State Capacity and Economic Development: A Network Approach*

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Abstract

We study the direct and spillover effects of local state capacity using the network of Colombian municipalities. We model the determination of local and national state capacity as a network game in which each municipality, anticipating the choices and spillovers created by other municipalities and the decisions of the national government, invests in local state capacity and the national government chooses the presence of the national state across municipalities to maximize its own payoff. We then estimate the parameters of this model using reduced-form instrumental variables techniques and structurally (with GMM or simulated GMM). To do so we exploit both the structure of the network of municipalities over which spillovers take place and the historical roots of local state capacity as the source of exogenous variation. These historical instruments are related to the presence of colonial royal roads and local presence of the colonial state in the 18th century, factors which we argue are unrelated to current provision of public goods and prosperity except through their impact on their own and neighbors' local state capacity. Our estimates of the effects of state presence on prosperity are large and also indicate that state capacity decisions are strategic complements across municipalities. As a result, we find that bringing all municipalities below median state capacity to the median, without taking into account equilibrium responses of other municipalities, would increase the median fraction of the population above poverty from 57% to 60%. Approximately 57% of this is due to direct effects and 43% to spillovers. However, if we take the equilibrium response of other municipalities into account, the median would instead increase to 68%, a sizable change driven by equilibrium network effects.

JEL Classification: H4, H7, P16.

Keywords: Colombia, economic development, networks, public goods, state capacity.

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1 Introduction

Though, in the West, we take for granted the existence of central and local states with the capacity to enforce law and order, regulate economic activity and provide public goods, many states throughout history and today in most less-developed parts of the world lack this capacity. In Migdal's (1988, p. 33) words: "In parts of the Third World, the inability of state leaders to achieve predominance in large areas of their countries has been striking..."

The idea that such state capacity is vital for economic development, though latent in the writings of Thomas Hobbes and Max Weber, began to attract more attention as a consequence of analyses of the "East Asian Miracle". A series of books by Johnson (1982), Amsden (1989), Wade (1990), and Evans (1995) argued that a key to the economic success of East Asian economies was that they all had states with a great deal of capacity. Others, such as Herbst (2000) and Centeno (2002), linked the economic failure of African or Latin American nations to their limited state capacity. This hypothesis also receives support from the cross-country empirical evidence presented in Gennaioli and Rainer (2007) and the within-country evidence in Michalopoulos and Papaioannou (2013) and Bandyopadhyay and Green (2012). All three papers find a positive impact of historical measures of political centralization across African polities on contemporary public goods provision and various measures of economic development.[1]

In this paper, we contribute to this literature in several dimensions. We study the effect of state capacity of Colombian municipalities on public goods provision and prosperity. We conceptualize "state capacity" as the presence of state functionaries and agencies. This represents one aspect of what Mann (1986, 1993) calls the "infrastructural power" of the state (see also Soifer, 2008). Colombia provides an ideal laboratory for such an investigation for several reasons. There is a wide diversity of local state presence, public goods provision and prosperity across the country. In addition, many aspects of local state capacity in Colombia are decided at the local level, including notary offices, health centers, health posts, schools, libraries, fire stations, jails, deed registry offices, or tax collection offices. Finally, and importantly for our empirical strategy, Colombia's history of colonization provides us with sources of potential exogenous variation in local state capacity which we exploit in order to deal with endogeneity and reverse causality concerns and to isolate the impact of state capacity (rather than other social and institutional factors). In particular, we focus on the historical presence of colonial state officials, colonial state agencies, and the colonial "royal road" network. The road network, for example, was partially based on pre-colonial indigenous roads and was overhauled when the modern system of roads was built in Colombia starting in the 1930s. This network has disappeared and thus provides an attractive source of

[1] Relatedly, Evans and Rauch (2000), Acemoglu (2005), Besley and Persson (2009, 2011), and Dincecco and Katz (2013) document positive correlations between tax to GDP ratio or measures of meritocracy in the state bureaucracy and economic development. Bockstette, Chanda and Putterman (2002) show a positive cross-country association between early state centralization and economic development, and Osafo-Kwaako and Robinson (2013) show similar correlations using ethnographic data on political centralization from the Standard Cross-Cultural Sample.

variation in the historical presence of the state and the cost of building and expanding local state capacity (especially when we control for distance to current roads). We exploit this royal road network, as well as information on the location of various colonial state offices and officials, in order to isolate historical sources of variation in the cost of building state capacity today.

Our main contribution is that, differently from all of the literature in this area, we model the impact of state capacity in one municipality on public goods provision and economic outcomes in neighboring areas. We expect (and empirically find) such neighborhood externalities to be important both because borders across municipalities are porous and because building a functioning bureaucracy in the midst of an area where state capacity is entirely missing is likely to be much more difficult.

Cross-municipality effects also imply that building state capacity will be a strategic choice for each municipality. To the extent that municipalities free-ride on their neighbors' investments, state capacity choices might be strategic substitutes. Conversely, to the extent that municipalities find it harder or less beneficial to build state capacity when it is missing in their neighborhood, these choices will be strategic complements. Other important reasons for strategic complementarities include: (1) when there is a functioning state in the neighborhood, voters may be more likely to demand it of their own politicians; (2) some problems, such as defeating criminal organizations or dealing with contagious diseases, may be beyond the capability of the local state at the municipality level; (3) the judicial system may not function just in a single municipality.

We incorporate these strategic aspects by modeling the building of state capacity as a network game in which each municipality takes the national government's as well as their neighbors' actions into account and chooses its own state capacity. We then estimate the parameters of this model, exploiting both the network structure and the exogenous sources of variation discussed above. The key parameters concern: (1) the impact of own state capacity on own public goods provision and prosperity; (2) externalities on neighbors; and (3) the parameters of the best response equation concerning how state capacity decisions depend on neighbors' state capacities. In the process, we clarify why both empirical approaches that ignore the endogeneity concerns and those that do not model the network structure of interactions will lead to potentially misleading estimates.

Our approach leads to precise estimates of the "best response" equations linking a municipality's state capacity to its neighbors, which indicate that in all cases state capacity decisions are strategic complements. We estimate the effect of own and neighbors' state capacity on various measures of public goods provision (school enrollment, utilities coverage) and prosperity (proxy by indices for quality of life and poverty) using one of three empirical approaches: (1) linear instrumental variables applied to each dimension of prosperity, or (2) generalized method of moments (GMM) and (3) simulated method of moments (SMM) using all dimensions of prosperity simultaneously. In each case, we clarify how the reduced-form parameters map into the structural ones. Our results show large and fairly precise effects of both own and neighbors' state capacity on all measures of prosperity we consider.

Our benchmark estimates imply, for example, that moving all municipalities below median state capacity to the median will have a "partial equilibrium" direct effect (holding the level of state capacity of all municipalities above the median constant) of reducing the median poverty rate by 3 percentage points, increasing the median coverage rate of public utilities (electricity, aqueduct and sewage) by 4 percentage points, and increasing the median secondary enrollment rate by 3 percentage points. About 57% of this impact is due to a direct effect, while 43% is due to network spillovers. The "full equilibrium" effect is very different, however. Once we take into account the equilibrium responses to the initial changes in local state capacity in the network, median coverage rate of public utilities increases 10 percentage points, the median fraction of the population in poverty falls by 11 percentage points, and median secondary enrollment rates increase by over 26 percentage points. These large impacts, which are entirely due to network effects, highlight not only the central role that state capacity plays in economic development but also the importance of taking the full equilibrium effects into account.

In addition to bolstering the case for our empirical strategy using falsification exercises, overidentification tests and a number of specification checks, we also demonstrate that our main estimates are quite robust. They are very similar (i) when we only exploit historical sources of variation from neighbors of neighbors (instead of relying on variation of the neighbors); (ii) if we do not control for the current road network (our baseline results do control for this network); (iii) when we focus on subsets of our instruments; (ii) when we assign different weights on the spillovers from different neighbors or even when we allow spillovers to go beyond adjacent municipalities; (v) when we include a battery of additional controls; (vi) when we exclude high crime areas or capital cities; (vii) when we use more flexible functional forms; and (viii) when we vary the form of spillovers.

We also extend our structural model to incorporate the decisions of the national government concerning local state capacity. In Colombia, while municipalities themselves hire and pay for a range of local state employees (a large part of it with transfers from the central government), the number of police and judges in the municipality are decided by the national government. Incorporating this additional layer of interaction in the structural model has little effect on our estimates of the impact of local state capacity, but allows us to estimate some key features determining the distribution of national state presence across the country.

We are unaware of any other study that either estimates the effect of local (municipality-level) state capacity on local outcomes, or models and estimates the network externalities and strategic interactions in this context.[2] Nevertheless, our paper relates to several literatures. First, we build on and extend

[2]The only partial exceptions we are aware of are Dell's (2013) study of how changes in law enforcement shift the activities of drug gangs across the transport network linking Mexican municipalities to the United States; a recent paper by Durante

the literature on the effect of state capacity on economic development which has already been discussed. In addition to the empirical and historical studies mentioned above, there has recently been a small literature on the modeling of the emergence of state capacity or persistence of states which lack capacity ("weak"). Acemoglu (2005) constructs a model in which a self-interested ruler taxes and invests in public goods and citizens make investment decisions. Lack of state capacity or weak states are detrimental to economic development because they discourage the ruler from investing in public goods as he anticipates that he will not be able to raise taxes in the future. Besley and Persson (2009, 2011) also emphasize the importance of state capacity and suggest that state building will be deterred when each group is afraid that the state they build will be used against them in the future. Acemoglu, Ticchi and Vindigni (2011) and Acemoglu, Robinson and Santos (2013) provide various models of persistence of weak states with low state capacity.[3] Our model takes a different direction than those, and in the process, highlights a new effect: state building will be deterred unless a national government plays a defining role in this process, because local governments will underinvest in state capacity as they ignore the spillovers they create on their neighbors. Since our estimates suggest that these externalities are sizable, this effect could be quite important in practice.

In utilizing a network game to model state building investments and for our empirical work, our paper also relates to the literature on network games. Theoretically, our model is a variant of Bramoulle, Kranton and D'Amours (2014), extended to allow investments to be strategic complements or substitutes (their model constrains them to be strategic substitutes). Empirically, as mentioned above, Bramoulle et al. (2009) propose a creative approach to identify network effects, while avoiding endogeneity within the network, which relies on using characteristics of neighbors of neighbors. Though we verify the robustness of our results to this alternative approach, our main strategy instead relies on exploiting historically-exogenous sources of variation in both own and neighbors' state capacity, which ensures consistency even if there are spatially correlated omitted factors affecting state capacity, public goods and prosperity—a first-order concern in this and many other contexts. Other papers dealing with related issues include, among others, Calvo-Argemgol, Patacchini, and Zenou (2009), Topa (2001), Katz, Kling, and Liebman (2001), Bayer, Ross, and Topa (2008), Sacerdote (2002), and Nakajima (2007), though, to the best of our knowledge, no other study uses a similar empirical strategy or combines structural modeling and historical instrumental variables to estimate the structural parameters of this type of model.

