The “Watershed” of Collaboration: The Impact of Legislation and Collaborative Actions on Environmental Outcomes

Yixin Liu, Jiho Kim, Tina Nabatchi

Abstract

Cross-boundary collaboration is used widely in environmental management, yet little research examines the connections between collaborative actions and collaborative outcomes. To address this gap, this article evaluates the impact of the *Oregon Plan for Salmon and Watersheds* (OPSW), a policy that authorizes and encourages the use collaboration to improve environmental outcomes. Specifically, the study empirically assesses whether state legislation authorizing collaborative actions (i.e., watershed restoration projects) improves environmental outcomes and whether characteristics of collaborative actions (convener, leader, and goal multiplicity) lead to different environmental outcomes. We explore these research questions by combining multiple data sources spanning the period of 1980-2021 in the state of Oregon. Employing a regression discontinuity in time (RDiT) design, we find that water quality improved by about 5 percent after the passage of the OPSW. Furthermore, our longitudinal analyses show that projects convened by collaborative governance regimes (i.e., Watershed Council) do not always outperform projects convened by ad hoc collaborations, while local government leaders are more effective than civic group or state government leaders. Also, leaders from the state government become the most effective as the number of goals per project increases. These findings indicate the importance of system context and collaborative actions in environmental outcomes of cross-boundary collaboration.

Keywords: collaborative governance, legislation impact, environmental management

---

Yixin Liu (yliu533@syr.edu) is a post-doctoral fellow in Maxwell School of Citizenship and Public Affairs at Syracuse University. Jiho Kim (jkim36@syr.edu) is a doctoral candidate in Maxwell School of Citizenship and Public Affairs at Syracuse University. Tina Nabatchi (tnabatch@syr.edu) is the Joseph A. Strasser Endowed Professor in Public Administration in Maxwell School of Citizenship and Public Affairs at Syracuse University.

We thank Tom Koontz, Qiaozhen Liu, and Tomás Olivier for feedbacks during different stages of this project. We are also grateful to insightful comments from participants at the American Political Science Association Annual Conference 2023 and Association for Public Policy & Management Annual Conference 2023.

1 Introduction

Collaborative governance is recognized widely as an effective tool for addressing complex environmental issues (Emerson and Nabatchi 2015a; Koontz et al. 2010). The underlying theoretical rationale is straightforward: the management of cross-boundary natural resources, such as rivers and forests, extends beyond the coordination ability of a single organization or individual (Ostrom 1990). It requires collaboration among multiple policy actors across different sectors to establish "shared core goals" and take actions for the benefit of the socio-ecological system (Bryson et al. 2016, 914). In recognition of this reality, many governments (both national and subnational) have passed legislation that mandates or incentivizes the use of collaboration to address cross-boundary environmental issues. Such externally directed collaborative efforts (Emerson and Nabatchi 2015a) sometimes are overseen by a designated collaborative platform, an organization or program dedicated to helping create and support multiple collaboratives operating in the same policy field and working toward the same (or similar) ends (Ansell and Gash 2018; Cochran et al. 2019).

Although a number of studies examine various aspects of externally directed collaborations, such as resource allocation (e.g., Scott 2016), participant representation (e.g., Mehdi and Nabatchi 2023), and network structures (e.g., Liu and Tan 2022; Wang et al. 2019), important research gaps remain. This study addresses two. First, the overall effectiveness of using legislation to externally direct cross-boundary collaborations remains unclear. Current empirical studies have not assessed systematically whether legal authorizations of cross-boundary collaboration make a difference in environmental outcomes. Instead, researchers have collected data on structural, procedural, financial, and network aspects of externally directed collaboration (e.g., Mehdi and Nabatchi 2023; Scott 2016; Siciliano et al. 2021; Siddiki et al. 2015), most of which are determined after the enactment of the legislation (Kim et al. n.d.). However, without understanding the overall causal effects of legislation – a key element of the broader system context for collaborative governance – on environmental outcomes, we cannot further compare collaborations with potential alternatives in a counterfactual state (e.g., self-initiated or independently convened collaborations) (Emerson and Nabatchi 2015a; Emerson et al. 2012). Given the lack of large-n panel datasets on collaborative governance (Scott et al. 2019), scholars have tended to measure perceptions of improvements in environmental outcomes (e.g., Leach et al. 2002) and only a few have produced plausibly causal estimates of the performance of externally directed collaborations (Liu and Tan 2022; Lubell 2004; Scott 2015).

Second, the existing literature does not examine how the design of collaborative projects affects outcomes in environmental management. Even with policies that mandate collaboration, actors retain some degree of autonomy in coordinating project activities, as commonly observed in watershed management (Bitterman and Koliba 2020; Scott 2016) and alternative fuel implementation (Lee 2023). Despite continued calls for research on the measurement and determinants of environmental outcomes (Koontz et al. 2020; Thomas and Koontz 2011), scholars have yet to address how variations in collaborative actions affect environmental outcomes.

To fill these gaps, we ask two questions: (1) Does externally directed collaborative governance improve environmental outcomes? (2) Do variations in collaborative project characteristics (collaboration form, leader, number of goals) generate heterogeneous policy outcomes? This article addresses both questions by investigating watershed management in the state of Oregon. Specifically, it conducts two analyses using a novel dataset of water quality monitoring over 41 years. First, we use a Regression Discontinuity in Time (RDiT) design to test the overall impact of the 1997 *Oregon Plan for Salmon and Watersheds* on water quality improvement in the state. This state-level legislation authorizes and encourages cross-sectoral policy actors to collaborate on watershed restoration projects. Second, we carry out a longitudinal analysis of 8,853 collaborative watershed restoration projects. The analysis examines the effects of different collaborative forms and the sectoral affiliation of the project leaders (i.e., citizen groups, local governments, and the state government) on water quality. It also explores whether project leaders from particular sectors achieve better environmental outcomes than others as the number of goals per project increases. To this end, the article first reviews existing studies and offers hypotheses about the effects of legislation and collaborative projects on environmental outcomes. Next, it explains the data and empirical strategy and presents the results. It concludes with a discussion of theoretical and practical implications.

2 Collaborative Governance in Environmental Management

Collaborative governance is a collective decision-making arrangement in which actors work together across boundaries (e.g., organization, sector, jurisdiction, geography, interest) to address public policy problems that cannot be solved readily or easily by a single actor working alone (Agranoff and McGuire 2003; Ansell and Gash 2008; Bryson et al. 2006; Emerson and Nabatchi 2015a). Based on this definition, we use 'collaborative governance' and 'cross-boundary collaboration' as loosely interchangeable terms throughout the article.

In developing a general analytical framework for collaborative governance, Emerson and Nabatchi (2015a) suggest various components of cross-boundary collaboration, including system context (i.e., external environment), drivers (i.e., collaboration-inducing factors), collaboration dynamics (i.e., process characteristics), actions (i.e., agreed-upon decisions, plans, and projects to be implemented), outcomes (i.e., results of collaborative actions), and adaptation (i.e., adjustment of other components in response to collaborative outcomes). They also identify three types of cross-boundary collaboration: (1) "self-initiated" through a voluntary cooperation of stakeholders; (2) "independently convened" by an autonomous third party; and (3) "externally directed" by an entity with enough power and resources to predetermine and affect how collaboration works (Emerson and Nabatchi 2015a, 159). In this article, we focus on evaluating the environmental outcomes of watershed restoration projects undertaken as a result of externally directed cross-boundary collaboration.

Collaborative governance is crucial in many cases of environmental management (Koontz et al. 2010), and particularly those involving natural resources that transcend the jurisdiction of a single government entity, such as water and air. Cross-boundary collaborations in environmental management vary in the degree to which external entities exert direct influence over the formation and process of collaboration (DeCaro et al. 2017). In some contexts, internal participants alone may have the capacity to self-sustain their voluntary collaboration without requiring any authority or resources from outside (e.g., Agrawal 2003; Cox et al. 2010; Ostrom 1990). However, an increasing number of environmental cross-boundary collaborations are legally mandated and/or financially incentivized by federal, state, and local government (e.g., Amsler and Vieilledent 2021; Leach et al. 2002; Liu and Tan 2022; Mehdi and Nabatchi 2023; Scott 2016; Sørensen et al. 2018). This often is a strategic choice, either by the government or other authorities, to cover various costs of collaboration through "governmental [and other] contributions in expertise, technical information, manpower, institutional networks, or other resources" (Koontz and Thomas 2006, 15).

The enactment of legislation and/or the disbursement of funding creates a system context conducive to the creation of cross-boundary collaborations and initiation of collaborative actions. Collaborative actions are "intentional efforts undertaken as a consequence of the collective choices" made through collaboration dynamics and serve as means to achieving shared goals (Emerson and Nabatchi 2015a, 82). Collaborative actions also may be considered "outputs" that yield various outcomes. Collaborative actions can take many forms, including but not limited to conservation or natural resource plans, emissions trading schemes, and infrastructure construction blueprints (Koontz et al. 2020; Thomas and Koontz 2011). Often, a collaborative action takes the form of a specific project that "identifies the problem(s) to be addressed, stipulates the objective(s) to be pursued, and, in a variety of ways, 'structures' the implementation process" (Sabatier and Mazmanian 1980, 540).

Among the different stages of collaboration, the 'carrying-out' of collaborative actions is the most direct and immediate step taken to achieve the intended goals of collaboration, and often requires careful, specific, strategic, and continuous design thinking. However, existing legislation on collaborative governance is often general and broad, all the more so at the state level, and may not necessarily include all the ‘nitty-gritty’ details of what should be done, how, or by whom (Amsler 2016). Even when the legislation mentions collaborative actions or outputs, it does not tend to be strictly compulsory, instead allowing participants to use their discretion to adapt to local-specific contexts and dynamic needs (Kim et al. n.d.). As a result of such legislative ambiguity, externally directed collaborative efforts are likely to vary across a number of characteristics, and such variations may affect the efficiency, efficacy, and equity of collaborative actions, and therefore outcomes.

