We Both Step and Do Not Step in the Same Rivers

Municipal Cooperation and Water Pollution Spillovers in Mexico

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About me

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- Economics master's student at Uppsala University in Sweden
- Working as an RA at CIE
- Received my BA in Economics in 2021 from ITAM

Motivation

Externalities

- Decentralized systems improve service delivery as they adjust to local preferences, but generate externalities across boundaries (Oates, 1972).
- Rivers represent a classic textbook example of negative externalities.
- Upstream communities do not internalize the costs of the pollution emitted to the rivers since these pollutants are transferred to downstream communities.
- Diseases transmitted by freshwater pollution, such as diarrhoeal infections, are a significant cause of mortality in developing countries (Duflo et al., 2015).

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  - cap and trade (e.g., Montgomery (1972))
  - **COOPERATION**

Solutions to externlities?

- This thesis tries to contribute to literature on the role of cooperation as an alternative for a better management of natural resources (Ostrom, 1990; Roemer, 2020)
- Emphasize the importance of inter-jurisdictional **horizontal** arrangements in decentralized systems.

Context

Mexican Background

- In Mexico, municipalities are responsible for providing public services such as sewerage, street lighting, public safety, etc.
- The highest authority is the Municipal President, elected by plurality every three years in a multi-party system.
- Much of the inter-party competition takes place in the ideological space, it is easier for voters to distinguish between parties within a simplified political reality (Llamazares and Sandell, 2002).

Mexican Background

- The National Water Law (LAN) regulates the distribution and control of water in Mexico. CONAGUA is responsible for exercising the authority and administration of water.
- Mexico is home to 51 major rivers and 1,471 hydrographic basins, which CONAGUA has grouped into 731 basins.

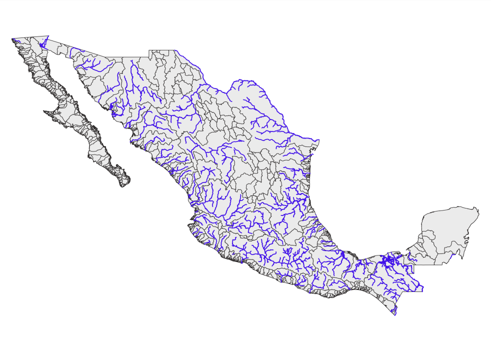

Figure 1: Mexico's basins and major rivers. Source: CONAGUA

Mexican Background

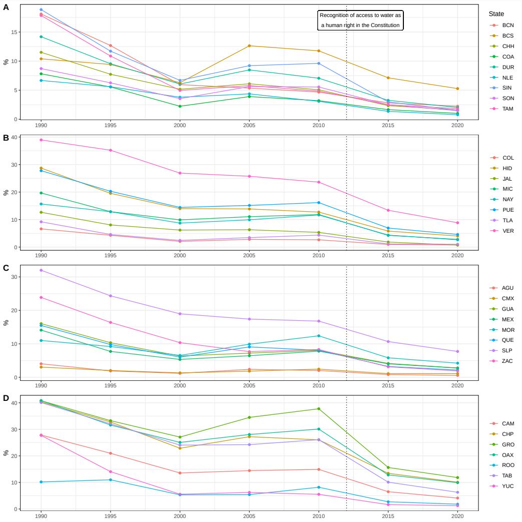

Figure 2: Proportion of Inhabited Private Housing Units without Access to Piped Water by State. Source: INEGI

Theoretical Framework

Two fundamentally different views on the role of elections in policy formation:

1. Competing candidates have incentives to adopt policies tailored to the electorate's preferences.
   - Ideology does not have great relevance, candidates moderate policies to adjust to a greater number of preferences.
2. Voters simply choose policies previously decided by the candidates.
   - In a single-shot game, only consistent equilibrium is candidates choose to carry out their preferred policy instead of keeping their word (Alesina, 1988).
   - Alesina's assumptions are too simplistic, there might be other factors that can influence a candidate's behavior (e.g.,maintaining credibility).
   - Provides a useful framework for understanding the behavior of candidates in elections incorporating **partisanship**.