In addition to the literature we cited above on the role of state capacity in national economic development, a small literature has emphasized within-country variation in state capacity. O'Donnell (1993) did

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and Guiterrez (2013) on the role of inter-jurisdictional cooperation in crime-fighting across Mexican municipalities; Case, Hines, and Rosen's (1993) work on the relationship between the public expenditures of neighboring US states, and Di Tella and Schargrodsky's (2004) work showing (negative) spillovers in policing from one part of Buenos Aires to neighboring areas.

[3]Another branch of literature, including Thies (2005), Gennaioli and Voth (2011), and Cardenas, Eslava and Ramirez (2011) for Colombia, investigates the historical determinants of state capacity.

this in the case of Latin America, arguing that the uneven distribution of state capacity led to variation in the quality of democracy at the sub-national level. Related ideas have emerged in the literature on civil wars with scholars suggesting that conflict starts and persists in parts of countries with low state capacity (e.g., Goodwin, 1999, Fearon and Laitin, 2003, and Kalyvas, 2006, as well as Sanchez, 2007, for the Colombian case).[4] Research on within-country income differences has pointed to institutional differences as likely causes of this variation (e.g., Acemoglu, and Dell, 2010, Acemoglu, Garcia-Jimeno and Robinson, 2012, Bruhn and Gallego, 2012), but has not focused on variation in state capacity.

The rest of the paper proceeds as follows. Section 2 provides a discussion of the Colombian context, particularly focusing on the weakness of the local and national state. Section 3 presents a simple model of investments in state capacity within a network. Section 4 presents our data. Section 5 discusses our empirical strategy and presents our main estimates and some robustness checks focusing on the simplified model without the national state. Section 6 describes our empirical strategy and results for the general model that includes investments by the national state. Section 7 shows how the estimates can be used for determining the gains from optimally reallocating state capacity investments across municipalities. Section 8 concludes, while the Online Appendix contains additional results.

2 Context

This section provides a brief overview of some key features of the historical development of state capacity in Colombia. The sources of variation in historical state development are discussed below.

State capacity in Colombian history has been notable in its relative absence on average and its great variability. In 1870, with a total population of around 2.7 million, the total number of both state and national level public employees in Colombia was 4,500, or just 0.0015 bureaucrats per inhabitant (Palacios and Safford, 2002). In contrast, public employees per capita in the United States in 1870 were 0.011, an order of magnitude higher (1870 US Census).

The Colombian state also did not have the capacity to raise fiscal revenues, another key aspect of state capacity, which was also lacking all the way into the 20th century (as Deas, 1982, and Rincon and Junguito, 2007, note). As late as 1970, tax revenue was only around 5% of GDP (Rincon and Junguito, 2007). As a result, some isolated regions, such as the Choco or the eastern plains, have yet to be fully integrated with the rest of the country economically or politically.[5] For example, commenting on this

[4]In the literature on state formation in the 19th-century United States, there is a heavy emphasis on the critical role of federal and local government (e.g., Novak, 2008), and similar concerns have emerged in the literature on Latin America (see, e.g., Soifer, 2012).

[5]One of the main purposes of the 1991 Constitution was to increase the extent of decentralization in Colombia and in the process to contribute to local state building. The Constitution mandated transfers from the central government to the local level, which would be used for public good provision at the municipality level. Despite these major institutional changes in the late 20th century, large swathes of Colombia still have very weak state presence. Moreover, it was during the 1990s and early 2000s that the national state lost control of large areas of the country to the hands of private armies of guerrillas and

issue in 1912, Rufino Gutierrez argued that

> "...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..." (Our translation)

There are several historical root causes of state weakness in Colombia. During the colonial period, Spain restricted migration to its American colonies so that the settler population was very small and did not consitute an effective voice pushing for a more effective colonial state. The colonial state also used direct methods to extract rents from indigenous people, such as tribute and forced labor, rather than developing a tax system that would later become the foundation of state capacity. The topography of the country also constrains the reach of the state. The Andean Cordillera running south to north splits the country into a patchwork of relatively disconnected regions. Furthermore, Colombians resisted the Bourbon attempts at state centralization in the late 18th century so that, uniquely in the Americas, the Spanish were not able to set up their new system (see Paquette, 2012, Phelan, 1978, and McFarlane, 1993, for Colombia). Though as a consequence of these reforms, the province of *Nueva Granada* became a viceroyalty in 1717 and then again in 1739, the colonial state remained absent throughout most of the territory, except in and around a few cities and towns. For example, in 1794, the capital Bogota and the major slave and gold trading port Cartagena housed 70% of all crown employees in the viceroyalty.

After independence, the colonial fiscal system was continued (Jaramillo, Meisel, and Urrutia, 2006) until the Liberals' rise to power in 1850. The Liberal regime cut tariffs and abolished monopolies, causing a fiscal crisis and a significant downsizing of the already emaciated state (Deas, 1982). In the mid 19th century Colombia adopted a federal system, further weakening the attempts of national state-building. Each of the states during this federal period had its own army, so that even the monopoly of violence of the state was not attempted until the end of the War of a Thousand Days in 1903. Palacios and Safford (2002, p. 27) describe state weakness in Colombia during this epoch:

> "In the decade of the 1870s, an attempt to use national funds to build a railroad that would benefit the east triggered intense antagonism in the west and the [Caribbean] coast... as a result, small, poorly financed and often failed projects proliferated..."

This context, underpinning pervasive and geographically-varied state weakness and lack of state capacity, makes the study of the implications of local state capacity in Colombia particularly relevant.

paramilitaries.

3 A Simple Model of State-Building in a Network

Building on the literature on games of public goods provision in networks (e.g., Ballester, Calvo-Armengol and Zenou, 2006; Bramoulle, Kranton and D'Amours, 2014), in this section we develop a simple game-theoretic model of the determination of local and national state. The economy consists of a network of municipalities, and a national state. Each municipality is a node in this network, municipalities sharing a border are connected, and all links are undirected. Prosperity in each municipality depends on local state capacity, the spillover effects of state capacity from neighboring municipalities, and on national state capacity allocated to the municipality. We further allow the strength of the spillovers to depend on topographic features of the Colombian landscape. All municipalities and the national state simultaneously choose their levels of state capacity to maximize their payoff, which is a function of the relative costs and benefits of state capacity provision. State capacity positively impacts several dimensions of prosperity, and its provision has a convex cost. The national state has heterogeneous preferences over prosperity across municipalities. This model determines the equilibrium distribution of local and national state capacity across municipalities, and hence the equilibrium distribution of prosperity.

3.1 Network Structure and Preferences

Let i denote a municipality, and $\mathbf{F}$ be an $n \times n$ matrix with entries f_{ij} given by

$$f_{ij} = \frac{1}{1 + \delta_1 d_{ij}(1 + \delta_2 e_{ij})},$$

where d_{ij} denotes the distance along the geodesic connecting the centroids of municipalities i and j, and e_{ij} is a measure of variability in altitude along the geodesic connecting the centroids of municipalities i and j. The parameters f_{ij}'s allow for differential decay of spillovers between municipalities, depending on topographic features of the landscape. This is important in the Colombian context since topographic conditions are highly variable and rapidly changing.

Let $N(i)$ denote the set of municipalities connected to i, meaning the municipalities that will create spillovers on i. In our baseline, these will be the municipalities that are adjacent to i, though we also experiment with alternative definitions of the set $N(i)$, for example defining a link between any two municipalities within a certain distance of each other, between not only neighbors but also neighbors of neighbors, and between all municipalities with decaying strength of links.

The matrix $\mathbf{N}(\boldsymbol{\delta})$ denotes the symmetric matrix with entries n_{ij} representing both the presence of a link between two municipalities and the strength of any spillovers that may take place along that link:

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

We allow several dimensions of prosperity in a municipality to depend upon own state capacity and neighboring state capacity in the following way:

$$p_i^j = \kappa_i s_i + \phi s_i \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + \gamma^j \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + u_i^j, \tag{1}$$

where p_i^j is the j-th dimension/index of prosperity in municipality i and $s_i \in [0, \infty)$ is municipality i's state capacity. In addition, κ_i is the effect of own state capacity on prosperity, which we allow to be municipality specific, and will model below to be a function of historical and other characteristics of a municipality and an unobservable random effect.[6] In particular, we assume that

$$\kappa_i = g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta}) + \varsigma_i^D + \tilde{\xi}_i, \tag{2}$$

where $\mathbf{c}_i$ and $\mathbf{x}_i$ are vectors of historical and contemporary municipality characteristics, $g(\cdot)$ is an arbitrary smooth function, the ς_i^D's denote a full set of department fixed effects, and $\tilde{\xi}_i$ is a random effect, which is unobserved to the econometrician but observed by the players in the game, so that we have a game of complete information. In addition, ϕ captures any interaction (or cross) effects between own prosperity and neighbors' state capacity, while γ^j is the direct effect of neighboring state capacity on own prosperity outcome j. $\mathbf{N}_i(\boldsymbol{\delta})$ denotes the i'th row of the network matrix, and $\mathbf{s}$ denotes the full column vector of state capacity levels. Finally, the u_i^j's denote the error term, which will also be a function of observable covariates, in particular

$$u_i^j = \mathbf{x}_i\boldsymbol{\beta}_u^j + \varsigma_i^{Dj} + \epsilon_i^j, \tag{3}$$

where ϵ_i^j is a mean zero random effect. Relative to (2), this equation excludes the variables in the vector $\mathbf{c}_i$, which will be the exclusion restrictions discussed in detail below (and in addition also imposes linearity, which is for simplicity).

Notice that though γ^j is allowed to vary across the different dimensions of prosperity, the cross effects and own effects are imposed to be the same for all these dimensions (i.e., ϕ and κ_i do not vary by j).

[6] Observed and unobserved heterogeneous effects of state capacity on on prosperity are quite plausible in this context, since various geographic historical, political and social factors will create variation in the effectiveness of state capacity, for example, because there is greater need for the local state to provide health care or public services in some municipalities, or because patronage appointments driven by the highly clientelistic nature of local Colombian politics (e.g., Davila and Leal, 2010) may be reducing the impact of measured state presence on prosperity in some municipalities.

This is because, as we will see below, these parameters will be identified from the best response equations which do not depend on the dimension of prosperity we are considering. These restrictions are plausible in view of the fact that the p_i^j's will be standardized z-scores.

3.2 The General Case

Our general model allows state capacity in municipality i to be a constant elasticity of substitution (CES) composite of both locally chosen $l_i \in [0, \infty)$, and nationally-chosen state capacity, $b_i \in [0, \infty)$:

$$s_i = \left[\alpha l_i^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(\tau b_i)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \quad \sigma > 0, \tag{4}$$

where $\tau > 0$ allows for a national bureaucrat or agency to have a different impact than a local state employee.

