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# Transboundary water institutions in action



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### ABSTRACT

This analysis compares three game theory scenarios of how transboundary water institutions facilitate sovereign country management of transboundary water pollution along international borders of North America through bearing pollution abatement costs, sharing water monitoring responsibility and formal decision-making for pollution control. The three scenarios include a noncooperation game from an earlier period of unilateral decision-making, a cooperation game with water monitoring and information sharing for decisions, and a Stackelberg game with formal financial channels for one country separate from decisions for wastewater pollution reduction of each country. A numerical comparison of costs, damages and pollution levels for each scenario evolves with data from the US–Mexico border. Results show total costs and damages are minimized at \$13,100,000 through cooperation, with the Stackelberg game at the next highest costs and damages for the steady state at \$13,300,000. The Stackelberg solution improves considerably the situation for both the US and Mexico compared to the Nash Equilibrium (NE) where total steady costs and damages are \$18,700,000. Cost minimization occurs as the US can finance pollution abatement in Mexico in the Stackelberg case cheaper than domestically to reduce damages. A sensitivity analysis explores changes in abatement cost financing and size of transboundary pollution. The divergence between the noncooperative independent action game and the Stackelberg game grows, while the Stackelberg solution continues to stay close to the cooperative solution. Solution strategies with increased wastewater pollution levels show that if wastewater management efforts are delayed without particular coordination from transboundary institutions in a waterway, pollution stock can grow profusely along with abatement cost and damages.

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## 1. Introduction

Studying the economics of transboundary water management and institutional design can help in addressing problems around the world as waterways straddling international boundaries are vulnerable and not infinitely bountiful and resilient. Transboundary settings offer interdependencies, opportunities and challenges for water management on the same scale as the natural connectedness of water flow across borders. Transaction costs can make or break transboundary management efforts as they surround coordination incentives, information acquisition and processing, contracting, search, enforcement, bargaining, measurement and lobbying [36]. Transaction costs specific to transboundary water management in the present analysis start with monitoring and data exchange on the interconnectedness of hydrology and economic channels that may straddle boundaries, dispute resolution and institutional design [45]. Without the transactions costs covered, delays translate into more stock pollution accumulation downstream in the waterway. This paper focuses on resolving delays in transboundary water management and pollution accumulation through a comparison of institutions and the transactions costs they cover. Achieving adaptive management of water institutions requires information through frequent monitoring of the stock and flow of water resources to solve continuous challenges. Where information is incomplete and asymmetric, difficulties in water protection arise. For example, riparian countries generally have asymmetric access to data and information because of jurisdictional domain of data collection and processing abilities. Data has a bargaining value to the country that owns it because it can be used strategically in negotiation with other riparian countries. In the presence of asymmetric information better institutions can go a long way to mitigate problems [25].

What are the “better institutions” to facilitate water cooperation for transboundary water resources? This paper provides economic analysis of institutional design from real world “better institutions” that overcome the obstacles Just and Netanyahu [30] have identified as barriers to transboundary water cooperation: asymmetric information among riparian countries, existence of scientific gaps and technical uncertainties, lack of effective enforcement mechanisms and institutions, national claims for sovereignty, conflicting national and international interests, obvious asymmetric country characteristics, and geographical upstream and downstream considerations. Two contributions of the paper include first, providing an analytical model to compare three institutional options between sovereign countries, with interdependent management of transboundary environmental resources that move beyond simply a treaty. The institutional options differ in terms of the transaction costs they cover which translate nicely into different game theory solution concepts to compare. The three scenarios include a noncooperation game from an earlier period of unilateral decision-making, a cooperation game with water monitoring and information sharing for decisions, and a Stackelberg game with formal financial channels for one country separate from decisions for wastewater pollution reduction of each country. The second contribution is to measure the institutional variation across the three game solutions through an empirical application with data that helps tie results and policy implications to specific funding mechanisms and institutions on North America's international borders.

The institutional support in this paper fosters formal channels from each country to commit financial and knowledge resources to carry out necessary transboundary management with new environmental infrastructure to address dynamics of pollution over time and space. Transaction costs of coordination are clearly addressed in this analysis of institutions that provide the benefit of longer term interaction and timely response without having to reestablish lines of communication between transboundary stakeholders. The institutional support allows a country to better calculate their potential payoff and make decisions in a timely manner to avoid late response to pollution problems with new monitoring information for adaptive water pollution control. Timely action means achieving lower pollution stock sooner.

The transaction cost approach to understanding organizations was spearheaded by Ronald Coase and developed by Oliver Williamson and asserts that the optimal design of institutions minimizes various costs of production and transaction. This perspective may help in studying the institutional design of three institutions at the helm of coordinating timely action among Canada, the US and Mexico for transboundary water management.

This paper investigates the economics of institutional variation between sovereign countries in North America over shared waterways along the US–Canada and US–Mexico borders in the past,

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