What's the Relation of Political Partisanship and Cooperation?

One of the purposes of political parties might be acting as facilitators of cooperation. How?

1. Political parties win elections and government positions are granted.
2. Political ideology materializes into anticipated public policies.
3. Cooperation arises through these policies if the political ideologies of the candidates involved have a certain degree of affinity.

If two mayors share a political party both of their actions will follow a shared set of beliefs, which can translate into inter-jurisdictional cooperative policies and agreements.

What's the Relation of Political Partisanship and Cooperation?

Political ideology is not the only thing driving cooperation. We can think of other situations where cooperation is fostered:

- What if mayors know each other?
- What if the party leaders force mayors to cooperate?

Research Question: What happens to water pollution levels in contexts where cooperation is fostered?

Horizontal cooperation can arise from any of these theoretical justifications and according to cooperative models, such as Kantian optimization, the cooperative equilibrium of any monotone decreasing game (e.g., polluting rivers) is Pareto efficient (Roemer, 2010).

- Testable prediction: if two mayors of neighboring municipalities are politically aligned, there is reason to believe that cooperation will be fostered.

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- Cooperation will translate into costly actions from upstream municipalities to prevent spillovers to neighboring municipalities.
- What about opposite predictions?

Data

Water Data

- River GIS data. In vector data, the basic units of spatial information are points, lines (arcs) and polygons.
- Data from 2006 to 2020 from over 1,300 different stations obtained from the National Water Information System (SINA).
- Three main pollution measures: Biochemical Oxygen Demand at five days (BOD5), Chemical Oxygen Demand (COD), and Total Suspended Solids (TSS).

Municipal Data

- Historical data on mayors of each municipality from Institute for Federalism and Municipal Development (INAFED).
- Polygons from municipalities from INEGI.

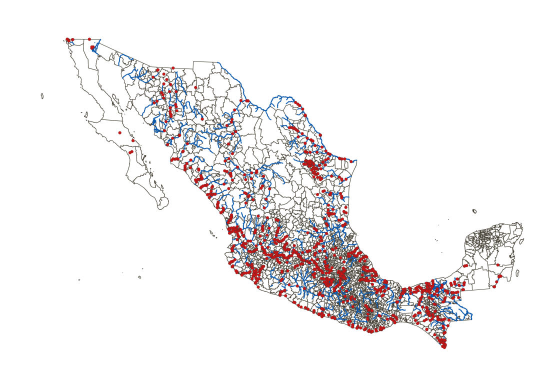

Figure 3: Municipalities and water quality monitoring stations in 2019. Source: CONAGUA.

GIS Modeling

- A Digital Elevation Model (DEM) was used to determine the direction of each river flow.
- Using the DEM and the coordinates (X, Y) of each station, the elevation value (Z) was assigned to each station.

Figure 4: Mexico's Digital Elevation Model. Source: CEM, INEGI.

Constructing a Usable Dataset

Panel data constructed merging the water quality data and the mayors data, where each observation was set up to be a pair of upstream-downstream stations.

To assign each upstream station its downstream pair, it was verified that three conditions were met:

1. Both stations shared the same river.
2. Both stations were located in different and neighboring municipalities.
3. $Z_{downstream} < Z_{upstream}$.

Constructing a Usable Dataset

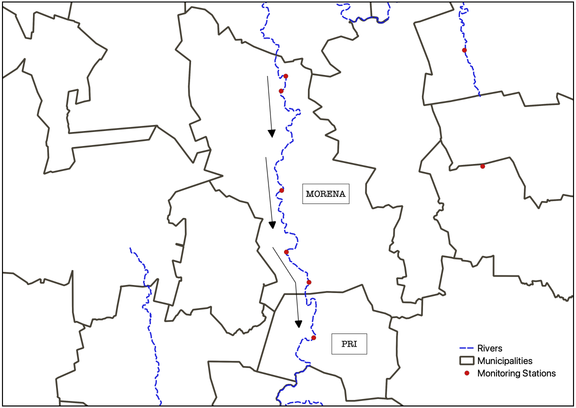

Figure 5: Example of party alignment in neighboring municipalities that share a river.