We explore these issues by systematically assessing (1) whether legislation mandating collaborative governance achieves or makes progress towards its intended outcomes, and (2) whether variations in the characteristics of collaborative actions (i.e., collaborative projects) matter for outcomes. More specifically, we examine whether legislation mandating collaboration in watershed management in the state of Oregon improves environmental outcomes, and whether the characteristics of collaborative watershed restoration projects (e.g., collaboration form, leader, and number of goals) make a difference beyond the overall effects of the legislation.

2.1 Legislation

Legislation is an important element of the system context that can foster cross-boundary collaboration in principle and practice, but it remains largely understudied in collaborative governance research (Bingham 2009, 2010)). Although some scholars have examined legal mandates for collaborative governance at the local (Amsler and Vieilledent 2021), state (Kim et al. n.d.), national (Batory and Svensson 2020), and international levels (Newig and Koontz 2014), or across multiple levels (Amsler 2016), these studies are primarily normative or descriptive. To our knowledge, no studies have empirically examined the effects of legislation - whether local, state, federal, or multi-level - on collaborative outcomes, using a large-n dataset and producing plausibly causal estimates of effects.

Legislation may help with collaborative efforts through formalization of rules on participants and decision-making (Doberstein 2016) or "process design" for interactions (Edelenbos and Klijn 2006). However, if too loose or too rigid, legislation might hinder the collective action of participants and negatively affect collaborative outcomes (Amsler 2016). For instance, state legal mandates can constrain collaborative problem-solving approaches in local communities through "intrastate preemption" (i.e., limitations imposed by state laws on the actions of local government and community members) (Amsler and Vieilledent 2021), while weak institutional and legal frameworks for collaboration may fail to overcome political tensions and uncertainties and negatively affect process and productivity performance (Avoyan et al. 2017).

Nevertheless, as long as it is unrestrictive and binding for participants, we expect that state legislation authorizing and encouraging collaboration would have a positive net effect on target outcomes. Specifically, a legal mandate can raise the salience and urgency of an environmental issue (Agnone 2007), formalize and sustain the implementation of collaborative actions (Margerum 2011), and exert institutional pressure on the participants to make progress toward improving environmental quality (Frumkin and Galaskiewicz 2004). This leads to the first hypothesis:

H1: Legislation authorizing collaborative projects will improve environmental outcomes.

2.2 Collaboration Form

Cross-boundary collaboration can take many forms. Two forms are of particular interest in this study: ad hoc collaborations and collaborative governance regimes. An ad hoc collaboration is a collaborative effort that "forms in response to an immediate need or instrumental purpose and is temporary, existing only for the duration of a well-defined, narrow and bounded, one-off project" (Mehdi and Nabatchi 2023, 499). After a project has been completed, an ad hoc collaboration disbands, although a successful project may stimulate additional collaborative efforts (Mehdi and Nabatchi 2023). Given its short duration, an ad hoc collaborative is less likely to build strong social capital among participants and otherwise leverage collaborative advantage (Bryson et al. 2016).

In contrast, a collaborative governance regime (CGR) is a governing arrangement "in which cross-boundary collaboration represents the predominant mode for conduct, decision-making, and activity between autonomous participants who have come together to achieve some collective purpose defined by one or more target goals" (Emerson and Nabatchi 2015b, 18). Typically, the collective purpose centers on "multifaceted problems that require a well-developed theory of change, replete with multiple, interconnected projects", which in turn requires participants to "engage in repeated interactions sustained over the longer term" (Mehdi and Nabatchi 2023, 499). Given its more continuous duration, a CGR is more likely to build strong social capital among participants and otherwise leverage collaborative advantage (Bryson et al. 2016).

Given these structural differences, the collaborative actions or projects undertaken by ad hoc collaborations and CGRs are also likely to differ. For example, because an ad hoc collaborative forms to address a relatively simple, distinct issue, its collaborative project(s) tend to be narrow, highly focused, and site-specific. In contrast, because a CGR forms to address multiple, interrelated problems, it tends to juggle numerous projects that emerge directly from its comprehensive strategy to address both site-specific and systems-wide issues. Because CGRs must have developed a shared theory of change and engage in long-term, organized planning and execution (Guarneros-Meza et al. 2018), they are likely to leverage various knowledge, skills, social capital, and resources accumulated over time. In turn, this may have a greater positive effect on environmental outcomes. This leads to our second hypothesis:

H2: Projects convened by CGRs will improve environmental outcomes more than projects convened by ad hoc collaborations.

2.3 Leaders

Leaders are essential components of cross-boundary collaboration (Ansell and Gash 2008; Bryson et al. 2015; Douglas et al. 2020; Emerson and Nabatchi 2015a; Page 2010; Scott and Thomas 2017). However, scholars have yet to examine empirically whether collaborative outcomes differ depending on who leads. Although a few studies explore the effects of representational diversity in the participant makeup on collaborative outcomes (e.g., Mehdi and Nabatchi 2023; Scott 2015; Siddiki et al. 2017), leader effects have not been at the center of analysis.

The characteristics of leaders can be measured along numerous dimensions (e.g., demographic factors, motivations, commitment to the collaborative effort, past experience in collaboration, efficiency, network capacity, ability to secure internal and external legitimacy, facilitation skills, inclusiveness, and conflict resolution techniques). Among these dimensions, this study focuses on the sectoral affiliation of leaders, in part because it can act as a proxy variable for the capacity and resources needed to integrate actors from diverse sectors in collaborative efforts (Crosby and Bryson 2010). More specifically, we expect that leaders from the public and private sectors may be more effective at improving environmental outcomes than leaders from nonprofit or civic sectors, largely due to their relative strengths in political authority, financial and human resources, expertise, knowledge, and experience vis-à-vis environmental management. Postulating that who takes the wheel in carrying out collaborative actions matters for collaborative outcomes (Bianchi et al. 2021), we suggest the third hypothesis:

H3: Projects will have different magnitudes of environmental outcomes depending on which sector the leader is from.

2.4 Number of Goals

Goal setting is crucial to finding meaning in collaboration and moving it forward. Among other key dimensions of public sector goals, such as goal ambiguity (e.g., Chun and Rainey

2005), goal conflict (e.g., Resh and Pitts 2013), and goal displacement (e.g., Bohte and Meier 2000), goal multiplicity stands out as particularly salient in matters of implementation (O'Toole 1989). This is because public managers, whether they are collaborating across various boundaries or working alone, "operate in complex political environments where numerous external actors attempt to exert influence over administrative decision making, and they face greater goal multiplicity than managers in the private sector" (Fernandez 2004, 206-207). Goal multiplicity in the actions of cross-boundary collaboration, or the existence of more than one goal guiding collaborative outputs, is a "ubiquitous part of the interorganizational setting" and even observed in cases where the goals are readily understood, easily measured, widely accepted, and hardly in conflict with each other (O'Toole Jr 1993, 241). The prevalence of goal multiplicity in collaborative projects raises an important but understudied question for scholars and practitioners - if we pursue more goals, do we achieve better outcomes?

Previous studies offer mixed answers. On the one hand, more goals could mean more complex and cumbersome implementation, especially when multiple decision points demand "clearances" by multiple actors involved in the process and 'too many cooks spoil the broth' (Pressman and Wildavsky 1984). Even when all the goals align well with each other, the participants may lean towards prioritizing goals that are relatively noticeable, tractable, or quantifiable, while overlooking others that might be pivotal to improving environmental outcomes (Boyne 2003). On the other hand, an increase in the number of goals in collaborative projects has the potential to generate more and strong benefits because of the comprehensive and holistic approach to problem-solving (Siddiki et al. 2015). For example, inclusion and integration of multiple goals across diverse policy areas and actors can create synergistic effects on environmental sustainability by addressing a broad range of interrelated factors such as "ecological integrity, economic viability, and social and cultural harmony" (Rogers and Weber 2010, 559).

Given these conflicting perspectives, we propose that the effect of goal multiplicity is contingent upon other characteristics of collaborative projects. First, we postulate that the collaboration form will moderate the impact of goal multiplicity on environmental outcomes. Specifically, CGRs may cope better with goal multiplicity in collaborative projects than ad hoc collaborations because of their more extensive collaborative experiences. Although collaborative projects convened by ad hoc collaborations can be effective at addressing a small number of narrowly targeted objectives, they may incur higher marginal costs when handling additional goals than CGRs (Mehdi and Nabatchi 2023). Second, we expect that who leads the collaborative project may moderate the relationship between the goal multiplicity and outcomes. Collaborative projects led by organizational representatives who work at a larger scale than others may better manage a greater number of goals at the same time. For instance, compared to leaders from local-specific and community-based organizations, leaders from statewide government agencies can leverage a wider range of perspectives, expertise, technology, and resources in dealing with multiple goals, perhaps without having to compromise the performance of collaboration. Thus, we offer the final set of hypotheses.

H4: As the number of goals increases, projects convened by CGRs will improve environmental outcomes more than projects convened by ad hoc collaborations.

H5: As the number of goals increases, projects will have different magnitudes of environmental outcomes depending on which sector the leader is from.

3 Empirical Strategies

3.1 Context

We test our hypotheses within the context of watershed management in Oregon. Located on the Pacific Coast in the northwestern part of the United States, Oregon sustains a thriving high-tech and fishing industry. However, by the 1990s, watersheds in Oregon had been severely degraded and polluted due to decades of overfishing and industrial pollution. In 1997, the state legislature enacted the *Oregon Plan for Salmon and Watersheds* (OPSW), which among other things, provided two formal mechanisms promoting cross-boundary collaborations in watershed management.

