008)^{***}$
Constant	$0.232\ (0.019)^{***}$	$0.285\ (0.021)^{***}$	$0.330\ (0.031)^{***}$
R^2	0.205	0.214	0.211
Observation	4534	4534	4534

Note: Conservatism is coded from a scale from 1 (very liberal) to 5 (very conservative). Standard errors are in brackets (clustered by individuals). $^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

form partnership with cities that costed them \$500,000, when compared to the cities that costed them \$250,000. The magnitudes of cost aversion increase when costs change from low to high. However, the model does not detect the effect of fair sharing of costs (H1b). To support H1b, the component "500:500" should has at least the same level of the magnitude as "250:750", which means that fair sharing of cost is equally important as the lowest self-cost in a partnership. However, "250:750" was more preferred than "500:500" in the model, as above mentioned.

H2 assumes that municipal officials will prefer high benefit when comparing collaborative

partners. This hypothesis is also supported in Model (1). Respondents were 34% ($p = 0.00$) more likely to prefer the collaborative programs that offered them 800 job creations, when compared to the programs that offered them 200 job creations. Similarly, respondents were 19% ($p = 0.00$) more likely to prefer the programs that offered them 500 job creations, when compared to the programs that offered them 200 job creations. Respondents' collaborative willingness became stronger when benefits increase.

Regarding to ideological homophily, H3 assumes that municipal officials will prefer partners that in the same party as them. Results in Model (2) support this hypothesis. Relative to Democrat respondents, Republican respondents were 20% ($p = 0.00$) more likely to form partnership when the program was proposed by Republicans rather than Democrats in the partner city. Model (3) generates similar findings as Model (2). When respondents' self-conservatism increased by 1 degree, the probability of them preferring Republican proposed programs increased by 8% ($p = 0.00$).

Finally, Model (1) supports the relational trust hypothesis (H4), which assumes that municipal officials will prefer collaborative partners that they have good interactions before. Respondents were 36% ($p = 0.00$) more likely to prefer the collaborative programs when they had good rather than bad working experiences with the partner cities. Even for cities that had no interaction before, respondents were 24% ($p = 0.00$) more likely to form partnership with them than cities with bad interactions.

To make better comparisons of effects from the testing theories, the next section reports the subgroup analysis by respondents' party affiliations. By doing so, we not only simultaneously compare treatment effects of different theories, but also test any heterogenous effect across partisanship subgroups.

1.4.3 Subgroup Analysis by Party Affiliation

The left panel of Figure 1.3 shows the AMCE results for Democrat respondents, Republican respondents, and other respondents (including who were independent or from other

parties). The right panel of Figure 1.3 shows the difference-in-AMCE results between each subgroup, using Democrat respondents as the reference group. The difference-in-AMCEs were identical to the interaction coefficients between respondents' party affiliation and each attribute in linear probability models by party affiliation subgroups.

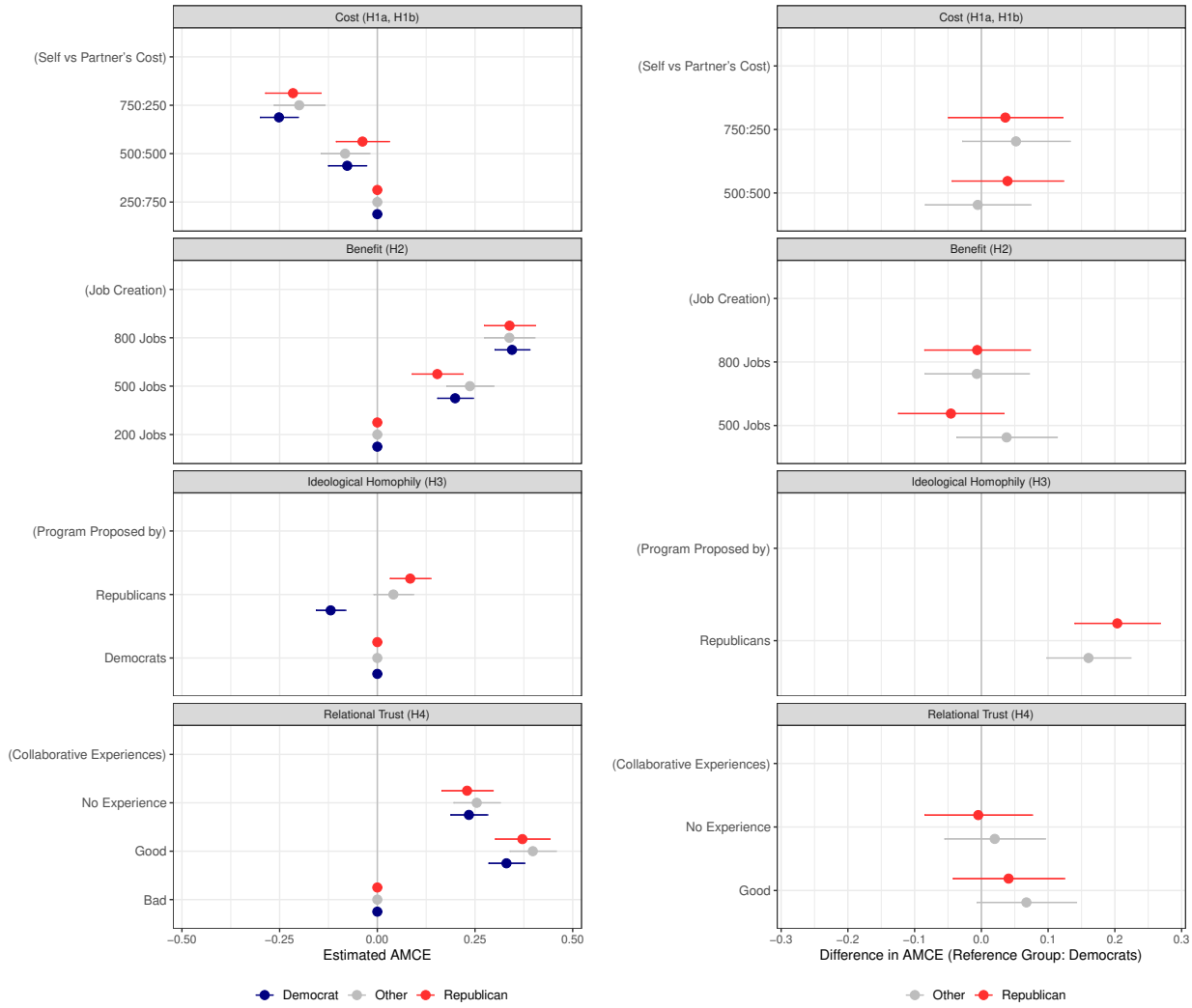

Figure 1.3: Subgroup Analysis by Party Affiliation
Note: Bars are 95% confidence intervals.

In the left panel, both Republican respondents and Democrat respondents expressed stronger preferences to their ideological matched collaborators, and the effects were similar: 12% ($p = 0.00$) among Democrats and 8% ($p = 0.00$) among Republicans. By contrast, other respondents had no preference toward either party. These results further confirm the

ideological homophily hypothesis (H3). The right panel indicates that respondents from different party affiliations had similar preferences of each attribute component, except for ideological homophily. Although the ideological homophily was prominent in the result, it had relatively smaller effects than other attributes. The theories of rational choice (cost-benefit analysis) and social capital (relational trust) contributed more than 25% of effects in explaining respondents' collaborative decisions.

It is worth noting that respondents from different party affiliations had diverse views on fair sharing of cost. The effects of cost aversion among Democrats and others were consistent with the full sample analysis, but Republicans did not express preference difference between "500:500" and "250:750" (effect = 4%; $p = 0.27$). Although the statistical difference between Democrats and Republicans on cost fairness was not significant with the Difference-in-AMCE measurement, this variable is worth to be further study. Therefore, I conducted an interaction analysis between cost and collaborator's party in each party affiliation subgroup in the next section.

1.4.4 Exploratory Analysis

Analysis in this section has not been pre-registered, because it was an exploratory and post-hoc analysis that based on the above subgroup analysis by party affiliations. The purpose of this exploratory analysis is to further understand the effects of cost fairness and ideological homophily on municipal officials' collaboration decisions. Figure 1.4 combines the interaction results of cost and party in each partisan subgroup. Republicans showed consistent indifference between "500:500" and "250:750" cost options, regardless collaborators' party affiliation. In contrast, rational cost calculation predicted Democrats' collaboration decisions when the collaborators were also Democrats. Surprisingly, they showed indifference between the fair but more expensive option and the unfair but cheaper option when the collaborators were Republicans. Other respondents did not show heterogenous preferences on collaborators from either party. This exploratory analysis suggests a potential for future

study to make in-depth investigations about the relations between ideological homophily and fairness on the willingness to intergovernmental collaborate.

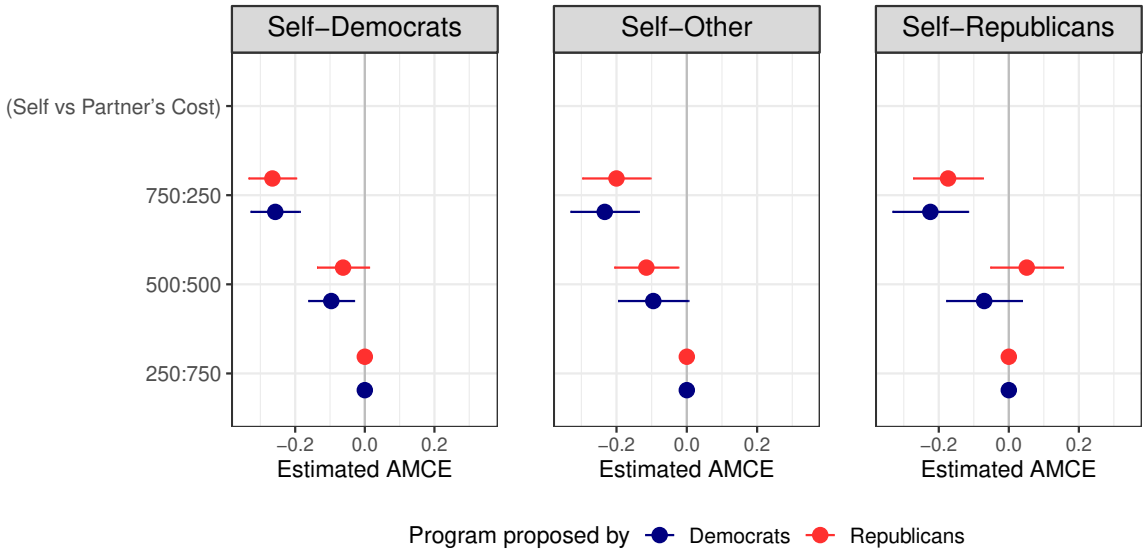

Figure 1.4: Attribute Interaction: AMCE of Cost Conditional on Ideological Homophily
Note: Bars are 95% confidence intervals.

1.4.5 Robustness Check

In addition to the above analyses, I performed multiple robustness checks in the appendices. First, I practiced the standard diagnostic tests of conjoint experiment in Appendix 1.E. Specifically, I display the frequencies of attribute components to check the randomization, the carryover effect across three comparison tasks, and the comparison between left- and right-hand program proposals. There was no systematic bias from the results of these tests, which encouraged that the findings in this study were robust.

Second, I conducted additional subgroup analyses (Appendix 1.F) by respondents' ideology categories (liberal, moderate, and conservatives) and government position (elected or municipal manager). I did not detected systematically difference for each subgroup, which again confirm the findings' validity of this study.

1.5 Discussion and Conclusion

Intergovernmental collaboration and network formation are driven by diverse theoretical factors, but network scholars have yet to systematically theorize and compare the explanatory power between different theories. Inspired from Berry et al. (2004) categorization of network research traditions, I offer the first systematic comparison of three fundamental theories, which have very different assumption about human behavior. In order to advance the network scholarship, I provide new evidence of these theories from micro level data, which demonstrate how municipal officials make decisions of intergovernmental network formation.

The main contribution of this study is that it validates the fundamental network theories at public official level. The experimental evidence indicates that costs-benefits analysis under rational calculation, ideological homophily, and relational trust built on prior interaction are jointly important to explain public officials' collaborative willingness. As I mentioned at the outset, these theories are not mutually exclusive. They demonstrate the complexity of human decision-making and encourage public administration scholars to develop more careful comparisons on these theories.

The findings from this study complement and extend earlier scholarship on network formation. They bridge the network theories across different units of analysis. Although previous studies often test the probability of network activities at organizational or network levels, data were often generated from surveys. Network analysis of collaborative governance aggregated survey responses to organizational measurements then tested the interorganizational behaviors. This strategy helped network scholars to measure many environmental and institutional factors that affect network formation, but whether these perceived measurements can accurately predict actual behaviors of organizations remain unknown. In addition, we have relatively few evidence about the collaborative motivations of public officials before network start. On these grounds, results from this study fill this research gap. They suggest the theoretical consistency between individual officials' collaborative willingness and organizational behaviors that have been repeatedly tested in the network literature.

Moving beyond the traditional network literature, this study also discuss the explanatory power of political motivated reasoning and its ideological homophily effect on government actions. Although some scholars argue that this effect is stronger among politicians than normal citizens (Baekgaard et al. 2019; Christensen and Moynihan 2020), results from this study state that its explanatory power is weaker than the rational calculation and social capital consideration in intergovernmental collaboration decisions. Therefore, we should test this theory in different institutional scenarios to extend its theoretical reliability.

In addition, the exploratory analysis in this study recommends a complex interaction between municipal officials' party affiliation and the preference on fair sharing of cost. Republicans express similar preferences between cost fairness and cost aversion, while Democrats only express the similar preference between these two options when facing Republican collaborators. Regarding Democrats have relatively low trust level to Republicans, this result implies that cost fairness is more important when Democrats perceive higher levels of collaboration risks from the Republican collaborators. Fair sharing of cost can be a signal to Democrats that the bargaining power could be more balance in the collaboration process, given the power dynamic is critical in a collaboration relation (Provan and Kenis 2008). However, alternative explanations of this phenomenon could exist. Therefore, we should further investigate the theoretical mechanisms between ideological homophily and cost fairness on collaboration decisions in the future.

In a broader sense, this article is the first to provide a proactive worldview of intergovernmental network formation by investigating public officials' collaborative willingness before the actual network has been formed. By investigating network theories with the conjoint experimental method, this study integrates the two important areas: behavioral public administration and collaborative governance. With a representative sample and constructive analysis, I believe that the findings of this study advance public administration theory from a new angle.