As a first step in this approach, we adopt a major simplification and use a reduced-form representation of decisions within municipalities focusing on costs and benefits of state capacity (and thus essentially ignoring political economy factors). In particular, each municipality decides its own state capacity l_i taking as given the choices of its neighbors and the national government. Preferences of municipality i are assumed to take the form

$$U_i = \mathbb{E}_\epsilon \left[\frac{1}{J} \sum_j p_i^j - \frac{\theta}{2} l_i^2 \right], \tag{5}$$

where J is the total number of prosperity outcomes. Preferences of the national level are

$$W_i = \mathbb{E}_\epsilon \left[\sum_i \left\{ U_i \zeta_i - \frac{\eta}{2} b_i^2 \right\} \right], \tag{6}$$

where the ζ_i's are the heterogeneous weights that the national state puts on each municipality, determined by political economy factors, for example, depending on the distribution of swing voters (e.g., Stromberg, 2008), or on who is in control of local politics (e.g., Acemoglu, Robinson and Santos, 2013).[7]

We assume, as noted above, that local and national state capacities are chosen simultaneously. The first-order conditions for the municipalities and the national state determine the equilibria of this game. Those with respect to l_i give the best response of the state capacity choice of municipality i as:

$$\alpha \left[\frac{s_i}{l_i} \right]^{\frac{1}{\sigma}} [\kappa_i + \phi \mathbf{N}_i(\boldsymbol{\delta}) \mathbf{s}] - \theta l_i \begin{cases} < 0 & l_i = 0 \\ = 0 & l_i > 0 \end{cases}, \tag{7}$$

[7] However, equation (5) rules out situations in which the national state just cares about extracting resources from some municipalities, or those in which there is an explicit competition between local and national states or politicians.

which is written in complementary slackness form.[8] The sign of ϕ determines whether this is a game of strategic substitutes ($\phi < 0$) or strategic complements ($\phi > 0$). Equation (7) then implies that with strategic complements, in any equilibrium all municipalities will invest in a strictly positive level of state capacity (see the Appendix).

For the national level, the first-order conditions with respect to each b_i imply that the national state's best responses yield

$$(1-\alpha)\tau^{\frac{\sigma-1}{\sigma}}\left[\frac{s_i}{b_i}\right]^{\frac{1}{\sigma}}\left\{\zeta_i\left[\kappa_i+\phi\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}\right]+\phi\mathbf{N}_i(\boldsymbol{\delta})(\mathbf{s}*\boldsymbol{\zeta})+\frac{\sum_j\gamma^j}{J}\mathbf{N}_i(\boldsymbol{\delta})\boldsymbol{\zeta}\right\}-\eta b_i\begin{cases}<0 & b_i=0\\ =0 & b_i>0\end{cases}, \tag{8}$$

where $*$ designates element by element multiplication. Notice from equation (8) that for any set of non-negative weights $\boldsymbol{\zeta}$ such that $\zeta_k > 0$ for at least one $k \in N(i)$ for all i, $\phi > 0$ and $\gamma^j > 0$ for all j is a sufficient condition for $b_i > 0$ in any equilibrium. In other words, if spillovers are positive and the game is one of strategic complements, the only way the national level could allocate no state presence in municipality i is if both this municipality's weight and the weights of all of its neighbors are zero. As we will describe below, in our data both local and national state capacity choices are strictly positive for all municipalities. This will allow us to focus on interior equilibria.[9]

The next proposition draws on recent research by Allouch (2012), who establishes that for network games with nonlinear best responses, a bound on the slope of the best responses is a sufficient condition for uniqueness. This bound is a function of the lowest eigenvalue of the network matrix $\mathbf{N}(\boldsymbol{\delta})$, which quantify the extent to which the spillovers across agents are spread through the network structure. Adapting this result to our setting and denoting the smallest eigenvalue of the matrix $\mathbf{N}(\boldsymbol{\delta})$ by λ_{min}, we have the following:

Proposition 1. *(Allouch (2012)). If for every player* $1+\frac{1}{\lambda_{min}(\mathbf{N}(\boldsymbol{\delta}))} < \left(\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}}\right)^{-1} < 1$*, then the game has a unique Nash equilibrium.*

For the estimated parameter vector $(\alpha, \sigma, \theta, \phi, \gamma, \boldsymbol{\delta})$, the conditions in Proposition 1 is readily verifiable. Equations (1), (7), and (8) determine the joint equilibrium distribution of state capacity, both local and national, and prosperity.

[8] Note that if, as is natural, $(\kappa_i + \xi_i) \geq 0$, then $\phi < 0$ is necessary for $l_i = 0$.

[9] Existence of pure-strategy equilibria can be guaranteed straightforwardly either if $\phi > 0$, so that this is a game of strategic complements, or if $\alpha < l_i^{\frac{\sigma+1}{\sigma}} s_i^{\frac{\sigma-1}{\sigma}}$ for all l_i and s_i that are a solution to (7), ensuring quasi-concavity and thus enabling us to apply Kakutani's fixed point theorem. Propositions 2 and **??** provide sufficient conditions for existence and uniqueness of pure-strategy equilibria.

3.3 The Linear Case ($\alpha = 1$):

Our model simplifies considerably in the case where $\alpha = 1$, which imposes $s_i = l_i$ in equation (7), so that the national state's choices are irrelevant. In this case, the best response equation (7) becomes linear in neighbors' state capacity:

$$s_i = \frac{\phi}{\theta}\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + \frac{\kappa_i}{\theta}. \tag{9}$$

Equation (9) also illustrates that even if properly identified, the interpretation of the linear regression estimate of the "endogenous effect" should take into account that it is a reduced-form coefficient.[10] It corresponds not to a simple causal effect, but to the ratio of the interaction (cross) effect to the elasticity of the marginal cost of investment in state capacity.

Now substituting for s_i from (9) into (1), we obtain the observed relationship between prosperity and own and neighbors' state capacity as:

$$p_i^j = \theta s_i^2 + \gamma^j \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + \epsilon_i^j. \tag{10}$$

Equation (10) highlights that the identification of the impact of own state capacity on prosperity, (κ_i, ξ_i), and of the interaction effect, ϕ, requires some care. This is because the optimizing choices of a municipality ensure that κ_i and ϕ drop out of the relationship between prosperity and state capacity, and cannot be identified. Instead, such a regression can only identify (in addition to the spillover parameters γ^j) the cost parameter θ. Our empirical approach, detailed below, will overcome this difficulty as well.[11]

With $\alpha = 1$, existence of pure strategy equilibria follows immediately from concavity and Kakutani's fixed point theorem, and uniqueness of an interior (positive) equilibrium (where all municipalities choose a positive investment in state capacity) is also guaranteed, since such an equilibrium is given by the solution to a set of linear equations. However, multiple equilibria with some municipalities choosing zero investment is possible. A tighter sufficient condition for equilibrium uniqueness than the one contained in Proposition 1 follows from the work of Bramoulle, Kranton, and D'Amours (2014) and this contained in the next proposition.

Proposition 2. *(Bramoulle, Kranton, and D'Amours (2014)). If $|\lambda_{min}(\mathbf{N}(\boldsymbol{\delta}))| < \left(\frac{\phi}{\theta}\right)^{-1}$, then there exists a unique equilibrium.*

For an estimated parameter vector $(\theta, \phi, \gamma, \boldsymbol{\delta})$, the uniqueness condition in this proposition can also

[10] In particular, $\frac{\phi}{\theta}$ in equation (9) is referred to in the peer effects literature as an "endogenous effect," corresponding to the effect of neighbors' or peers' choice on own choice, while the γ^j 's in equation (10) are referred to as "contextual effects" (see, e.g., Manski, 1993).

[11] In addition, the spillovers and feedbacks between municipality choices within the network game imply a quadratic reduced-form relationship between own state capacity and prosperity, so linear regressions may lead to misspecification, though we will see below that marginal effects from the estimation of "naive" linear regressions, when properly instrumented, are similar to our structural estimates.

be verified empirically.

Equations (9) and (10) determine the joint distribution of local state capacity and prosperity across municipalities, and will be the focus of the first part of the paper. The just explained identification challenge notwithstanding, all the key parameters (θ, ϕ, γ, $\boldsymbol{\delta}$) can be identified if these two equations are estimated simultaneously (and of course with the appropriate sources of variation, which we discuss in detail in Section 5). The parameter θ is identified from (10), and given this parameter, ϕ can be recovered from the endogenous effect estimated in equation (9) and the local average of the κ_i's from the intercept in equation (9).

4 Data

For our empirical implementation, the data we use, summarized as $\{(\mathbf{p}_i, l_i, b_i, \mathbf{x}_i, \mathbf{c}_i)_{i=1}^n, \mathbf{D}, \mathbf{E}, \mathbf{A}\}$, include cross-sectional information on several dimensions of prosperity $\mathbf{p}_i$, local (l_i) and national (b_i) choices of state capacity, municipality characteristics $\mathbf{x}_i$, and colonial state presence characteristics $\mathbf{c}_i$. In addition, $\mathbf{D}$, $\mathbf{E}$, and $\mathbf{A}$ are $n \times n$ matrices containing the geodesic distances between the centroids of all pairs of municipalities, an index of variability in altitude along these geodesics, and the adjacency status of each pair of municipalities, respectively. We describe the nature and sources of these data below.

We compiled the data from several sources. The *Fundacion Social* (FS), a Colombian NGO, collected and put together detailed data on state presence at the municipality level in 1995. Out of a total of 1,103 municipalities in Colombia, FS collected data for 1,019 of them, which comprise our main sample and the number of nodes in our network.

Descriptive statistics for all of our data are presented in Table 1. For each municipality, FS recorded the number of municipality (local) public employees, the number of national stated public employees, the number of police stations, courts, notary offices, Telecom offices, post offices, agricultural bank branches, public hospitals, public health centers, public health posts, public schools, public libraries, fire stations, jails, deed registry offices, and tax collection offices.

Because our theoretical framework stresses and exploits the difference between locally and nationally chosen levels of state capacity, we rely on the Colombian legislation to establish the presence and the number of employees of agencies which are decided at the local level, and those which are decided at the national level.[12] Police, courts, and public hospitals fall under the responsibility of the national government. The location of agricultural bank branches was also partly determined centrally. All other agencies are under the jurisdiction of the municipality. Because, as noted in the Introduction, our interest is closely related to the "infrastructural" features of state capacity, we construct two measures of

[12]Law 60 of 1993 and Law 04 of 1991 establish the distribution of responsibilities among the national and subnational levels in Colombia.

local state capacity l_i: (a) the number of municipality-level bureaucrats, which excludes police officers, judges, all other judicial employees, and public hospital employees, and (b) the total count of municipality state agencies, namely, notary offices, Telecom offices, post offices, health centers, health posts, schools, libraries, fire stations, jails, deed registry offices, and tax collection offices. We treat these two variables as alternative measures of local state capacity. We use the number of national public employees as our measure of national state capacity b_i.

Municipalities have three main revenue sources to finance public spending and investment in state infrastructure and bureaucracy: Local taxes (industry and commerce tax, and property tax, mainly), royalties from mining activities, and transfers from the central government. The bulk of central government transfers ("situado fiscal") are allocated to each municipality using a fixed rule (geographically, this allocation is at the departmental level). These resources directly enter into the municipality's budget. Though the law stipulates that at least 60% of these transfers must go to education, and at least 20% to health (Law 60 of 1993), it also grants full discretion to the municipality on their specific allocation and use. In particular, mayors (who are elected officials since 1988) propose a budget to elected municipality councils, which is implemented if approved by the council.