First, the OPSW enabled the creation of watershed councils, coordinating cross-sectoral actors in collaborative efforts to "protect and enhance the quality of the watershed" (Oregon Statute § 541.910) through long-term planning and action. Watershed councils "engage people in their communities to participate in collaborative, voluntary restoration of watersheds" (OWEB n.d.a). Watershed councils are CGRs, rather than ad hoc collaborations, because "cross-boundary collaboration represents the prevailing pattern of behavior and activity" (Emerson and Nabatchi 2015b, 18) which is sustained over the long term and is focused on developing, executing, and evaluating multiple projects identified through assessment or planning process and aimed at systematically addressing issues at the watershed or ecosystem level.[1] This empirical setting allows us to examine whether legislation authorizing externally directed CGRs for watershed management has any effect on overall environmental outcomes.

Second, the OPSW authorized the Oregon Watershed Enhancement Board (OWEB), a state agency, to provide grants for collaborative restoration and recovery projects in Oregon watersheds. Some of these projects are undertaken by CGRs (i.e., watershed council), while others are undertaken by ad hoc collaborations led by actors from governments, private firms, citizen groups, and nonprofits. In both cases, the projects represent collaborative actions intended to "address the factors that affect fish populations and watershed health," most of which "focus on water quality, stream flows, and habitat restoration" (OWEB n.d.b). Therefore, although these collaborative projects may have multiple project goals, they all share a common objective: the improvement of water quality in Oregon watersheds.

3.2 Data

We use data from multiple sources. Specifically, we use: (1) the Oregon Water Quality Index (OWQI), provided by the Oregon Department of Environmental Quality (ODEQ), to

---

[1] For more information on watershed councils in Oregon, please visit: https://www.oregonwatersheds.org/who-we-are/oregon-watershed-councils/

measure environmental outcomes, (2) the Oregon Watershed Restoration Inventory (OWRI) for data on restoration and recovery projects (i.e., collaborative actions), and (3) geospatial information about watersheds from the US Geological Survey's Hydrologic Unit Code (HUC) to delineate watershed boundaries in Oregon.

Oregon Water Quality Index: The OWQI consolidates eight indicators (water temperature, pH, dissolved oxygen, biological oxygen demand, total solids, nitrogen, phosphorus, and bacteria) into a single index using the following formula, in which SI_i refers to the i-th subindex (e.g., nitrogen) and n denotes the number of subindices:

$$\mathrm{OWQI} = \sqrt{\frac{n}{\sum_{i=1}^{n} \frac{1}{{SI_i}^2}}}$$

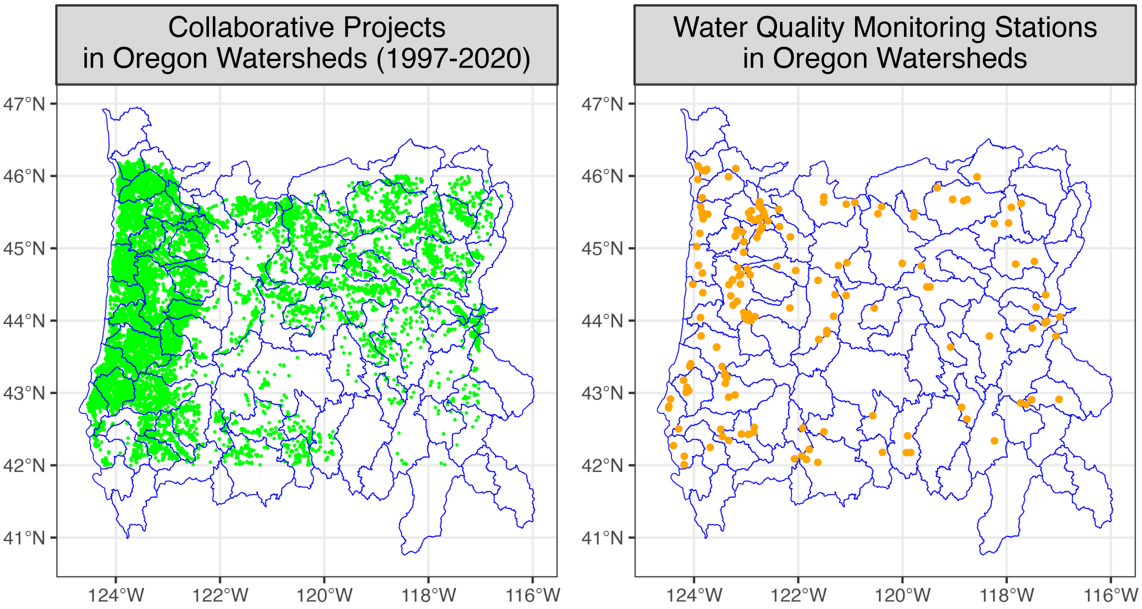
The OWQI scale ranges from 10, indicating the worst water quality, to 100, representing the ideal. The ODEQ categorizes these scores into five groups signifying a different level of water quality: 10-59 (very poor), 60-79 (poor), 80-84 (fair), 85-89 (good), and 90-100 (excellent). Overall, water quality data collection is irregular. The ODEQ retrieves the OWQI from 160 water quality monitoring stations scattered across the state. Data is sampled intermittently on a monthly basis at each station, with records available from 1980 to 2021. Some water quality monitoring stations collect samples three to four months per year, while most stations collect data once every other month. Moreover, the specific dates of sample collection within a given month are not fixed, but rather are distributed throughout the year. In total, our data contains 29,797 monthly water quality observations over 42 years. To address the irregular nature of the data, we employ a RDiT design to assess the impact of the legislation (i.e., the *Oregon Plan for Salmon and Watersheds*). We also aggregate the data into a watershed-year panel to evaluate the performance of collaborative actions. We elaborate on both strategies in the methods section.

Oregon Watershed Restoration Inventory: The OWRI is a comprehensive dataset that encompasses information on all 19,396 watershed projects funded by OWEB. It identifies over 150 different kinds of projects, all of which focus on watershed restoration and recovery in Oregon. The OWRI includes details such as project start and end dates, activities, geographic coordinates, costs associated with project activities, project goals, and land use. It also documents all project participants and leaders, provides their sectoral information, and indicates whether the project was undertaken by a CGR.

OWEB mandates that all funded projects report their information to the OWRI. OWEB staff review these projects to ensure the accuracy of the information provided (OWEB n.d.b). Projects not funded by OWEB are also encouraged, but not required, to contribute their details to the database. For this research, we only focus on OWEB funded projects as they result directly from the enactment of OPSW. Our final sample includes 8,853 projects completed between 1997 and 2020.

Hydrologic Unit Code: We leverage geospatial information at the HUC8 level to identify watershed boundaries in Oregon (Scott 2016). Each watershed at the HUC8 level carries a unique identifier in the form of an eight-digit code. Although Oregon has 92 watersheds in total, only 68 contain at least one water monitoring station. Therefore, our study includes collaborative projects and water quality that are within these observed watersheds. Figure 1 illustrates the locations of collaborative projects (green dots) and water quality monitoring stations (orange dots) within watershed boundaries (blue lines). In the methods section, we elaborate on the process for formulating our independent variables based on the project information.

Figure 1: Locations of Collaborative Projects and Water Quality Monitoring Stations in Oregon



3.3 Methods

We use two methods to examine our hypotheses. First, we use a regression discontinuity in time (RDiT) design to estimate the overall impacts of the OPSW legislation on water quality (H1). We then further estimate the effects of OWEB-funded collaborative project characteristics on water quality, using watershed-year panel data with longitudinal models (H2-5).

3.3.1 Regression Discontinuity in Time Design

RDiT is used widely in environmental studies to estimate policy effects on environmental outcomes (e.g., Dang and Trinh 2021; Greenstone et al. 2022; Lang and Siler 2013). It assumes that any significant change in the outcome variable, occurring around a specific cutoff date when an intervention is introduced, can be attributed to this intervention (Hausman and Rapson 2018). It proves particularly useful for inferring causal impacts in scenarios where random assignment or a natural control group is unavailable, especially when policies are implemented across the entire observed region. Given the universal impact of OPSW on all Oregon watersheds, identifying a suitable control group within the state is challenging. Furthermore, neighboring states like Washington and California have distinct water quality index indicators of their own, making direct comparisons with Oregon's water quality problematic.[2] Hence, RDiT is a suitable method for our study.

Moreover, the monthly, rather than yearly, observations of water quality at monitoring stations align with the data structure requirements of RDiT. This method demands a larger sample size, compared to other causal inference methods, because it designates a "small window" around the cutoff, ensuring the treated and control units have comparable observed and unobserved characteristics (Cattaneo and Titiunik 2022). As previously mentioned, we have 29,797 monthly water quality observations distributed across observed years. Therefore, our sample has sufficient statistical power to select comparable observations "slightly before" and "slightly after" the OPSW implementation cutoff, which serve as our control and treatment groups.

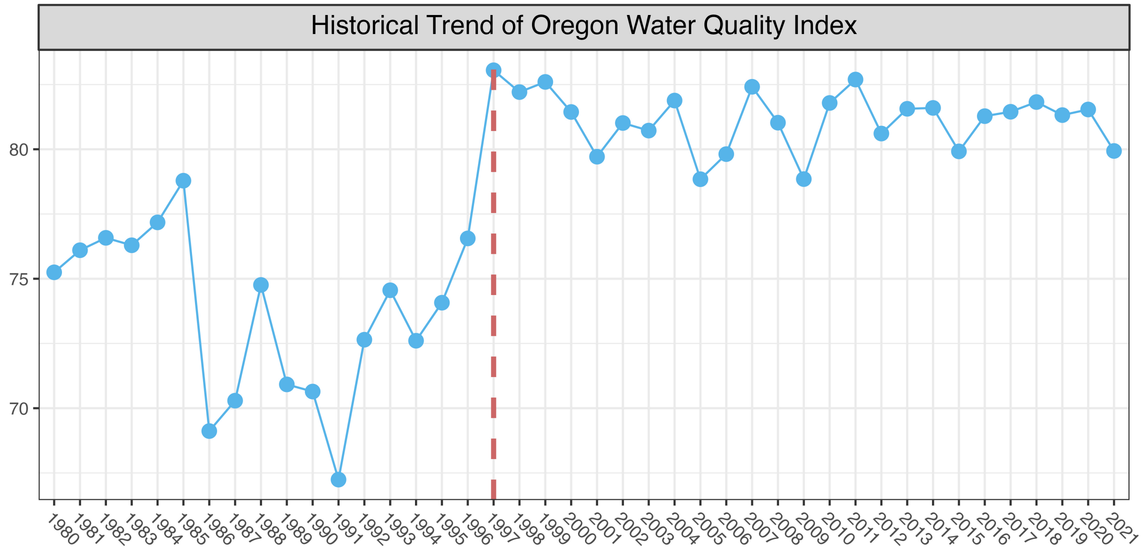
We chose January 1, 1997 as our cutoff date. This is when OPSW went into effect and OWEB began funding collaborative projects.[3] Figure 2 depicts the historical trend of the OWQI, with a noticeable jump from 75.56 to 83.05 (highlighted by a vertical red line), descriptively suggesting the validity of our chosen cutoff date. Based on the collection time of each observation from the monitoring stations, we calculate the time distance of each sample from the cutoff date. Then, we compute a "relative time" variable to decide how many observations should be included within the window.