CHAPTER 2
The Effectiveness of Network Administrative Organizations in Governing Inter-jurisdictional Natural Resources

Abstract

Can network administrative organizations (NAOs) improve networks' effectiveness to overcome complex social and environmental problems? This is a classical question in collaborative governance. The public management literature examines collaborative outcomes at either the organization (network node) or the entire network level, but lacks "edge level" outcomes to evaluate structured interactions among network actors. Therefore, we investigate collaborative outcomes in an inter-jurisdictional area, which reflects collaborative efforts between local governments. Recently, Guangdong Province in China enacted the River Chief System (RCS), an institutional reform that mandates the provincial government to establish a NAO to coordinate inter-city rivers' management. To assess how well the reform worked to reduce pollution, we employ the synthetic control method using monthly water quality data from 14 river monitoring sites in two neighboring cities. Our results indicate that the reform reduced the inter-jurisdictional river sites' pollution level effectively by 36%. This finding contributes to the collaborative governance theory and provides new evidence on whether the NAO model improves the shared outcomes between local governments.

Keywords: Network administrative organization, Environmental management, Common pool resource, Synthetic control

2.1 Introduction

Grouping multiple organizations with different interests into a governance network to achieve shared goals is a topic central to public management scholars (Bodin 2017; Ostrom 2010). Management problems in environmental governance can be described often as interdependent subproblems among network members (Bodin 2017). In fragmented jurisdictions, local governments often face complex social and environmental conditions when governing common pool resources (CPR). Their organizational goals may conflict with shared network-level goals, and unclear responsibilities may aggravate free-riding behaviors among them. This collective action dilemma limits local governments' ability to achieve shared environmental outcomes. In particular, if each local government prioritizes organizational benefits over the network-level benefits, the outcomes for all will be worse in the long-term.

After decades of development, public management scholarship has posited that collaborative governance is a remedy for free-riding behaviors, and therefore, is an effective tool to improve network outcomes. Two major research topics have emerged within this intellectual tradition and the literature on collaborative governance: (1) Motivation and formation of collaborative governance, and (2) outcomes of collaborative governance (O'Toole Jr 2015). This article is consistent with the second topic, which emphasizes the way collaborative governance performs differently in varying social and institutional contexts. In contrast to most of the studies on this topic, which are conducted in Western countries, we investigate collaborative governance and its environmental outcomes in China.

Based upon the premises in the existing environmental management literature, we identify two theoretical gaps in the discussion on forms of collaborative governance and their outcomes. First, scholars often treat collaboration as a broad concept and examine its results, while the treatment of network structure is considered a "black box" (Bitterman and Koliba 2020, 638). Under different institutional conditions, networks form different structures that yield highly varied outcomes. As Provan and Kenis (2008) suggested, network structures can be summarized as three models: Participant-governing network; lead

organization-governed network, and network administrative organization (NAO). Therefore, investigating each of these network modes' effectiveness is necessary for public management scholars to study collaborative governance's outcomes.

Second, we lack "edge level" evidence to study collaborative outcomes. Most of the outcome measurements of collaborative governance are either at the organizational or network level. These units of analysis help us understand each network participant's productivity and the entire network ecological system's effectiveness (Scott 2015, 2016; Yi 2018). However, the central arenas of collaborative actions in environmental management are cross-boundary areas that require multiple network members to manage them collectively (Emerson and Nabatchi 2015). Studying environmental outcomes in cross-boundary areas reflects what Bryson et al. (2016, 914) referred to as "shared core goals" of collaborative governance that "...cannot easily be achieved except by collaborating."

To fill both theoretical gaps, we focus on one specific collaboration mode: The NAO model, and ask the following research question: Compared to non-collaborative governance, can the NAO model improve environmental outcomes in cross-boundary areas?

Our study answers this question by investigating water pollution control in an inter-jurisdictional river in China. China has a long history of suffering from water pollution as a trade-off with its economic development, and local governments game and free-ride each other in environmental governance. In the case of rivers, the inner-city rivers' water quality is often better than that in cross-boundary rivers. To resolve this governance dilemma, the Guangdong provincial government enacted the River Chief System (RCS) at the beginning of 2018 to improve river management and water quality. Before the RCS was enacted, neighboring cities self-governed inter-jurisdictional rivers. Since the RCS has been implemented, the provincial government has become the NAO and coordinates its subordinate city governments' management of inter-jurisdictional rivers. This institutional reform provides a unique opportunity to compare the network effectiveness between a fragmented local governance system and the NAO model.

To evaluate this institutional reform's effect, we collected water quality data from monthly samples during 2017-2018 from fourteen river quality monitoring sites in the two most important industrial cities in Guangdong Province: Shenzhen and Dongguan. Thirteen of our sample river sites are in inner-city locations in either city, and one treated river site is at the two cities' inter-jurisdictional boundary. The synthetic control method allows us to identify the causal relation between the RCS institutional reform and improvement in the inter-jurisdictional river water quality in the study area. By comparing the water quality patterns between this inter-jurisdictional site and its synthetic control counterfactual before and after the RCS was implemented, we find that the RCS institutional reform improved the inter-jurisdictional river water's quality significantly.

Our findings have two major theoretical implications. First, the NAO model is more effective than is fragmented local governance as a method to govern environmental outcomes in inter-jurisdictional areas. Second, this study is the first to use inter-jurisdictional natural resources as the units of analysis to investigate network activities, so our finding adds new "edge level" evidence to the collaborative governance literature.

2.2 Jurisdictional Fragmentation and Free-riding Behaviors in China

Limiting opportunistic behaviors is a central issue in environmental governance (Carroll et al. 2018; Konisky and Woods 2012; Sigman 2002). Natural resources such as rivers and air are interconnected across multiple political jurisdictions. Local governments have responsibilities to reduce environmental contamination within their jurisdiction, but they lack incentives to control pollution spillovers to their neighbors. Even worse, local governments may "free ride" their neighbors strategically by discharging pollutants to them (Konisky and Woods 2010). Local governments can acquire political and economic benefits from these behaviors in the short run, but the environment overall will suffer continuous harm in the long-term. Conflicts among stakeholders in the inter-jurisdiction will increase, and eventually these conflicts can lead to what Hardin (1968) referred to as "the tragedy of the commons."

Although China has a strong central government and a top-down political system, its environmental management is not coordinated effectively often because of jurisdictional fragmentation among local governments (Guo and Lu 2019). This phenomenon is similar to what Bodin (2017, 4) argued, "Actors do not collaborate with others in management of ecologically interconnected resources more than would be expected by chance." Thus, it is apparent that institutional obstacles limit network actors' collaboration across jurisdictions.

There are two major institutional reasons that contribute to jurisdictional fragmentation in China's environmental management. First, local governments do not have sufficient bottom-up motivations to collaborate with each other in environmental issues. In the Western tradition, local governments' self-organizing networks originated with a democratic assumption: Local preferences and reelection pressures motivate their policy actions (Gerber and Hopkins 2011). For example, two neighboring cities may treat the water pollution problem in a cross-boundary river that flows between them collaboratively because residents from both sides complain about the water quality issue. However, this assumption does not apply in many developing countries with authoritarian governments, where policy decisions are top-down nearly exclusively. In such systems, local officials' policy motivations derive largely from hierarchical competition for promotion: The centralized cadre system (Anderson et al. 2019). Therefore, local officials' responsiveness is weak. A recent field experiment in China Buntaine et al. (2021) conducted revealed this phenomenon. They found that citizens' monitoring contributes no effect to urban waterway's water pollution control, but higher authority government's oversight reduces water pollution significantly. Although this study does not test inter-governmental collaboration, it suggests that China's bottom-up incentive for government action is very limited.

Second, the hierarchical competition for promotion has an adverse side effect on environmental management. Although the Chinese government attempts to improve environmental conditions by including environmental performance in its promotion indicators, this approach ameliorates environmental contamination only within jurisdictions, and can even aggravate

free-riding behaviors in cross-boundary areas. Further, high stakes pressure for organizational performance motivates local governments to compete with each other. To game the system, local governments may discharge pollutants to neighboring jurisdictions, report false performance information, and reduce enforcement efforts (Anderson et al. 2019; Cai et al. 2016; Zhang and Cao 2015). These rat race competitions destroy trust between local governments and increase upper-level governments' difficulties in monitoring local behaviors. Thus, local governments are often adversarial and lack sufficient trust and consensus to collaborate on environmental problems in cross-boundary areas. Therefore, simply establishing oversight of local river performance cannot overcome these complexities effectively.

In addition to the fragmented local politics, complex environmental conditions and financial shortcomings are other major challenges for river governance in China (Han et al. 2016). Without effective coordination, combining local governments to form effective collaboration is extremely difficult. In general, high levels of common trust and consensual goals among network actors are keys to achieve a participant-governed network (Provan and Kenis 2008). Although this network mode is common in Western democracies, it is difficult to find in China for the reasons aforementioned. Without a collaborative environment, fragmented local authorities and their opportunistic behaviors have harmed China's interconnected natural resources continuously over the past three decades. These challenges in river governance reflect a classical question Ansell and Gash (2008, 549) asked: "Is collaborative governance more effective than adversarial or managerial governance?"

2.3 Theoretical Rationale

To solve the jurisdictional fragmentation problem and end the adversarial governance in managing China's interconnected natural resources, local governance requires a better coordination mechanism. Consistent with China's institutional context, this mechanism should be top-down and have the ability to motivate local governments to achieve common goals. According to Provan and Lemaire (2012, 640), the NAO model "... may be formally

established and/or mandated through a top-down process." Unlike a fragmented local system, the NAO model includes an external member that governs the network. This external member can be a person or an organization that supervises, coordinates, and integrates the collaborative actions among network members (Provan and Kenis 2008). In local politics, NAOs can be upper-level government entities that have authority to coordinate policy instruments among lower-level governmental actors (Wang et al. 2019). In this section, we address the NAO model's advantages in overcoming free-riding behaviors in cross-boundary areas. In addition, we introduce the theoretical association between the NAO model and its outcomes from the collaborative governance regime perspective. By theorizing the NAO model's mechanisms to achieve interconnected natural resources management, we provide a comprehensive demonstration of why it is consistent with China's institutional context.

2.3.1 Network Administrative Organization

When interlocal governmental network actors do not have high levels of trust and goal consensus, the NAO model has several advantages over the fragmented system to reduce free-riders in cross-boundary areas. First, NAOs coordinate and facilitate interorganizational activities to achieve network-level objectives (Isett and Provan 2005). As a goal-directed approach, NAOs shape policies to reduce conflicts among network actors, simplify the action process, and formalize coordination mechanisms (Macciò and Cristofoli 2017; Saz-Carranza et al. 2016). For example, Macciò and Cristofoli (2017) found that NAOs with strong managerial leadership support healthcare networks' persistence. They also suggested certain effective leadership practices, such as regular meetings with members, forging agreements between partner organizations, and serving as a mediator among parties. As Provan and Kenis (2008) argued, when the policy problems become more complex, networks are more likely to form a centralized mode to maintain their effectiveness.

The NAO model's second benefit derives from its ability to monitor network performance and minimize opportunistic behaviors. As a feasible strategy to unify network actors to

achieve network-level objectives, NAOs often set task standards for actors and evaluate them periodically (Wang et al. 2019). In governing cross-boundary environmental resources, tasks are often highly interdependent and difficult to accomplish unilaterally. Thus, a fragmented system is favored less than is the NAO model as a system to monitor task quality (Provan and Kenis 2008). This issue can be even more serious when actors perceive that collaboration is contradictory to their organizational goals (Saz-Carranza et al. 2016). Therefore, in addition to coordinating actors' network activities, NAOs also have the ability to monitor performance at both the organizational and network levels, which motivates network members to keep their agreements to accomplish network goals.

Finally, NAOs allocate external resources to subsidize network members, which improves the incentives and competencies in network-level collaboration (Provan and Lemaire 2012). When faced with complex environmental problems, local governmental actors lack financial, technical, and political resources to implement regional policies (Wang et al. 2019). NAOs can not only provide resources to assist local actors, but also satisfy external demands for networks, such as buffering macro-level environmental shocks, lobbying and fundraising externally, and building networks' external legitimacy (Provan and Kenis 2008). Resource capacity is one of the most critical reasons for local governments to collaborate with higher-level governments. Scholars have found evidence for this phenomenon in different contexts: Mullin and Daley (2009) showed that American local agencies are more likely to cooperate with the federal government when they have less total revenue; Wang et al. (2019) found that Chinese regional watersheds' protection relies on the NAO model with upper-level governments' financial subsidies; Bitterman and Koliba (2020) found that the Vermont State government provides financial and human assistance to stormwater projects' local mandated networks.

2.3.2 Collaborative Governance Regime

Although several studies have tested the NAO model's advantages in coordinating complex network activities, its effectiveness in governing cross-boundary environmental resources has yet to be explored. If we view inter-jurisdictional collaboration on environmental issues as an integrated collaborative governance regime (CGR), the units of analysis of collaborative outcomes include participant organizations, the CGRs, and target goals (Emerson and Nabatchi 2015). Abundant studies of collaborative performance in environmental governance have set their units of analysis on participant organizations (e.g. Bitterman and Koliba 2020; Park et al. 2019; Scott 2016). Scholars have also investigated outcomes of the entire network's target goals (Scott 2015; Yi 2018). However, we lack evidence from examinations of CGR's collective productivity in "...the arena for structured interactions among its participants" (Emerson and Nabatchi 2015, 726). This level of analysis is central to network governance in public administration, and it should be attractive to more public management scholars (Agranoff 2007).

Using CGRs as the units of analysis is even more critical when studying pollution problems in environmental governance, because opportunistic behaviors often occur in cross-boundary areas. One important topic in the environmental policy literature locates the analysis at the jurisdictional borders. If the assumption of inter-jurisdictional political actors' free-riding holds, each government would have different enforcement levels for inner- and inter-jurisdictional pollution. To examine this phenomenon, social scientists use distance indicators of the boundary frequently to measure differences in enforcement. For example, Sigman (2005) studied transboundary spillovers among American states using water monitoring sites within 50 miles of the state boundary as the distance threshold. Her findings suggested that free-riding behaviors are stronger when the water monitoring stations are closer to the boundaries, even with the federal Clean Water Act regulation. Helland and Whitford (2003) obtained similar findings when they combined the Environmental Protection Agency's (EPA) Toxic Release Inventory data and American counties' characteristics,

and found that the facilities' pollutant emissions are higher in counties that border other states. Recently, Carroll et al. (2018) constructed a new dataset of 6,000 U.S. state regional environmental offices and found that when state boundaries bisect the watersheds, federal enforcement provides better treatments than do regional offices' efforts. In contrast, when the watersheds are interconnected among in-state counties, fragmented regional offices provide better responses to pollution spillovers.

