State Capacity and Economic Development

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Second Munich Lecture, November 18, 2015.

Equilibrium State Capacity

- The previous lecture discussed the political economy of state capacity and political centralization, taking it for granted that state capacity can emerge under certain circumstances and play a productive role in the economy.
- We will now tackle this question from two angles:
- **Theory**: Acemoglu and Wolinsky (2015)—what is the value of (incentive compatible) political centralization?
  - The comparison is decentralized enforcement of rules and norms, similar to the private order of Greif (1993, 2006).
- **Theory and Empirics:** Acemoglu, Garcia-Jimeno and Robinson (2015)—how does (local) state capacity impact public goods and prosperity, not just in one's own locality, but in the neighborhood?
  - A network approach to the determination and impacts of local state capacity.

Part I: Introduction

- Sustaining cooperation — helping others, following conventions, refraining from cheating, crime or negative externality actions, etc. — is a major objective of all human societies.
- Two polar methods of sustaining cooperation:

1. **Community enforcement** (similar to "private order"): transgressions punished by other "private citizens" withholding cooperation
    - Extreme case in large societies with anonymity: contagion strategies a la Kandori (1992) which lead to the collapse of cooperation in the entire society.
    - Prominent examples: Shasta country (Ellickson, 1990), Magribi traders (Greif, 1993), but in modern society this is the exception rather than the norm.
2. **Centralized enforcement** (similar to "public order") is much more common: transgressions punished by specialized agents tasked with direct punishment (law enforcement, mafia etc.) without any disruption in cooperative behavior in the rest of society

Main Idea

- To understand the nature of centralized enforcement, we need to ask two related questions:
  1. How does society provide incentives to the state's agents (enforcers)? (Related to "who will guard the guardians?").
  2. Is relying solely on centralized enforcement optimal? (Rather than a hybrid system in which everybody, including private enforcers, punish transgressions).
- Consider a society consisting of:
  - producers ("citizens") who choose effort/investment creating benefits to their partners in the match, and
  - specialized enforcers who can undertake costly punishments against producers deviating from the prescribed behavior.

Key Idea

- Enforcers need to be incentivized to carry out costly punishments by future cooperation in society (which creates direct rewards or tax revenues out of which they will be get paid).
- But this implies that if a transgression triggers a decline in cooperation in society (e.g., as with contagion strategies), then this will damage the enforcers' incentives to punish.
- If the centralized enforcement technology is sufficiently effective, then it is optimal to rely solely on enforcers without any community enforcement to complement it:
  - centralized enforcers (law enforcement institutions) punish law-breakers;
  - misbehavior by centralized enforcers triggers a collapse of trust in institutions.
- Conversely, if the centralized enforcement technology is sufficiently ineffective, pure community enforcement is optimal.
  - Implication: centralized enforcement more likely in technologically more advanced societies.

Summary of Results

- Under (anonymous) perfect monitoring:
- A particularly simple form of centralized enforcement — **single punishment equilibrium** — where transgressions are punished only for one period and only by centralized enforcers is optimal when the centralized enforcement technology sufficiently effective.
  - There is no community enforcement complementing it.
  - Specialized enforcers are incentivized by having all producers switch to zero effort following an enforcer deviation (a failure to punish a deviating producer) — misbehavior by enforcers leads to collapse of "trust" in "institutions" of society.
- When the centralized enforcement technology sufficiently ineffective, then (pure) contagion strategies, which make no use of centralized enforcement, are approximately optimal.

Summary of Extended Results (Not Covered Today)

- Results broadly generalize to environments with private monitoring:
  1. When agents observe the play in their partners' last matches, the same single punishment strategies remain the most cooperative equilibrium under private monitoring.
  2. When enforcers are at least as well informed as the producers they match with (due to information sharing among them or communication), single punishment equilibria are optimal.
  3. But when producers have superior information, combining community enforcement with graduated punishments with punishments by centralized enforcers may outperform single punishment equilibria.
  4. Under Stability refinement (play returns to the equilibrium path after a single deviation), single punishment equilibria are optimal.
  5. Single punishment strategies also outperform contagion strategies under more general private monitoring setups when the centralized enforcement technology sufficiently effective or when the discount factor is large.
  6. The results can be extended to include ostracism.

Matching

- There is random matching between kn producers and ln enforcers into matches consisting of k producers and l enforcers.
- The game within a match has two stages:
  1. *Cooperation stage:* each producer i chooses a level of cooperation x_i which has a cost of x_i for producer i and creates a benefit of

     $$f(x_i)$$

     on all other agents in the match. We assume that f is increasing, concave, bounded and differentiable with $f(0) = 0$.
  2. *Punishment stage:* each enforcer j chooses a level of punishment y_{ji} directed against some producer i in the match. This costs y_{ji} for the enforcer and creates a damage of

     $$g(y_{ji})$$

     on its intended target, where g is increasing and differentiable with $g(0) = 0$.

Anonymous Perfect Monitoring

- Our baseline assumption is that there is anonymous perfect monitoring, in the sense that each player observes the entire history of play in all matches, but does not know which action was taken by which player.
- This environment builds *anonymity*, which is relevant for the problem of sustaining cooperation in large societies, while at the same time simplifying informational structure.
- We will discuss how our results extend to private monitoring next.

Equilibrium Concept

- This game is played an infinite number of times and all players have discount factor δ.
- *Equilibrium concept*: Perfect Bayesian Equilibrium (PBE) with the additional refinement that all beliefs (on and off path) form a conditional probability system (i.e., following Meyerson, 1991, there are well-defined conditional probabilities shared by all agents).
- But under perfect monitoring, there is no relevant issue of private information and we may alternatively focus on *subgame perfect equilibria* (SPE), and the results are identical.

Contagion Strategies

- A *contagion* (or *grim trigger*) *strategy profile* is characterized by a cooperation level $\hat{x}$ and is represented by the following 2-state automaton:
    - *Normal state:* Producers play $x_i = \hat{x}$.
    - *Infected state:* Producers play $x_i = 0$.
    - Producers start in the normal state, and permanently transition to the infected state if they observe the outcome of a match (including their own) in which some producer i' plays $x_{i'} \neq \hat{x}$.
    - A contagion strategy profile involves no punishment by enforcers.

Single Punishment Strategies

- A *single enforcer punishment strategy profile* is characterized by a cooperation level x^* and a punishment level y^*, and is represented by the following 2-state automaton:
  - *Normal state*: Producer i plays $x_i = x^*$. If all producers in the match play $x_i = x^*$, then enforcer j plays $y_{ji} = 0$ for all i in the match. If instead some producer i in the match plays $x_i \neq x^*$, then enforcer j plays $y_{ji} = y^*$ (choosing randomly who to punish if more than one producer i in the match played $x_i \neq x^*$).
  - *Infected state:* Players always take action 0 (producers never cooperate; enforcers never punish).
- Players start in the normal state, and permanently transition to the infected state if they observe the outcome of a match (including their own) in which some producer i has played $x_i \neq x^*$ *and* some enforcer j has played $y_{ji'} \neq y^*$ against all deviations.

Single Punishment SPE

- The SPE that generates the greatest amount of cooperation with single punishment strategies is represented by (x^*, y^*) corresponding to the greatest solution to the system of equations:

$$\begin{aligned} x^* &= lg\left(y^*\right) \\ y^* &= \frac{\delta}{1-\delta} kf\left(x^*\right). \end{aligned}$$

- This is intuitive: in a single punishment SPE, a deviation from the prescribed level of cooperation, x^*, garners a total punishment of $lg\left(y^*\right)$, while a deviation by an enforcer triggers a complete collapse of cooperation, costing him $\frac{\delta}{1-\delta} kf\left(x^*\right)$ (the future benefit of cooperation at level x^* from k producers).