---

[2] For more information, please see water quality index summaries in the Department of Ecology, State of Washington and California State Water Resources Control Board.

[3] We searched for federal and multi-state water quality regulations around 1997 that involve the Oregon state but found none beyond the 1977 Clean Water Act, reducing concerns about other policy confounding factors in relation to the OPSW effect. For more information, please visit: https://www.epa.gov/laws-regulations/history-clean-water-act.

Figure 2: Mean Oregon Water Quality Index from 1980 to 2021



To create a valid RDiT estimate, it is crucial to select the appropriate time window, or bandwidth (Villamizar-Villegas et al. 2022), for observations (Hausman and Rapson 2018). We select our optimal bandwidth through a data-driven process, leveraging a widely accepted method aimed at minimizing the asymptotic mean squared error (Calonico et al. 2014; Imbens and Kalyanaraman 2012).

Next, we introduce our formal estimate using the following regression equation:

$$Y_{i,w,t} = \beta D(t \geq \text{OPSW}_{i,w,t}) + \delta T(t - \text{OPSW}_{i,w,t}) + \gamma D \times T + \phi X_{i,w,t} + \mu_{i,w,t}$$

$Y_{i,w,t}$ represents the water quality index reported by station i of watershed w at time t. $D(t \geq \text{OPSW}_{i,w,t})$, where D represents discontinuity, is an indicator variable that equals one if station i at time t is under the OPSW treatment. Therefore, β captures the RDiT estimate. $T(t - \text{OPSW}_{i,w,t})$ denotes the number of days from OPSW and serves as the running variable. The interaction of $D \times T$ allows the effect of T to differ before and after OPSW implementation. $X_{i,w,t}$ is a vector of covariates, including a binary variable for land use (1 for forest, 0 otherwise), and the lagged dependent variable to control for the temporal autocorrelation (Hausman and Rapson 2018). $\mu_{i,w,t}$ is the error term. In addition, we cluster standard errors by watersheds to handle serial dependence in residuals (Cattaneo and Titiunik 2022).

3.3.2 *Longitudinal Analysis*

We conduct a longitudinal analysis to assess the correlations between collaborative projects and water quality, aggregating both OWQI and OWRI data at the watershed-year level for several reasons. First, the OWQI data is irregular, and retaining the monthly data structure in a longitudinal analysis would result in serious missing data issues. Therefore, we calculate annual water quality, our dependent variable, by averaging all available monthly OWQI within a given watershed for each year. Second, the geographic locations for water monitoring stations and collaborative projects are mismatched (see Figure 1). It is not feasible to directly connect a specific project's effort to a water quality measure at a particular monitoring station. Finally, watersheds span multiple local jurisdictions. Thus, establishing a connection between collaborative projects and watershed-level outcomes provides a more accurate measure of the effectiveness of cross-boundary collaboration. Next, we explain the variable measurements and model specification.

Collaborative Governance Regime reflects the form of the collaborative that undertakes each project within each watershed (i.e., whether a project is launched by a CGR or an ad hoc collaboration). This variable measures the total number of collaborative projects that CGRs (i.e., watershed councils) convene within a watershed area in a given year. Therefore, the coefficient of this variable indicates the degree to which one additional CGR-convened project affects water quality improvement in a given watershed-year.

Leader denotes the number of projects in a given watershed in a given year that are led by individual actors from different sectors. Specifically, our models incorporate three leader variables: citizen groups, local governments, and state government.[4] Citizen group

---

[4] While the OWRI also documents leaders from other sectors, such as private and non-profit organizations, these sectors have significantly fewer project leaders. Therefore, they lack the statistical power to be included

leaders come from conservation groups, extension services, individual researchers, sporting groups, and volunteers. Local government leaders include city and county governments, local agencies, and soil and water conservation districts. State government leaders are from state agencies. All projects led by a representative of citizen groups, local governments, or the state government fall under the umbrella of ad hoc collaboration. By comparing the coefficients of these three leader variables with the CGR variable, we can investigate whether projects launched by CGRs generate more environmental improvements than ad hoc collaborations.

Goals measures the average number of goals per project within a given watershed each year. Collaborative projects encompass a total of 50 different goal types, such as "increase net area of wetland," "decrease livestock access to stream," and "improve aquatic habitat." Each of these goals has a direct or indirect impact on water quality in watersheds.

Alongside the main explanatory variables, we include several control variables in our models. $Representation$ reflects the diversity of participants in collaborative projects, averaging the number of different organizational types represented by project participants. $Project - N$ denotes the total number of projects. We also include the square terms of both variables, considering that their impacts on water quality may be nonlinear (Mehdi and Nabatchi 2023). $In - kindshare$ indicates the ratio of nonmonetary in-kind contributions to the total cost of all collaborative projects (Mehdi and Nabatchi 2023; Scott 2016). We include this variable because OWEB encourages diverse funding and ensures that self-reported in-kind contributions are not unreasonable or exaggerated in grant applications (Mehdi and Nabatchi 2023). Lastly, we add three environmental variables: $Forestlanduse$, $Airtemperature$, and $Precipitation$. These respectively capture the percentage of area classified as forest, the average air temperature, and the total annual precipitation in the watershed area. The $Forestlanduse$ variable is obtained from the OWQI dataset. The $Airtemperature$ and $Precipitation$ variables are collected from the PRISM climate group

---

in our analysis. We report the total observations of collaborative projects led by each leader type in Table A.1 in Supplementary Appendix.

at Oregon State University.[5] We transform monthly raster image data into annual values within each HUC8 watershed unit. We report the summary statistics of all variables in Table A.2.

We specify the longitudinal analysis model based on the panel data structure. Given the combination of OWQI and OWRI data, the analysis spans the period from 1997 to 2021. All independent and control variables, except for the environmental control variables, were lagged by one year based on the project completion dates to avoid reverse causality issues in our models. Moreover, we diagnose cross-sectional and time unobservable effects by performing the Hausman tests (Wooldridge 2010). Results from these tests do not reject the null hypothesis at 0.10 level, suggesting that the two-way random effects models have a better fit with our data than the fixed effects models. Therefore, we control for the watershed and year-specific effects as unobserved random variables. Based on this assumption, we use two-way random effects models in our main analysis and report p-values from Hausman tests in Table 2 to justify these models. In addition, we perform Moran's I test for observations in each year, which suggest spatial autocorrelation in water quality (see Table A.3). Therefore, we use the geographical coordinates of watersheds to compute a distance weighting matrix and create a spatial lag dependent variable in our models.

4 Results

4.1 The Effect of Legislation on Environmental Outcomes

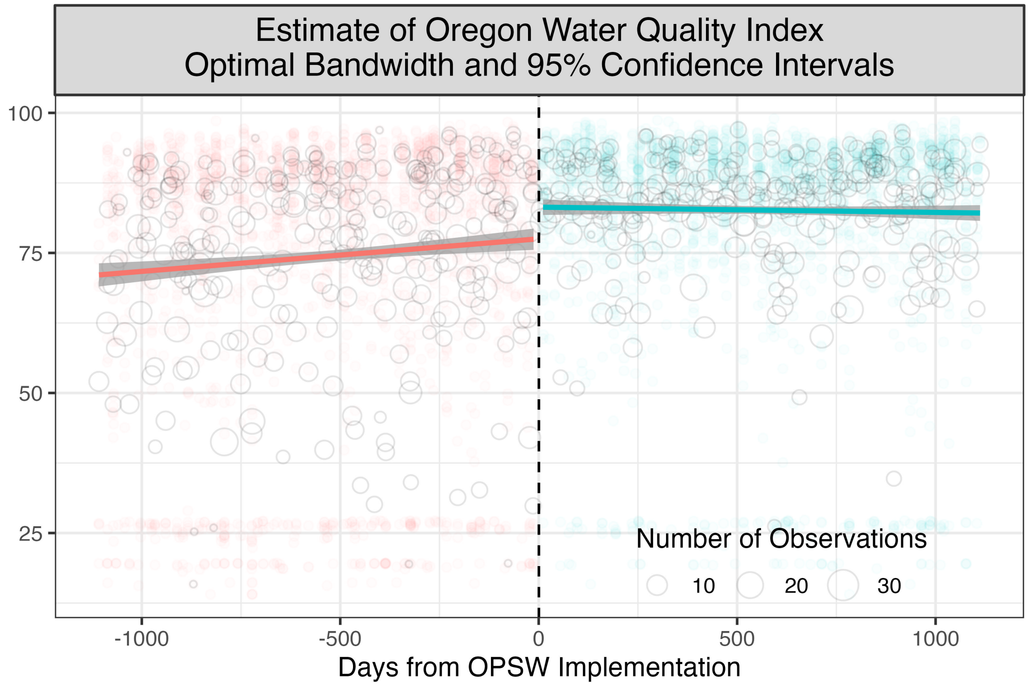
The RDiT estimate supports H1. The optimal bandwidth selection indicates a time window of 1,112 days before and after the implementation of OPSW (January 1, 1997) and observations within this window are suitable for inferring the causal effect. Figure 3 provides the visualization of this effect, with the x-axis representing the number of days since the implementation of OPSW, and the y-axis showing the OWQI reported from monitoring stations. The grey areas represent the 95% confidence intervals. In this figure, we can see a

---

[5] https://prism.oregonstate.edu/

noticeable improvement in water quality after the cutoff date.