Given the poor environmental outcomes in cross-boundary areas, setting the units of analysis at CGRs is crucial to understand collaborative governance. Therefore, we compare the fragmented local governance and the NAO model's effectiveness in environmental management. Moreover, the inter-jurisdictional natural resource is our action arena. Its environmental quality reflects the shared core goal among participating organizations and captures "... what is ordinarily meant by collaborative advantage" (Bryson et al. 2016, 914).

Hypothesis: When local governments collaborate with each other under the NAO model, the network (compared to a fragmented system) governs environmental outcomes in inter-jurisdictional areas more effectively.

2.4 River Chief System: The NAO Model in China

The RCS is an institutional attempt to implement the NAO model in China, which employs the leading officials in senior governments who are appointed as "river chiefs" for inter-jurisdictional rivers. These river chiefs establish a river chief office and work closely with their subordinate local governments and coordinate river quality management with multiple sectors and agencies (Liu et al. 2019).

This innovation can be traced back to 2007, the time of the water supply crisis in Wuxi City, Jiangsu province (Wang and Chen 2020). The explosion of blue algae in Taihu Lake (a large lake that spanned multiple counties' boundaries) forced the Wuxi municipal government to rearrange its management model, which coordinated county and district governments to

control the water pollution collectively [5]. Since then, this model has diffused to other areas in China. At the end of 2016, 16 of 31 mainland Chinese provinces had adopted the RCS fully or in part.

Before the RCS was implemented, neighboring governments self-governed the management responsibilities for inter-jurisdictional rivers. Since the RCS was implemented, the upper-level government serves as the NAO that governs network activities in these rivers externally. River chiefs have been appointed to four different governmental levels (from high to low): Provincial; city; county, and district (Wang and Chen 2020). Provincial heads are general chiefs for all inter-city rivers in the region, and chief executives of cities, counties, and districts are river chiefs for their own jurisdictions. The government leaders and their departmental agencies form the river chiefs' offices and manage subordinate intergovernmental networks.

Several studies have shown the RCS's contributions in improving river water quality (Liu et al. 2019; She et al. 2019; Wang and Chen 2020). The key elements of the RCS reflect the NAO model's major advantages in coordinating network activities. First, river chiefs facilitate collaborations among local governments. They hold regular meetings with lower-level government leaders and coordinate actions among other departmental agencies, such as the water affairs bureau, environmental protection, agriculture, land and resources, and financial departments directly (Liu et al. 2019; Wang and Chen 2020). With this mechanism, relationships between local governments change from competitive to collaborative. Local governments responsibilities' in inter-jurisdictional rivers become clear, communication between local governments increases, and most importantly, the RCS consolidates each CGR's shared core goals.

Second, the RCS improves the mechanism of rivers' water quality oversight. Every river receives a water pollutant reduction target. River chiefs monitor their subordinate rivers'

[5]In China's political system, counties and districts are subordinate governments of a city. This hierarchy differs from that in the United States and certain other Western contexts, in which the county is the political subdivision of states.

annual performance and adjust the targets in the following year (She et al. 2019). The RCS also surveys residents' opinions about water quality near their residences and encourages them to report pollution on the part of firms or government entities (Wang and Chen 2020). For example, the river chief office provides an online billboard for residents to upload daily information about their observations of the river.

Third, river chiefs provide resources to help subordinate governments manage rivers, and often have a special fund that supports the implementation of water pollution reduction measures (She et al. 2019). In addition, they may also invite university professors to serve as external experts and participate in the river management plan design and implementation stages (Li, Tong, and Wang 2020). Hence, both financial and expertise resources improve the network's capacity.

Figure 2.1 illustrates two alternative configurations of river governance. Panel A shows a non-collaborative local governance system, in which the provincial government provides direct oversight of water quality in each city's rivers. Under this system, cities care about the water quality of rivers within their jurisdictions, but they have less incentive to manage inter-jurisdictional rivers. Panel B shows the river governance under the RCS, in which the provincial government engages actively in river governance and coordinates cities surrounding inter-jurisdictional rivers into effective CGRs.

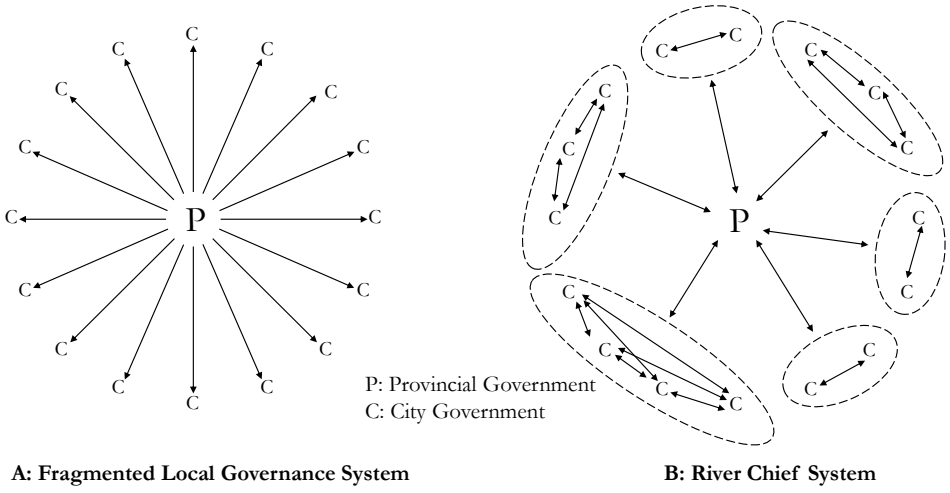

Figure 2.1: Alternative Network Configuration of River Governance

2.5 Empirical Strategy

2.5.1 Case Study: Maozhou River between Dongguan and Shenzhen

Although the RCS has been implemented in many provinces, it is technically difficult for researchers to conduct a large-scale comparison of water quality between inter- and inner-jurisdictional rivers, largely because rivers are often interconnected. Hence, treatments on inter-jurisdictional rivers may spillover to inner-jurisdictional rivers. To overcome this research barrier and investigate collaborative governance's effects on water pollution control causally, we find a special case: Maozhou river, which flows between the two major industrial cities in Guangdong Province: Dongguan City and Shenzhen City. The Maozhou river is located most downstream, close to the marine outfall, and other inner-city rivers in both cities are farther upstream (see Figure 2.2). This special case improves our research's internal validity, because a downstream river's water quality is unlikely to affect upstream rivers.

Figure 2.2: Study Area

Note: The red dot is the inter-jurisdictional Maozhou river site, black dots are the inner-jurisdictional control river sites. The yellow area is Changan district, and the pink area is Shajing district. Light blue lines indicate the sample watersheds and black lines are Shenzhen and Dongguan's jurisdictional boundaries.

This case's scope has limitations, but it still serves as a valuable reference for other

inter-jurisdictional rivers in China. As one of the most important economically-developed provinces, Guangdong's economy is greater than that of any other province in China. Further, Dongguan and Shenzhen are in the center of the Pearl River Delta Economic Zone, which is the hub of Chinese high-tech and manufacturing industries. While on the one hand, this region has been leading China's economic advancement in the past 40 years, on the other, it has been suffering from severe environmental costs in air and water pollution for a long while (Huang et al. 2017; Yi et al. 2018).

In recent years, both cities' governments have declared policy intentions to solve their water pollution problems, and their inner-city water quality conditions have been improving continuously. However, the water treatment of the inter-jurisdictional Maozhou river continues to underperform, primarily because of industrial pollution discharge. Both Dongguan and Shenzhen have many polluting plants that have been regulated to limit their discharge into inner-city rivers, but could still discharge into the inter-city Maozhou river, in which the managerial responsibility was unclear. Even worse, from the Figure 2.2 map we can see that Maozhou river is at a downstream location and connects to the marine outfall, where the pollution is discharged directly into the ocean ultimately.

The RCS has been implemented formally in Guangdong Province since the beginning of 2018, and thereafter, the provincial government has coordinated river management with both cities. To resolve free-riding behaviors from both cities' pollution discharge into Maozhou river, the provincial government organized monthly meetings with both municipal governments and county and district governments adjacent to the river. The meetings clarified government authorities' responsibilities, shared information among network members, and coordinated managerial tasks in each period. The major enforcement goal to reduce water pollution was to regulate polluters. Thus, both municipal governments and their subordinate agencies, counties, and districts inspected those polluters' discharge behaviors collaboratively and negotiated with them to identify alternative environmentally sound solutions. Moreover, the provincial government provided financial resources for both cities to coproduce green ar-

eas along both banks of the river, which encouraged sustainable development for both cities in that surrounding area.

The 2018 institutional reform affected the inter-city Maozhou river's management model significantly, but theoretically, had no effect on other inner-city rivers, which creates a natural counterfactual for us to compare. City, county, and district-levels' RCSs have been implemented in 10 cities in Guangdong Province since 2015, including Shenzhen and Dongguan, so inner-city rivers' governance responsibility had been clarified by then. The institutional reform shifted the responsibility to manage inter-city rivers from neighboring cities to the provincial government beginning in 2018 (Wang and Chen 2020). Since then, every city can be viewed as a single policy actor in the network, with the provincial government as the NAO. This institutional change provides us a unique opportunity to study the provincial government, Maozhou river, and the cities on both sides of the river as an integrated CGR.

2.5.2 Data

Given the short implementation period to date, it is difficult for researchers to collect large-N water performance data for inter-jurisdictional rivers in Guangdong Province. Thus, to obtain a preliminary understanding of the RCS's treatment effect on the cross-boundary area, we collaborated with the Guangdong Research Institute of Water Resource and Hydropower (GRIWRH) to obtain two years (2017-2018) of monthly river water quality panel data from the two cities.

These data include three major water quality indicators: Chemical oxygen demand (COD); ammonia nitrogen (NH3-N), and total phosphorus (TP) from fourteen rivers' water monitoring sites in both cities. Among them, thirteen sites are located in the inner-city (seven in Shenzhen, six in Dongguan). In addition, one river site, the Maozhou river in the Gonghe village monitoring station, lays on the inter-jurisdictional boundary between Shenzhen and Dongguan. All fourteen rivers have severe water pollution problems and are located in close proximity within the greater Maozhou watershed area. In 2002, the Ministry

of Environmental Protection categorized water quality performance into six levels (from good to bad): I, II, III, IV, V, and poor V (Yan et al. 2015). The provincial government classified all rivers in our sample as level poor V water. Thus, they all have the common target to improve water performance from level poor V to V. Specifically, COD, NH3-N, and TP should be less than 40 mg/L, 2.0 mg/L, and 0.4 mg/L, respectively.

2.5.3 The Synthetic Control Method

The synthetic control method that Abadie, Diamond, and Hainmueller (2010, 2015) ddeveloped matches our time-series cross-sectional water quality data perfectly, in which we have only one treated unit and multiple control units in the sample.

In small-N case studies, the comparability among different cases is tainted by likely unobserved confounding variables, and treated and control units' characteristics match well rarely. Hence, it is difficult to conduct statistical falsification. The synthetic control method is a remedy for this problem. This method's major property is that it combines all comparative control units and weights them on the treated unit in the pre-intervention period. This method has become popular in environmental studies in recent years (e.g. Bueno and Valente 2019; Maamoun 2019). Most relevant to our study, Sun et al. (2019) applied this method to investigate the Chinese green credit policy in Jiangyin. They used 17 cities in the Jiangsu province to construct the synthetic Jiangyin city. By comparing the actual and synthetic Jiangyin, they found that the policy motivated firms to reduce COD discharges effectively.

The treated unit in this study is the inter-jurisdictional Maozhou river monitoring site, while other inner-city river sites in the sample are our control units. After constructing them as the synthetic Maozhou river site, this synthetic control unit reproduces the treated unit without the treatment effect in the post-intervention period. Comparing the time-series patterns between the actual treated unit and the synthetic control unit after the treatment assignment is better than simply comparing each unit in the pool (Abadie et al. 2010).

We used both socioeconomic and environmental covariates to construct a weighting matrix, which made the control units' characteristics as similar to the treated unit as possible. With this weighting matrix, we reproduced the synthetic control treated unit that had similar outcomes in the pre-intervention period. Therefore, the difference between the treated unit and synthetic treated unit's outcome indicated the treatment effect. To identify the causal effect accurately, we minimized the mean square prediction error (MSPE) in the pre-intervention period. Appendix 2.A documents the detailed steps in the synthetic control method's causal procedure and the mathematicalal expression of MSPE.

The key in the synthetic control method is to have a lengthy pre-intervention period, a comparable donor pool of control units, a set of time-constant predictors, and an effective treatment cut-off point (Abadie 2019). The water quality data from 2017-2018 combined yielded 24 time points in total. Although the RCS was enacted at the beginning of 2018, the provincial government finalized dividing the inter-jurisdictional rivers' work arrangement with its subordinate governments at the beginning of November 2017. Therefore, we use January to November 2017 as the pre-intervention period. Further, Abadie et al. (2015) suggested that the donor pool units' characteristics should be as similar as possible to those of the treated unit. In this sense, all river sites and their corresponding jurisdictions in our sample are from two cities in a small region. Thus, we are less concerned about interpolation biases. In addition, the synthetic control method has the no-interference assumption, which requires the intervention to have no spillover effects on control units (Abadie 2019). As mentioned above, it is highly unlikely for the RCS intervention to spill over from the most downstream treated site to other upstream control sites.

2.5.4 Measurement of The Water Quality

Using the Ministry of Environmental Protection's (2002) *Environmental Quality Standards for Surface Water* (GB3838-2002), we build our main dependent variable with the comprehensive water pollution index (PI) (Liu et al. 2019; Yan et al. 2015). In the following

formula, C_i contains i categories of pollutants (mg/L), and S_i represents each pollutant's corresponding target standard.

$$PI = \frac{1}{n}\sum_{i=1}^{n}\frac{C_i}{S_i} \tag{3}$$

In this case, we weight the pollutant values on the level V target standards: $PI = 1/3(COD/40 + NH_3N/2 + TP/0.4)$. In addition, we also measure the effect of the RCS's implementation on each pollutant separately. Figure 2.3 displays the PI trends for the treated unit and the average of the control units before and after the RCS was enacted (trends for each pollutant shown in Appendix 2.B).