Empirics

Empirical Strategy

Two-way fixed effects regression model (TWFE). The estimating equation is:

$$\begin{aligned} ln(Y_{i,t}^{downstream}) =& \beta_1 \text{Political Alignment}_{i,t} + \beta_2 ln(Y_{i,t}^{upstream}) \\ &+ \beta_3 ln(\Delta\text{Elevation}_{i,t}) + \alpha_i + \lambda_t + u_{i,t} \end{aligned} \tag{1}$$

- where $Y_{i,t}^{j}$ with $j = \{downstream, upstream\}$ represents one of the pollution metrics at the corresponding station in station pair i at year t; $\text{Political Alignment}_{i,t}$ is a dummy variable indicating if pair i has the same political party.
- $\Delta\text{Elevation}_{i,t} = \text{Elevation}_{i,t}^{upstream} - \text{Elevation}_{i,t}^{downstream}$

Identifying Assumptions

Strict Exogeneity

$$\mathbb{E}[u_{i,t}|\mathrm{PA}_{i,2006},\ldots,\mathrm{PA}_{i,t},\ldots,PA_{i,2020},W_{i,t}] = \mathbb{E}[u_{it}|W_{i,t}]$$

Much stronger than contemporaneous exogeneity.

1. There can be no omitted lagged effects of *PA*.
2. There can be no feedback from $u_{i,t}$ to future $PA_{i,t}$ (i.e., strict exogeneity is violated if *PA* responds to changes in $Y^{downstream}$)

Identifying Assumptions

Additionally we need to assume:

1. ATET is homogeneous across treatment units.
2. ATET is homogeneous over time.

By fulfilling these assumptions β_1 would be identifying ATET.

Validity Tests

1. **Control for linear time trends specific to each station-pair**. These help to rule out the possibility that politically aligned pairs and non-aligned pairs were already on differential growth trajectories in the outcome variable.

$$
\begin{aligned}
ln(Y_{i,t}^{downstream}) = & \beta_1 \text{Political Alignment}_{i,t} + \beta_2 ln(Y_{i,t}^{upstream}) \\
& + \beta_3 ln(\Delta \text{Elevation}_{i,t}) + \beta_4 (i \times t) + \alpha_i + \lambda_t + u_{i,t}
\end{aligned} \tag{2}
$$

Validity Tests

2. **Adding a lead of 6 years to the treatment**. Future alignment should not influence the outcome variable once we control for present alignment and all the fixed effects.

$$
\begin{aligned}
ln(Y_{i,t}^{downstream}) = & \beta_1 \text{Political Alignment}_{i,t} + \beta_2 \text{Political Alignment}_{i,t+6} \\
& + \beta_3 ln(Y_{i,t}^{upstream}) + \beta_4 ln(\Delta \text{Elevation}_{i,t}) + \alpha_i + \lambda_t + u_{i,t}
\end{aligned} \tag{3}
$$

Negative Weights

Following de Chaisemartin and D'Haultfœuille (2020) under common trends assumption and **heterogeneous** treatment effects, β will identify the expectation of the weighted sum of treatment effects.

$$\beta = \mathbb{E}\left[\sum_{i,t} W_{i,t} TE_{i,t}\right]$$

- Where $W_{i,t}$ represents weights summing to one, and $TE_{i,t}$ represents the average treatment (ATE) effect for an individual i at time t.

In designs where the treatment switches on and off, such as this paper, weights can be strictly negative ($W_{i,t} < 0$), implying that β could be negative even if all the $TE_{i,t}$ are positive.