Figure 3: RDiT Estimate of the Legislation Effect on Water Quality



We formally evaluate the OPSW effect using linear regressions, as shown in Table 1. Overall, the OPSW effect, D, is statistically significant in models (1)-(3). With optimal bandwidth, OPSW is estimated to yield a 3.91-point improvement in water quality. Compared to the baseline outcome mean, OPSW implementation enhances the water quality by 5%. Models (2) and (3) narrow down the bandwidth to one-year and half-year windows, respectively, for a more conservative estimation of the OPSW effect, thus minimizing potential time-varying confounders. RResults in both models with these shorter timeframes reveal even more substantial OPSW effects. Within two years (one-year bandwidth) and one year (half-year bandwidth), OPSW implementation improved water quality by 8.70 and 13.25 points (equivalent to 11% and 18% improvements), respectively. Next, we relax the causal assumption to analyze the long-term effect of OPSW by including the complete data from 1980 to 2021 in model (4) of Table 1. In the long run, the implementation of OPSW is estimated to improve the water quality by 2.75 points (equivalent to a 3% improvement).

We offer the visualization of RDiT estimates for models (2)-(4) in Figure A.1.

Table 1: RDiT Estimate of the Legislation Effect on Water Quality in Different Bandwidths

	Optimal bandwidth (1)	One-year bandwidth (2)	Half-year bandwidth (3)	Full Sample (4)
Baseline mean	74.435	76.557	75.230	73.705
D	3.909***	8.692***	13.249***	2.748***
	(0.913)	(1.712)	(2.807)	(0.396)
T	0.001	−0.018**	-0.016	-0.0002
	(0.001)	(0.007)	(0.020)	(0.0001)
D × T	−0.003*	0.007	-0.033	0.0001
	(0.001)	(0.008)	(0.024)	(0.0001)
Forest	4.613***	6.272***	4.175**	4.482***
	(0.507)	(0.839)	(1.264)	(0.180)
OWQI_{t-1}	0.634***	0.562***	0.582***	0.638***
	(0.017)	(0.031)	(0.045)	(0.007)
Constant	26.218***	28.305***	27.060***	25.180***
	(1.600)	(2.854)	(4.331)	(0.603)
N	4,456	1,538	740	29,637
R^2	0.478	0.416	0.428	0.468

Note: Standard errors are clustered at the watershed level and are reported in parentheses. Baseline means are mean values of OWQI in pre-OPSW periods.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

We incorporate two more steps to test the robustness of our evidence. First, we conduct a placebo test using an alternative cutoff date: January 1, 1998, a year after the actual cutoff (see Figure A.2). The result shows that no discontinuity appears at this placebo cutoff date, thereby confirming January 1, 1997, as the actual start date of the treatment intervention (Hausman and Rapson 2018). SSecond, we conduct a density test of observations near the cutoff (Cattaneo and Titiunik 2022). This test assesses whether, after the implementation of OPSW, water monitoring stations intentionally manipulated their sampling dates to bias the water quality estimates, for example by increasing collections in watersheds with good conditions and decreasing collections in watersheds with poor conditions. The results of this test, reported in Figure A.3, indicate no statistically significant difference in the number of observations before and after the implementation of OPSW. Therefore, density bias does not seem to be a concern in the results.

4.2 Explaining Outcome Improvement Through Collaborative Actions

We evaluate H2-5 using longitudinal models in Table 2. H2 suggests that projects convened by CGRs will enhance water quality more than those led by ad hoc collaborations. The estimated coefficient on CGR in Table 2 denotes a marginal effect of having one additional CGR-convened project in a given watershed-year, and the coefficients on other independent variables (Citizen group, Local gov, State gov, and Goals) are interpreted in the same way. The statistical significance of the CGR coefficient in model (5) indicates that increasing the CGR-convened projects would improve water quality in a watershed. However, the magnitude of the coefficient on CGR is not always larger than the coefficients on leader variables in ad hoc collaboration. For instance, one additional ad hoc collaboration project led by a local government representative is estimated to have a greater positive impact on water quality improvement compared to one additional CGR project. This finding thus partially supports H2.

H3 assumes that projects will have different magnitudes of environmental outcomes depending on which sector the leader is from. The results in model (5) support this hypothesis, demonstrating heterogeneous coefficient signs across the three types of leaders. Specifically, an additional project led by local government is estimated to have a statistically significant positive effect on water quality, while an additional project led by a citizen group is estimated to have a statistically significantly negative impact. The coefficient on the number of projects led by state government, however, indicates a null effect on water quality.

H4 and H5 posit that projects will have varying capacities to manage goal multiplicity, depending on their collaboration form and leaders. Our results yield mixed findings. We incorporate four interaction variables in models (6)-(9). Model (6) demonstrates that CGR projects do not make statistically significant changes in water quality as the number of goals increases. Model (7) indicates that citizen group projects perform worse as the number of

Table 2: Longitudinal Analysis of Collaborative Actions on Water Quality

	(5)	(6)	(7)	(8)	(9)
CGR	0.084^{**}	0.081^{**}	0.110^{***}	0.091^{***}	0.074^{**}
	(0.027)	(0.031)	(0.027)	(0.027)	(0.027)
Leader variables:					
Citizen group	-0.075^{*}	-0.073^{*}	0.306^{***}	-0.070^{*}	-0.082^{*}
	(0.035)	(0.035)	(0.048)	(0.035)	(0.035)
Local gov	0.130^{***}	0.131^{***}	0.147^{***}	0.212^{***}	0.126^{***}
	(0.027)	(0.027)	(0.027)	(0.033)	(0.027)
State gov	-0.032	-0.029	-0.013	-0.029	-0.174^{***}
	(0.030)	(0.030)	(0.030)	(0.030)	(0.041)
Goals	0.006	0.006	0.042^{***}	0.028^{*}	-0.014
	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
CGR × goals		0.001			
		(0.003)			
Citizen group × goals			-0.096^{***}		
			(0.009)		
Local gov × goals				-0.022^{***}	
				(0.005)	
State gov × goals					0.038^{***}
					(0.008)
Representation	0.041	0.042	0.011	0.012	0.081
	(0.053)	(0.054)	(0.053)	(0.054)	(0.054)
Representation^2	-0.034^{***}	-0.035^{***}	-0.033^{***}	-0.031^{***}	-0.037^{***}
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
N-Project	-0.157^{***}	-0.157^{***}	-0.168^{***}	-0.160^{***}	-0.159^{***}
	(0.027)	(0.027)	(0.027)	(0.027)	(0.027)
N-Project^2	0.002^{***}	0.002^{***}	0.002^{***}	0.002^{***}	0.002^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
In-kind share	0.385^{*}	0.377^{*}	0.220	0.327	0.314
	(0.183)	(0.183)	(0.183)	(0.184)	(0.185)
Forest land use	8.674^{***}	8.640^{***}	7.903^{***}	8.782^{***}	8.628^{***}
	(0.566)	(0.568)	(0.572)	(0.568)	(0.569)
Air temperature	-0.324^{***}	-0.325^{***}	-0.331^{***}	-0.315^{***}	-0.312^{***}
	(0.058)	(0.057)	(0.053)	(0.059)	(0.060)
Precipitation	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}	0.001^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Spatial lag	0.025^{***}	0.025^{***}	0.026^{***}	0.025^{***}	0.025^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	68.690^{***}	68.626^{***}	68.434^{***}	68.608^{***}	68.613^{***}
	(0.674)	(0.671)	(0.643)	(0.686)	(0.688)
Two-way random effects	Yes	Yes	Yes	Yes	Yes
Hausman test (p-value)	0.981	0.987	0.963	0.992	0.989
R^2	0.237	0.236	0.231	0.237	0.236
N Watershed (HUC8)	68	68	68	68	68
Observation	1410	1410	1410	1410	1410

Note: Standard errors are reported in parentheses. $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

goals increases, and model (8) suggests that the positive impact on water quality diminishes for local government projects as the number of goals increase. Finally, model (9) suggests that state government projects improve water quality when the number of goals increases.

5 Discussion and Conclusion

In this section, we discuss the implications of our findings and conclude with the limitations and contributions of this study.

5.1 The Importance of Legislation Support: Effectiveness and Sustainability

Our findings reveal that the implementation of the *Oregon Plan for Salmon and Watersheds*, state-level legislation that launched externally directed collaboration in Oregon watersheds, has improved water quality. In part, this legislation authorizes and encourages cross-boundary and cross-sectoral collaboration by funding restoration and recovery projects. Such projects, which represent collaborative actions, also have mitigated water quality problems in the state. While it is reasonable to expect that state legislation authorizing collaborative actions of cross-boundary collaborations would encourage joint efforts to enhance environmental conditions, little research has examined actual effects. Our analyses of Oregon watersheds provide valuable empirical findings that connect authorizing legislation, collaborative actions, and their resulting environmental impacts.

An ongoing challenge in the field of collaborative governance is the identification of causal impacts on policy outcomes (Liu and Tan 2022; Lubell 2004; Scott 2015). Ideally, to best evaluate the impact of OPSW legislation, one would randomly assign collaborative projects to half of Oregon's watersheds, leaving the remaining half as a control group. However, such a scenario is unrealistic in real-world policy settings, as decisions to execute such projects are influenced by numerous confounding factors, including local water conditions (Erickson 2015), community willingness to collaborate (Rosenberg and Margerum 2008), and local industries (Nielsen-Pincus and Moseley 2013). By leveraging the RDiT technique, we select observations that are comparable within an optimal time window before and after the implementation of OPSW. This time-based causal inference strategy not only provides new insights into collaborative outcomes, but also underscores the importance of legislative support for cross-boundary collaboration in environmental management.