To measure local prosperity, we collected available data from various sources. The *Centro de Estudios sobre Desarrollo Economico* (CEDE) at *Universidad de los Andes* provided us with average 1992-2002 primary and secondary enrollment rates. From the OCHA group at the United Nations, we collected data on aqueduct, sewage, and electricity household coverage rates in 2002, and on vaccination rates in 2002. Finally, from the Colombian national statistics bureau (DANE) we have data on the fraction of the population in poverty (under the poverty line) in 1993 and 2005, and on a life quality index for 1998. Based on these data, we focus on four prosperity outcomes which are likely to depend on local state capacity: (a) the life quality index p_i^1, (b) the average public utilities coverage in 2002 (aggregating aqueduct, sewage, and electricity) p_i^2, (c) the population above the poverty line in 2005 p_i^3, and (d) the secondary enrollment rate p_i^4. All of our prosperity measures are standardized z-scores (number of standard deviations the observation is above the mean for that measure). We focus on these four prosperity outcomes because, although they are positively correlated, as Figure 2 shows the shape of each distribution is significantly different. Thus, each of these dimensions of prosperity is likely to provide relevant information.

In contrast to these measures, primary school enrollment and vaccination coverage should not depend on local state capacity. Public investments targeting these outcomes are highly centralized. In fact, the Colombian Constitution mandates universal primary school enrollment. The descriptive statistics in Table 1 show the very high average levels of primary enrollment, and the small variation of this variable across municipalities. Moreover, the Ministry of Health directly operates the vaccination efforts through national campaigns. In our robustness section below we use these two development outcomes in a falsification exercise, showing their lack of relationship to own and neighbors' state capacity. Additionally, we constructed historical literacy and school enrollment rates from the 1918 National Census.

We built the adjacency matrix of municipalities **A** based on the Colombian national geographic institute (IGAC).[13] Using Arc-GIS georeferenced data, we computed the geodesic ("as the bird flies") distance between the centroid of each pair of municipalities d_{ij}, and organize this data in matrix **D**. Also using Arc-GIS and georeferenced topographic data for Colombia, we computed e_{ij}, the index of the variability in altitude along the geodesic connecting the centroid of every pair of municipalities, capturing the frictions that a more uneven path connecting two municipalities imposes over the opportunities for contact and spillovers between them. More specifically, we divided each geodesic into a number of intervals for a given altitude range along the geodesic itself, and computed the average altitude of each of the intervals. The e_{ij} is then computed as the variance of the average altitude across intervals, where each interval is appropriately weighted by its length. We organize these data into the matrix **E**.

As already mentioned, we exploit variation in several dimensions of Spanish colonial state presence in Colombia by using historical data originally collected by Duran y Diaz (1794).[14] This document specifies the location of officials and state administrations. Of particular interest, Duran y Diaz (1794) has a complete record of every colonial official and of several state agencies throughout the viceroyalty. From this document we compiled municipality-level data on the number of crown employees, and indicators on the presence of an *alcabala,*[15] a tobacco or playing cards *estanco,*[16] a liquor or gunpowder *estanco*, and a post office. In addition to these variables, we collected information from historical maps in Useche (1995) which depict the location of colonial royal roads. We georeferenced these maps using Arc-GIS, and computed the distance between the centroid of each municipality and the closest royal road. Based on these data, we then constructed three measures of colonial state presence: (a) the number of crown employees, denoted by c_i^1, (b) a count of the number of agencies reported by Duran y Diaz, denoted by c_i^2,[17] and (c) the distance to the closest royal road, denoted by c_i^3. We also collected the population data from the 1843 National Census, which we use as an instrument for current population in specifications where we allow for current population to be endogenous.

Finally our main covariates included in all specifications (in the vector $\mathbf{x}_i$) are distance to a current highway, longitude, latitude, surface area, altitude, and average annual rainfall (all obtained from CEDE)

[13]We are excluding from our analysis the two municipalities in the Department of San Andres, which is an archipelago in the Caribbean comprised of several smaller islands and located 775 kms. from the mainland.

[14]This source is located at the National Library in Bogota that contains a full account of state officials, salaries, the military, tariffs, taxes and fiscal revenue among others for all of the Viceroyalty of *Nueva Granada* in the late 18th century. We thank Malcolm Deas for pointing us to this document.

[15]The *alcabala* was a sales tax (usually at 2%). The indicator denotes the presence of the local agency in charge of collecting the tax.

[16]An *estanco* was a state monopoly over the sale of a particular good, which also often allocated production rights and regulated quantities. The indicator denotes the presence of the local agency in charge of administering the *estanco*.

[17]Thus, this variable takes values in the set $\{0, 1, 2, 3, 4\}$.

as well as (log) population in 1995 (obtained from the Colombian government's national statistical institution, the DANE). In some specifications, we also use the following additional covariates: the density of primary, secondary, and tertiary rivers (from CEDE), and the distribution of land in each municipality by land quality, coded as the share of each of eight qualities, and by land type, classified as under water, valley, mountain, hill and plain (obtained from IGAC).

5 Empirical Strategy and Results: The Linear Case

Our structural model fully determines the cross-sectional distribution of equilibrium state capacity choices and prosperity outcomes.[18] Our empirical strategy has multiple components. In this section we first discuss the exclusion restrictions implied by our use of several historical variables as instruments in the context of the linear case where $\alpha = 1$. The same arguments also apply to the general model discussed in the next section. We then turn to various estimation strategies and empirical findings. As a preview, we find municipalities' state capacity investment decisions are strategic complements, and that the complementarity is weak enough that our parameter estimates are always consistent with the network game having a unique equilibrium. Our findings indicate that all of our prosperity outcomes are strongly dependent on the overall levels of state capacity in a municipality, and that state capacity spillovers are significant. Quantitatively, we find that in partial equilibrium, the own effect of state capacity on prosperity is larger than the average effect of neighbors' state capacity. The picture is very different in full equilibrium, when the endogenous responses of state capacity in the network are factored in. In this case, network effects are about 5-10 times the own effect of a municipality's state capacity.

5.1 Exclusion Restrictions

In addition to the identification problem encapsulated in equation (10) discussed above, we face the standard challenges resulting from endogeneity and omitted variable biases (in view of the fact that state capacity is endogenous determined) and the problems associated with the estimation of contextual and endogenous effects (e.g., Manski, 1993). To discuss these problems and our strategy for dealing with them, let us substitute for (2) and (3) into (9) and (10) to obtain the equations we will estimate in our empirical work (for the $\alpha = 1$ case). The response equation then becomes

$$s_i = \frac{\phi}{\theta}\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + \frac{1}{\theta}g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta}) + \varsigma_i^D + \xi_i, \tag{11}$$

[18] One could suppose that our cross-sectional data reflect the resting point of a long-run dynamical process, for example, reflecting some sort of adaptive dynamics. If these dynamics are driven by the best responses of the model outlined above, then the conditions for uniqueness in Propositions 1 and 2 also ensure convergence (stability) of the dynamical process to the equilibrium characterized above.

where $\xi_i \equiv \tilde{\xi}_i/\theta$, and recall that the ς_i^D's are department fixed effects, as well as a set of prosperity equations (one for each dimension of prosperity indexed by j):

$$p_i^j = \theta s_i^2 + \gamma^j \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + \mathbf{x}_i \tilde{\boldsymbol{\beta}}^j + \tilde{\varsigma}_{is}^{jD} + \epsilon_i^j. \tag{12}$$

The standard endogeneity problem (for the case of $\alpha = 1$) is a simple consequence of the fact that the error term in (12) may be correlated with s_i, i.e., $cov(s_i, \epsilon_i^j) \neq 0$. Moreover, there are also good reasons to suspect that spillover effects—the contextual effects in (12)—cannot in general be estimated consistently with OLS because of correlation of the error term in this equation with neighbors' state capacity, i.e., $cov(\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}, \epsilon_i^j) \neq 0$. The main reason for such a correlation is that the omitted influences on prosperity are likely to be spatially correlated; in other words, assuming spatial independence of the error terms in this setting would be highly implausible.

In addition, as already noted, the estimation of the own and cross effects of state capacity on prosperity necessitate the joint estimation of the best response equation (11), and the same spatial correlation concerns applied to this equation, i.e., $cov(\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}, \xi_i) \neq 0.$, imply that the endogenous effects in this equation cannot be estimated consistently with OLS either.

Our strategy for dealing with both sets of concerns is to rely on historical sources of variation in state capacity represented by the vector $\mathbf{c}$ in the above equations. In particular, we argue that colonial state presence likely altered the relative costs and benefits of subsequent investments in local state presence and thus, the magnitude of the own effect. This means that colonial state presence (and distance to royal roads) can be interpreted as shifters of the best response equations. Moreover, these colonial variables are also arguably unrelated to current prosperity outcomes, i.e., $cov(\mathbf{c}, \xi_i) = 0$.

This is the standard requirement for a valid instrument, and is motivated by the nature of the colonial state in Colombia. Figure 1 presents the geographic distribution of two of our measures of colonial state presence, the size of the crown bureaucracy, and the number of state agencies. The salient feature of these figures is the lack of uniformity in colonial state presence across (contemporary) municipalities. The clustering of state presence around specific areas, beyond which the colonial state was mostly absent, is notable. The colonial settlement strategy led to the concentration of bureaucracies and agencies in particular cities, which would have control and jurisdiction over surrounding areas. As such, towns with relatively high levels of colonial state presence got to be surrounded by towns with relatively low presence. The main reasons for this specific state-building strategy by the Spanish colonial state are related to the objectives and constraints faced by the Spanish authorities, which were likely to be varied and heterogeneous across space. For example, in regions heavily involved in gold mining during the 17th and 18th centuries, the presence of colonial officials and crown agencies was narrowly related to taxation functions and followed the gold reserves. In regions with higher densities of Spanish settlers and their descendants, on the other hand, the demand for public services such as legal adjudication and market regulation translated into a different type of colonial state. Finally, in strategically located places such as the Caribbean coast or key outposts along the Magdalena River (the main communications channel at the time) the presence of the Spanish colonial state was related to military objectives such as the provision of services to the Spanish fleet.

As mentioned above, we additionally collected information on royal roads as a proxy for colonial state presence. The royal roads network was the main investment in communications infrastructure during the colonial period (see Useche, 1995). It was partially inherited from pre-colonial roads, and partially built under Spanish authority. Pre-colonial roads often involved steep flights of steps unsuited to horse or cart traffic (see Langebaek, Giraldo, Bernal, Monroy, and Barragan, 2000). There is also archaeological evidence that indigenous roads were partly developed for pilgrimage to sacred places which were irrelevant to the Spanish. The difficulties of converting colonial royal roads into modern motor roads were significant (see Pachon and Ramirez, 2006). Some were built for porterage along difficult geographic paths such as mountain edges, making them hard to subsequently reconvert to railroads or highways. As a result, though the location of these roads reflects accurately the presence of the colonial state and thus the regions where the Spanish authorities were more interested in controlling the territory, most of the royal roads network was subsequently abandoned and is unlikely to be a direct influence on current state capacity, public goods or prosperity (especially since we also control for the current road network).