Main Result

- Let

$$m \equiv \frac{(k-1)\,n}{(kn-1)\,l} \in [0,1)\,.$$

Theorem

With perfect monitoring,

1. *If $g'(y) \geq m$ for all $y \in \mathbb{R}_+$, then the single enforcer punishment strategy profile with cooperation level x^* and punishment level y^* is the most cooperative equilibrium.*
2. *For all $\varepsilon > 0$, there exists $\eta > 0$ such that if $g'(y) < \eta$ for all $y \in \mathbb{R}_+$, then the contagion strategy profile with cooperation level $\hat{x}$, where $\hat{x} = \delta\,(k-1)\,f\,(\hat{x})$, attains within ε of the maximum level of cooperation.*

Interpretation

- If the centralized enforcement technology is sufficiently effective, meaning that $g'(y) \geq m$, it is optimal to rely solely on enforcers and only for a one period punishment.
  - If enforces deviate, then this triggers an agent strategies leading to total collapse of trust/cooperation in society.
- If the centralized enforcement technology is very ineffective, then (pure) contagion strategies are optimal.
- *Implication:* Specialized enforcement is more likely to emerge in technologically more advanced societies and community enforcement in technologically less advanced societies.

Intuition

- From Abreu (1988), it would appear that the optimal arrangement should seek to minimize continuation payoffs, and thus combine centralized enforcement and community enforcement (withdrawal of cooperation).
- But this intuition is not right because community enforcement would interfere with the effectiveness of centralized enforcement — or arrangements that are desirable under "private order" would damage the workings of "public order".

Understanding the Theorem

- The direct effect of reducing a producer's cooperation after producer deviation by one unit is to reduce the deviator's payoff by

$$\frac{k-1}{kn-1} f'(x)$$

where $\frac{k-1}{kn-1}$ is the probability that the deviator matches with a given producer. This effect increases on-path incentives for cooperation.

- It also has an indirect effect on on-path incentives by

$$\frac{l}{n} f'(x) g'(y).$$

as it reduces the payoffs of enforcers and thus the amount of enforcers punishment by $\frac{1}{n} f'(x)$ units (as $\frac{1}{n}$ is the probability that the enforcer matches with a given producer), and each unit of reduced punishment decreases the deviator's payoff by $lg'(y)$.

- Therefore, withdrawing producer cooperation following a deviation on on-path producer incentives is negative if $g'(y) \geq \frac{(k-1)n}{(kn-1)l} = m$.

Uniqueness

- When $g'(y) > m$, the single enforcer punishment strategy profile (x^*, y^*) is essentially the *unique* most cooperative equilibrium in the sense that any equilibrium that supports cooperation level x^* for each producer must have the following features:

1. Each producer i plays $x_i = x^*$ at every on-path history.
2. If a single producer i deviates to $x_i = 0$ at an on-path history, she is punished at level y^*, and the path of play then returns to all producers playing x^* forever.
3. If a single producer i deviates to $x_i = 0$ at an on-path history and an enforcer j in the match deviates to $y_{ji} = 0$, then all producers stop cooperating forever.
4. The path of continuation play where all producers play x^* forever is always supported by the threat of punishment at level y^*—which in turn is always supported by the threat of all producers withdrawing cooperation—even when this continuation path starts at an off-path history.

Intermediate Equilibria

- In the intermediate region of the effectiveness of the centralized enforcement technology, equilibria take a hybrid form.

Proposition

Suppose money burning is allowed. Then, with perfect monitoring, if $g'(y) < m$ for all $y \in \mathbb{R}_+$ and money burning is available, then single enforcer punishment strategies are not optimal, and the most cooperative equilibrium involves "community enforcement".

- Here "community enforcement" means that there will be some amount of withdrawal of cooperation following a deviation.
- Money burning here plays a technical role (and whether money burning is allowed or not has no impact on our main theorem).
- But this result overstates role of hybrid arrangements.

More on Contagion Strategies

- If society could also choose the allocation of agents between these two occupations, then we get (pure) contagion strategies under weaker sufficient conditions.

Theorem

Suppose a social planner can choose k and l (along with an equilibrium) subject to $k + l = s$ to maximize utilitarian social welfare. Then, assuming the maximum level of cooperation is below the first best level, if

$$g'(y) \leq \frac{1}{\frac{1}{n} + \frac{\delta}{1-\delta} s} \text{ for all } y \in \mathbb{R}_+ \tag{1}$$

then the social planner would prefer to have all agents become producers (i.e., set $k = s$) and support cooperation using pure contagion strategies.

Part II: State Capacity and Development—A Network Approach

- State capacity first requires the presence of the state or what Michael Mann called the "infrastructural power" of the state—presence of state agencies and public employees.
- State capacity is as much about local state presence.
- But in a country with endemic absence of the state, such as Colombia, local state presence doesn't just have direct effects.
- Indirect effects (spillovers) may be important:
  - public good provision, policing, and law enforcement will impact neighboring municipalities.
  - possibility of strategic interactions, free riding or complementarities in investments.

Question

- This paper:
  - Game theoretic model to understand interactions among municipalities and between municipalities and the national state in state capacity choices.
  - Estimate this model using data from Colombian municipalities to uncover:
    1. the **own effect** of state capacity on public goods and prosperity;
    2. the **spillover effects** of state capacity;
    3. the (strategic) **interaction effects** in state capacity choices (in particular, whether these are strategic complements or substitutes);
    4. the relationship between local and national state capacity choices.

Challenges

- We face and address several key challenges:
  1. State capacity choices are endogenous.
  2. The estimation of spillovers ("contextual effects") is fraught with econometric difficulties because of reasons that relate to both endogeneity and correlated effects.
  3. The estimation of strategic interactions is even more difficult, taking us to the territory of Manski's "endogenous effects".

Approach

- Estimate the parameters of the game between municipalities structurally.
- This is necessitated by a general observation:
    - When choices are strategic in this class of games, the relevant effects—in particular, own effects and interaction effects—cannot be estimated from the outcome equation (even with perfect instruments).
- However, our model makes it clear how these can be identified using the structure of the model with the right source of variation.
- Use several sources of historical variation in conjunction with the network structure for estimation.
    - Methodology dealing specifically with the presence of correlated effects in outcomes and state capacity today.
    - Verify that specific functional forms are not driving our results.
- Use estimates for counterfactual analysis—where equilibrium (network) interactions turn out to be hugely important.

Preview of Results

- In the Colombian context, we estimate large, precise and robust effects of own and neighbors' state capacity on public goods and prosperity.
- State capacity investments are strategic complements
- In partial equilibrium (holding best replies constant) the effect of a change in own state capacity has an own effect an order of magnitude larger than the spillover effect on a neighbor.
- A 1/4 standard deviation increase in the number of own state agencies leads to:
  - 1 pp reduction in own population below the poverty line;
  - 0.1 pp reduction in a 25 kms-away neighbor's population below the poverty line.
- Total effects of neighbors larger, of the same order of magnitude as own effect, because externalities imposed on several neighbors.
- The full equilibrium effects, with equilibrium responses from the network, much much larger—an additional 80 to 90% shift.