Interestingly, when we narrow the time window to either one or two years, the impact of the legislation becomes even stronger. This finding contradicts the conventional wisdom that the outcomes of environmental governance often necessitate a substantial amount of time to manifest (Koontz et al. 2010), especially when the governance strategy is collaborative. Among other challenges, collaboration requires more of policy actors in terms of communication, conflict management, and consensus building on resource allocation and task management (McLaughlin et al. 2022; Newig et al. 2018; Provan and Kenis 2008). The results from our study suggest that a legal mandate establishing and funding collaborative projects could address environmental issues more rapidly than anticipated.

Moreover, the findings suggest that the legislation effect lasts over time. The descriptive time series pattern of OWQI in Figure 2 shows that the overall water quality has remained at a higher level than in the years after OPSW implementation as compared to the years before. More specifically, water quality in Oregon has scored above the "fair" category ($OWQI \geq 80$) in most years after 1997, suggesting that the positive impacts of legislation on collaborative outcomes are cumulative and sustainable. The full sample RDiT in model (4) of Table 1 formally confirms that the OPSW legislation has had a positive overall effect on water quality throughout its 25-year implementation period. This evidence points to the sustainability of the legislative effect.

5.2 Heterogenous Collaborative Actions and Environmental Impacts

Beyond the overall impact of the OPSW, our analysis also investigates the characteristics of collaborative projects fostered as a result of this legislation. First, projects executed by CGRs are estimated to generate more positive effects on water quality and lead to better environmental outcomes than those executed by ad hoc collaborations led by a state government or a citizen group representative. This outcome is consistent with the theoretical expectation that CGRs tend to have advantages in situations where collaborative actions demand high levels of coordination, such as the management of cross-boundary natural resources. These advantages may come from formalized structures, repeated interactions between participants, and close oversight of network activities (Bryson et al. 2006; Emerson and Nabatchi 2015b; Margerum 2011). While CGRs typically mitigate interconnected issues within the whole socio-ecological system, ad hoc collaborations offer narrower, short-term solutions to case-based issues.

Nevertheless, our longitudinal models suggest that ad hoc collaborations can increase water quality even more than CGRs when led by a local government representative. Thus, both CGRs and ad hoc collaborations with leaders from local government can generate positive impacts on environmental outcomes and be complementary management strategies. In other words, we suggest integrating both forms of collaboration to manage natural resources in a sustainable manner and acknowledging the importance of leaders in cross-boundary collaborations, rather than presuming CGRs are a one-size-fits-all solution for environmental management (Scott and Thomas 2017).

One possible explanation for the finding on the heterogeneous leader effects is the ability of local government actors to leverage local-specific knowledge and experience for a given watershed (Koontz and Newig 2014). Although the state government may have a stronger coordination capacity, it might not have direct access to knowledge essential for resolving place-based issues (Doberstein 2016; Vangen and Huxham 2012). Conversely, while citizen groups possess substantial local knowledge, they may be less likely to complete projects (Moore et al. 2003) or lack the necessary coordination power to foster cross-sectoral collaborations (Fung 2006). Positioned in the middle ground, local governments may be able to obtain information from both citizens and the state government, enabling them to effectively lead collaborative projects.

In addition, our findings suggest that leaders of different types exhibit varying capabilities in managing goal multiplicity. Our findings suggest that the performance of CGRs in managing water quality is not affected by a greater number of goals. While goal multiplicity is estimated to negatively influence the performance of local governments and citizen groups, it is positively associated with the performance of state government. These results imply that strong coordination abilities are needed to juggle multiple goals simultaneously during the project implementation process, and the state government has the management capacity and political authority to handle a large number of goals. Therefore, we suggest local policy actors – including CGRs, citizen groups, and the local government – avoid overloading a single project with too many goals, as this may backfire.

6 Conclusion

This study systematically examines the relationship between collaborative governance and environmental outcomes, discussing its impacts both in the short term – before and after the enactment of legislation mandating environmental collaboration – and over the long run during 25 years of collaborative efforts. It further assesses how various characteristics of collaborative projects – collaboration form, leader, and goal multiplicity – affect outcomes. Despite the substantial influence that collaboration leaders can have on policy outcomes, very few empirical studies systematically assess their impacts and the existing literature largely has focused on the relationship between participant diversity and collaborative actions (e.g., Mehdi and Nabatchi 2023; Siddiki et al. 2017). Our study extends this body of literature by examining the effect of leaders on collaborative outcomes. Together, analyses of this article offer new insights into the use of collaborative governance to manage a complex cross-boundary watershed ecosystem that contains numerous interdependent natural resources.

We conclude with two suggestions for future research. First, while this article focuses on collaborative governance in Oregon watersheds, future studies should examine the generalizability of these findings in different locations or on a larger scale than a single state. Second, it is worth exploring whether the relationships between legislation, collaborative actions, and outcomes differ in policy domains beyond environmental management. Challenging as it may be, integrating and comparing findings from different contexts remains an important task for scholars. Only through the robust and rigorous examination of collaborative governance and its impacts will we be able to determine whether collaborative governance is really a watershed in the policy processes.

References

Agnone, Jon. 2007. Amplifying public opinion: The policy impact of the us environmental movement. *Social Forces* **85** (4):1593–1620.

Agranoff, Robert and Michael McGuire 2003. *Collaborative public management: New strategies for local governments*. Georgetown University Press.

Agrawal, Arun. 2003. Sustainable governance of common-pool resources: context, methods, and politics. *Annual Review of Anthropology* **32** (1):243–262.

Amsler, Lisa B. 2016. Collaborative governance: Integrating management, politics, and law. *Public Administration Review* **76** (5):700–711.

Amsler, Lisa B and Thibault Vieilledent. 2021. Collaborative governance in local government: How state law shapes community problem-solving through intrastate preemption. *Perspectives on Public Management and Governance* **4** (2):159–169.

Ansell, Chris and Alison Gash. 2008. Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory* **18** (4):543–571.

——. 2018. Collaborative platforms as a governance strategy. *Journal of Public Administration Research and Theory* **28** (1):16–32.

Avoyan, Emma, Jan van Tatenhove, and Hilde Toonen. 2017. The performance of the black sea commission as a collaborative governance regime. *Marine Policy* **81**:285–292.

Batory, Agnes and Sara Svensson. 2020. Regulating collaboration: The legal framework of collaborative governance in ten european countries. *International Journal of Public Administration* **43** (9):780–789.

Bianchi, Carmine, Greta Nasi, and William C Rivenbark. 2021. Implementing collaborative governance: models, experiences, and challenges. *Public Management Review* **23** (11): 1581–1589.

Bingham, Lisa B. 2009. Collaborative governance: Emerging practices and the incomplete legal framework for public and stakeholder voice. *Journal of Dispute Resolution* **2**:269–325.

——. 2010. The next generation of administrative law: Building the legal infrastructure for collaborative governance. *Wisconsin Law Review* **2**:297–356.

Bitterman, P and CJ Koliba. 2020. Modeling alternative collaborative governance network designs: An agent-based model of water governance in the lake champlain basin, vermont. *Journal of Public Administration Research and Theory* **30** (4):636–655.

Bohte, John and Kenneth J Meier. 2000. Goal displacement: Assessing the motivation for organizational cheating. *Public Administration Review* **60** (2):173–182.

Boyne, George A. 2003. What is public service improvement? *Public Administration* **81** (2): 211–227.

Bryson, JM, F Ackermann, and C Eden. 2016. Discovering collaborative advantage: The contributions of goal categories and visual strategy mapping. *Public Administration Review* **76** (6):912–925.

Bryson, John M, Barbara C Crosby, and Melissa Middleton Stone. 2006. The design and implementation of cross-sector collaborations: Propositions from the literature. *Public Administration Review* **66**:44–55.

——. 2015. Designing and implementing cross-sector collaborations: Needed and challenging. *Public Administration Review* **75** (5):647–663.

Calonico, S., M.D. Cattaneo, and R. Titiunik. 2014. Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica* **82** (6):2295–2326.

Cattaneo, M.D. and R. Titiunik. 2022. Regression discontinuity designs. *Annual Review of Economics* **14**:821–851.

Chun, Young Han and Hal G. Rainey. 2005. Goal ambiguity and organizational performance in us federal agencies. *Journal of Public Administration Research and Theory* **15** (4): 529–557.

Cochran, B., K.R. Fields, B.E. Barthuly, T. Nabatchi, R. McLain, and Q. Mehdi. The atlas of collaboration: Oregon volume, version 1.0 2019. URL `https://static1.squarespace.com/static/5d8153ba2bde7b44932649c5/t/5ded935ec8c6fd1d1c83ab2f/1575850858971/OAC+summary+only+120519.pdf`.

Cox, Michael, Gwen Arnold, and Sergio Villamayor Tomás. 2010. A review of design principles for community-based natural resource management. *Ecology and Society* **15** (4): 38–56.

Crosby, Barbara C. and John M. Bryson. 2010. Integrative leadership and the creation and maintenance of cross-sector collaborations. *The Leadership Quarterly* **21** (2):211–230.

Dang, H.A.H. and T.A. Trinh. 2021. Does the covid-19 lockdown improve global air quality? new cross-national evidence on its unintended consequences. *Journal of Environmental Economics and Management* **105**:102401.

DeCaro, Daniel A., Brian C. Chaffin, Edella Schlager, Ahjond S. Garmestani, and J.B. Ruhl. 2017. Legal and institutional foundations of adaptive environmental governance. *Ecology and Society* **22** (1):1–32.

Doberstein, Carey. 2016. Designing collaborative governance decision-making in search of a 'collaborative advantage'. *Public Management Review* **18** (6):819–841.

