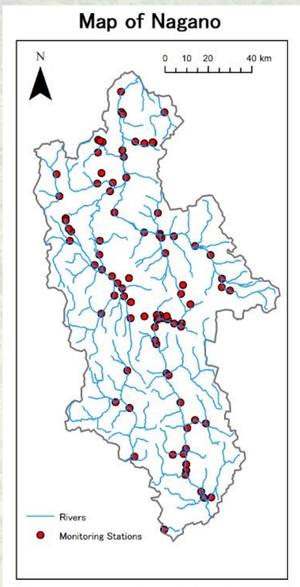
Do Municipal Mergers Improve Water Quality?

Spatial Patterns of Pollution Along Rivers in Nagano, Japan

Introduction

Municipal mergers are often pushed forward by policy-makers for economic reasons, but little is known about their environmental impacts, including water pollution in rivers. Interestingly, recent economic theory (Lipscomb and Mobarak (2017)) suggests that municipal mergers should lower river pollution. Empirical tests of this novel theory remain scarce to date. Analyzing spatial patterns and examining the theory are thus both empirically relevant and potentially rich in policy implications.



In this study, I focus on Nagano, Japan. Nagano experienced a wave of municipal mergers in the early to mid 2000s, and is a great setting to analyze the impact of mergers.

Theoretical Background

The novel theory builds on the 'negative spillover' notion that emissions in an upstream municipality have negative impacts on downstream municipalities, and that the fewer municipalities a river flows through, the easier it is to coordinate pollution control along the river path. The theory equally predicts several spatial patterns in river pollution.

Testable predictions:

1. Municipal mergers decrease pollution
2. Pollution increases the closer a monitoring station is to a downstream municipality border, and the farther away a station is from an upstream border.

Data

I use NIES data on monitoring station location and water pollution (BOD). River location and node data, as well as information on municipal mergers, were collected from government (MLIT, MIC) websites. Municipality boundaries data were obtained from Ritsumeikan University.

Summary statistics for key variables are provided below. Unit of observation is at the station level. BOD over the sample period (1990-2009) in Nagano was quite low, with a mean of 1.2 mg/L. Roughly half of the monitoring stations were situated in municipalities that experienced mergers. On average, a monitoring station in Nagano is located 4.8km from an upstream border and 4.6km from a downstream border.

Table 1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
BOD (mg/L)	1.22	0.77	0.5	6.9	1564
Merger	0.49	0.5	0	1	1564
Upstream (km)	4.82	4.28	0.08	30.67	963
Downstream (km)	4.64	4.57	0.01	22.96	1129

Data Sources:

Monitoring station data (National Institute for Environmental Studies (NIES))

Status of municipal mergers (Ministry of Internal Affairs and Communications (MIC))

National Land Numerical Information (Ministry of Land, Infrastructure, Transport and Tourism (MLIT))

Municipality Map Maker Database (Ritsumeikan University)

Background photo: Azusa River, Nagano (Photographer: 663highland)

Projection:

Map of Japan: Transverse Mercator

Maps of Nagano: Equidistant Conic

Tufts UNIVERSITY

Cartographer: Michiyoshi TOYA

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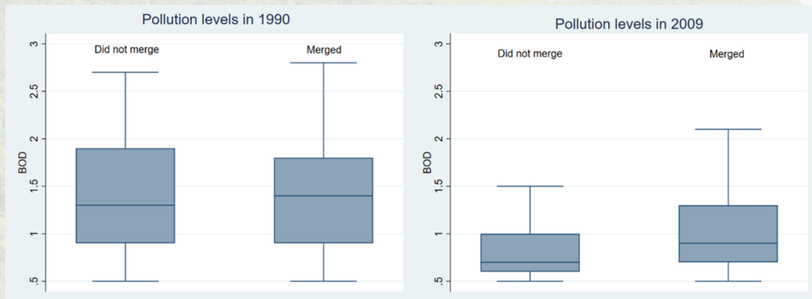
Analysis

1. Do municipal mergers lower pollution?

I first geocode monitoring stations and perform spatial joins to identify which monitoring stations belong to municipalities that merged, using municipality merger information.

Result: Mergers increase pollution!

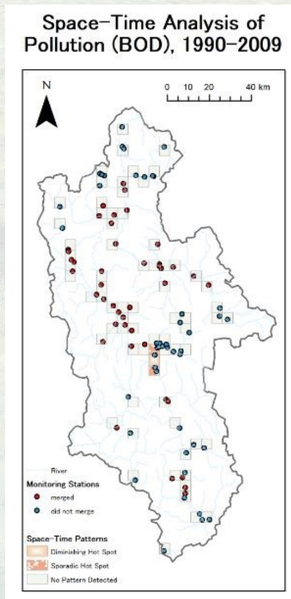
To directly assess the impact of mergers, I compare BOD levels between 'stations located in municipalities that merged' and 'stations located in municipalities that did not merge', for two different years: 1990 (a pre-merger year) and 2009 (a post-merger year).



In 1990, as can be seen from similar mean values and distributions in the boxplot, BOD levels in municipalities that would eventually merge were not statistically different from those that never merged. However, in 2009, BOD levels were around 16% higher in municipalities that merged (relative to those that did not), and this difference is mildly significant at 10% level. Contrary to theory, mergers seem to increase river pollution.