Colombian Context

- General agreement that the weakness of the state and lack of economic integration have been a major problem in Colombian history and economic development.
- Country split by the Andes creating relatively isolated subregions.
- Colonial state concentrated in a few places and absent from much of the rest of the country.
- In the 19th century, number of public employees relative to population about 1/10 of contemporary US level.
- Rufino Gutierrez in 1912:

> *"...in most municipalities there was no city council, mayor, district judge, tax collector... even less for road-building boards, nor whom to count on for the collection and distribution of rents, nor who may dare collect the property tax or any other contribution to the politically connected..."*

Model

- Network game of public goods provision
- Interpret the administrative municipality-level map as a network:
  - Each municipality is a node
  - Each adjacency implies a link (undirected).
- Municipalities (and the national level) choose their levels of state capacity simultaneously.
- Utility functions are “reduced form” for a political economy process where state capacity has both costs and benefits.
- The national state has heterogeneous preferences over outcomes of different municipalities (cares more about some).

Model: Network Structure

Network Structure:

- We represent the network with matrix $\mathbf{N}(\delta)$ with entries n_{ij} where

$$n_{ij} = \begin{cases} 0 & \text{if } j \notin N(i) \\ f_{ij} & \text{if } j \in N(i) \end{cases}$$

where

$$f_{ij} = f(d_{ij}, e_{ij}, \delta).$$

- $N(i)$ is the set of neighbors of i, d_{ij} is geodesic distance between i and j, e_{ij} is variability in altitude along the geodesic.
- In our benchmark, a network link is given by adjacency between municipalities.

Model: Technology

- We allow different dimensions of prosperity $j = 1, \ldots J$ to depend upon own and neighbors' state capacity:

$$p_i^j = (\kappa_i + \xi_i)s_i + \psi_1 s_i \mathbf{N}_i(\delta)\mathbf{s} + \psi_2^j \mathbf{N}_i(\delta)\mathbf{s} + \epsilon_i^j.$$

  where $\mathbf{N}_i(\delta)$ denotes the ith row of the network matrix.
- $\kappa_i + \xi_i$ is the effect of own state on own prosperity (heterogeneous, has observable and unobservable components);
- ψ_1 is the interaction effect (its sign determines whether this is a game of strategic complements or substitutes)
- ψ_2^j is a pure spillover effect from neighbors;

Model: State Capacity

- We allow “state capacity” to be a CES composite of locally chosen l_i and nationally decided b_i measures of state presence:

$$s_i = \left[\alpha l_i^{\frac{\sigma-1}{\sigma}} + (1-\alpha) b_i^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \quad , \sigma > 0$$

- We will separately treat the special case where $\alpha = 1$ and the general case where $\alpha > 0$ and national bureaucracy also matters and is endogenously determined.

Model: Preferences

- Municipality i maximizes

$$U_i = \mathbb{E}_\epsilon \left[\frac{1}{J} \sum_j p_i^j - \frac{\theta}{2} l_i^2 \right].$$

- The national state maximizes

$$W_i = \mathbb{E}_\epsilon \left[\sum_i \left\{ U_i \zeta_i - \frac{\eta}{2} b_i^2 \right\} \right]$$

where the ζ_i are unobserved weights the national state puts on each i.

Model: Game

- National and local-level state capacities are chosen simultaneously. This gives us straightforward first-order conditions.
- Municipality choices:

$$\alpha \left[\frac{s_i}{l_i}\right]^{\frac{1}{\sigma}} \left[(\kappa_i + \xi_i) + \psi_1 \mathbf{N}_i(\delta)\mathbf{s}\right] - \theta l_i \begin{cases} < 0 & l_i = 0 \\ = 0 & , l_i > 0 \end{cases}.$$

- A game of strategic complements or substitutes depending on ψ_1:

$$\frac{\partial l_i}{\partial \mathbf{N}_i(\delta)\mathbf{s}} > 0 \Longleftrightarrow \psi_1 > 0$$

- We also derive the national state's first-order conditions (not shown here):
    - The main difference is that the national state does take into account spillovers, and weights municipalities heterogeneously.

Model: Linear Case

- When $\alpha = 1$ the game described above simplifies considerably.
- National-level choices no longer relevant, and $s_i = l_i$.
- Best responses become linear in neighbors' choices

$$s_i = \frac{\psi_1}{\theta}\mathbf{N}_i(\delta)\mathbf{s} + \frac{\kappa_i}{\theta} + \tilde{\xi}_i. \tag{2}$$

Proposition

(Bramoulle, Kranton, and D'Amours (2012)): If $|\lambda_{min}(\mathbf{N}(\delta))| < \left(\frac{\psi_1}{\theta}\right)^{-1}$ *the game has a unique Nash equilibrium.*

- Notice that the reduced-form coefficient $\frac{\psi_1}{\theta}$ is analogous to what Manski (1993) would call an "endogenous effect"
  - Thus we must deal with the "reflection problem". Particularly serious since $\tilde{\xi}_i$'s likely to be spatially correlated.

Model: Identification Problem

- Substitute best responses into the prosperity equation

$$p_i^j = \theta s_i^2 + \psi_2^j \mathbf{N}_i(\delta)\mathbf{s} + \epsilon_i^j. \tag{3}$$

- In equilibrium, the own effect, κ_i, and the interaction effect, ψ_1, drop out, and cannot be identified by running a regression of outcomes.
- This is because state capacity choices are (endogenously) a function of κ_i and ψ_1.
  - In addition, a quadratic relationship.
- Another identification challenge: ϵ_i^j's also likely to be spatially correlated.

Model: Identification Idea

- Parameter κ_i a function of historical variables (described below) which are plausibly exogenous to the current development of state capacity and current prosperity.
  - Also, conveniently, they happen to be spatially uncorrelated.
- Using these variables and the network structure, estimate (2) and (3)—using linear IV, system GMM, or simulated method of moments (SMM).
- From (2), we estimate $\frac{\psi_1}{\theta}$ (from the endogenous effect) and (local) average κ_i (from the intercept).
- From (3), we estimate θ and ψ_2, fully identifying all of the parameters.
- Note the importance of estimating the endogenous effect, from which the crucial identification of the outcome equation comes.

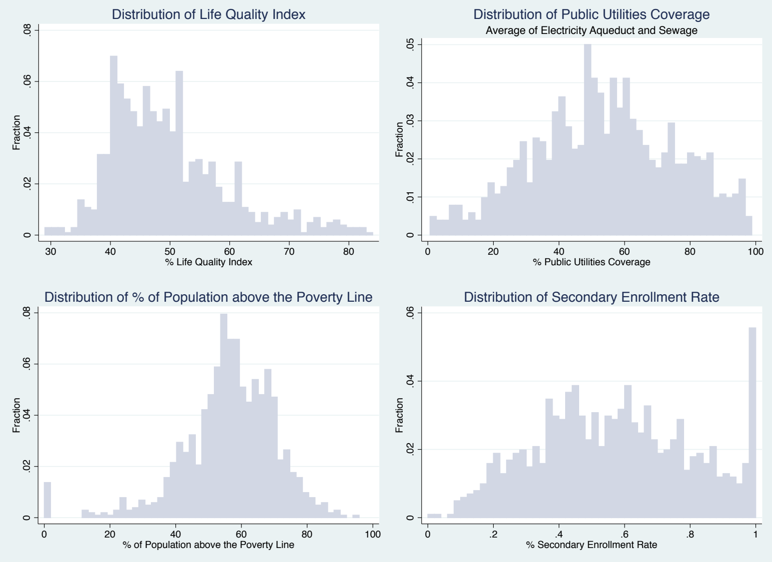
Data: Network

- Given the cross-sectional nature of the data $\{(\mathbf{p}_i, l_i, b_i, \mathbf{x}_i, \mathbf{c}_i)_{i=1}^n, \mathbf{D}, \mathbf{E}, \mathbf{A}\}$, we consider our data to reflect the resting point of a long-run process of best reply dynamics
- Data for 1,019 of the 1,103 Colombian municipalities:
- We constructed:
  - Adjacency matrix of Colombian municipalities $\mathbf{A}$.
  - Matrix of geodesic distances between centroids of municipalities $\mathbf{D}$.
  - Matrix of altitude variability of geodesics between municipalities $\mathbf{E}$.