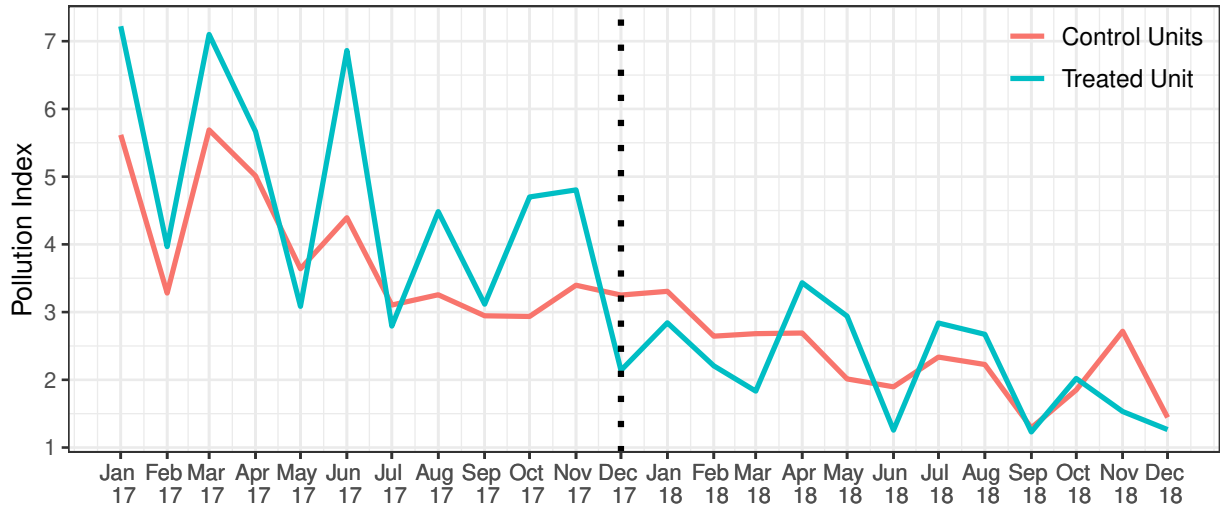

Figure 2.3: Trends of PI: Treated Unit versus Average Control Units

2.5.5 Measurement of Predictors

According to the formal justification, we select valid predictor variables to construct a comparable synthetic control unit for the treated unit (Table 2.1). Both the local socioeconomic and environmental conditions affect river water quality (Scott 2015, 2016).

We collect district-level socioeconomic data in which each river monitoring site is located from Dongguan and Shenzhen's Statistical Yearbooks. The socioeconomic predictors include local population, economy size, and the local government's financial capacity (Konisky and

Table 2.1: Predictors for the Water Quality

Variable Name	Variable Description
Socioeconomic predictors	**Township level**
GDP per capita	The 2017 annual Gross Domestic Product per capita in the district where a river is located (RMB/per capita)
Gov. revenue per capita	The 2017 annual government revenue per capita in the district where a river is located (RMB/per capita)
Gov. expenditure per capita	The 2017 annual government annual expenditure per capita in the district where a river is located (RMB/per capita)
Population density	The 2017 annual population/area in the district where a river is located (10,000 people/1km^2)
Environmental predictors	**Site level**
River flow rate	The 2017 annual average water velocity at the water monitoring site point
Industrial land use	Area in the one-kilometer radius circle (km^2)
Agricultural land use	Area in the one-kilometer radius circle (km^2)
Water quality in Spring 2017	The average water quality in January, February and March 2017
Water quality in Summer 2017	The average water quality in April, May and June 2017
Water quality in Fall 2017	The average water quality in July, August and September 2017
Water quality in Winter 2017	The average water quality in October and November 2017

Woods 2012; Scott 2015, 2016; Sun et al. 2019). As a river in the inter-jurisdictional area, our treated unit provides a challenge in constructing comparable values that match the predictors above. According to the definition of CPR, the Maozhou river at the Gonghe village monitoring site does not belong to either Shenzhen or Dongguan's administrative territory, but is located in the center of two similar-sized adjacent districts: Changan district (area = 97.87 km^2, population = 663,800) from Dongguan, and Shajing district (area = 66.69 km^2, population = 360,300) from Shenzhen. For this natural setting, we average the values from each of the two areas' socioeconomic predictors to approximate the socioeconomic predictors for the unit treated.

We also collect environmental data for each river monitoring site. The annual river flow rate is obtained from GRIWRH and the authors collected land use data manually from Google Earth. To measure the local land use condition precisely, we employ the areal appointment technique with ArcGIS to construct a one-kilometer radius circle and calculate each water monitoring site's industrial and agricultural areas (Konisky and Woods 2010). In addition, river water quality fluctuates seasonally according to different weather conditions.

Thus, we include the mean values of the water quality in each of the four seasons in the pre-intervention period.

Table 2.2: Water Quality Predictor Means in the Pre-intervention Period

	Treated Unit	Synthetic Unit	Donor Sample
GDP per capita	90154.55	91940.43	94896.41
Gov. revenue per capita	4977.57	5056.92	6449.14
Gov. expenditure per capita	5901.28	8160.74	10980.78
Population density	0.62	0.30	0.38
River flow rate	10.67	11.16	8.46
Industrial land use	2.26	1.38	1.73
Agricultural land use	0.39	0.34	0.19
Avg. PI in spring	6.10	6.02	4.86
Avg. PI in summer	5.21	5.37	4.35
Avg. PI in fall	3.46	3.64	3.10
Avg. PI in winter	4.75	4.48	3.17

Note: Pre-intervention MSPE = 0.300

Table 2.2 compares the pre-intervention predictor means for the treated river site, the synthetic treated river site, and the donor sample average. We can see clearly that the treated unit's predictor values are more similar to the synthetic unit than is the donor sample average.

Table 2.3: Weights in the Synthetic Inter-jurisdictional River Site

Unit Name	Synthetic Control Weight
DG1	0.041
DG2	0.000
DG3	0.206
DG4	0.000
DG5	0.001
DG6	0.414
SZ1	0.005
SZ2	0.092
SZ3	0.240
SZ4	0.000
SZ5	0.000
SZ6	0.000
SZ7	0.000

Next, we summarize the weights assigned to each river site in the donor pool (Table 2.3). These weights describe their similarity to the treated river site according to the socioeconomic and environmental predictors matrix. In total, all weights sum to one (see mathematic

expression in Appendix 2.A). We label the river sites DG1 to DG6 for the sites in Dongguan and SZ1 to SZ7 for the sites in Shenzhen. Summing these weights of each control site's water quality values, we construct the synthetic treated river site.

2.6 Results

2.6.1 The Main Effect of The RCS

Figure 2.4 displays our main finding on the RCS's treatment effect on reducing pollution in the inter-jurisdictional river site. The synthetic inter-jurisdictional river site's PI is very similar to that of the actual treated river site before the RCS was implemented, which indicates that our predictors achieved a good match between the treated unit and its synthetic control counterfactual in the pre-intervention period.

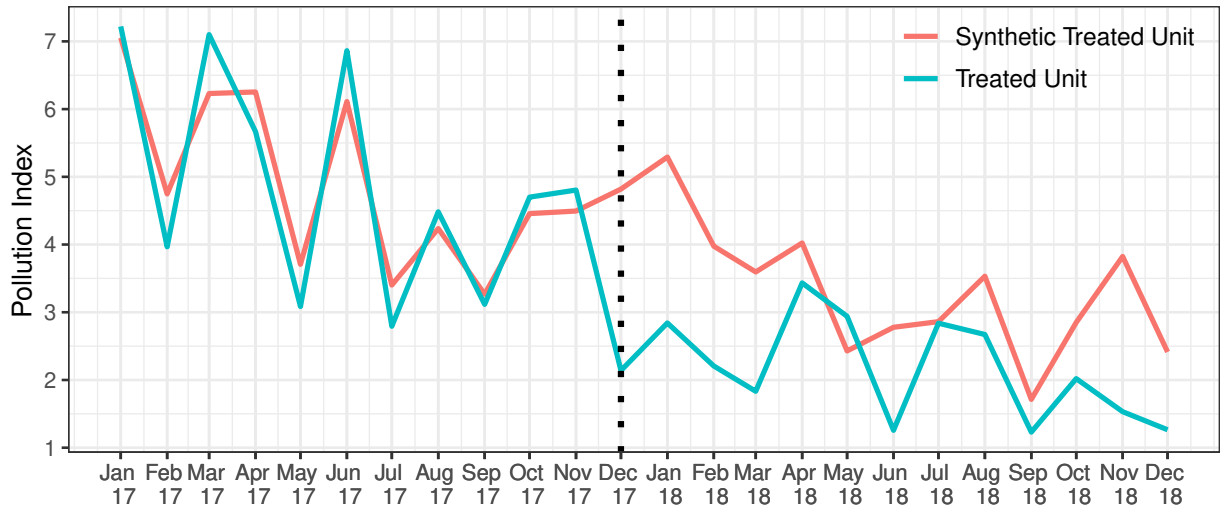

Figure 2.4: Trends of PI: Treated Unit versus Synthetic Treated Unit

After the RCS was enacted, the inter-jurisdictional river site's water quality improved immediately, and the river's PI was 56% lower than its synthetic control unit in December 2017. However, this pollution reduction effect did not hold consistently in the middle of 2018, but increased again to 48% at the end of the year. If we measure each pollutant indicator separately, NH3-N and TP showed similar patterns, but with different magnitudes

of fluctuation. COD did not show a pattern that differed greatly from its synthetic control unit. Details of each pollutant indicator are provided in Appendix 2.C Figure C1.

The RCS's treatment effect overall is sizeable. Figure 2.5 reports the average treatment effect on the treated unit (ATT) during the thirteen months post-intervention (December 2017 to December 2018). We estimate the ATT based upon Appendix 2.A equation (4), which is obtained from a t-test of PI between the treated unit and the synthetic treated unit in the post-intervention period. This estimation generates our model's overall effect size. On average, the PI in the actual inter-jurisdictional river site is 1.22 (36%) lower than its synthetic control unit (SE = 0.346, $p = 0.0017$). The ATT for each pollutant is reported in Appendix 2.C Figure C2.

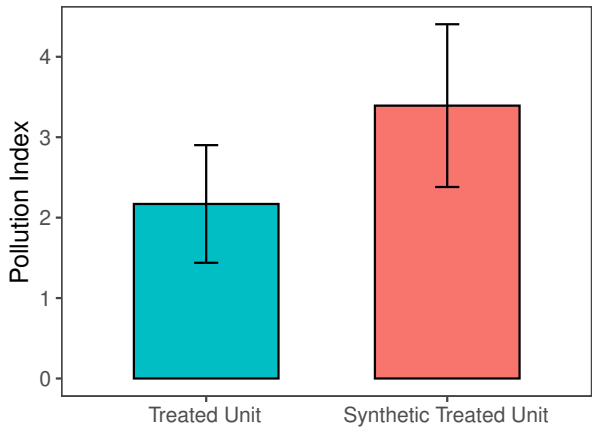

Figure 2.5: ATT in the Post-Intervention Period

2.6.2 Placebo Test

Conventional regression-based studies often test hypotheses by comparing results with the benchmark significance levels, but the small-N synthetic control approach relies on a placebo test (Abadie et al. 2010). We reassign the treatment to other control units in the donor pool to see whether they result in effects similar to that in the inter-jurisdictional river site.

First, Figure 2.6 illustrates that the treatment effect of the treated inter-jurisdictional

river site (green line) was larger than that of other river sites with placebo assignments (grey lines). The distances between these lines and the horizontal dashed line are the differences in value between each river site and its synthetic control counterfactual. The vertical dashed line is the RCS implementation period. Following Abadie et al.'s (2010) recommendation, we discard four extreme control units because their pre-intervention MSPEs are more than two times higher than the treated unit.

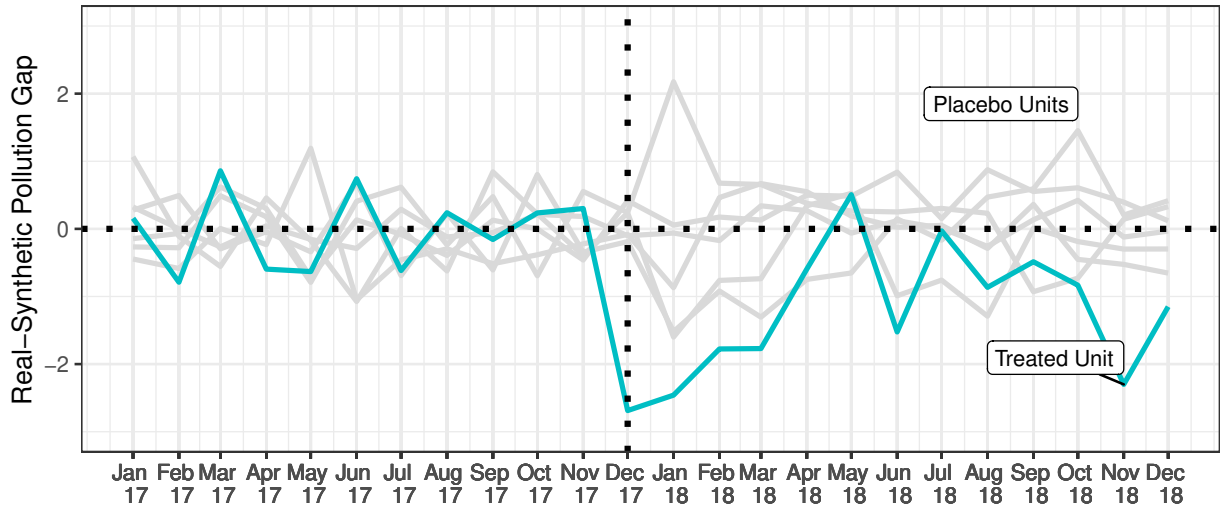

Figure 2.6: PI Gaps in the Actual Treated Unit and Placebo PI Gaps in Control Units

Next, we employ significance tests with the post- and pre-intervention $\text{MSPE}_{\text{ratio}}$. Figure 2.7 reports the $\text{MSPE}_{\text{ratio}}$ comparisons between the treated inter-jurisdictional river site and the others. The result demonstrates that the inter-jurisdictional river site's $\text{MSPE}_{\text{ratio}}$ is at least 2.67 times larger than that of any other control site. Not a single control site's $\text{MSPE}_{\text{ratio}}$ is close to the inter-jurisdictional river site. The larger $\text{MSPE}_{\text{ratio}}$ value indicates that the water quality difference between the treated and synthetic control unit increased in the post-intervention period. Therefore, if one assigns the treatment to these data randomly, the probability of obtaining a $\text{MSPE}_{\text{ratio}}$ as large as the inter-jurisdictional river is 1/14 ($p = 0.07$) [6].

[6]Of note, the comparably large p-value ($0.07 > 0.05$) does not mean our explainatory power is weak, because the total sample size in the donor pool determines the probability of significance largely. According to Abadie et al. (2015), researchers often need to restrict the donor pool to those with units with similar characteristics, and the larger sample size may lead to overfitting problems in the comparison.