Douglas, Scott, Chris Ansell, Charles F Parker, Eva Sørensen, Paul 'T Hart, and Jacob Torfing. 2020. Understanding collaboration: Introducing the collaborative governance case databank. *Policy and Society* **39** (4):495–509.

Edelenbos, Jurian and Erik-Hans Klijn. 2006. Managing stakeholder involvement in decision making: A comparative analysis of six interactive processes in the netherlands. *Journal of Public Administration Research and Theory* **16** (3):417–446.

Emerson, Kirk and Tina Nabatchi 2015a. *Collaborative governance regimes*. Georgetown University Press.

——. 2015b. Evaluating the productivity of collaborative governance regimes: A performance matrix. *Public Performance & Management Review* **38** (4):717–747.

Emerson, Kirk, Tina Nabatchi, and Stephen Balogh. 2012. An integrative framework for collaborative governance. *Journal of Public Administration Research and Theory* **22** (1): 1–29.

Erickson, Adam M. 2015. Nested localized institutions for adaptive co-management: A history of state watershed management in the pacific region of the united states. *Society & Natural Resources* **28** (1):93–108.

Fernandez, Sergio. 2004. Developing and testing an integrative framework of public sector leadership: Evidence from the public education arena. *Journal of Public Administration Research and Theory* **15** (2):197–217.

Frumkin, Peter and Joseph Galaskiewicz. 2004. Institutional isomorphism and public sector organizations. *Journal of Public Administration Research and Theory* **14** (3):283–307.

Fung, A.. 2006. Varieties of participation in complex governance. *Public Administration Review* **66**:66–75.

Greenstone, M., G. He, R. Jia, and T. Liu. 2022. Can technology solve the principal-agent problem? evidence from china's war on air pollution. *American Economic Review: Insights* **4** (1):54–70.

Guarneros-Meza, Valeria, James Downe, and Steve Martin. 2018. Defining, achieving, and evaluating collaborative outcomes: A theory of change approach. *Public Management Review* **20** (10):1562–1580.

Hausman, C. and D.S. Rapson. 2018. Regression discontinuity in time: Considerations for empirical applications. *Annual Review of Resource Economics* **10**:533–552.

Imbens, G. and K. Kalyanaraman. 2012. Optimal bandwidth choice for the regression discontinuity estimator. *The Review of Economic Studies* **79** (3):933–959.

Kim, Jiho, Brian Ohl, Nara Yoon, and Tina Nabatchi. Blueprint for collaborative governance: An exploration of state legal mandates. Working Paper n.d.

Koontz, T.M., T.A. Steelman, J. Carmin, K.S. Korfmacher, C. Moseley, and C.W. Thomas 2010. *Collaborative environmental management: What roles for Government-1.* Routledge.

Koontz, Tomas M. and Craig W. Thomas. 2006. What do we know and need to know about the environmental outcomes of collaborative management? *Public Administration Review* **66**:111–121.

Koontz, Tomas M, Nicolas W Jager, and Jens Newig. 2020. Assessing collaborative conservation: A case survey of output, outcome, and impact measures used in the empirical literature. *Society & Natural Resources* **33** (4):442–461.

Lang, C. and M. Siler. 2013. Engineering estimates versus impact evaluation of energy efficiency projects: Regression discontinuity evidence from a case study. *Energy Policy* **61**:360–370.

Leach, William D, Neil W Pelkey, and Paul A Sabatier. 2002. Stakeholder partnerships as collaborative policymaking: Evaluation criteria applied to watershed management in california and washington. *Journal of Policy Analysis and Management* **21** (4):645–670.

Lee, H.. 2023. Collaborative governance platforms and outcomes: An analysis of clean cities coalitions. *Governance* **36** (3):805–825.

Liu, Yixin and Chao Tan. 2022. The effectiveness of network administrative organizations in governing interjurisdictional natural resources. *Public Administration.* doi: 10.1111/padm.12834.

Lubell, Mark. 2004. Collaborative environmental institutions: All talk and no action? *Journal of Policy Analysis and Management* **23** (3):549–573.

Margerum, Richard D. 2011. *Beyond consensus: Improving collaborative planning and management.* Mit Press.

McLaughlin, D.M., J.M. Mewhirter, and M. Lubell. 2022. Conflict contagion: how interdependence shapes patterns of conflict and cooperation in polycentric systems. *Journal of Public Administration Research and Theory* **32** (3):543–560.

Mehdi, Qasim and Tina Nabatchi. 2023. Saving the salmon: Examining the cost-effectiveness of collaboration in oregon. *Journal of Public Administration Research and Theory* **33** (3): 498–511.

Moore, Elizabeth A, Tomas M Koontz, et al.. 2003. A typology of collaborative watershed groups: Citizen-based, agency-based, and mixed partnerships. *Society and Natural Resources* **16** (5):451–460.

Newig, J., E. Challies, N.W. Jager, E. Kochskaemper, and A. Adzersen. 2018. The environmental performance of participatory and collaborative governance: a framework of causal mechanisms. *Policy Studies Journal* **46** (2):269–297.

Newig, Jens and Tomas M Koontz. 2014. Multi-level governance, policy implementation and participation: the eu's mandated participatory planning approach to implementing environmental policy. *Journal of European public policy* **21** (2):248–267.

Nielsen-Pincus, Max and Cassandra Moseley. 2013. The economic and employment impacts of forest and watershed restoration. *Restoration Ecology* **21** (2):207–214.

Ostrom, Elinor 1990. *Governing the commons: The evolution of institutions for collective action.* Cambridge University Press.

O'Toole, Laurence J.. 1989. Goal multiplicity in the implementation setting: Subtle impacts and the case of wastewater treatment privatization. *Policy Studies Journal* **18** (1):1–20.

O'Toole Jr, Laurence J.. 1993. Interorganizational policy studies: Lessons drawn from implementation research. *Journal of Public Administration Research and Theory* **3** (2):232–251.

OWEB. About us n.d.a. URL `https://www.oregon.gov/oweb/about-us/Pages/about-us.aspx`. Accessed: 2023-04-03.

OWEB. Grant programs n.d.b. URL `https://www.oregon.gov/oweb/grants/Pages/grant-programs.aspx`. Accessed: 2023-04-03.

Page, Stephen. 2010. Integrative leadership for collaborative governance: Civic engagement in seattle. *The Leadership Quarterly* **21** (2):246–263.

Pressman, Jeffrey L. and Aaron Wildavsky 1984. *Implementation: How great expectations in Washington are dashed in Oakland; Or, why it's amazing that federal programs work at all, this being a saga of the Economic Development Administration as told by two sympathetic observers who seek to build morals on a foundation.* volume 708 University of California Press.

Provan, Keith G and Patrick Kenis. 2008. Modes of network governance: Structure, management, and effectiveness. *Journal of Public Administration Research and Theory* **18** (2): 229–252.

Resh, William G. and David W. Pitts. 2013. No solutions, only trade-offs? evidence about goal conflict in street-level bureaucracies. *Public Administration Review* **73** (1):132–142.

Rogers, Ellen and Edward P. Weber. 2010. Thinking harder about outcomes for collaborative governance arrangements. *The American Review of Public Administration* **40** (5):546–567.

Rosenberg, Stacy and Richard D Margerum. 2008. Landowner motivations for watershed restoration: lessons from five watersheds. *Journal of Environmental Planning and Management* **51** (4):477–496.

Sabatier, Paul and Daniel Mazmanian. 1980. The implementation of public policy: A framework of analysis. *Policy Studies Journal* **8** (4):538–560.

Scott, Tyler. 2015. Does collaboration make any difference? linking collaborative governance to environmental outcomes. *Journal of Policy Analysis and Management* **34** (3):537–566.

Scott, Tyler A.. 2016. Is collaboration a good investment? modeling the link between funds given to collaborative watershed councils and water quality. *Journal of Public Administration Research and Theory* **26** (4):769–786.

Scott, Tyler A. and Craig W. Thomas. 2017. Unpacking the collaborative toolbox: Why and when do public managers choose collaborative governance strategies? *Policy Studies Journal* **45** (1):191–214.

Scott, Tyler A., Craig W. Thomas, and José Manuel Magallanes. 2019. Convening for consensus: Simulating stakeholder agreement in collaborative governance processes under different network conditions. *Journal of Public Administration Research and Theory* **29** (1):32–49.

Siciliano, M.D., J.B. Carr, and V.G. Hugg. 2021. Analyzing the effectiveness of networks for addressing public problems: Evidence from a longitudinal study. *Public Administration Review* **81** (5):895–910.

Siddiki, S., J. Kim, and W.D. Leach. 2017. Diversity, trust, and social learning in collaborative governance. *Public Administration Review* **77** (6):863–874.

Siddiki, Saba N., Julia L. Carboni, Chris Koski, and Abdul-Akeem Sadiq. 2015. How policy rules shape the structure and performance of collaborative governance arrangements. *Public Administration Review* **75** (4):536–547.

Sørensen, Eva, Peter Triantafillou, and Bodil Damgaard 2018. Governing eu employment policy: Does collaborative governance scale up? In *How Does Collaborative Governance Scale?*, ed. C. Ansell and J. Torfing, 21–42. Policy Press.

Thomas, Craig W. and Tomas M. Koontz. 2011. Research designs for evaluating the impact of community-based management on natural resource conservation. *Journal of Natural Resources Policy Research* **3** (2):97–111.

Vangen, Siv and Chris Huxham. 2012. The tangled web: Unraveling the principle of common goals in collaborations. *Journal of Public Administration Research and Theory* **22** (4):731–760.

Villamizar-Villegas, M., F.A. Pinzon-Puerto, and M.A. Ruiz-Sanchez. 2022. A comprehensive history of regression discontinuity designs: An empirical survey of the last 60 years. *Journal of Economic Surveys* **36** (4):1130–1178.