Data: Prosperity

- Life Quality Index p_i^1 (computed by statistical office using house characteristics, e.g., sewage, water, garbage collection, kind of stove, material of house floors, number of people per room).
- Average coverage rate of public utilities (aqueduct, sewage, electricity) p_i^2.
- Fraction of the population above the poverty line p_i^3.
- Secondary Enrollment rate p_i^4.

Data: Prosperity



Data: State Capacity

- Local state capacity l_i. Two alternate variables:
  - Number of municipality-level public employees.
  - Number of municipality-level public agencies:
    - notary offices, telecom offices, post offices, agricultural bank offices, health care centers, health posts, public schools, public libraries, fire stations, tax collection offices.
- National state capacity b_i:
  - Number of national bureaucrats (includes police, military, judges, other judicial employees).

Data: Spanish Colonial State

- We coded detailed data on the presence of the colonial state in 1794 from an original source (Duran y Diaz, 1794).
  - Contains a full account of state officials, salaries, the military, tariffs, taxes, revenue, for the Viceroyalty of Nueva Granada.
  - Based on it we coded two variables:
    - **Number of crown employees** c_i^1.
    - **Count of the number of state agencies** (Duran y Diaz reports information on the presence of alcabalas, estancos and post offices) c_i^2.
- Additionally, we georeferenced historical maps depicting **royal roads**, and computed the distance of each municipality to the closest royal road c_i^3.
- We also collected historical population data from the 1843 Census.

Strategy: What We Don't Do

- Common in the literature are two strategies. First, assume away correlated effects.
- Second, exploit network structure to break the "reflection problem".
- Most creatively: Bramoulle et al (2009):
  - If for every node i $\exists k$ such that $k \in N(j)$, $j \in N(i)$, and $k \notin N(i)$, then covariate x_k is a valid instrument.
  - Thus use powers of $\mathbf{N}_i(\delta)\mathbf{x}$ as instruments for s_i.
  - But problem: we may not know network structure exactly and more importantly, correlated effects that extend beyond immediate neighborhood.

Empirical Strategy: Exclusion Restrictions

- Formally:

$$cov(\mathbf{N}_i(\delta)\mathbf{c}, \tilde{\xi}_i) = cov(\mathbf{N}_i^2(\delta)\mathbf{c}, \tilde{\xi}_i) = 0$$

  and

$$cov(\mathbf{c}, \epsilon_i^j) = cov(\mathbf{N}_i(\delta)\mathbf{c}, \epsilon_i^j) = cov(\mathbf{N}_i^2(\delta)\mathbf{c}, \epsilon_i^j) = 0.$$

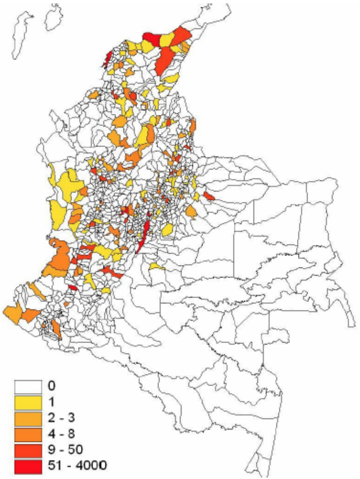
- Why is this plausible?

Empirical Strategy: Colonial State Presence

- Highly concentrated colonial state presence around key cities and resources:
  - Colonial state presence in gold mining regions related to taxation purposes.
  - Colonial state presence in high native population regions related to control of the population, legal adjudication, etc.
  - Colonial state presence in geographically strategic places related to military aims.
- Gold mining, native populations and those military aims are no longer relevant. So the direct effect of colonial state presence is by creating the infrastructure for current state presence.

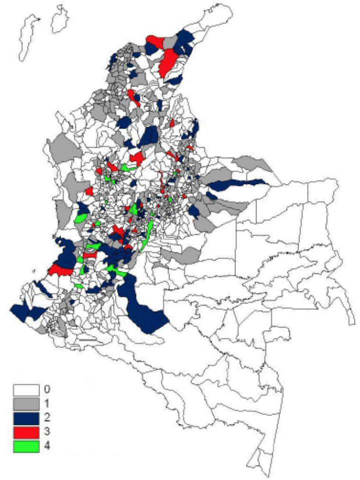
Colonial State Presence, 1794

Crown Employees



Source: Duran y Díaz (1794)

State Agencies



Source: Duran y Díaz (1794)

Empirical Strategy: Royal Roads

- Royal roads were one of the few investments in infrastructure (building upon pre-colonial roads).
- The presence of royal roads is a good indicator of where the colonial state was interested in reaching out, and controlling territory.
- But most of these royal roads were subsequently abandoned as transportation infrastructure.
  - Most of these were built for porterage along difficult geography, making them hard to subsequently reconvert to new transportation technologies.
- Good case that these are excludable (especially conditional on current road network).

Royal Roads

Empirical Strategy: Correlated Effects

- If instruments are spatially correlated, the spatial correlation of current outcomes might project on them, leading to bias.
- Very little spatial correlation of these variables.

Within-Department Spatial Correlation of the Historical State Presence variables

	1	**2**	**3**
1. Own Distance to Royal Roads	1.000		
2. Neighbors' average distance to Royal Roads	0.283	1.000	
3. Neighbors of neighbors' distance to Royal Roads	0.045	0.615	1.000
1. Own Colonial officials	1.000		
2. Neighbors' average colonial officials	-0.061	1.000	
3. Neighbors of neighbors' colonial officials	-0.062	-0.070	1.000
1. Own Colonial state agencies	1.000		
2. Neighbors' average colonial state agencies	0.022	1.000	
3. Neighbors of neighbors' colonial state agencies	0.078	0.289	1.000

Empirical Strategy: Linear Model

- Now focus on $\alpha = 1$ (linear best responses and prosperity equations).
- Suppose that $\frac{\kappa_i}{\theta} = g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta}) + \varsigma^D$, where ς^D are department fixed effects.
- Then we have

$$s_i = \frac{\psi_1}{\theta}\mathbf{N}_i(\delta)\mathbf{s} + g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta}) + \varsigma^D + \tilde{\xi}_i.$$

$$p_i^j = \theta s_i^2 + \psi_2^j\mathbf{N}_i(\delta)\mathbf{s} + \mathbf{x}_i\tilde{\boldsymbol{\beta}}^j + \tilde{\varsigma}^{jD} + \epsilon_i^j.$$

- Two econometric strategies
  - Linear IV (normalizing $\delta = (1, 1)$) estimate these equations separately.
  - System GMM ($J + 1$ equations) that exploits the joint dependence on θ, and allows for estimation of δ.