More importantly in our setting, if this assumption is satisfied, then we can also expect that these colonial variables are so also orthogonal to the error term is in the prosperity equations of neighbors, i.e., $cov(\mathbf{N}_i(\boldsymbol{\delta})\mathbf{c}, \xi_i) = 0$ and in fact, $cov(\mathbf{N}_i^k(\boldsymbol{\delta})\mathbf{c}, \xi_i) = 0$, where $\mathbf{N}_i^k(\boldsymbol{\delta})$ denotes the i-th role of the k-th integer power of the matrix $\mathbf{N}(\boldsymbol{\delta})$ (e.g., $\mathbf{N}^2(\boldsymbol{\delta})$ is the matrix of neighbors of neighbors). But the same reasoning can also be applied to the best response equation, (11), so that we also have fact, $cov(\mathbf{N}_i^k(\boldsymbol{\delta})\mathbf{c}, \epsilon_i) = 0$ for any integer k.[19]

One concern with the strategy utilized here is that even if the argument for the validity of the colonial variables as instruments for own state capacity is plausible, they may happen to be spatially correlated (particularly likely outcome for historical and geography-related variables), making the lack of correlation with neighbors' error terms less plausible. In the Colombian setting, however, consistent with the heterogeneous objectives of the colonial authorities, the spatial correlation of the colonial state is very weak or negative. This can be seen in Table 2, which presents the within-department spatial correlation matrix of our three colonial state presence variables. Own colonial state employees are weakly negatively correlated with neighbors' and neighbors of neighbors' colonial state employees (-0.061 and -0.062 respectively).

[19] These observations also imply that we will have more instruments than endogenous variables, enabling us to check the robustness of our results to assuming different types of network interactions.

Similarly, own colonial state agencies are basically uncorrelated with neighbors' and neighbors of neighbors' colonial state agencies (0.022 and 0.078 respectively). Perhaps somewhat more surprisingly, the same is also true of the distance to royal roads variable. Table 2 shows that own and neighboring distance to royal roads has only a 0.28 correlation, and the correlation falls to 0.045 between own and neighbors of neighbors' distance to royal roads. In conjunction with the colonial state presence variables that are spatially negatively correlated, this pattern alleviates any concerns resulting from spatially correlated instruments leading to biased estimates.

5.2 Instrumental-Variables Estimates

We propose several alternative estimation strategies, all relying on the exclusion restrictions outlined above.

The first and most straightforward approach we pursue is to fix $\boldsymbol{\delta}$ and let $g(\cdot)$ be approximated by a linear function, enabling the estimation of equations (11) and (12) separately using linear instrumental variables. Specifically, we use six instruments for $\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}$ in our benchmark specification of (11): Neighbors' crown employees, number of neighbors' colonial agencies, neighbors' distance to royal roads, and neighbors of neighbors' crown employees, number of neighbors of neighbors' colonial agencies, and neighbors of neighbor's distance to royal roads.

Our model is overidentified, enabling us to perform overidentification tests to verify the (internal) validity of our instruments (and also below we report estimates using only subsets of the instruments). For our benchmark specification of equation (12) we use the same set of instruments, but also exploit the nonlinear reduced-form relationship between prosperity and state capacity by including a quartic of these instruments. For the case of the prosperity equation, we have two first stages, one for s_i^2 and one for $\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}$.

Table 3 presents the estimates for equation (11), where we impose $\boldsymbol{\delta} = (1, 1)$ and assume $g(\cdot)$ to be a linear function: $g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta})/\theta = a + \mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta}$. In our benchmark estimates, as noted in the previous section, our vector of covariates $\mathbf{x}_i$ includes longitude, latitude, surface area, elevation, rainfall, a dummy for department capital, distance to a current highway, and current (1995) population. We measure state capacity alternately as the number of public agencies (columns 1-3) or the number of municipality employees (columns 5-7). All reported values are average marginal effects for ease of comparison. Throughout, all standard errors are corrected for spatial correlation using the Conley (1996) adjustment, adapted to our network structure.[20] Standard errors for the reported marginal effects are computed using the delta method.

[20]The robust spatial correlation-corrected variance matrix of the IV estimator takes the form

$$(\mathbf{X}'\mathbf{Z}(\mathbf{Z}'\mathbf{Z})^{-1}\mathbf{Z}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Z}(\mathbf{Z}'\mathbf{Z})^{-1}\mathbf{Z}'\hat{\mathbf{W}}\mathbf{Z}(\mathbf{Z}'\mathbf{Z})^{-1}\mathbf{Z}'\mathbf{X}(\mathbf{X}'\mathbf{Z}(\mathbf{Z}'\mathbf{Z})^{-1}\mathbf{Z}'\mathbf{X})^{-1}, \text{ where}$$

Columns 1 and 5 present OLS estimates as a benchmark. Columns 2 and 6 present the instrumental variables estimates for the same equation (with log population treated as an exogenous covariate). Estimates for the first stage of this model are presented in the bottom panel of Table 3, together with the results of an overidentification test on the IV models. The bottom panel includes the first stage for $\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}$, where we can see a clear positive and strong correlation between neighboring measures of colonial state presence, and neighboring contemporary state capacity. In no specification do we reject the null hypothesis that instruments are valid, giving us some confidence in our exclusion restrictions. Columns 3 and 7 treat population as endogenous, instrumenting it using the 1843 population (we also include a dummy for municipalities without population data in the 1843 Census).

All of our estimates in Table 3 show a positive and precisely estimated slope for the best response equation, also implying a positive interaction effect ϕ. These estimates imply that the game between municipalities exhibits strategic complementarities. Interestingly, the IV estimates are always close to the OLS estimates. The estimate in the top of column 3, 0.020 (s.e.= 0.003), implies that moving the number of state agencies of a neighbor from the median (10) to the mean (21) leads to a 1.5% increase in own state agencies at the median of the distribution.[21] Notice this is only the direct ("partial equilibrium") response, and does not take into account equilibrium feedbacks that take place through network effects as other municipalities also respond (due to strategic complementarities).

Column 6 of Table 3 presents the results of the IV estimate of ϕ/θ (0.022, *s.e.* = 0.004) with the alternative measure of state capacity, municipality employees. The estimates in this case have very similar magnitude to those using the number of local state agencies and are also estimated with similar precision.

The bottom panel of the table presents the first stages. Throughout, colonial state presence is associated with increased current state capacity. When all measures of historical state presence are introduced simultaneously, colonial state officials remain significant. Due to collinearity among them, the number of colonial state agencies and distance to royal roads are typically insignificant (except in the System GMM estimates discussed below). Nevertheless, in all models where we introduce only subsets of our colonial state measures, colonial state agencies and distance to royal roads are statistically significant with the expected sign. Results are also very similar when we treat (log) population as endogenous and instrument it by historical population (compare columns 2 to 3 and 6 to 7).

$$\hat{\mathbf{W}} = \boldsymbol{\Omega} * \mathbf{I} + \sum_{j=1}^{t} \frac{t+1-j}{t+1} \left(\boldsymbol{\Omega} * \mathbf{N}^t(\boldsymbol{\delta}) + \left[\boldsymbol{\Omega} * \mathbf{N}^t(\boldsymbol{\delta}) \right]' \right),$$

t is the highest network degree at which we truncate spatial correlation (we truncate the spatial correlation at second-degree adjacency, in practice allowing for arbitrary decaying spatial correlation between neighbors and neighbors of neighbors), $\boldsymbol{\Omega}$ is the outer product of the residuals, $*$ denotes element-by-element multiplication, and $\mathbf{N}^t(\boldsymbol{\delta})$ denotes the t-th degree network matrix (the matrix whose ij'th entry is zero if i and j are not neighbors of degree t, and f_{ij} otherwise).

[21] $10.15 = \exp\left((0.02)\ln(22/11) + \ln(11)\right) - 1$, which is a 1.5% increase from the median state capacity of 10.

Marginal effects from the estimates of equation (12) are presented in Tables 4A and 4B. Similarly to the estimates reported for equation (11), we present benchmark OLS and IV results from the estimation of each of our four prosperity outcomes equations separately. Columns 1-3 present results for the life quality index, columns 5-7 for utilities coverage, columns 9-11 for the fraction of the population above the poverty line, and columns 13-15 for the secondary enrollment rate. Table 4A presents the estimates for the models using the number of agencies, and Table 4B presents the estimates for the models using the number of municipality employees. Once again, we first control for population and subsequently instrument it with historical (1843) population. In all cases, we find both strong own effects that are quite significant and also very precisely estimated spillover effects. Across outcomes and specifications, we find an own marginal effect ($2\theta\bar{s}$) that is an order of magnitude larger than the spillover effect.[22] A p-value for the joint significance of the set of instruments in both first stages is reported in the bottom panel of Tables 4A and 4B. IV estimates are somewhat smaller than OLS estimates, and very similar regardless of whether log population is treated as exogenous or endogenous.[23]

To assess the quantitative magnitudes of our estimates, Table 5 presents the results of a counterfactual experiment showing the implications of increasing local state presence to the median, in all municipalities below median local state presence. The first two panels of the table present the results from the linear IV estimates reported in this subsection (the third and fourth panels contain estimates from the general model and will be discussed in the next subsection). The first panel depicts the partial equilibrium effects (holding the response of other municipalities constant) and shows significant and sizable impacts on the quality of life index, the fraction of the population above poverty, utilities coverage and secondary enrollment. For example, the median fraction of the population above poverty increases from 57% to 60%. The table also indicates that about 57% of this is due to direct effects, so that spillover effects are not implausibly large, though still sizable. The second panel then factors in the full equilibrium responses through network effects. Now the quantitative magnitudes are much larger—reflecting the positive responses due to strategic complementarities. For example, the median fraction above poverty now rises to 68%. This is indicative of the importance of network effects in this setting.

5.3 System GMM

Separately estimating equations (11) and (12) is in general inefficient because that the system of $J+1$ equations imposes several cross-equation restrictions due to their joint dependence on θ, ϕ and $\boldsymbol{\delta}$.

[22] The average spillover effect is computed as $\psi_2^j \bar{n}_i$, where $\bar{n}_i$ is the average number of "weighted" neighbors of a municipality, with f_{ij}'s as weights. Because this spillover is on more than one municipality, in the quantitative exercise in Table 5 the partial equilibrium direct effect and spillovers are roughly of the same order of magnitude.

[23] Moreover, in all specifications, at our estimated parameters, the uniqueness condition from Proposition 2 is comfortably satisfied. This still leaves the question of whether, for a different set of parameters, there might be multiple equilibria and we may incorrectly estimate a parameter vector implying uniqueness. We believe this is unlikely, since our estimates are far from the values that would imply multiplicity.