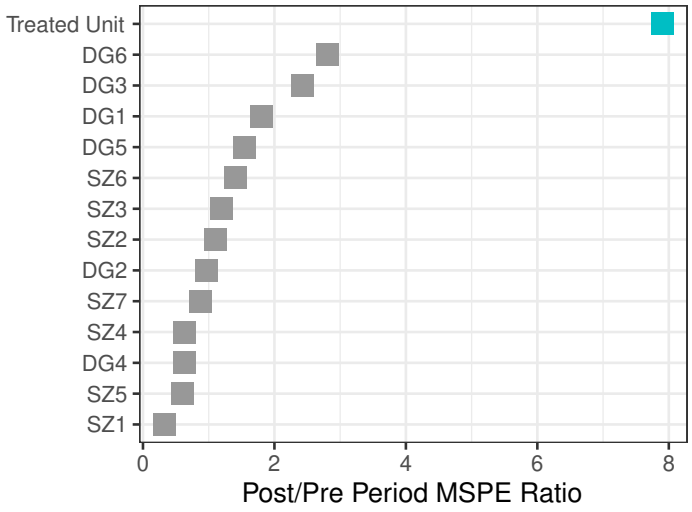

Figure 2.7: PI $\text{MSPE}_{\text{ratio}}$ of Post-/Pre- Intervention: The Treated and Control Units

We also rerun the placebo test for each pollutant indicator, and obtain a similar result for NH3-N as the PI, but COD and TP fail to pass the $p = 0.1$ threshold. These results suggest that the RCS effect is significant for NH3-N, but largely not for COD or TP. We report these results in Appendix 2.D. Various human activities' effects and pollutants' different corresponding target performances can explain these heterogenous results. COD indicates industrial wastewater, NH3-N indicates primarily industrial sewage and domestic wastewater, and TP indicates primarily agricultural pollution from fertilizers (Ministry of Environmental Protection 2002). Governments can reduce COD and NH3-N by regulating polluting industries. However, agricultural fertilization is based upon local farmers' individual behavior. Therefore, reducing the TP level often requires longer than the other two pollutants. Moreover, COD in the inter-jurisdictional river site is lower than 40 mg/L (the target performance) during most of the study time frame, which explains why governments have not implemented aggressive measures to treat it.

2.7 Discussion and Conclusion

2.7.1 Theoretical Implication

By investigating the way shifting from fragmented local governance to the NAO model affects water pollution control in a cross-boundary area, we advance our knowledge of collaborative governance's effectiveness. When facing different public problems, the optimal collaborative strategies also differ. While our case study in China offers direct evidence for ways to govern rivers in a complex institutional environment, it also has general implications for the network governance modes and their collaborative outcomes.

By comparing water quality performance before and after the network structure changed from the fragmented system to NAO, we demonstrate that the NAO model is a better strategy to improve environmental outcomes. This finding is consistent with Provan and Kenis's (2008, 236) view that NAO enhances a network's capacity to deal with "unique and complex network-level problems and issues." As we discuss at the outset, river management often includes social and environmental complexity that a single organization cannot possibly manage. With formalized network coordination, strict performance supervision, and external resource provision, the NAO enhances collaborations among network actors and ultimately improves environmental outcomes.

One intent of our analysis is to provide empirical evidence of collaborative efforts in the cross-boundary area. To the best of our knowledge, this is the first study in the collaborative governance literature to use an inter-jurisdictional natural resource as the unit of analysis. Our special case overcomes the spillover effect in identification, which has prevented previous studies from comparing management of inter- and inner-jurisdictional natural resources. Performance of interconnected natural resources in cross-boundary areas serves as a bridge between organizational performance and network ecology-level performance. Hence, we refer to it as "edge level" evidence. Controlling environmental quality within a jurisdiction is fundamentally important for every local government, but we cannot achieve long-term beneficial

outcomes for the entire network overall unless local governments coordinate to solve pollution problems on their shared borders jointly. To study why collaborative governance succeeds or fails, we must disentangle network members' shared outcomes. Therefore, our findings contribute to the collaborative governance theory, and provide new evidence to determine whether the NAO model improves the shared outcomes between local governments.

The NAO model's utility we identify in the Maozhou River has implications not only for China, but also has theoretical associations with other countries' contexts. In the United States, Bitterman and Koliba (2020) found that Vermont's state-established mandated networks subsidies improved municipalities' capacity, so they became more competent in controlling water pollution. Vermont's mandated network model outperforms not only non-collaborative networks, but also voluntary collaborative networks. In Australia, a study of bushfire planning Brummel et al. (2012) conducted demonstrated the importance of mandated collaboration in facilitating network members' communication, which is the critical method to maintain high quality services. When the mandated planning was completed, local authorities diminished interorganizational communication. and the networks transformed back to voluntary forms. Combining these findings and the results from our study, the NAO model's ability to facilitate collaboration has been established well in different contexts. Moving beyond this research topic, we suggest that public management scholars need to disentangle the "black box" of collaborative structure continuously as we study network effectiveness. As noted earlier, we should not only examine collaborative governance as a broad concept, but also observe and compare outcomes between different network modes from a closer and more rigorous perspective.

2.7.2 Limitation and Future Research Agenda

This research makes a unique contribution to the study of inter-jurisdictional collaborative behaviors, but it faces three main limitations. First, we focus on detecting the RCS institutional reform's treatment effect overall, but are unable to explain several internal

mechanisms further, such as formalized coordination, performance supervision, and external resource provision. We have no opportunity to access the communication process among network actors, polluting firms' regulation activities, or financial input for the RCS. Therefore, exploring and comparing major determinants of the policy output within the NAO model is beyond our research scope. To overcome this limitation and improve our knowledge of NAO, we recommend that future research use diverse research methods, such as qualitative interviews with policy insiders and surveys with stakeholders about their collaborative experiences.

This study's second limitation is its small research scope. Based upon the data available, we focus our analysis on only one inter-jurisdictional river site and its nearby inner-jurisdictional river sites. Thus, our findings' external validity should be examined in future studies with samples that can be generalized better. Moreover, environmental governance is not a short-term effort, so we also hope to examine the RCS's treatment effects during a longer time period. Further, we expect to see our research design replicated with data with much larger sample sizes in both cross-sectional and time-series dimensions.

Finally, the research context is another limitation. Although China's top-down structure is a unique context in which to study mandated networks, the institutional differences between it and democracies becomes a major barrier for scholars to generalize results. As mentioned earlier, we encourage scholars to test our hypothesis in other institutional environments and compare the structural differences between NAOs in China and other countries to develop the collaborative governance theory further.

CHAPTER 3
Bottom-up Approach to Fight Climate Change: An Empirical Assessment of the Community Choice Aggregation Program

Research Proposal

3.1 Introduction

Fighting climate change at the subnational level becomes central to environmental policy. Compared to the traditional federal level top-down policy solutions, local governments with deeper understandings of local knowledge and culture may have better abilities to promote environmental consensus among residents and interest groups. When local governments lead bottom-up environmental policies, a critical question is, how much environmental and social impacts these policies can achieve? Do local level environmental policies only affect residents? Or given spillover impacts from pollution, can local policies have impacts on a larger scale?

To answer the above research questions, I conduct a nationwide policy analysis on the U.S. Community Choice Aggregation Program (CCA). CCA is a bottom-up energy policy that authorizes local governmental entities to purchase renewable energy generation on behalf of community residents within their service territories. Through a citizen-government coproduction form, CCA breaks the power monopoly from the traditional investor-owned utilities; local governments and their residents can obtain lower electricity rates, cleaner energy, and stronger local control to the electricity markets. The potential benefits of CCA include increasing renewable energy consumption and local air quality improvement.

In the United States, seven states have enabled legislation allowing CCAs, including California, Illinois, Massachusetts, New Jersey, New York, Ohio, and Rhode Island. In total, there are 750 CCAs nationwide and they serve more than five million customers (O'Shaughnessy et al. 2019). The current study plans to investigate the social and environmental impacts of the CCA implementations atboth the state and local levels. The first CCA legislation was enacted by Massachusetts in 1997 and the most recent one was by New York in 2015. To make a comprehensive policy analysis, I have collected air quality data and energy consumption data at the state level from 1990 to 2019. To accurately examine the policy effects of CCA, I employ two estimation methods–both the difference-in-difference design in multiple time periods and the generalized synthetic control method– to measure

the CCA treatment effects on state energy consumption and air quality.

With the above planned analyses, this study will help us to understand the policy effectiveness of the CCA and the form of bottom-up citizen-government coproduction in fighting climate change. In addition, this study offers further insights for environmental policy impacts from the subnational level perspective.

3.2 Backgrounds

In the traditional U.S. electricity market, most consumers purchase their electricity from electric utilities, which are either investor-owned utilities (IOU), cooperative (co-op) utilities, or municipal utilities. Among them, IOUs are private for-profit providers; co-ops are nonprofit organizations that are managed by their member-owners; municipal utilities are public own utilities that are regulated by municipalities (Michaud 2018). Share of these three types of utilities are not evenly distributed in the market, of which IOUs serve over 70% of American customers.

Since the electricity market is dominated by private utility providers, individual consumers and governments have weak bargaining power in negotiating electricity pricing. Even worse, this market structure creates barriers for lower income consumers to participate in renewable energy, in which they need to pay high upfront costs (Michaud 2018). Although some state governments provide incentive guidance for solar energy investment such as tax credits, loan programs, solar renewable energy credits, and other financial models, not so many customers made active choices to buy renewable energy, and most people maintain the status quo and are served by IOUs (O'Shaughnessy et al. 2019).

CCA is a new model that attempts to overcome the "sellers' market" dilemma for individual customers. According to the definition from U.S. Environmental Protection Agency (EPA), CCAs are "...programs that allow local governments to procure power on behalf of their residents, businesses, and municipal accounts from an alternative supplier while still receiving transmission and distribution service from their existing utility provider." The

implementation process of the CCA model enhances democracy and local control of the electricity market. In the first step, local communities would pass a ballot to initiate a CCA organization, and then all ratepayers in the area would be automatically enrolled in the program. Next, CCA would choose an electricity supplier and individual ratepayers can opt-out from the program. Electricity suppliers maintains their roles in electricity distribution, metering, and billing (Michaud 2018). CCAs are not traditional utility suppliers, but they are a "electricity buyers' clubs" (Henderson 2017). Under this framework, local governments and residents have stronger bargaining power than individual customers in the market to negotiate electricity costs and use of renewable energy sources (Michaud 2018). Table 3.1 summarizes the differences between IOU, municipal utility, and CCA models.

Table 3.1: Utility Structures (Table adapted from Michaud (2018))

IOU	CCA	Municipal Utility
IOU contracts with suppliers	CCA contracts with suppliers	Municipal Utility contracts with suppliers
IOU manages transmission	IOU manages transmission	Municipal Utility manages transmission
IOU responsible for customer service	IOU responsible for customer service	Municipal Utility responsible for customer service

According to Whitaker (1980) classical definition, the CCA model is a citizen-agent mutual adjustment model of coproduction since local governments and citizens would establish a common understanding of citizens' utility preferences by ballot. Local government entities need to report cost allocation and revenue model to citizens during the program implementation process, which improve the transparency and democracy in the public goods provision. Similarly, (Ostrom 1996, 1073) defines coproduction as "the process through which inputs used to provide a good or service are contributed by individuals who are not in the same organization." This definition reflects the triangle relations between ratepayers, government, and electricity supplier in coproducing residential electricity. As a new electricity model, CCA overcomes the information and power asymmetric problem in electricity markets, therefore it will encourage more citizens to switch from traditional electricity suppliers to renewable

energy programs. Therefore, I expect that the implementation of CCAs will benefit the society in a larger scale.

In CCA programs, ratepayers' participation rates are between 85-95%, which outperform most of the other green pricing programs that only have 5-20% participation rates (O'Shaughnessy et al. 2019). Behavioral economics literature may explain this difference: individuals generally like to stay in the default option, therefore only a few customers opt-out from the CCA programs (Tversky and Kahneman 1991). By the end of 2017, there are 750 CCAs in California, Illinois, Massachusetts, New Jersey, New York, Ohio, and Rhode Island. In average they have 5% of total State electricity sales and serve 12% of total state customers, and these numbers are increasing every year (O'Shaughnessy et al. 2019).

Based on the above statistics, I assume that the CCA programs are not only contributing to local level public goods provision, but also have larger scale impacts. Therefore, this study will investigate the CCA model's outcomes at the states level, particularly the greenhouse gas (GHG) emission and renewable energy consumption.

3.3 Research Design

3.3.1 Data

The outcome variables in this study are air quality and renewable energy consumption at the states level. State air quality and GHG emission data are available at EPA; energy consumption data is available at U.S. Energy Information Administration website. I will collect annual data of both outcomes across 50 states from 1990 to 2019.

The core explanatory variable is the launch time of CCAs in each state. I will use the CCA launch years as treatments to examine whether CCAs contribute any effect after their implementations. I will also collect other state level data as control variables, such as government revenue and expenditure, other state level renewable energy policies, population density, capacity of power generators, political institutions, and economic indicators (e.g., GDP and unemployment rate). Table 3.2 summarizes the variables and data sources.

Table 3.2: Variables and Sources

	Variable Description	Source
Dependent variables	Air quality index and GHG emission	EPA: https://www.epa.gov/outdoor-air-quality-data/download-daily-data
	Energy consumption	EIA: https://www.eia.gov/electricity/data/state/
Treatment variables	(1) Launch time of the first CCA in the state: California (2010), Illinois (2012), Massachusetts (1997), New Jersey (2012), New York (2016), Ohio (2001), Rhode Island (2002)	From each state's CCA website
	(2) Numbers of active CCAs in each year	From each state's CCA website
Control variables	Government finance	Census bureau
	State level energy policies	Database of State Incentives for Renewable Energy (DSIRE)
	Population density	Census bureau
	Capacity of power generators	EIA: https://www.eia.gov/electricity/data/eia860/
	Political institution	Collected by the author
	Economic indicators	U.S. Bureau of Economic Analysis (BEA)

3.3.2 Planned Analysis

The difference-in-difference (DiD) is a standard practice for my case study of the CCA program effects, because DiD helps me to compare outcomes between CCA states and states without CCAs as well as the years before and after the CCAs have been launched. However, the CCA launch years are different across the seven states, which make the comparisons more difficult. Therefore, I employ the DID with multiple time periods method developed by Callaway and Sant'Anna (2020).

Another issue in identification is that the number of CCA states and no CCA states are not balanced. There are only 7 CCA states in the sample, so the parallel trend assumption in the DiD framework may be violated. Therefore, I plan to employ the generalized synthetic control method (GSC) as a robustness check, which relaxes the parallel trend assumption and allows the treatment to be correlated with unobserved units and time heterogeneities

under certain assumptions (Xu 2017).

In addition to the above analyses, I also plan to control the spillover effect of air pollutants with geospatial models for robustness check. With these analyses, I believe that the results will be scientifically rigorous.