Results: First Stage for Best Response

Contemporary State Equilibrium Best Response

State Capacity Measured as log of Number of:		State Agencies		Municipality Employees	
		(2) IV	(3) IV	(6) IV	(7) IV
		First Stage for $N_i(\delta)$s			
Neighbors' Colonial State officials		0.320	0.338	0.556	0.637
		(0.093)	(0.097)	(0.142)	(0.152)
Neighbors' Colonial State agencies		1.275	1.242	1.673	1.631
		(0.124)	(0.129)	(0.210)	(0.222)
Neighbors' Distance to Royal Road		-1.031	-0.992	-1.497	-1.456
		(0.208)	(0.211)	(0.266)	(0.274)
Neighbors of Neighbors' Colonial State officials		0.209	0.269	0.311	0.427
		(0.169)	(0.176)	(0.238)	(0.255)
Neighbors of Neighbors' Colonial State agencies		0.649	0.568	1.085	0.937
		(0.176)	(0.184)	(0.263)	(0.279)
Neighbors of Neighbors' Distance to Royal Road		0.178	0.172	0.268	0.296
		(0.166)	(0.170)	(0.228)	(0.233)
First stage R squared:		0.681	0.671	0.681	0.658
F-test for excluded instruments**:**		17.0	145.6	19.55	171.0
F-test p-value		0.000	0.000	0.000	0.000
Overidentification Test:	**Test statistic**	4.053	6.350	4.399	5.775
Chi-Squared(2)	**P-value**	0.542	0.385	0.494	0.449

Results: First Stage for Best Response

- Very strong first stage.
- Overidentification tests never reject the validity of subsets of instruments.
- Effects plausible:
  - Neighbors' colonial state officials and agencies significantly increase neighbors' state capacity today.
  - Neighbors' distance to royal roads significantly reduce neighbors' capacity today.
  - Weaker but still significant effects of neighbors of neighbors.

Results: Best Response Equation

Contemporary State Equilibrium Best Response

State Capacity Measured as log of:	Number of State Agencies			Number of Municipality Employees		
	(1)	(2)	(3)	(5)	(6)	(7)
	OLS	IV	IV	OLS	IV	IV
Average Marginal Effects	Equilibrium Best Response					
ds_i/ds_j	0.016	0.017	0.019	0.021	0.022	0.022
	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)
ds_i/dColonial state officials_i	0.127	0.128	0.108	0.129	0.130	0.105
	(0.031)	(0.031)	(0.033)	(0.043)	(0.043)	(0.046)
ds_i/dColonial state agencies_i	0.003	0.001	-0.016	0.017	0.017	-0.002
	(0.032)	(0.033)	(0.032)	(0.058)	(0.059)	(0.061)
ds_i/dDistance to royal road_i	0.008	0.010	0.007	-0.035	-0.035	-0.038
	(0.019)	(0.019)	(0.021)	(0.034)	(0.035)	(0.036)
Population	Control	Control	Instrum	Control	Control	Instrum
Observations	975	975	975	1017	1017	1017

Results: Best Response Equation

- Best responses slope upward (investments in state capacity are strategic complements).
- Own colonial state officials significantly increase own state capacity today.
- Conditional on this, colonial state agencies and distance to royal roads insignificant, but significant with the right sign when colonial state officials are excluded.

Results: Prosperity Equation

Prosperity and Public Goods Structural Equation

State Capacity Measured as: Log of Number of Municipality State Agencies

Dependent variable	LIFE QUALTY INDEX 1998			PUBLIC UTILITIES COVERAGE 02		
	(1) OLS	(2) IV	(3) IV	(5) OLS	(6) IV	(7) IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**					
dp_i/ds_i	0.802	0.394	0.389	0.602	0.563	0.567
	(0.044)	(0.133)	(0.141)	(0.037)	(0.125)	(0.133)
dp_i/ds_j	0.015	0.024	0.025	0.022	0.020	0.020
	(0.004)	(0.006)	(0.006)	(0.003)	(0.005)	(0.006)
First Stage Linear Model:	**First Stage for s_i^2**					
F-test for excluded instruments**:**		31.23	35.39		31.01	35.06
F-test p-value		0.000	0.000		0.000	0.000
First Stage R squared		0.670	0.655		0.670	0.655
First Stage Linear Model:	**First Stage for $N_i(\delta)$s**					
F-test for excluded instruments**:**		526.7	523.7		524.6	522.1
F-test p-value		0.000	0.000		0.000	0.000
First Stage R squared		0.769	0.770		0.769	0.770
Population	Control	Control	Instrum	Control	Control	Instrum
Observations	973	973	973	975	975	975

Results: Prosperity Equation

Prosperity and Public Goods Structural Equation

State Capacity Measured as: Log of Number of Municipality State Agencies

Dependent variable	NOT IN POVERTY 2005			SECONDARY ENROLLMENT 92-02		
	(9)	(10)	(11)	(13)	(14)	(15)
	OLS	IV	IV	OLS	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**					
dp_i/ds_i	0.520	0.342	0.353	0.515	0.178	0.223
	(0.038)	(0.139)	(0.145)	(0.049)	(0.178)	(0.185)
dp_i/ds_j	0.019	0.021	0.021	0.023	0.036	0.035
	(0.004)	(0.005)	(0.006)	(0.005)	(0.007)	(0.007)
First Stage Linear Model:	**First Stage for s_i^2**					
F-test for excluded instruments**:**		31.01	35.06		30.46	35.70
F-test p-value		0.000	0.000		0.000	0.000
First Stage R squared		0.670	0.655		0.675	0.662
First Stage Linear Model:	**First Stage for $N_i(\delta)$s**					
F-test for excluded instruments**:**		524.6	522.1		579.3	583.1
F-test p-value		0.000	0.000		0.000	0.000
First Stage R squared		0.769	0.770		0.771	0.773
Population	Control	Control	Instrum	Control	Control	Instrum
Observations	975	975	975	965	965	965

Results: Prosperity Equation Interpretation

- At the estimated parameter values, the uniqueness condition is always satisfied.
- Own effect more than 10 times the impact on neighbors, which is plausible.
- But the externality is on several neighbors, so the partial equilibrium spillover and direct effects comparable.
- But full equilibrium effects, factoring in endogenous responses, indicate much larger network effects than direct effect.