Moreover, since the shape of the function $g(\cdot)$ is in general unknown, we would like to allow the intercept of the best response to depend on the covariates in $\mathbf{x}_i$ and colonial state $\mathbf{c}_i$ more flexibly. Motivated by this reasoning, we estimate equations (11) and (12) as a system through a semi-parametric GMM approach building on Ichimura and Lee (1991). Following this methodology, we created moment conditions using the orthogonality of our instruments and the residuals in equations (11) and (12), and estimated the parameters of this system through a semi-parametric GMM estimator. This enables us to explictly include the cross-equation restrictions, to allow for the network links to depend nonlinearly on topographic features, and to estimate $g(\cdot)$ semi-parametrically.[24]

To identify $\boldsymbol{\delta}$ (when it is not imposed), we include as moment conditions functions of d_{ij} and e_{ij}. In particular, we use the average distance of each municipality to neighboring municipalities, and the average variation in elevation along geodesics connecting municipality i to its neighbors.[25]

For ease of comparison with our IV estimates, the system GMM estimates are also presented in Tables 3, 4A and 4B. The results in column 4 of Table 3 are jointly estimated with the results of columns 4, 8, 12 and 16 of Table 4A, where we measure state capacity with the number of local agencies, and column 8 of Table 3 is jointly estimated with columns 4, 8, 12 and 16 of Table 4B. Marginal effects based on

[24]Following Ichimura and Lee (1991), we use a flexible semi-parametric index-function approach for the purpose of estimating $g(\cdot)$ by constructing the conditional expectation of the unknown function using only the empirical distribution. To smooth out the distribution, we use a density kernel that gives greater weights the closer observations. In particular, we divide the range of the function in many bins.

$$\mathbb{E}\left[g(\mathbf{c}_i\boldsymbol{\varphi}+\mathbf{x}_i\boldsymbol{\beta})\right]=\frac{\sum_{j=1}^{n}\left[s_j-\frac{\phi}{\theta}\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}-\varsigma_i^D\right]K\left(\frac{(\mathbf{c}_i-\mathbf{c}_j)\boldsymbol{\varphi}+(\mathbf{x}_i-\mathbf{x}_j)\boldsymbol{\beta}}{a_n}\right)}{\sum_{k=1}^{n}K\left(\frac{(\mathbf{c}_i-\mathbf{c}_j)\boldsymbol{\varphi}+(\mathbf{x}_i-\mathbf{x}_j)\boldsymbol{\beta}}{a_n}\right)},$$

where j denotes observations and i is the grid point.

[25]Letting $\boldsymbol{\psi}=(\theta,\phi,\gamma,\boldsymbol{\varphi},\boldsymbol{\beta},\boldsymbol{\varsigma},\tilde{\boldsymbol{\beta}},\tilde{\boldsymbol{\varsigma}})$, our semi-parametric system GMM estimator is given by

$$\min_{\boldsymbol{\psi},\boldsymbol{\delta}}\left[\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta})'\mathbf{q}_i(\boldsymbol{\psi},\boldsymbol{\delta})\right]'\left(\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta}_0)'\hat{\mathbf{W}}_i\mathbf{Z}_i(\boldsymbol{\delta}_0)\right)^{-1}\left[\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta})'\mathbf{q}_i(\boldsymbol{\psi},\boldsymbol{\delta})\right],$$

where $\mathbf{q}_i(\boldsymbol{\psi},\boldsymbol{\delta})=[\epsilon_i^1,...,\epsilon_i^J,\xi_i]'$, $\hat{\mathbf{W}}_i=\hat{\mathbf{u}}_i\hat{\mathbf{u}}_i'+\sum_{j=1}^{t}\frac{t+1-j}{t+1+20}\left(\boldsymbol{\Omega}_{ij}+\boldsymbol{\Omega}_{ij}'\right)$, $\boldsymbol{\Omega}_{ij}=\frac{\sum_{j\in N^t(i)}f_{ij}\hat{\mathbf{u}}_i\hat{\mathbf{u}}_j'}{|N^t(i)|}$, t is the highest network degree at which we truncate spatial correlation (in practice we allow spatial correlation between neighbors and neighbors of neighbors), $\hat{\mathbf{u}}_i$ are residuals from a first stage estimate, given by $\hat{\mathbf{u}}_i=\mathbf{q}_i(\boldsymbol{\psi}_0,\boldsymbol{\delta}_0)$ and $(\boldsymbol{\psi}_0,\boldsymbol{\delta}_0)=\arg\min_{\boldsymbol{\psi},\boldsymbol{\delta}}\left[\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta})'\mathbf{q}_i(\boldsymbol{\psi},\boldsymbol{\delta})\right]'\left(\sum_{i=1}^{n}\mathbf{Z}_i(\mathbf{1})'\mathbf{Z}_i(\mathbf{1})\right)^{-1}\left[\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta})'\mathbf{q}_i(\boldsymbol{\psi},\boldsymbol{\delta})\right]$. Moreover,

$$\mathbf{Z}_i(\boldsymbol{\delta})=\begin{bmatrix}\mathbf{I}_J\otimes\mathbf{z}_i^p(\boldsymbol{\delta}) & \mathbf{0}\\ \mathbf{0} & \mathbf{z}_i^{BR}(\boldsymbol{\delta})\end{bmatrix}$$

is the matrix of instruments for observation i, $\mathbf{z}_i^p(\boldsymbol{\delta})$ is the vector of instruments for the prosperity equations, and $\mathbf{z}_i^{BR}(\boldsymbol{\delta})$ is the vector of instruments for the best response equation. These are exactly the same as the set of instruments we used with the linear IV strategy in the previous subsection.

The analytic spatial correlation consistent asymptotic variance for this estimator is given by

$$\left(\left[\sum_{i=1}^{n}\mathbf{Z}_i(\hat{\hat{\boldsymbol{\delta}}})'\nabla_{\boldsymbol{\psi},\boldsymbol{\delta}}\mathbf{q}_i(\hat{\hat{\boldsymbol{\psi}}},\hat{\hat{\boldsymbol{\delta}}})\right]'\left(\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta}_0)'\hat{\mathbf{W}}_i\mathbf{Z}_i(\boldsymbol{\delta}_0)\right)^{-1}\left[\sum_{i=1}^{n}\mathbf{Z}_i(\hat{\hat{\boldsymbol{\delta}}})'\nabla_{\boldsymbol{\gamma},\boldsymbol{\delta}}\mathbf{q}_i(\hat{\hat{\gamma}},\hat{\hat{\boldsymbol{\delta}}})\right]\right)^{-1}.$$

Notice this estimator allows for both arbitrary spatial and across-equations correlation. The choice of weights for the spatial correlation terms must be such that they approach 1 as $t\to\infty$, and $\left(\sum_{i=1}^{n}\mathbf{Z}_i(\boldsymbol{\delta}_0)'\hat{\mathbf{W}}_i\mathbf{Z}_i(\boldsymbol{\delta}_0)\right)^{-1}$ is positive definite.

GMM estimates are remarkably similar to the linear IV estimates, but are estimated more precisely. This partly reflects the fact that by estimating the full system of five equations jointly, we are imposing the restriction that the coefficient of s_i^2 is the same for all of our prosperity outcomes, leading to a gain in efficiency (and this explains why the estimate for the own effect is the same across columns in Tables 4A and 4B).[26]

Figure 3 below presents our estimated function $g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta})/\theta$ from the System GMM. Over most of its range, the function is very precisely estimated. Recall that in our model, $g_i(.) = \kappa_i$, is proportional to the average effect of own state capacity on prosperity. The figures show that this function is positive for all its relevant range and is decreasing nonlinearly but monotonically. Table 3 also presents the average marginal effects $\boldsymbol{\varphi} g'(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta})$ for the historical state presence variables, where $g'(\cdot)$ is the average slope. These estimates show that own colonial state officials and state agencies have a positive effect on own contemporary state.

Because the parameter estimates from the system GMM are very similar to those from the linear IV models discussed in the previous subsection, the implied quantitative magnitudes are also very similar to those reported in the first two panels of Table 5 and are omitted to save space.

Finally, Figure A1 in the Appendix presents scatterplots of the observed and predicted values of the endogenous variables (when state capacity is measured with public employees) from the System GMM estimates. The implied fit is very good.

5.4 Falsification Exercises

We now report two falsification exercises, supporting the validity of the exclusion restrictions used in our analysis so far. The first exercise, reported in Table 6, investigates whether own and neighbors' local state presence is correlated with two outcomes, primary enrollment and vaccination coverage, that are mostly determined at the national level and are thus unlikely to be affected by local state presence. In particular, we report OLS and IV estimates of equation (12) for the these two outcomes. This table shows that these variables are indeed unaffected by own and neighbors' local state presence, bolstering our confidence in the exclusion restrictions and the estimates reported so far.

The second exercise, reported in Table 7, examines whether the reduced-form correlation between neighbors' historical variables (colonial state presence and royal roads) and current prosperity and public good outcomes may reflect persistent unobservables affecting historical and current prosperity. In particular, one concern may be that this correlation is a consequence of the fact that these colonial variables impacted historical prosperity and historical prosperity has persisted and affected both current local state

[26] The conditions for a unique equilibrium in Proposition 2 are again easily satisfied at our parameter estimates. At our GMM estimates, when measuring state capacity through agencies, we have $(\psi_1/\theta)^{-1} = 1.113 > |\lambda_{min}(\mathbf{N}(\boldsymbol{\delta}))| = 0.235$. When measuring state capacity through local bureaucracies, we have $(\psi_1/\theta)^{-1} = 2.0934 > |\lambda_{min}(\mathbf{N}(\boldsymbol{\delta}))| = 0.235$.

presence and current prosperity. Using data on literacy and school enrollment from the 1918 National Census, which are available for around 70 percent of the municipalities in our sample, Table 7 shows that this is unlikely to be the case. The top panel of the table presents the key reduced-form relationship underlying our IV estimates in Tables 4A and 4B between our four key prosperity outcomes and the excluded instruments in these tables (but focusing on the sample of 683 municipalities with the historical data on prosperity). Consistent with the results presented so far, there is a strong and robust positive relationship between neighbors' state presence and current prosperity. The pattern in the bottom panel, which presents analogous reduced-form estimates for the 1918 outcomes, is quite different, however. Though a few of the estimates have a similar size, none are statistically significant. This pattern is reassuring and bolsters our interpretation that the effects of colonial state presence and royal roads variables on current prosperity and public goods provision are working through current, or at the very least recent, presence of the local state.

5.5 Specification Tests

Table 8 presents OLS and IV results from a misspecified but simpler model where own state capacity enters linearly. This is very similar to the type of equation estimated in most of the rest of the peer effects literature. The estimates reported in Table 8 are still significant and quantitatively very similar to those in Table 4 (e.g., with state capacity measured with the number of agencies, the estimates in Table 4 are between 0.23 and 0.56, while those in Table 8 are between 0.1 and 0.36). This is reassuring as it suggests that both the general qualitative and the specific quantitative aspects of our estimation are not overly dependent on functional forms.[27]

Table 9 further recesses the validity of our approach by presenting the correlation coefficients between the residuals from the estimates of equations (11) and (12) and two standard measures of network centrality, the betweenness and the Bonacich centrality statistics (Jackson, 2008). Since the equilibrium levels of state capacity in our game are functions of the centrality measures (e.g., Ballester, Calvo-Armengol and Zenou, 2006; Bramoulle, Kranton and D'Amours, 2014), misspecification is likely to lead to a correlation between residuals and these centrality measures. Table 9 shows that there is essentially no correlation between these variables, bolstering our confidence in our empirical strategy.