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SUPPLEMENTAL INFORMATION

Appendix
Chapter 1

Appendix 1.A Pre-registration Report

Have any data been collected for this study already?
No, no data have been collected for this study yet

What's the main question being asked or hypothesis being tested in this study?

i Rational Choice Hypothesis: Local governments are more likely to form collaborations with partners which offer lower costs and higher benefits.

ii Political Homophily Hypothesis: Local governments are more likely to form collaborations with partners which share the same party affiliation.

iii Institutional Trust Hypothesis: Local governments are more likely to form collaborations with partners which they shared good collaborative experiences in history.

Describe the key dependent variable(s) specifying how they will be measured.
Choice: We will code choice as a dummy variable: 1 or 0, based on whether the participants select the program profile.

How many and which conditions will participants be assigned to?
We employ a choice-based conjoint design to obtain a more comprehensive picture of local government officials' opinions on collaboration partner selection. A hypothetical sustainable development program scenario will be introduced. I will ask subjects to compare 3 pairs of program proposals from different cities and indicate which city (in each pair) they are more willing to collaborate with. Each program profile includes 4 attributes:

1. Cost of the program: you pay: $250,000; this city pays $750,000/you pay: $500,000; this city pays $500,000/you pay: $750,000; this city pays $250,000 (theory: Cost)
2. Job creation: 200/500/800 jobs (theory: Benefit)
3. The program is proposed by either Democrats/Republicans (theory: Political Homophily)

4. Collaborative experience with this city: good/bad/no experience (theory: Institutional Trust)

Specify exactly which analyses you will conduct to examine the main question/hypothesis.
Analyses will be based on the standard practices in the conjoint experimental design:

i Average Marginal Component Effect (AMCE).

ii Marginal Means (MM).

Any secondary analyses?
We will conduct subgroup analyses by participants' characteristics, such as partisanship and ideology.

How many observations will be collected or what will determine the sample size? No need to justify decision, but be precise about exactly how the number will be determined.
This survey will be sent to American municipal government officials, including mayor, council members, and city managers. Based on power analysis of the conjoint attribute design, minimal requirement for sample size is 300.

Anything else you would like to pre-register? (e.g., data exclusions, variables collected for exploratory purposes, unusual analyses planned?)
Subjects' demographic information will be collected after they have answered the questions regarding key dependent variables. The information is collected for detecting the heterogeneity of the treatment effect.

Appendix 1.B Survey Instruments

First, the respondents saw an introduction to the sustainable development program vignette.

Introduction

We are interested in the intergovernmental collaborative decisions of American local governments. In the following part, we will show you several **hypothetical** decision-making situations and ask you to provide opinions. Please try to be honest in answering the questions. Describe what you would **really** do if a similar situation occurs in your working live. Remember that your answers to all questions in this survey will be kept **completely confidential**.

Assuming you and your municipal government plan to collaborate with another city on an interlocal sustainable development program. The potential benefits of the program include:

- Economic development
- Community development
- Environmental protection

Based on your consideration for the best option to develop your municipality, please evaluate the following hypothetical city partners and their proposals. In total, you are asked to evaluate 3 pairs of cities in 3 separate pages. Please provide your choice in each pair.

Note: There is **no** right or wrong answer to any comparisons.

Next, the respondents completed three pairs of comparison task like the following.

Suppose you can only collaborate with one out of the two cities:

Program Attributes:	**City A**	**City B**
The program will create	500 jobs in your city	800 jobs in your city
The program is proposed by	Democrats	Republicans
Your previous working experiences with this city	Good	No experience
Cost of the program	You pay: $250,000; This city pays: $750,000	You pay: $500,000; This city pays: $500,000

Please indicate which city do you prefer to collaborate with:

City A | City B

→

Next, the respondents answered political background questions and demographic questions.

Generally speaking, do you usually think of yourself as a...

- Democrat
- Republican
- Independent
- Other party (please specify)

How would you describe your political views as of today?

- Very liberal
- Liberal
- Moderate
- Conservative
- Very Conservative
- No opinion

How many years have you been in your current government position?

- Less than 1 year
- Less than 5 years
- Less than 10 years
- More than 10 years

Do you consider yourself to be...

- White, not Hispanic or Latino
- Black, not Hispanic or Latino
- Hispanic or Latino
- Asian, not Hispanic or Latino
- Other

Which of the following best describes your gender identity?

- Male
- Female

- Non-binary/third gender
- prefer not to say

Your age: _____

What is the highest level of education you have completed?

- Less than high school
- High school/GED
- Some college
- 2-year college degree
- 4-year college degree
- master degree
- doctoral degree
- Professional Degree (JD, MD)

Appendix 1.C Email Invitation Context

Subject line: Survey Research Invitation

Dear [Job Title] [Last Name]

As local governments have more opportunities and pressures to collaborate with other local governments, local government scholars seek to understand optimizing contexts based on your opinion as a local government [elected official/manager]. I value your perspective and I invite you to complete a very short and anonymous survey (about 3 minutes). This survey is conducted by researchers at [institution name]. The purpose of this survey is to study the intergovernmental collaborative decisions of American local governmental officials.

Follow this link to the survey: [survey link is here]

You are being invited to participate in this survey because you are currently serving or formerly served as an [elected official/manager] in an American local government. We will keep the information you provide confidential. Your participation in this study is completely voluntary. You may choose not to take part in it or you may stop participating at any time.

Thank you very much for your consideration of and participation in this research study, the results of which will be shared with you via email after we finish this study.

Your sincerely

Appendix 1.D Sample Characteristics

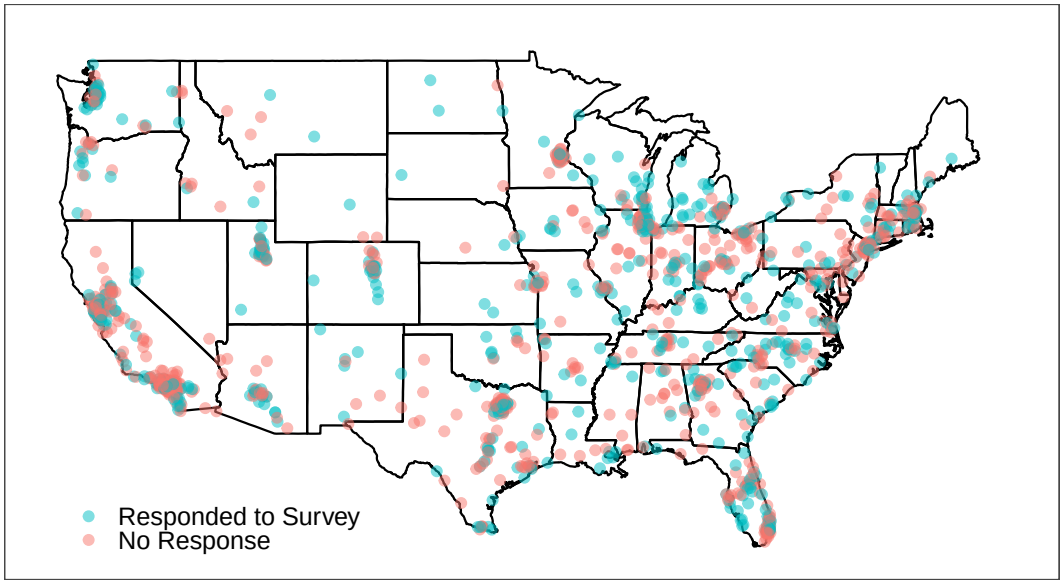

Figure D.1: Geographic Location of Survey Respondents

Table D.1: Descriptive Summary

	Mean	SD	Min	Max
City Level Variables				
Population (in 1000)	117.09	397.70	30.07	8336.82
Median houshold income (in $1000)	67.83	26.40	21.92	235.28
Female official ratio	34.24	17.92	0.00	100.00
Labor force participation	64.91	5.92	39.90	79.90
Home value (in $1000)	299.11	255.25	40.44	2000.00
Unemployment rate	5.36	2.25	1.40	16.90
White percentage	71.18	17.01	5.60	95.50
Black percentage	12.98	15.64	0.10	91.80
Individual Level Variables				
Democrats	0.47	0.50	0.00	1.00
Republicans	0.25	0.43	0.00	1.00
Ideology	2.89	0.97	1.00	5.00
Tenure	2.52	0.97	1.00	4.00
White	0.78	0.41	0.00	1.00
Black	0.09	0.29	0.00	1.00
Hispanic	0.07	0.26	0.00	1.00
Asian	0.02	0.15	0.00	1.00
Other	0.03	0.18	0.00	1.00
Female	0.39	0.49	0.00	1.00
Age	56.51	12.59	19.00	89.00
Grad School	0.57	0.49	0.00	1.00

Table D.2: Representativeness of City Level Variables

	Responded Cities	No Response Cities	P-value
Population	114995.24	117051.15	0.92
Median houshold income	67833.97	68341.71	0.74
Female official ratio	34.24	31.73	0.03
Labor force participation	64.91	64.99	0.81
Home value	299108.16	301116.71	0.89
Unemployment rate	5.36	5.56	0.13
White percentage	71.18	68.98	0.03
Black percentage	12.98	13.23	0.78

Appendix 1.E Conjoint Diagnostic Tests

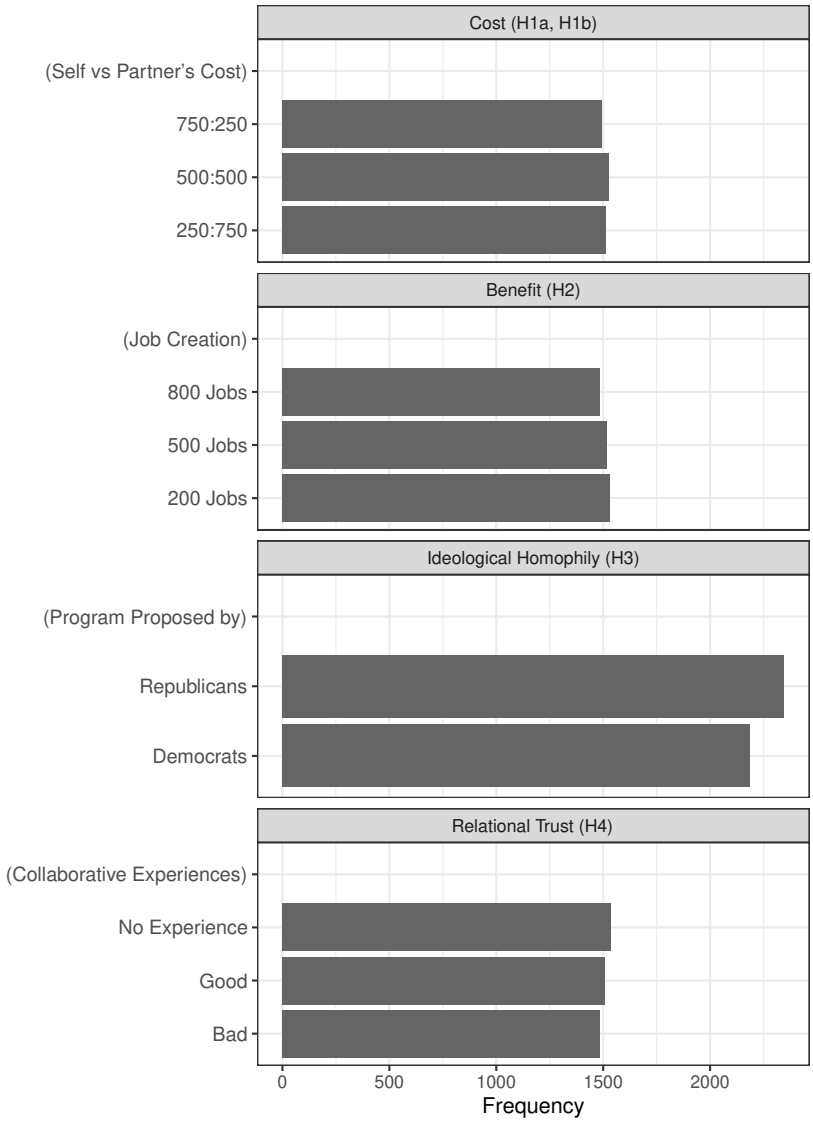

Figure E.1: Frequency of Attribute Components

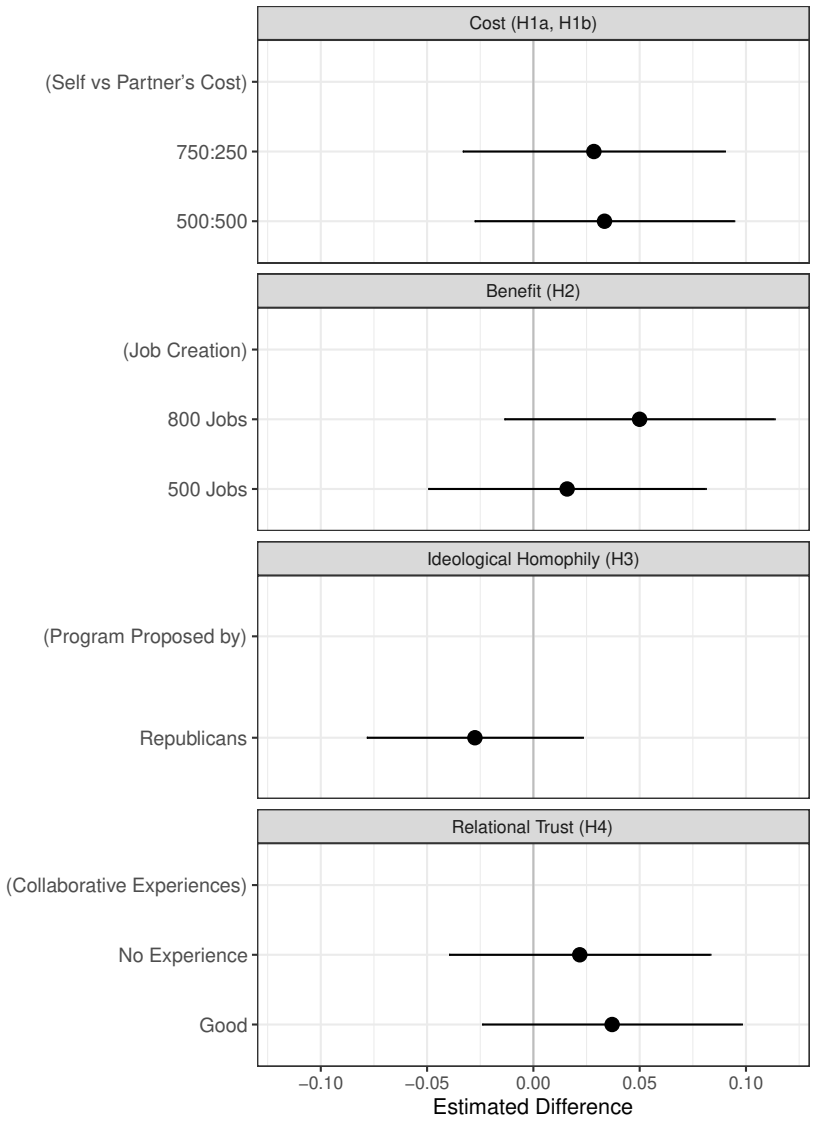

Figure E.2: Left-Right Effect

Note: Bars are 95% confidence intervals.