Results: Quantitative Magnitudes

Experiment:

Take all municipalities with local state capacity below median to the median

Panel I					Linear Model					
Partial Equilibrium change in:	**local agencies:**		**Life Quality Index**		**Utilities Coverage**		**% not in Poverty**		**Secondary Enrollment**	
	From	To	From	To	From	To	From	To	From	To
Change in median:	10	10	48.0	49.0	53.3	57.2	57.1	60.0	56.6	59.2
Fraction due to own effect:			53.4%		51.7%		57.1%		45.5%	
Fraction due to spillovers:			46.6%		48.3%		43.0%		54.5%	
General Equilibrium change in:	**local agencies:**		**Life Quality Index**		**Utilities Coverage**		**% not in Poverty**		**Secondary Enrollment**	
	From	To	From	To	From	To	From	To	From	To
Change in median:	10	20.6	48.0	58.2	53.3	73.7	57.1	68.3	56.6	82.4
Fraction due to direct effect:			9.8%		18.9%		25.5%		10.1%	
Fraction due to network effects:			90.2%		81.1%		74.5%		89.9%	

Results: Quantitative Magnitudes

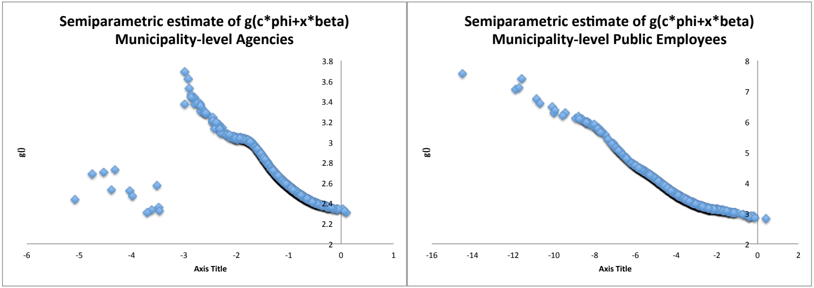
- For example, increasing local state presence in all municipalities below the median to the median of the country, holding all other state capacity choices fixed, increases fraction of the population above poverty from 57% to 60%.
- About 57% of this increase is due to direct effects, and the remaining 43% to spillovers.
- But this induced change in state capacities leads to further network responses—through strategic complementarities.
- Once these are factored in, fraction of the population above poverty rises to 68%— of course all of this due to network effects.

Results: System GMM

- Very similar results and magnitudes with System GMM.
- The $g(\cdot)$ function is indeed nonlinear, but implied quantitative magnitudes are essentially the same.

Results: System GMM

Figure 3



Results: System GMM

Contemporary State Equilibrium Best Response

State Capacity Measured as log of:	Number of State Agencies	Number of Municipality Employees
	(4)**	(8)**
	System GMM	System GMM
	Equilibrium Best Response	
Average Marginal Effects		
ds_i/ds_j	0.020	0.016
	(0.003)	(0.003)
ds_i/dColonial state officials_i	-0.041	0.084
	(0.052)	(0.065)
ds_i/dColonial state agencies_i	0.095	0.086
	(0.057)	(0.079)
ds_i/dDistance to royal road_i	0.073	-0.037
	(0.035)	(0.041)
Population	Instrum	Instrum
Observations	963	1003

Results: System GMM

Prosperity and Public Goods Structural Equation

State capacity measured as: log of number of municipality state agencies

Dependent variable	**Life Quality Index 1998**	**Public utilities coverage**
	(4)	(8)
	System GMM	System GMM
	Prosperity Equation	
dpi/dsi	0.314	0.314
	(0.041)	(0.041)
dpi/dsj	0.025	0.027
	(0.004)	(0.003)
Log population	Instrum	Instrum
Observations	963	963

State capacity measured as: log of number of municipality state agencies

Dependent variable	**Not in Poverty 2005**	**Secondary Enrollment 92-02**
	(12)	**(16)**
	System GMM	System GMM
	Prosperity Equation	
dpi/dsi	0.314	0.314
	(0.041)	(0.041)
dpi/dsj	0.021	0.035
	(0.003)	(0.004)
Log population	Instrum	Instrum
Observations	963	963

Specification Tests and Robustness

- Verify that:
    - Even with a "naive" prosperity equation, similar results—functional forms not crucial.
    - Residuals uncorrelated with network centrality statistics.
    - Placebo exercise: outcomes not determined by local state presence are unaffected.
    - Placebo exercise: Historical outcomes not correlated with neighboring colonial state presence.
    - Similar results when we do not control for distance to current highways.
    - Similar results combining our instruments with Bramoulle et al (2009) strategy (useful if there are concerns of correlation of instruments).

Specification Tests and Robustness

- Verify that:
  - Similar results if spillovers also on neighbors of neighbors.
  - Similar results with subsets of instruments.
  - Similar results decomposing state presence into components.
  - Similar results excluding high-violence municipalities.
  - Similar results conditioning on national bureaucrats—preparing for the general model.
  - Similar results with a quadratic-in-neighbors'-state capacity prosperity equation.
  - Similar results including contextual effects.

Robustness: Naive Prosperity Equation

Prosperity and Public Goods "Naïve" Equation (without an interaction term)

State Capacity Measured as: Log of Number of Municipality State Agencies

Dependent variable	LIFE QUALTY INDEX 1998		PUBLIC UTILITIES COVERAGE 02		NOT IN POVERTY 2005		SECONDARY ENROLLMENT 92-02	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation (linear on s_i)**							
dp_i/ds_i	0.669	0.145	0.556	0.360	0.457	0.199	0.426	0.106
	(0.043)	(0.095)	(0.034)	(0.082)	(0.038)	(0.094)	(0.050)	(0.117)
dp_i/ds_j	0.015	0.031	0.021	0.024	0.019	0.025	0.023	0.038
	(0.004)	(0.006)	(0.003)	(0.005)	(0.004)	(0.005)	(0.005)	(0.007)
Observations	973	973	975	975	975	975	965	965

State Capacity Measured as: Log of Number of Municipality Employees

Dependent variable	LIFE QUALTY INDEX 1998		PUBLIC UTILITIES COVERAGE 02		NOT IN POVERTY 2005		SECONDARY ENROLLMENT 92-02	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation (linear on s_i)**							
dp_i/ds_i	0.465	0.112	0.288	0.279	0.240	0.196	0.216	0.143
	(0.024)	(0.068)	(0.022)	(0.066)	(0.023)	(0.073)	(0.028)	(0.091)
dp_i/ds_j	0.014	0.025	0.018	0.017	0.018	0.016	0.020	0.024
	(0.003)	(0.005)	(0.002)	(0.004)	(0.003)	(0.004)	(0.003)	(0.005)
Observations	1014	1014	1017	1017	1017	1017	1006	1006

Specification Test: Correlation of Residuals and Network Centrality

Specification Test: Correlations between Residuals and Network Centrality Statistics

Panel I	State capacity measured as: log of number of municipality state agencies				
	Best response equation residuals	Life quality index equation residuals	Utilities coverage equation residuals	% not in poverty equation residuals	Secondary enrollment equation residuals
Betweeness Centrality	-0.041	0.014	0.005	0.020	0.021
	[0.201]	[0.67]	[0.875]	[0.536]	[0.519]
Bonacich Centrality	0.035	0.035	0.018	0.015	0.032
	[0.278]	[0.282]	[0.569]	[0.644]	[0.314]
Panel II	State capacity measured as: log of number of municipality public employees				
	Best response equation residuals	Life quality index equation residuals	Utilities coverage equation residuals	% not in poverty equation residuals	Secondary enrollment equation residuals
Betweeness Centrality	-0.004	0.013	-0.007	0.009	0.021
	[0.896]	[0.675]	[0.834]	[0.774]	[0.500]
Bonacich Centrality	0.038	0.042	-0.011	-0.005	0.035
	[0.232]	[0.186]	[0.733]	[0.879]	[0.272]

Robustness: Placebo Regressions (Current outcomes)

Placebo Exercise: Nationally Determined Prosperity and Public Goods Outcomes Structural Equation