[27] The results are no longer similar, however, if one were to try to directly estimate equation (1) including the cross effects, i.e., the term $\phi s_i \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}$. This is exactly what theory predicts: given the form of the equilibrium is summarized by equations (11) and (12), it should not be possible to estimate the own and cross effects separately by estimating (1), so we find this result reassuring.

5.6 Robustness

Tables A1-A10 in the Online Appendix show that our results are also robust to a series of variations. For brevity, we focus on linear IV estimates of equation (12) for our four prosperity outcomes. In Panel I of Table A1 we estimate the model without controlling for the distance to a current highway, which is a useful robustness check against the potential endogeneity of the location of current highways. In Panel II, we control for a range of additional geographic covariates, including the density of primary, secondary and tertiary rivers, and the full distribution of land by qualities and type as described in Section 4. The estimates in this table are remarkably similar to our baseline estimates. The only exceptions are the own effect on secondary enrollment when we do not control for the proximity to a current highway, which is now significant only at 5% (columns 4 and 8 of Panel I in Table A1), and the own effect on the fraction of the population above poverty when we control for an additional 14 covariates and measure state presence with agencies, which becomes statistically insignificant (column 3 of Panel II in Table A1).

Table A2 presents robustness exercises related to the network structure itself. In Panel I we combine our IV strategy with Bramoulle, Djeebari, and Fortin's (2009) approach of using neighbors of neighbors' characteristics. In case our historical instruments are potentially spatially correlated, but we are willing to assume that our specification of the network captures the full set of spillovers, then using the third-degree neighbors' historical variables as instruments (instead of our benchmark first and second-degree neighbors' historical variables) will lead to consistent estimates — even though our baseline estimates may have been biased. In Panel II we present the results of redefining the meaning of a link, by considering both adjacent and second-degree adjacent municipalities as connected to check whether allowing longer-range spillovers has a meaningful impact on our results. Finally, in Panel III we allow for links to exist between every pair of municipalities with decaying link strength according to matrix $\mathbf{F}$. Reassuringly, in all three cases, the results are very similar to our baseline estimates (if anything, they become more precisely estimated).

In Table A3 we look at the sensitivity of our estimates to using subsets of our colonial state presence instruments. In Panel I we exclude all functions of distance to royal roads from the instrument set, and in Panel II we only use distance to the royal roads as instruments. As anticipated by the overidentification tests reported above, our estimates remain quite stable. In addition, when only the royal roads instruments are used, we can see more transparently that neighbors' distance to royal roads have the right sign in the first stage of the best response equation.

Tables A4-A6 further probe the sensitivity of our results to the functional form. In Table A4 we include additional quadratic terms in (1). This has little effect on the implied quantitative magnitudes, and the quadratic effects themselves are... XXX significant/insignificant. Tables A5 and A6 include additional contextual effects in the best response equation (from the neighbors' historical characteristic), thus making best use historical characteristics of neighbors of neighbors as instruments. The results are again very similar.

Another concern is that some areas of Colombia have been under the control of guerrillas and paramilitaries, creating a general lawlessness, which would supposedly reduce the effectiveness of the local and national state in these areas. In Table A7, we show that our results are not driven by municipalities most likely to suffer from such lawlessness. In particular, we exclude from our sample, or from the network entirely, municipalities with historically high levels of violence as measured by paramilitary attacks during the 1998-2004 period. In Panel I of Table A7 we report estimates of the prosperity equation when we exclude from the sample (but not from the network) municipalities above the 90th percentile of the distribution of paramilitary attacks. In Panel II we exclude this same subset of municipalities from the network. The results show that our baseline results are quite robust to these changes in sample and network.

A related concern is the role of capital cities as the source of spillovers. To show that our results are not driven by capital cities, Table A8 presents the estimates of the prosperity equation without these cities, which are very similar to the baseline.

Table A9 makes an attempt at unbundling our measures of all agencies. We separate them into four distinct types: health-related, regulation-related, services-related, and education-related. We then re-estimate the best response equation for each subset of agencies. Reassuringly, we find not only similar strategy complementarities to our baseline results, but also that each dimension of state capacity appears to be responding to variation in neighbors' state capacity in the same dimension (e.g., health-related agencies respond positively to health-related agencies of neighbors, not to other agencies of neighbors).

5.7 Controlling for National Bureaucracy

As a preparation for the results in the next section, in Tables 10 and 11 we also control for the national state's employees (bureaucrats). In our baseline estimates, these employees are effectively included in the error term and if they are correlated with our instruments, this could lead to inconsistent estimates. The results are very similar to our baseline, and are in fact more precisely estimated, which is plausible as the omission of national bureaucracy from our baseline models likely created additional residual variance.

6 General Case

In this section, we turn to the general model which relaxes the assumption that $\alpha = 1$ and thus allows national state capacity choices to matter. Our objective is to estimate whether national and local state capacities are complements or substitutes and investigate whether fully allowing for the endogenous determination of national state capacity affects the extent of direct and spillover effects of state capacity.

The reason why we view those presented in the previous section as our main results is that estimates from this more general model lead to very similar qualitative and quantitative patterns.

6.1 Empirical Strategy

Our empirical strategy relies on the same historical sources of variation (and same exclusion restrictions), but combines them with the first-order conditions of our more general model. In particular, in this case, we have two sets of first-order conditions, one for the national state, corresponding to (8) in the general model, and the other for the local state, corresponding to (7). These two first-order conditions can be written as

$$h_b(l_i, \mathbf{p}_i, b_i|\boldsymbol{\zeta}) \equiv (1-\alpha)\tau^{\frac{\sigma-1}{\sigma}} \left[\frac{s_i}{b_i}\right]^{\frac{1}{\sigma}} \left\{ \frac{\theta}{\alpha}\zeta_i l_i \left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}} + \mathbf{N}_i(\boldsymbol{\delta}) \left[\left(\phi \mathbf{s} + \frac{\sum_j \gamma^j}{J} \boldsymbol{\iota} \right) * \boldsymbol{\zeta} \right] \right\} - \eta b_i = 0, \tag{13}$$

and

$$h_\xi(l_i, \mathbf{p}_i, b_i) \equiv \frac{\theta}{\alpha} l_i \left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}} - \phi \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} - g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta}) - \varsigma_i^D = 0, \tag{14}$$

where $\boldsymbol{\iota}$ is a column vector consisting of 1s, and with overall state capacity s_i defined by equation (4). In addition, we rewrite the prosperity equation, (1), for this case after substituting for $\kappa_i s_i + \phi s_i \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}$ from (14):

$$h_{\epsilon^j}(l_i, \mathbf{p}_i, b_i) \equiv p_i^j - \frac{\theta}{\alpha} l_i s_i \left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}} - \gamma^j \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} - \mathbf{x}_i\tilde{\boldsymbol{\beta}}^j - \tilde{\varsigma}_i^{jD} = 0. \tag{15}$$

These three equations summarize the moment conditions for the general model. They show that this general model is identified up to a scaling: either $(\alpha, \eta) = (1, 0)$ or $(\tau, \eta) = (0, 0)$ make the first-order condition of the national state vanish. Thus, analogously as for the linear case, we proceed by normalizing $\alpha = 0.5$, and noticing that equations (14) and (15) do contain enough information to identify the parameters τ and σ characterizing the CES state capacity composite. We therefore proceed by first taking the national state's choices as predetermined and estimate these parameters based only on the variation coming from equations (14) and (15). We then estimate the entire system (13)-(15), by imposing the CES parameter estimates to obtain the full estimates from this most general model.

6.2 GMM with Predetermined National Choices

When national state capacity choices, the b_i's, are treated as predetermined in the network game between municipalities, the model reduces to equations (14) and (15). Then, conditional on the b_i's, these equations can be estimated straightforwardly by GMM. The GMM estimator is analogous to the one we utilized in the previous section (see footnote 25), with the difference that the moment condition coming from the best response equation is now the nonlinear function given by (14).

The corresponding GMM estimates are reported in the first column of Table 11. To compute standard errors, we again use the analogous spatial correlation consistent variance-covariance estimator in footnote 25. The table presents the estimates when we use the number of state agencies as our measure of state capacity. The elasticity of substitution between local and national state, σ, is estimated as 0.63 (standard error = 0.18). This implies local and national state presence are complementary inputs. The estimate for the interaction effect ϕ indicates that this is again estimated to be a game of strategic complementarities, and the magnitude of these complementarities is very similar to that estimated from our linear model. The table also presents the average (across the sample of municipalities) value of κ_i, the direct effect of own state capacity on prosperity, which we recover in our estimation as $\kappa_i = g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta})$. The table presents the standard deviation of the estimated κ_i's.[28]

6.3 Estimation of the Full Model by Simulated Method of Moments

We next estimate the full model given by equations (13), (14), and (15). Relative to the estimates in the previous subsection, this involves imposing the additional restrictions that national state capacities satisfy the first-order condition as given in equation (8).

Because national state's weights, the ζ_i's, are unobserved, we model them to be a function of a vector of observable characteristics related to within-network centrality of the municipalities, political variables, and an unobserved component modeled as

$$\zeta_i = \exp(\mathbf{v}_i\boldsymbol{\pi} + \omega_i).$$

In addition to a constant, $\mathbf{v}_i$ here includes four covariates: three standard network centrality statistics, the betweenness centrality, the Bonacich centrality, and the local clustering coefficient (see Jackson, 2008), and a proxy for the extent of historical political competitiveness of the municipality, which we measure as the standard deviation of the Liberal Party's elections share across the 1974-1994 presidential elections.