Wang, X., E.M. Berman, D.Y. Chen, and X. Niu. 2019. Strategies to improve environmental networks for pollution control: Evidence from eco-compensation programs in china. *Journal of Environmental Management* **234**:387–395.

Wooldridge, J.M. 2010. *Econometric analysis of cross section and panel data.* MIT Press.

Supplemental Information

Table A.1: Collaboration Forms and Leader Types of Collaborative Projects

Project Type	Observation	Example
CGR	3,501	Watershed council
Ad hoc collaboration		
• Lead by Citizen Group	531	Conservation group Extension service Research Sporting group Volunteer
• Lead by local government	3,452	City government County government Local agency Soil & water conservation district
• Lead by the state government	1,310	State agency
• Lead by private sector	59	Private forest industrial landowner Permitee or leaseholder Local business Contractor
• Lead by nonprofit	86	Educational institution/school Nonprofit organization Small woodlands association Private non-industrial landowner

Table A.2: Descriptive Statistics for Longitudinal Analysis (Watershed-Year Observations)

	Variable	N	Mean	SD	Min	Max
1	Water Quality Index	1480	80.63	16.00	21.78	96.06
2	N of Projects convened by CGR	1700	1.74	4.19	0.00	60.00
3	N of Projects led by Citizen Group	1700	0.26	1.13	0.00	26.00
4	N of Projects led by Local Govnt	1700	1.67	3.31	0.00	36.00
5	N of Projects led by State Govnt	1700	0.69	1.83	0.00	21.00
6	N of Goals per Project	1700	3.26	3.25	0.00	21.00
7	Representation	1700	2.63	1.94	0.00	10.25
8	Project-N	1700	4.61	6.59	0.00	61.00
9	In-kind Share (%)	1700	0.15	0.17	0.00	1.00
10	Forest Land Use (%)	1700	0.32	0.43	0.00	1.00
11	Air Temperature (℃)	1700	9.27	1.71	4.77	13.06
12	Precipitation (mm)	1700	1108.39	791.67	152.08	3757.56

Table A.3: Moran's I Test for Spatial Autocorrelation

Year	Moran's I	Expected I	Z score	p-value
1997	0.21	-0.02	10.65	0.00
1998	0.17	-0.02	8.48	0.00
1999	0.23	-0.02	11.22	0.00
2000	0.20	-0.02	9.83	0.00
2001	0.21	-0.02	10.16	0.00
2002	0.26	-0.02	12.32	0.00
2003	0.21	-0.02	10.13	0.00
2004	0.23	-0.02	11.02	0.00
2005	0.22	-0.02	10.66	0.00
2006	0.21	-0.02	10.52	0.00
2007	0.21	-0.02	10.28	0.00
2008	0.21	-0.02	10.60	0.00
2009	0.18	-0.02	9.20	0.00
2010	0.24	-0.02	11.39	0.00
2011	0.19	-0.02	10.60	0.00
2012	0.22	-0.02	12.67	0.00
2013	0.17	-0.01	10.88	0.00
2014	0.15	-0.01	9.63	0.00
2015	0.12	-0.01	7.64	0.00
2016	0.18	-0.01	11.38	0.00
2017	0.14	-0.01	9.06	0.00
2018	0.14	-0.01	9.19	0.00
2019	0.11	-0.01	7.32	0.00
2020	0.13	-0.02	8.28	0.00
2021	0.12	-0.01	7.77	0.00

Figure A.1: RDiT Estimates in Different Bandwidths

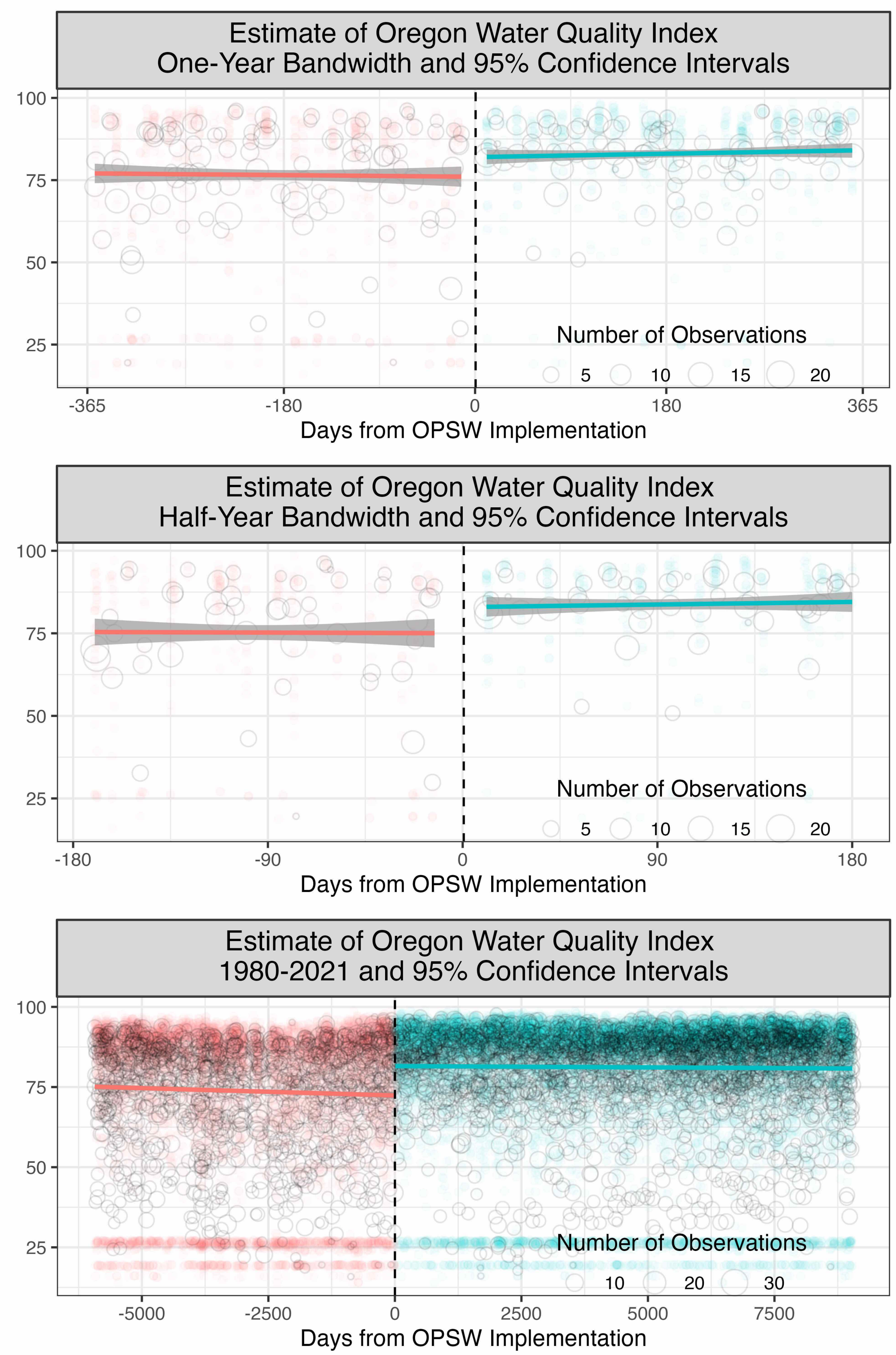


Figure A.2: Placebo Test

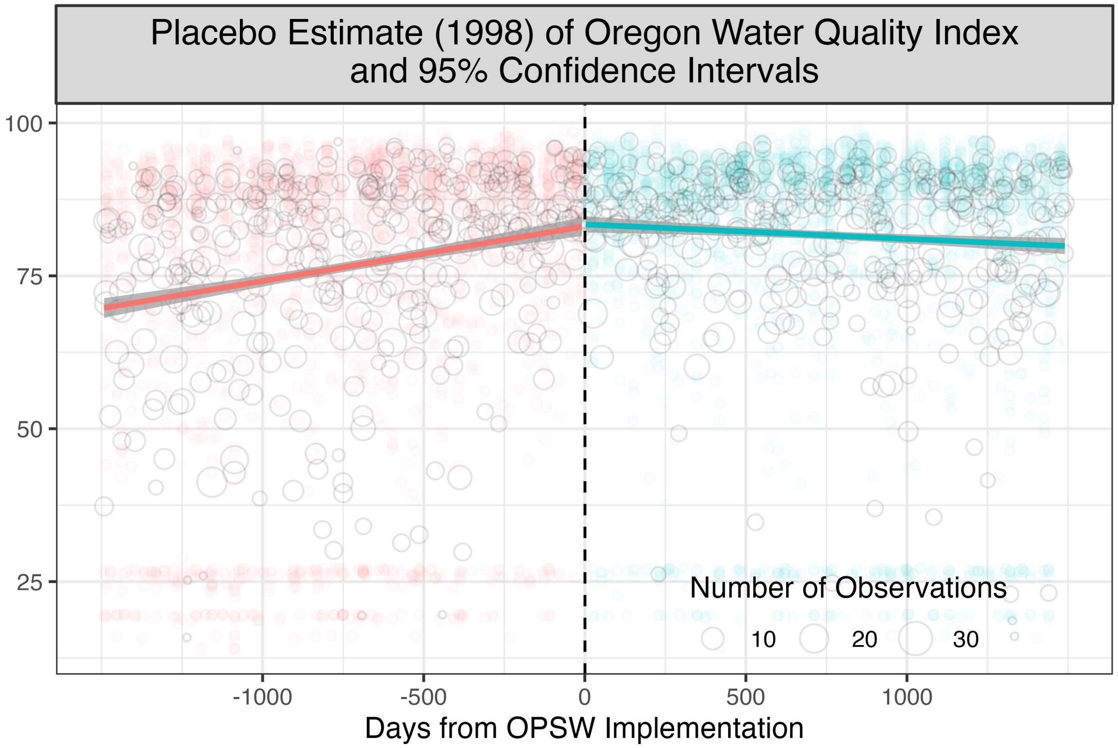


Figure A.3: Density Test