State Capacity measured as:	**Log of Number of Municipality State Agencies**				**Log of Number of Municipality Employees**			
Dependent variable	PRIMARY ENROLLMENT 92-02		VACCINATION COVERAGE 1998		PRIMARY ENROLLMENT 92-02		VACCINATION COVERAGE 1998	
	(1)	(2)	(4)	(5)	(7)	(8)	(10)	(11)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**							
dp_i/ds_i	-0.049	0.198	0.015	0.260	-0.007	0.355	0.013	0.134
	(0.050)	(0.208)	(0.046)	(0.198)	(0.027)	(0.154)	(0.025)	(0.142)
dp_i/ds_j	0.001	-0.002	0.004	-0.002	0.000	-0.011	-0.002	-0.005
	(0.005)	(0.007)	(0.005)	(0.008)	(0.003)	(0.007)	(0.003)	(0.006)
	First Stage on si^2							
F-test for excluded instruments**:**		36.41		35.06		29.33		27.42
F-test p-value		0.000		0.000		0.000		0.000
First Stage R squared		0.663		0.655		0.597		0.575
	First Stage on Ni(δ)si							
F-test for excluded instruments**:**		585.0		522.1		490.5		457.4
F-test p-value		0.000		0.000		0.000		0.000
First Stage R squared		0.773		0.770		0.768		0.758
Observations	963	963	975	975	1004	1004	1017	1017

Robustness: Placebo Regressions (Historical outcomes)

Placebo Exercise: Current vs. Historical Prosperity

Correlation between historical (1918) prosperity and instruments

	Literacy rate in 1918		Schooling rate in 1918	
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
	Reduced form			
Neighbors' colonial state officials	0.719	0.837	-0.579	-0.541
	(0.522)	(0.519)	(0.569)	(0.581)
Neighbors' colonial state agencies	-0.479	-0.545	1.553	1.532
	(0.697)	(0.692)	(0.936)	(0.945)
Neighbors' distance to royal road	-0.350	-0.377	-0.383	-0.392
	(0.654)	(0.646)	(0.696)	(0.697)
F-test for joint significance of instruments:	0.98	1.25	1.57	1.56
F-test p-value	0.401	0.289	0.194	0.197
Control for historical 1843 population	No	Yes	No	Yes
Observations	683	683	683	683

Robustness: Omitting Distance to Current Highways

Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Without Controlling for Distance to Current Highway

State Capacity measured as:	**Log of Number of Municipality State Agencies**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.436	0.648	0.400	0.304
	(0.138)	(0.132)	(0.146)	(0.181)
dp_i/ds_j	0.025	0.020	0.022	0.035
	(0.006)	(0.006)	(0.006)	(0.007)
Observations	973	975	975	965

State Capacity measured as:	**Log of Number of Municipality Employees**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.270	0.395	0.337	0.286
	(0.085)	(0.105)	(0.114)	(0.131)
dp_i/ds_j	0.021	0.015	0.013	0.020
	(0.004)	(0.005)	(0.005)	(0.006)
Observations	1014	1017	1017	1006

Robustness: Bramoulle et al (2009)

Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Using neighbors of neighbors of neighbors as instruments

State Capacity measured as:	**Log of Number of Municipality State Agencies**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.617	0.763	0.479	0.318
	(0.110)	(0.115)	(0.126)	(0.161)
dp_i/ds_j	0.024	0.028	0.026	0.038
	(0.007)	(0.007)	(0.007)	(0.009)
Observations	973	975	975	965

State Capacity measured as:	**Log of Number of Municipality Employees**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.411	0.423	0.330	0.222
	(0.066)	(0.079)	(0.088)	(0.103)
dp_i/ds_j	0.017	0.021	0.018	0.027
	(0.005)	(0.005)	(0.005)	(0.007)
Observations	1014	1017	1017	1006

Robustness: Neighbors of Neighbors also Linked

Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Defining links to include neighbors and neighbors of neighbors

State Capacity measured as:	**Log of Number of Municipality State Agencies**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.519	0.693	0.375	0.365
	(0.112)	(0.113)	(0.128)	(0.163)
dp_i/ds_j	0.007	0.007	0.007	0.011
	(0.002)	(0.002)	(0.002)	(0.003)
Observations	973	975	975	965

State Capacity measured as:	**Log of Number of Municipality Employees**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.374	0.331	0.296	0.226
	(0.068)	(0.078)	(0.094)	(0.105)
dp_i/ds_j	0.005	0.006	0.005	0.008
	(0.001)	(0.001)	(0.002)	(0.002)
Observations	1014	1017	1017	1006

Robustness: Unbundling State Agencies

Contemporary State Equilibrium Best Response

Subsets of Municipality Agencies

State Capacity Measured as Log of Municipality:	All Agencies	Health Agencies	Regulation Agencies	Services Agencies	Education Agencies
	(1)	(1)	(2)	(3)	(4)
	IV	IV	IV	IV	IV
Average Marginal Effects			Equilibrium Best Response		
ds_i/ds_j	0.019	0.050	0.029	0.024	0.018
	(0.003)	(0.010)	(0.009)	(0.005)	(0.006)
Colonial state officials_i	0.108	0.119	0.046	-0.068	0.103
	(0.033)	(0.083)	(0.088)	(0.053)	(0.084)
Colonial state agencies_i	-0.016	-0.034	0.0326	0.011	0.031
	(0.032)	(0.064)	(0.067)	(0.040)	(0.065)
Distance to royal road_i	0.007	0.012	-0.037	0.027	0.009
	(0.021)	(0.020)	(0.029)	(0.011)	(0.026)
Remaining Municipality Agencies		0.0008	-0.0002	0.004	0.002
		(0.002)	(0.002)	(0.002)	(0.005)
Neighbors' Remaining Municipality Agencies		-0.002	-0.002	0.000	0.018
		(0.008)	(0.009)	(0.005)	(0.025)
Observations	975	975	975	975	975

Robustness: Excluding Violent Municipalities

Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Excluding from the estimating sample municipalities in the 90th percentile of violence

State Capacity measured as:	**Log of Number of Municipality State Agencies**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.407	0.576	0.311	0.326
	(0.139)	(0.133)	(0.140)	(0.190)
dp_i/ds_j	0.026	0.021	0.023	0.032
	(0.006)	(0.006)	(0.006)	(0.008)
Observations	850	852	852	842

State Capacity measured as:	**Log of Number of Municipality Employees**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.188	0.290	0.216	0.246
	(0.100)	(0.119)	(0.117)	(0.145)
dp_i/ds_j	0.024	0.018	0.016	0.020
	(0.005)	(0.005)	(0.005)	(0.006)
Observations	887	890	890	879

Robustness: Excluding Violent Municipalities

Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Excluding from the network municipalities in the 90th percentile of violence

State Capacity measured as:	**Log of Number of Municipality State Agencies**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.663	0.778	0.386	0.772
	(0.144)	(0.147)	(0.150)	(0.209)
dp_i/ds_j	0.021	0.017	0.022	0.024
	(0.007)	(0.006)	(0.006)	(0.008)
Observations	850	852	852	842

State Capacity measured as:	**Log of Number of Municipality Employees**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.355	0.379	0.266	0.400
	(0.106)	(0.124)	(0.124)	(0.158)
dp_i/ds_j	0.019	0.016	0.014	0.017
	(0.006)	(0.006)	(0.006)	(0.008)
Observations	887	890	890	879

Robustness: Best Response Controlling for National-Level Bureaucrats

Contemporary State Equilibrium Best Response

Controlling for National-level bureaucracy

State Capacity measured as:	Log of Number of Municipality State Agencies	Log of Number of Municipality Employees
	(1)	(2)
	IV	IV
Average Marginal Effects	Equilibrium Best Response Equation	
ds_i/ds_j	0.018	0.017
	(0.003)	(0.001)
ds_i/dColonial state officials_i	0.102	0.002
	(0.030)	(0.007)
ds_i/dColonial state agencies_i	-0.014	0.010
	(0.031)	(0.008)
ds_i/dDistance to royal road_i	0.008	-0.010
	(0.020)	(0.004)
Observations	975	1017