Conclusions

Results

- Only BOD5 results were robust to the validity tests.
- The coefficient on the upstream pollution variable ($BOD^{upstream}$ is significant (1% level) and consistent with the theory of economic externalities. A 1% increase in upstream municipal pollution is related to a 0.43% increase in downstream pollution.
- Political Alignment displays a negative and significant coefficient at the 1% level. The mean downstream pollution for municipality pairs with politically aligned mayors likely being 14.44% lower than for municipality pairs that are not politically aligned.

Conclusion

- Take previous results with a grain of salt.
- The main contribution is that this paper shows evidence to us economics students that the competitive equilibrium is not the only theory of rationality, we can also think in cooperative terms!
- The underlying mechanism may not be clear, but it is probably made up of a combination of ideology, political discipline, and personal relationships, all of which are possible due to the party structure of democracies.
- Policies that seek to strengthen the authority of basin councils and promote the development of more organizations whose function is to facilitate cooperative agreements might be on the right direction.

Questions?

https://github.com/quinoba/Tesis_ITAM

Appendix: Results

Table 4: TWFE Regression: Determinants of Downstream Pollution Changes

	Dependent variable:		
	$\log(BOD^{down})$	$\log(COD^{down})$	$\log(TSS^{down})$
	(1)	(2)	(3)
$\log(\Delta Elevation)$	-0.109	-0.080	-0.140^{*}
	(0.077)	(0.052)	(0.073)
Political Alignment	-0.156^{***}	-0.095^{**}	-0.028
	(0.056)	(0.039)	(0.054)
$\log(BOD^{up})$	0.430^{***}		
	(0.036)		
$\log(COD^{up})$		0.318^{***}	
		(0.023)	
$\log(TSS^{up})$			0.332^{***}
			(0.038)
Station-pair fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Clustered S.E. by municipality-pair	Yes	Yes	Yes
Pairs of neighboring municipalities	608	612	609
Station pairs	3691	3708	3749
Observations	18,795	18,745	19,431
Adjusted R^2	0.793	0.736	0.632
Note:			*p<0.1; **p<0.05; ***p<0.01

Notes: The dependent variable is the log pollution level (BOD, COD, TSS) at the downstream station. All regressions include year, and station-pair fixed effects. Clustered standard errors by municipality-pair in parentheses. All regressions include the following independent variables: the log elevation difference between stations within pairs, a political alignment dummy variable, and the log pollution level at the upstream station.

Appendix: Validity Tests

Table 5: Robustness Test: Adding Pair Specific Linear Time Trends

	Dependent variable:		
	$\log(BOD^{down})$	$\log(COD^{down})$	$\log(TSS^{down})$
	(1)	(2)	(3)
$\log(\Delta Elevation)$	−0.137	−0.064	0.090
	(0.105)	(0.086)	(0.156)
Political Alignment	−0.166**	−0.074	0.025
	(0.074)	(0.075)	(0.069)
$\log(BOD^{up})$	0.369***		
	(0.045)		
$\log(COD^{up})$		0.296***	
		(0.026)	
$\log(TSS^{up})$			0.333***
			(0.050)
Station-pair fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Station-pair trends	Yes	Yes	Yes
Clustered S.E. by municipality-pair	Yes	Yes	Yes
Pairs of neighboring municipalities	608	612	609
Station pairs	3691	3708	3749
Observations	18,795	18,745	19,431
Adjusted R^2	0.803	0.743	0.635
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Notes: The dependent variable is the log pollution level (BOD, COD, TSS) at the downstream station. All regressions include year and station-pair fixed effects and station-pair trends. Clustered standard errors by municipality-pair in parentheses. All regressions include the following independent variables: the log elevation difference between stations within pairs, a political alignment dummy variable, and the log pollution level at the upstream station.