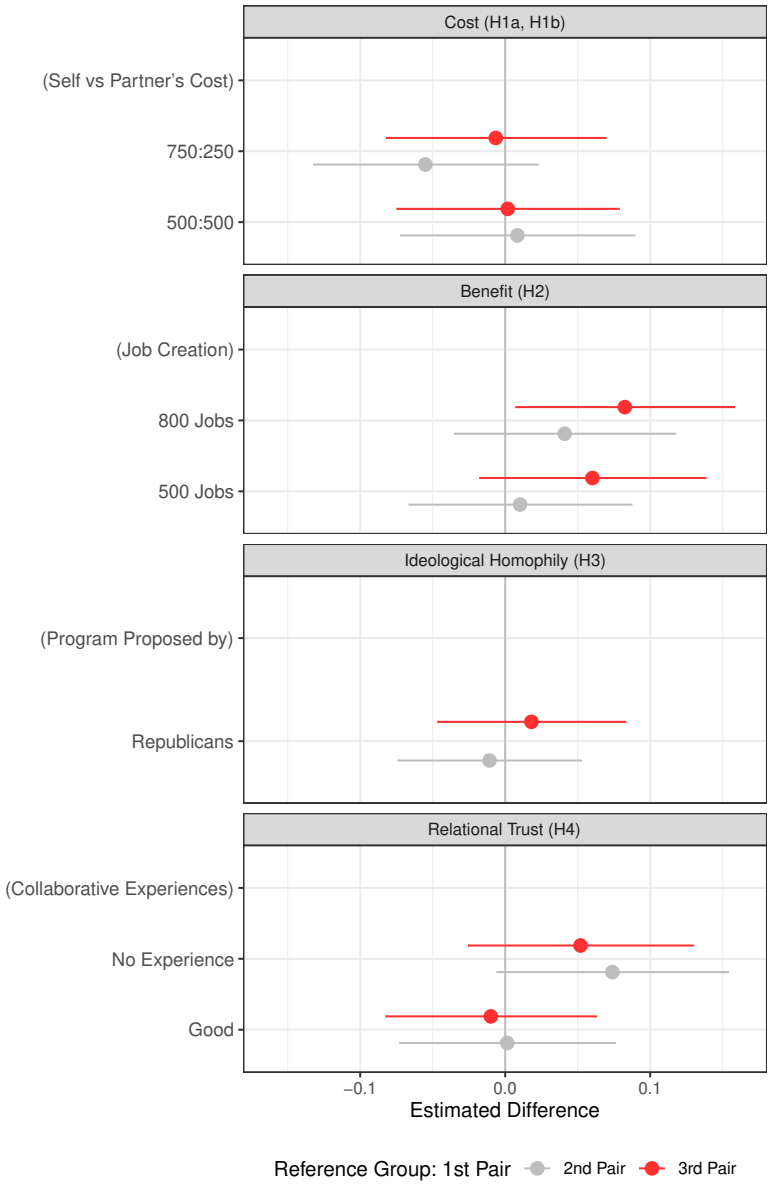

Figure E.3: Carryover Effect

Note: Bars are 95% confidence intervals.

Appendix 1.F Additional Subgroup Analysis

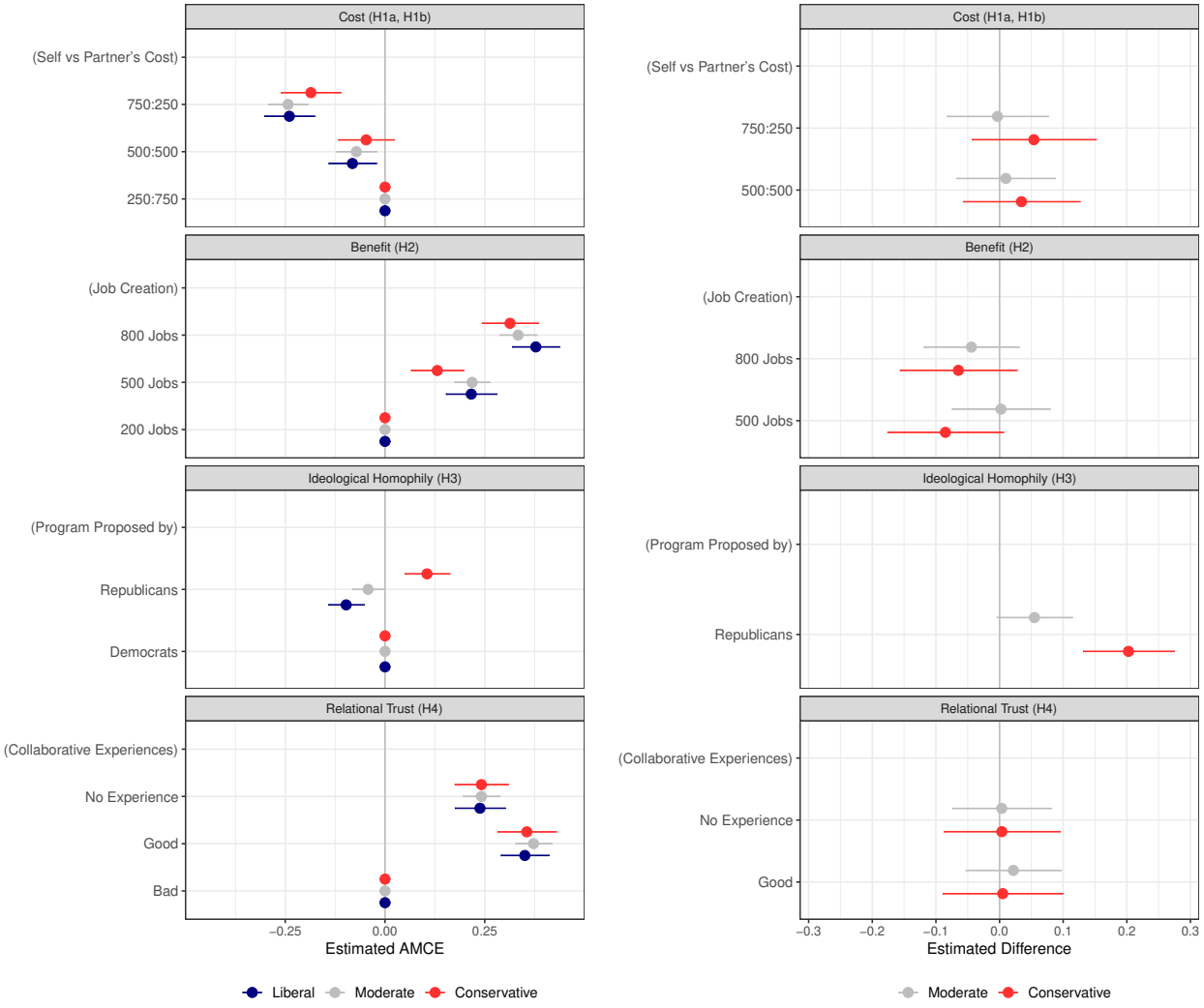

Figure F.1: Subgroup Analysis by Ideology

Note: Bars are 95% confidence intervals.

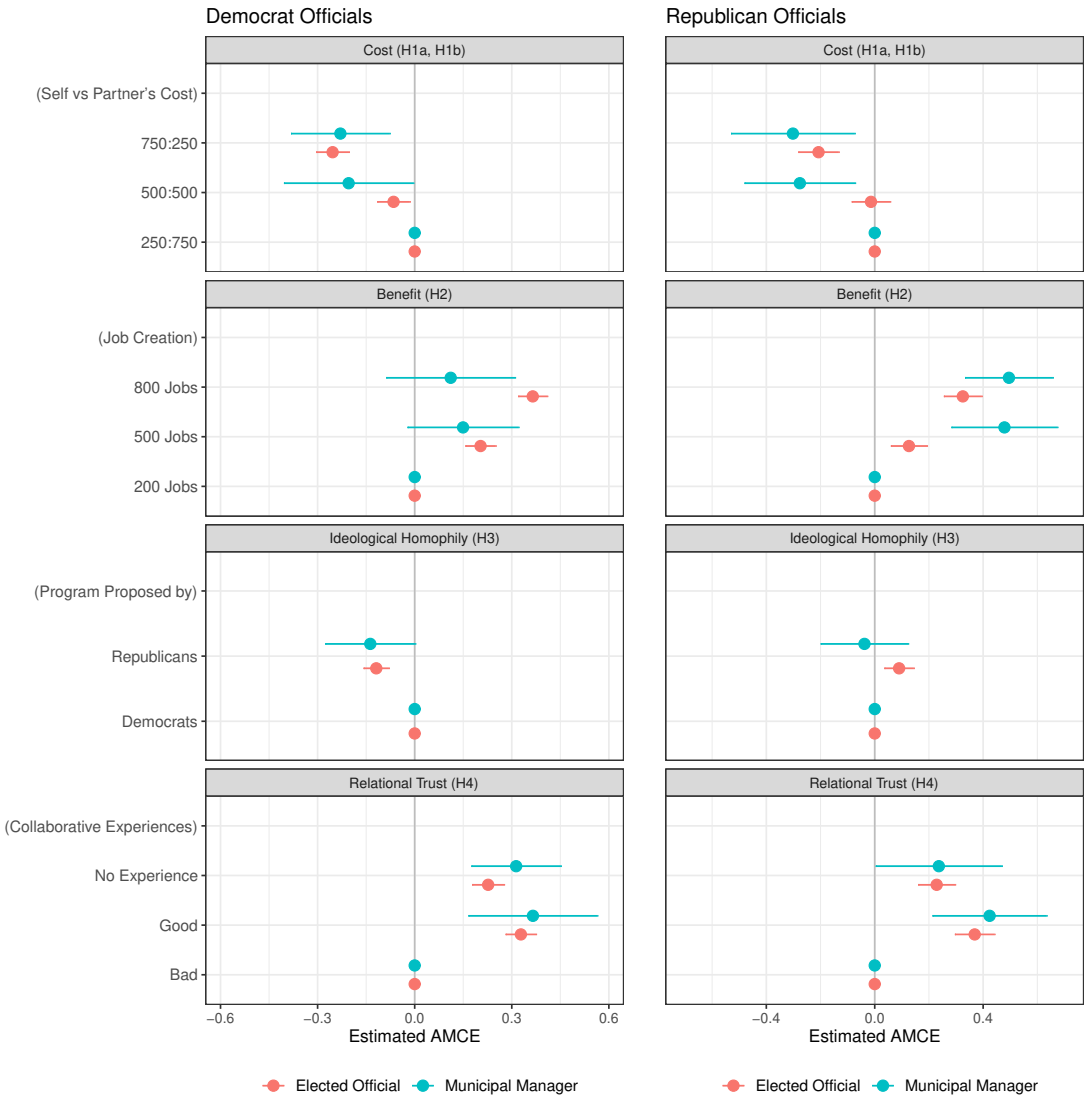

Figure F.2: Subgroup Analysis by Government Positions

Note: Bars are 95% confidence intervals.

Appendix
Chapter 2

Appendix 2.A Causal Identification

We follow Abadie et al.'s (2010; 2015) steps to demonstrate the synthetic control method's causal procedure. First, we have a sample of $J+1$ units. $J=1$ is the treated unit and $J=(2,...,J+1)$ is the donor pool of control units. All $J+1$ units have $T=T_0+T_1$ time points, T_0 and T_1 are the pre-intervention and post-intervention periods. To construct the synthetic control unit, we apply a weighting average of samples in the donor pool: $\mathbf{W}=(w_2,...,w_J+1)'$ with $(0 \leq w_j \leq 1)$. To select the best value of $\mathbf{W}$, we match the synthetic control unit's characteristics so they are similar to those of the treated unit. To obtain this, we include $\mathbf{X_1}$ $(k \times 1)$ vector of time-constant variables for the treated unit in the pre-intervention period, and $\mathbf{X_0}$ as the $k \times J$ matrix of the same time-constant variables for the control units. Then, we can construct the synthetic control unit by minimizing $\|\mathbf{X_1}-\mathbf{X_0W}\|$ to obtain the $\mathbf{W}^*$ (between 0 and 1), which minimizes the mean square prediction error (MSPE) in the pre-intervention period. The interpretation of MSPE is the lack of fit between the treated unit and its synthetic control part in the pre-intervention period: $MSPE=\frac{1}{T_0}\sum_{t=1}^{T_0}(Y_{1t}-\sum_{J=2}^{J+1}w_j^*Y_{jt})^2$. For more discussions of the MSPE, please read (Abadie et al. 2010).

Let Y be the outcome variable, and we can identify:

$$\hat{\alpha}_{1t}=Y_{1t}-\sum_{i=2}^{J+1}\mathbf{W_j^*}Y_{jt}, t=T_1 \tag{4}$$

$\hat{\alpha}_{1t}$ estimates the average treatment effect on the treated unit $J=1$. Y_{1t} and $\sum_{i=2}^{J+1}\mathbf{W_j^*}Y_{jt}$ are the outcomes of the treated unit and its synthetic control counterfactual in the post-intervention period.