Robustness: Prosperity Controlling for National-Level Bureaucrats

Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Controlling for National-level bureaucracy

State Capacity measured as:	**Log of Number of Municipality State Agencies**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.520	0.685	0.441	0.274
	(0.107)	(0.121)	(0.133)	(0.169)
dp_i/ds_j	0.018	0.017	0.018	0.032
	(0.005)	(0.005)	(0.005)	(0.007)
Observations	973	975	975	965

State Capacity measured as:	**Log of Number of Municipality Employees**			
Dependent variable	LIFE QUALTY INDEX 1998	PUBLIC UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLLMENT 92-02
	(5)	(6)	(7)	(8)
	IV	IV	IV	IV
Explanatory Variable (MARGINAL EFFECTS)	**Prosperity Equation**			
dp_i/ds_i	0.320	0.541	0.355	0.238
	(0.080)	(0.095)	(0.101)	(0.132)
dp_i/ds_j	0.017	0.011	0.012	0.021
	(0.004)	(0.004)	(0.004)	(0.005)
Observations	1014	1017	1017	1006

Empirical Strategy: General Model

- Now estimate the general model for $\alpha \in (0, 1)$, by MLE
- This allows us to assess the role of national state capacity and how restrictive is the model where only local choices matter.
- In this case the best responses of municipalities are nonlinear.
- Two strategies:
  1. Treat b_i's as predetermined, and estimate nonlinear best responses of municipalities.
  2. Estimate full structural model.

Equations of the General Model

- Our full structural model can be expressed as

$$(1-\alpha)\tau^{\frac{\sigma-1}{\sigma}}\left[\frac{s_i}{b_i}\right]^{\frac{1}{\sigma}}\left\{\frac{\theta}{\alpha}\zeta_i l_i\left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}}+\mathbf{N}_i(\delta)\left[\left(\psi_1\mathbf{s}+\frac{\sum_j\psi_2^j}{J}\boldsymbol{\iota}\right)*\boldsymbol{\zeta}\right]\right\}$$

$$-\eta b_i=0$$

$$\frac{\theta}{\alpha}l_i\left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}}-\psi_1\mathbf{N}_i(\delta)\mathbf{s}-g(\mathbf{c}_i\boldsymbol{\varphi}+\mathbf{x}_i\boldsymbol{\beta})-\varsigma^D=0,$$

and

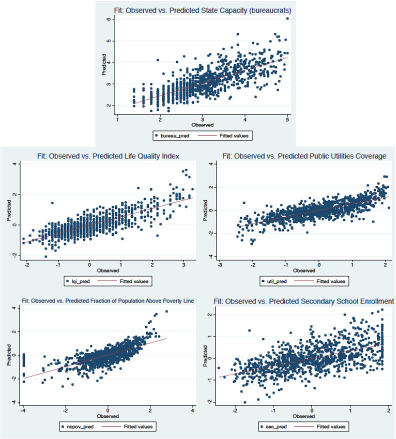
$$p_i^j-\frac{\theta}{\alpha}l_i s_i\left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}}-\psi_2^j\mathbf{N}_i(\delta)\mathbf{s}-\mathbf{x}_i\tilde{\boldsymbol{\beta}}^j-\tilde{\varsigma}^{jD}=0.$$

Results: Strategy 1

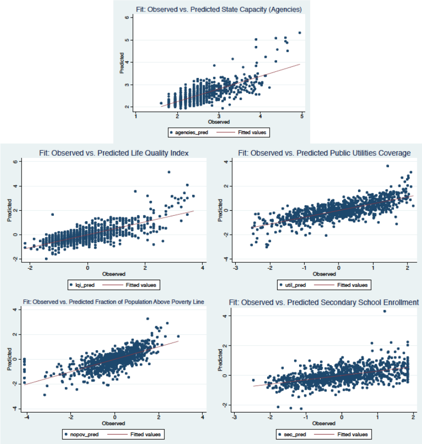
- Ignore the first (national state's) first-order condition and estimate the rest with Maximum Likelihood assuming normally distributed error terms.
- Fairly precise estimates consistent with what we have found so far.
    - But we can comfortably reject the hypothesis that the national state does not matter.
- Quantitative magnitudes very similar to before for changes in local state.
- But quantitative magnitudes of changing national state much smaller, because our estimates suggest it is local state presence that matters more.

Results: Strategy 1: Fit

Linear Model



General Model



Strategy 1: Quantitative Magnitudes

Experiment: Implications of Moving All Municipalities below Median State Capacity to Median

Panel IIa	Non-linear model (under GMM parameter estimates)									
Partial equilibrium change in:	Local agencies:		Life quality index		Utilities coverage		% not in poverty		Secondary enroll.	
	From	To	From	To	From	To	From	To	From	To
	10	10	48.0	48.4	53.3	54.8	57.1	57.9	56.6	58.5

Panel IIb										
General equilibrium change in:	Local agencies:		Life quality index		Utilities coverage		% not in poverty		Secondary enroll.	
	From	To	From	To	From	To	From	To	From	To
Change in median:	10	16.8	48.0	59.3	53.3	74.1	57.1	67.9	56.6	78.4

Experiment: Implications of Moving all Municipalities with National State Capacity below Median to Median

General equilibrium change in median of:											
State capacity				Life quality index		Utilities coverage		% not in poverty		Secondary enrollment	
National:		Local:									
From	To	From	To	From	To	From	To	From	To	From	To
220	220	10	11.01	48	48.20	53.29	53.70	57.13	57.45	56.55	57.04
Percent change:		8.7%		0.4%		0.8%		0.6%		0.9%	

Strategy 2

- Now estimate the full model.
- Fully endogenize the national-level's choices
- Assume that national state's weights, the ζ_i's, are unobserved and given by
$$\zeta_i = exp(\mathbf{v}_i \boldsymbol{\pi} + \omega_i).$$
- $\mathbf{v}_i$ includes two standard network centrality statistics, the betweenness centrality and the Bonacich centrality, and the standard deviation of the Liberal Party's elections share across the 1974-1994 presidential elections.
- Nonlinearities imply that the likelihood function cannot be written in closed form, so use simulated method of moments (SMM) on moment conditions.

Results: Strategy 2

- Again broadly similar estimates.
- Interestingly, weights are estimated to be fairly homogeneous. The large differences in national state's bureaucrats across municipalities due to the return to investing in different parts of the country.

Optimal Redistribution of State Capacity

- How can we optimally redistribute the existing bureaucracy across municipalities? What would the effects be?
- We can answer this question by solving the problem

$$max_{\mathbf{e}} \left\{ \sum_i w_i \frac{1}{J} \sum_j p_i^j(\mathbf{s}) \right\}$$

subject to

$$\sum_i e_i = 0$$

and

$$\mathbf{s} = \left(I - \frac{\psi_1}{\theta} \mathbf{N}(\delta) \right)^{-1} \left(\frac{1}{\theta} \kappa + \tilde{\xi} + \mathbf{e} \right)$$

- This problem has an analytical solution for **e**.
- The optimal **e** is proportional to network centrality measures.

Optimal Redistribution of State Capacity in the Linear Model (cont.)