Appendix: Validity Tests

Table 6: Robustness Test: Adding a Leading Political Alignment Variable

	Dependent variable:		
	$\log(BOD^{down})$	$\log(COD^{down})$	$\log(TSS^{down})$
	(1)	(2)	(3)
$\log(\Delta Elevation)$	−0.115	−0.006	−0.105
	(0.146)	(0.077)	(0.167)
Political Alignment	−0.267*	−0.173	0.072
	(0.147)	(0.136)	(0.095)
Political $Alignment_{+6}$	0.150	0.158	0.040
	(0.162)	(0.168)	(0.099)
$\log(BOD^{up})$	0.325***		
	(0.058)		
$\log(COD^{up})$		0.379***	
		(0.059)	
$\log(TSS^{up})$			0.472***
			(0.067)
Station-pair fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Clustered S.E. by municipality-pair	Yes	Yes	Yes
Pairs of neighboring municipalities	361	359	362
Station pairs	1464	1458	1521
Observations	3,600	3,509	3,754
Adjusted R^2	0.691	0.655	0.672
Note:	*p<0.1; **p<0.05; ***p<0.01		

Notes: The dependent variable is the log pollution level (BOD, COD, TSS) at the downstream station. All regressions include year and station-pair fixed effects. Clustered standard errors by municipality-pair in parentheses. All regressions include the following independent variables: the log elevation difference between stations within-pair, a political alignment dummy variable, the alignment dummy variable with a 6-year lead, the log pollution level at the upstream station.

Appendix: Kantian Optimization

Consider a set of n agents. Each agent i takes an action $E^i \in \mathbb{R}^+$. Define everyone else's actions $E^{-i} = (E^1, \ldots, E^{i-1}, E^{i+1}, \ldots E^n)$. A feasible contribution profile is $E = (E^1, E^2, \ldots, E^n)$. Agent i's payoff is $V^i(E^i, E^{-i})$; each agent's utility depends not only on her contributions but also on other's contributions, representing externalities.

Definition 1. A monotone decreasing game is a game in which every player's utility is decreasing in the contributions of other players.

Definition 2. A contribution profile $(E^*, E^*, \ldots, E^*)$ is a simple Kantian equilibrium if every player prefers this profile to any other constant contribution profile.

In Kant's words: "Take the action you would will be universalized."

Proposition. The simple Kantian equilibrium of any monotone game is Pareto efficient.

Proof. Suppose a decreasing monotone game. Let $(E^*, E^*, \ldots, E^*)$ be the simple Kantian equilibrium and suppose it is not Pareto efficient. Then there is another profile $(E^1, E^2, \ldots, E^n)$ that everyone prefers. Let E^1 be the smallest contribution in this profile. Then, Player 1 prefers $(E^1, E^1, \ldots, E^1)$ over $(E^1, E^2, \ldots, E^n)$ over $(E^*, E^*, \ldots, E^*)$, which is a contradiction.

Appendix: Neigboring Municipalities

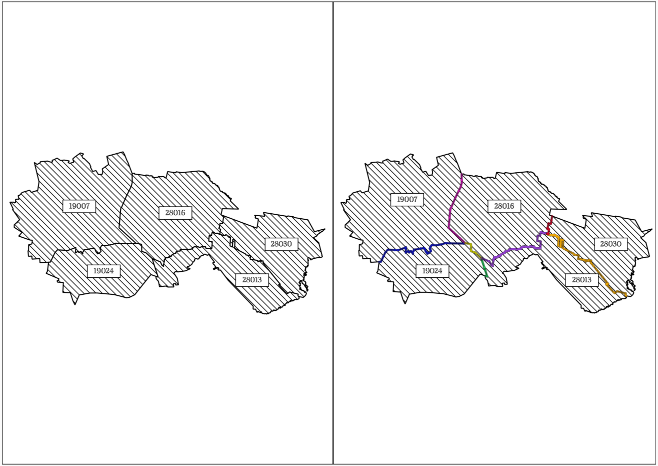

Figure 6: Neighboring municipalities

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