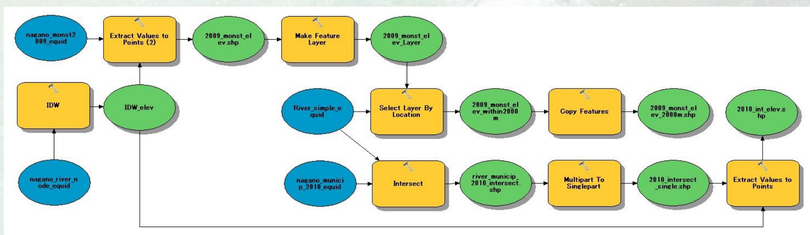
Space-time analysis further supports this finding.

If mergers were effective in reducing pollution, we may expect patterns such as 'diminishing hot spots', 'diminishing cold spots' and 'new cold spots' to appear in merged municipalities. However, we see no significant patterns in all merged areas. If anything, we worryingly find a 'diminishing hot spot' in a municipality that did not merge, suggesting that non-merging municipalities were more successful in reducing pollution over this period.

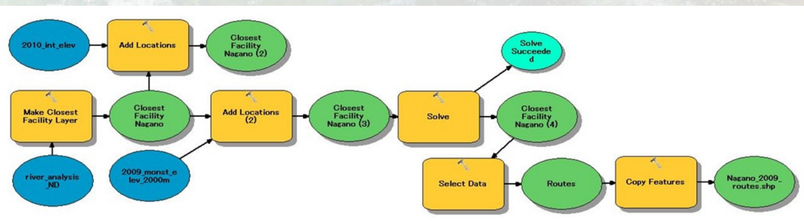


Diagrams of models used in river distance analysis

Data preparation model



Closest facility model



References:

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Moisio, Antti and Roope Uusitalo (2013) "The impact of municipal mergers on local public expenditures in Finland," Public Finance and Management, Vol. 13, No. 3, pp. 148-166.

Lipscomb, Molly and Ahmed Mushfiq Mobarak (2017), "Decentralization and Pollution Spillovers: Evidence from the Re-drawing of County Borders in Brazil," The Review of Economic Studies, Volume 84, Issue 1, Pages 464–502.

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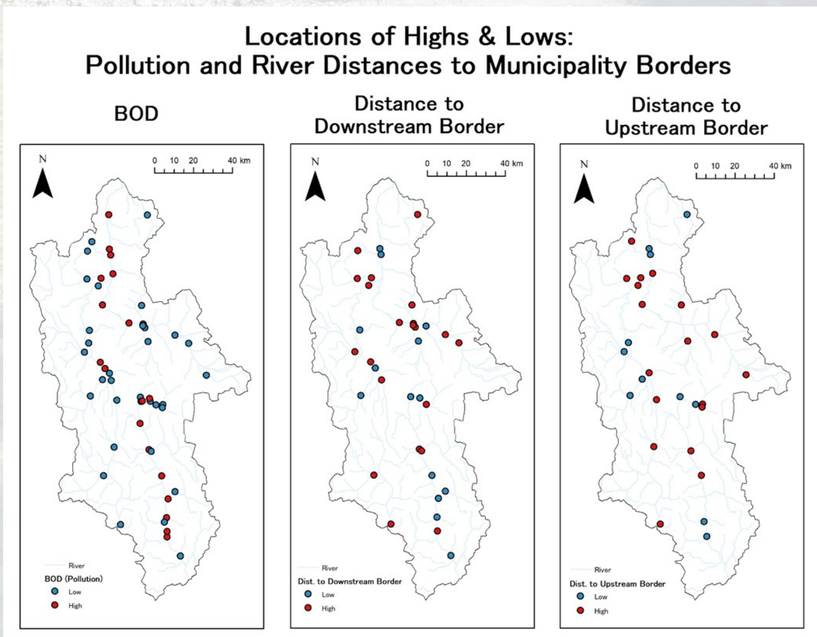
2. Do river distance predictions from the 'negative spillover' theory hold?

Variables of interest are 'distances along the river from a monitoring station to its closest upstream and downstream municipality borders'. I apply Network Analysis tools to calculate these distances.

Specifically, I first intersect the river polylines with municipality boundaries to obtain municipality entry/exit points of rivers. I then build a river network and perform a 'find closest facility' analysis to pick six closest border boundary points along the river for each monitoring station, and obtain distances for these routes. I use elevation information interpolated from river node data to determine whether each selected border boundary point lies upstream or downstream of the monitoring station. Finally, I perform SQL queries to find the closest upstream and downstream border boundaries for each monitoring station.

Result: Predictions do not hold firmly

According to the negative spillover theory, pollution should increase as the distance along the river from a monitoring station to its closest downstream border decreases, and as the distance to its closest upstream border increases. I compare locations where high and low values are observed for these variables. If the theory holds firmly, we should see high pollution locations to also have low downstream distance and high upstream distance, and vice versa.



In line with theory, we observe a fairly consistent pattern of 'high pollution' locations also being associated with 'low distance to downstream border' (and vice versa) across Nagano. However, the relationship between pollution and upstream distance appears ambiguous at best, with negative associations being widely observed for instance in Eastern and Southern regions. There does not seem to be strong evidence supporting the theory, implying that the negative spillover channel may not be prevalent.

Conclusion

Contrary to what recent economic theory would suggest, municipal mergers appear to increase pollution. Data do not strongly support the 'negative spillover' river distance predictions either.

Repeating the analysis for the whole of Japan, as well as exploring alternative hypotheses that can explain increased pollution, may be interesting extensions for future work.