Appendix 2.B Trends of Pollutants

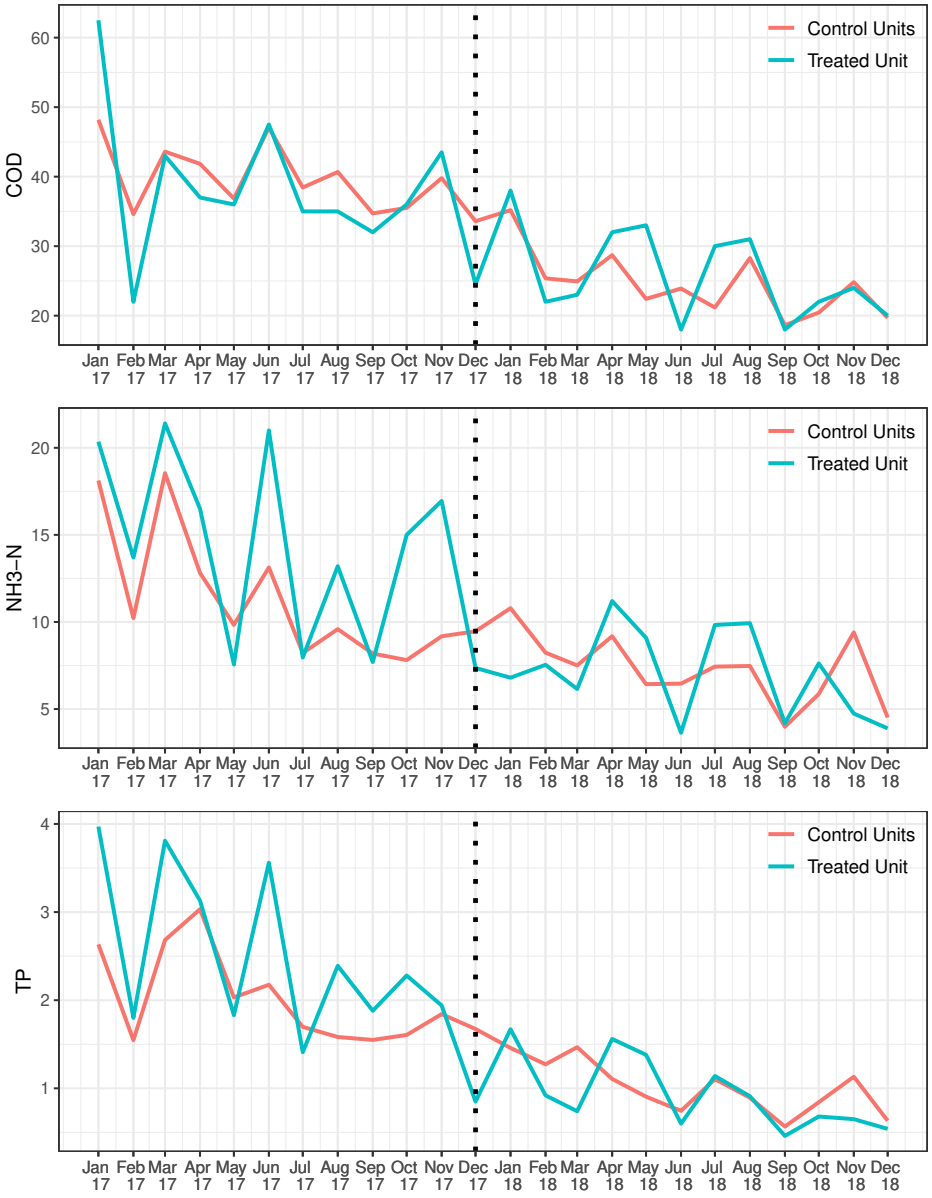

Figure B1: Trends of Pollutants: Treated Unit versus Average Control Units

Appendix 2.C Treatment Effect on Each Pollutant

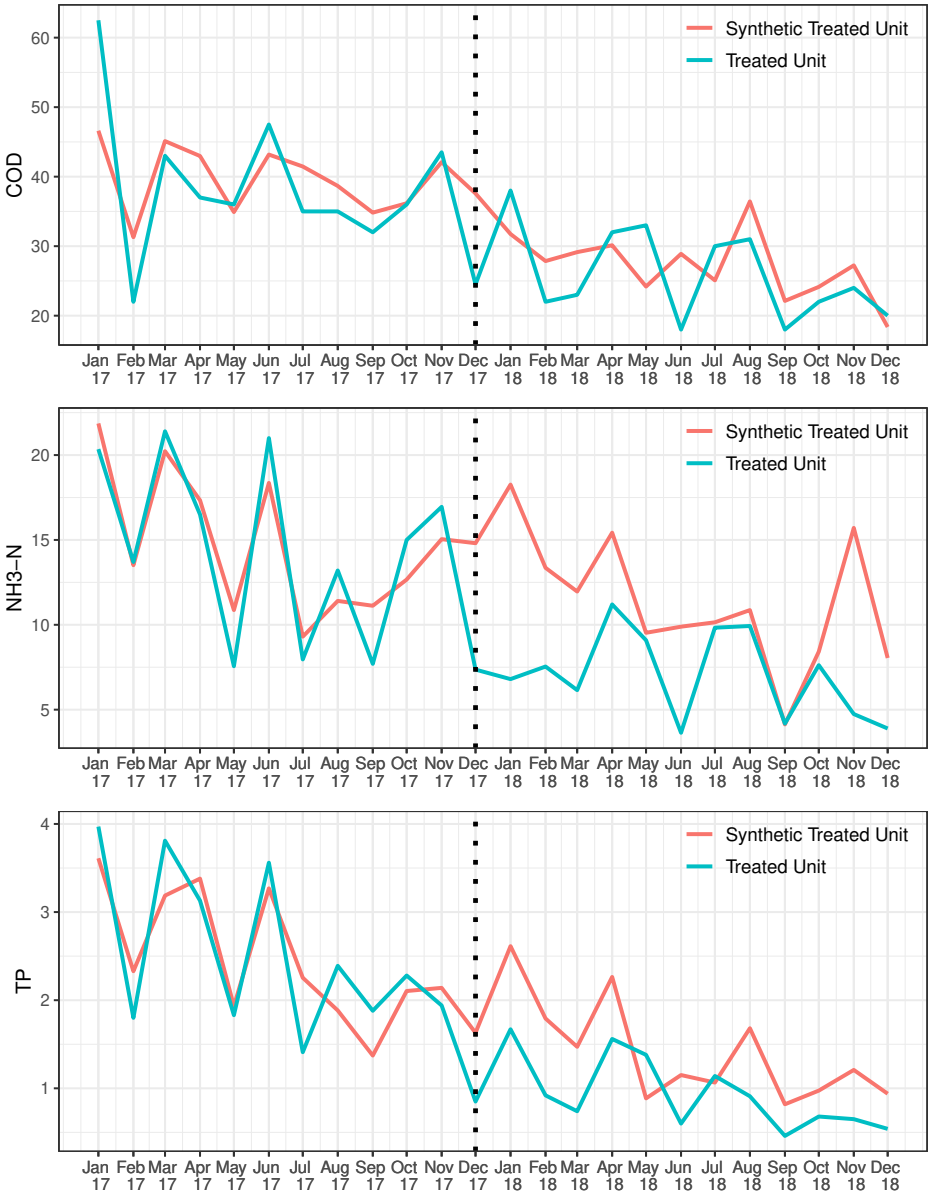

Figure C1: Trends of Pollutants: Treated Unit versus Synthetic Treated Units

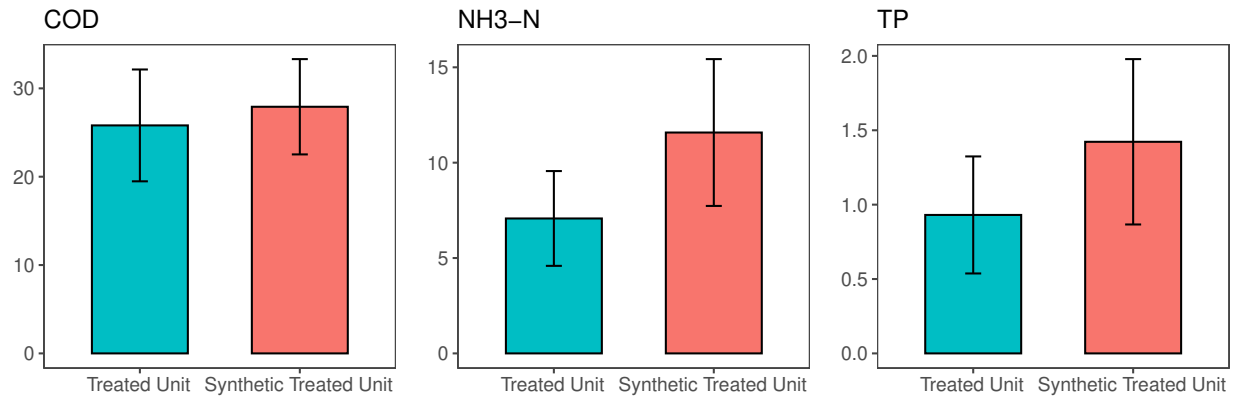

Figure C2: ATT of Pollutants in the Post-Intervention Period

Note:
COD: ATT = 2.11 (8%) (S.E. = 2.307, p-value = 0.369)
NH3-N: ATT = 4.51 (39%) (S.E. = 1.271, p-value = 0.00165)
Phosphorus: ATT = 0.49 (35%) (S.E. = 0.189, p-value = 0.0156)

Appendix 2.D Placebo Test of Pollutants

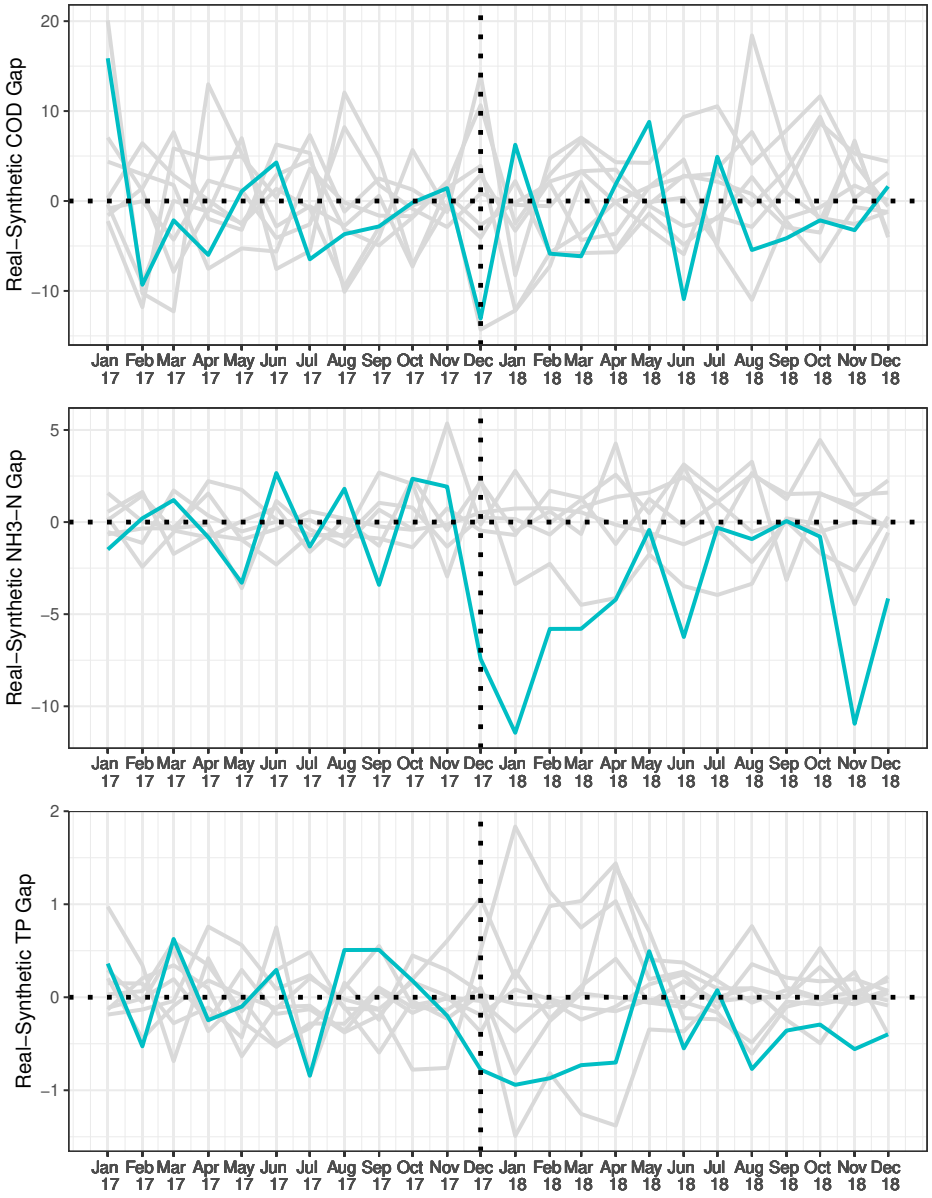

Figure D1: Pollutants Gaps in The Real Treated Unit and Placebo PI Gaps in Control Units

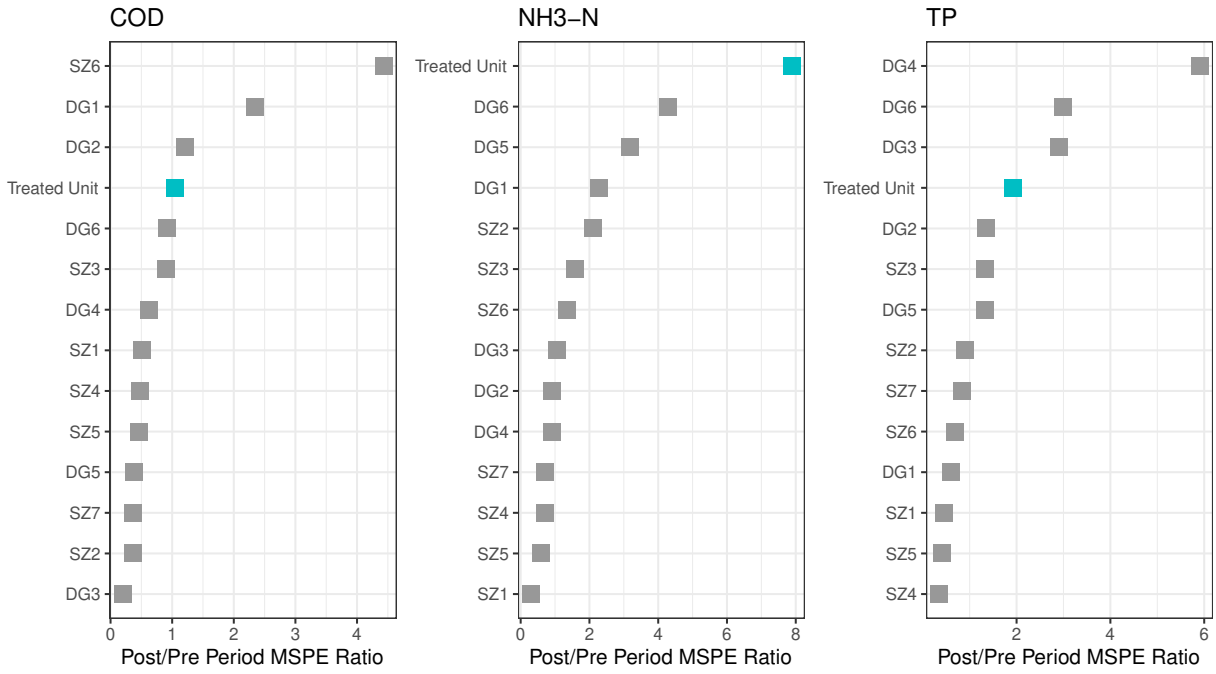

Figure D2: Pollutants $\text{MSPE}_{\text{ratio}}$ of Post-/Pre- Intervention: The Treated and Control Units