Because the national state's first-order conditions involve the full vector of unobserved weights for each municipality, we use a simulated method of moments (SMM) estimator using the moment conditions implied by (13), (14), and (15). Our SMM estimator is similar to the GMM estimator we used in the previous section (see footnote 25), except that we have $\mathbf{q}_i(\boldsymbol{\rho}, \boldsymbol{\delta}) =$

[28] Once again, at the parameter estimates in Table A3, the condition for uniqueness in Proposition 1 is easily satisfied. In particular, we have $1 + \frac{1}{\lambda_{min}(\mathbf{N}(\boldsymbol{\delta}))} = -0.236 < \min\left\{\left(\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}}\right)^{-1}\right\} = 0.127 < \max\left\{\left(\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}}\right)^{-1}\right\} = 0.186 < 1.$

$[h_{\epsilon^1}(l_i, \mathbf{p}_i, b_i), ..., h_{\epsilon^J}(l_i, \mathbf{p}_i, b_i), h_\xi(l_i, \mathbf{p}_i, b_i), \widehat{h}_b(l_i, \mathbf{p}_i, b_i)]'$, where

$$\mathbf{Z}_i(\boldsymbol{\delta}) = \begin{bmatrix} \mathbf{I}_J \otimes \mathbf{z}_i^p(\boldsymbol{\delta}) & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{z}_i^{BR}(\boldsymbol{\delta}) & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{z}_i^{NL}(\boldsymbol{\delta}) \end{bmatrix}.$$

Here $\mathbf{z}_i^{NL}(\boldsymbol{\delta})$ is a vector of instruments for the national state's best response equation, including $\mathbf{v}_i$, $\mathbf{x}_i$, historical population, average distance to neighboring municipalities, and average variability in altitude along geodesics to neighboring municipalities. We write the average (simulated) national state's first-order condition as

$$\widehat{h}_b(l_i, \mathbf{p}_i, b_i) = \int h_b(l_i, \mathbf{p}_i, b_i|\boldsymbol{\omega}) f_\omega(\boldsymbol{\omega}) d\boldsymbol{\omega}. \tag{16}$$

In equation (16), $f_\omega(\cdot)$ is the joint density of the unobserved component of the national state's random weights, and the vector $\boldsymbol{\rho}$ now also includes η and $\boldsymbol{\pi}$. Notice that the full vector of weights is assumed to be known to all players. In the estimation, we restrict the ζ_i's to be nonnegative, and test for the robustness of our estimator to several different densities $f_\omega(\cdot)$. Our benchmark specification presents results when using a standard normal density for the ω_i's, and where the draws are independent across i. As noted above, we are imposing the GMM CES parameter estimates (α, σ, τ), which allow the national state's weights to be estimated very precisely.

Estimates for the general model, when measuring local state capacity as the number of state agencies, are presented in the second column of Table 13. The magnitudes of the parameter estimates are remarkably close to those of the GMM estimation under predetermined national-level choices, but much more precisely estimated. Our estimates also imply that the national state's weights, the ζ_i's, are fairly skewed, with a mean of 4.97, a median of 3.92, and a standard deviation of 3.69. This squares well with the idea that the Colombian national state has been narrowly focused on a few areas of the country leaving large swathes of it unattended. The π's are estimated precisely, suggesting that a large part of the variation in national state presence reflects local characteristics of municipalities. In particular, the network characteristics and the historical political competitiveness of municipalities are strong predictors of larger national-weights, and have a significant impact on the variation in national state's choices.

Throughout, the quantitative magnitudes of the estimates are very similar to those from the linear model. For example, the average slope of the best response equation (the average $\frac{\partial l_i}{\partial l_j}|_{h_\xi}$ from equation (14)) at our SMM estimates is 0.021, compared to the average slopes of the linear best response reported in Table 4, which are between 0.016 and 0.022. Similarly, the average own effect in the prosperity equation (the average $\frac{\partial p_i}{\partial l_i}|_{h_\epsilon}$ from equation (15)) is 0.45, which is very close to our system GMM estimate for the linear model of 0.39 reported in the first row of Table 4A. Finally, the average spillover effects in the prosperity equations ($\frac{\partial p_i}{\partial l_j} |_{h_\epsilon}$) are $(0.019, 0.021, 0.016, 0.028)$ for the life quality index, utilities coverage, fraction above the poverty line, and secondary enrollment rates, respectively, which are close to the corresponding estimates in the second row of Table 4A, lying between 0.02 and 0.035.

We perform the same counterfactual exercise as in the bottom two panels of Table 5 and the results are reported in the next two panels of Table 5. The implementation of this counterfactual experiment requires us to compute the Nash equilibrium profile under the proposed change. Because the best responses are nonlinear, we cannot simply use the estimated parameters (and shocks) to predict the equilibrium outcomes. We therefore numerically solve for the equilibrium state capacities (using a Newton-Raphson approximation). Using the resulting equilibrium values of l_i's, we then compute the implied values for $\mathbf{p}_i$ using equation (15). The bottom two panels of Table 5 show that the quantitative results are very similar to those we obtain from the linear model (with $\alpha = 1$). This is the basis of the statement above that the qualitative and quantitative results from this general model are similar to those from the linear model.

We next perform two counterfactual exercises related to implications of changes in national state capacity. First, in Table A11 we investigate the implications of increasing all b_i's below the median to the median value. In contrast to the counterfactual experiment in which local state capacity levels were thus increased (which remain very similar to the baseline results presented in Table 5 as also shown in the table), the implied magnitudes are now small. These limited effects of a change in national state capacity argued to the low estimate of τ (recall equation (4)). They imply that for various local prosperity outcomes local state capacity is more important in the present than national state capacity in Colombia and justify our greater emphasis on local state presence in this context.

Second, in Table A12, we consider reducing the skewness (asymmetry) of the weights the national state attaches to different municipalities by increasing all ζ_i's below the median to the estimated median value. This experiment allows us to explore the general equilibrium implications of a national level that cares about municipalities in a much less asymmetric way. Now there are significant gains, corresponding, for example, to a 15% increase in the median fraction of population above the poverty line, and an 11% increase in median secondary enrollment rates. The reason for this greater impact is that when the national state changes the importance it attaches to less central and more remote municipalities, this alters incentives of all Colombian municipalities to increase their investments of state capacity.

7 Implications for Optimal Policy

Our structural estimates also allow us to provides some preliminary insights on optimal policy, in particular on the optimal allocation of state capacity across municipalities. For this exercise, suppose that the objective is to maximize average prosperity across municipalities. Thus we consider the problem of maximizing the sum of utilities across all municipalities by reshuffling local state capacity across municipalities. The interesting dimension here is the general equilibrium responses of all municipalities after this reallocation. Because we are focusing on a pure reallocation (and ignoring differences in relative prices across municipalities and costs of reallocation), there are no costs in this policy. Mathematically, the problem is

$$\max_{\mathbf{e}} \left\{ \sum_i w_i \frac{1}{J} \sum_j p_i^j(\mathbf{s}) \right\} \tag{17}$$

subject to $\sum_i e_i = 0$, and

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

Here $\mathbf{e}$ denotes the vector of state capacity reallocation, and the w_i's are population weights. In the Appendix we show this problem has an explicit-form solution, where, the optimal $\mathbf{e}$ is a function of centrality statistics of the network. Panel I in Table 12 presents the average changes in our prosperity outcomes under the optimal reallocation of local public employees. Average utilities coverage would increase by 4.5 percentage points, the poverty rate would be 3.5 percentage points lower, and secondary enrollment rates would be 5.6 percentage points higher. These are quite significant (population weighted) average changes.

More interestingly, Figure 4 illustrates the change in the distribution of our four prosperity outcomes following the optimal reallocation of state capacity. The figure shows that the increase in average prosperity takes place alongside a compression of the distributions because the optimal reallocation involves greater state capacity in the poorest municipalities. Our results thus suggest that a policy reallocating state capacity in this fashion would be a significant source of equalization, as well as an oral increase, in prosperity across municipalities.

The solution to the problem, given by equation (19) in the Appendix, shows that the optimal reallocation is a function of eigenvector centrality. To make the relationship between $\mathbf{e}$ and network position more explicit we ran a set of regressions of our estimated $\mathbf{e}$ on three network statistics: betweenness centrality, Bonacich centrality, and local clustering, controlling for local state capacity, historical population, and our benchmark set of controls. Table A10 presents the results. Our three network statistics are strong predictors of $\mathbf{e}$. This is true both when we obtain the optimal allocation on the model using state agencies (columns (1)-(4)) or municipality employees (columns (5)-(8)). Furthermore, the R^2's of these regressions are quite high (around 0.8) in all specifications, highlighting the keys role played by the network structure for the determination of the distribution of prosperity across municipalities.

Finally, we also perform a similar policy exercise with the general model. Because in this case there is no explicit-form characterization of the optimal reallocation, we use the estimates from the regressions of the optimal allocation on network centrality statistics presented in Table A10 to generate predicted values for the $\mathbf{e}_i$'s. We then compute numerically the Nash equilibrium starting at this allocation, and obtain estimates of the predicted prosperity outcomes. We present the results of this exercise in the bottom panel of Table 12, when we use the number of state agencies as our measure of local state capacity. The magnitude of the changes are very similar to those from the linear model, with the difference that in the general model the optimal reshuffling of state capacity has a larger toll on the largest municipalities. This translates into somewhat smaller population-weighted average increases in the prosperity outcomes.

8 Conclusions

In this paper we developed a framework for estimating the direct and spillover effects of local state capacity using the network of Colombian municipalities. We modeled the determination of local and national state capacity as a network game, where each municipality, anticipating the choices and spillovers created by other municipalities and the decisions of the national government, invests in local state capacity and the national government chooses the presence of the national state in various areas to maximize its own objective. Our methodology emphasizes the need for a structural model to correctly interpret the estimates within a framework of strategic investments.

We estimated the parameters of this model, which show large (but plausible) direct and spillover effects of local state capacity, both using instrumental variables techniques and using GMM, or simulated GMM. In all of our estimations, we exploited both the structure of the network of municipalities, determining which municipalities create spillovers on which others, and the historical roots of local state capacity as the source of exogenous variation for identifying both own and spillover effects. These are related to the presence of colonial royal roads and the historical presence of the colonial state, factors which we argued are unrelated both to the network and to current provision of public goods and prosperity except through their impact on own and neighbors' local state capacity.

Our estimates imply that local state presence is indeed a first-order determinant of current prosperity, but much of this impact works through network effects. For example, bringing all municipalities below median state capacity to the median, without taking into account equilibrium responses of other municipalities, would increase the median fraction of the population above the poverty line from 57% to 60%. Approximately 57% of this is due to direct effects and 43% due to spillovers. However, if we take the equilibrium responses of other municipalities into account, there are further network effects, reflecting in part the estimated strategic complementarities. Once these adjustments are made, the median of the fraction of the population above poverty would increase to 68%—a very large change driven by equilibrium network effects. This indicates not only that network effects are important, but also suggests why the national government must play a central role in effective state building: local state building will lead to major under-provision of state capacity (and thus public goods) because municipalities do not take into account these network effects.

We view our paper as a first step in the modeling and estimation of the direct and spillover effects of local state capacity. There are several interesting and important research directions. First, our results have focused only on some aspects of local state capacity. The typical view of the Weberian rational bureaucracy also stresses such things as meritocracy and predictability of the bureaucracy, which would be interesting to investigate at the local level as well. Second and more importantly, we have not addressed another aspect of Weberian state capacity, the monopoly of violence. This is a central issue in Colombia, where the local state often lacks this monopoly of violence. Third, our approach has been reduced-form in one crucial dimension: we have abstracted from political economy interactions. Though this is reasonable as a first-step simplification, political economy factors may be crucial underpinnings for some of these spillovers. In fact, we conjecture that underpinning the strategic complementarities documented in this paper is, in part, the pressure that high state capacity in one municipality puts on politicians in neighboring municipalities. Another important political economy dimension in the Colombian context is the control of politicians or armed groups over certain municipalities with very different objectives, and their ability to do so may depend on outcomes in neighboring municipalities. Finally, we believe that an important next step is to apply a similar approach to other settings in which law enforcement and policing are determined at the local level and create different types of spillovers on neighbors.

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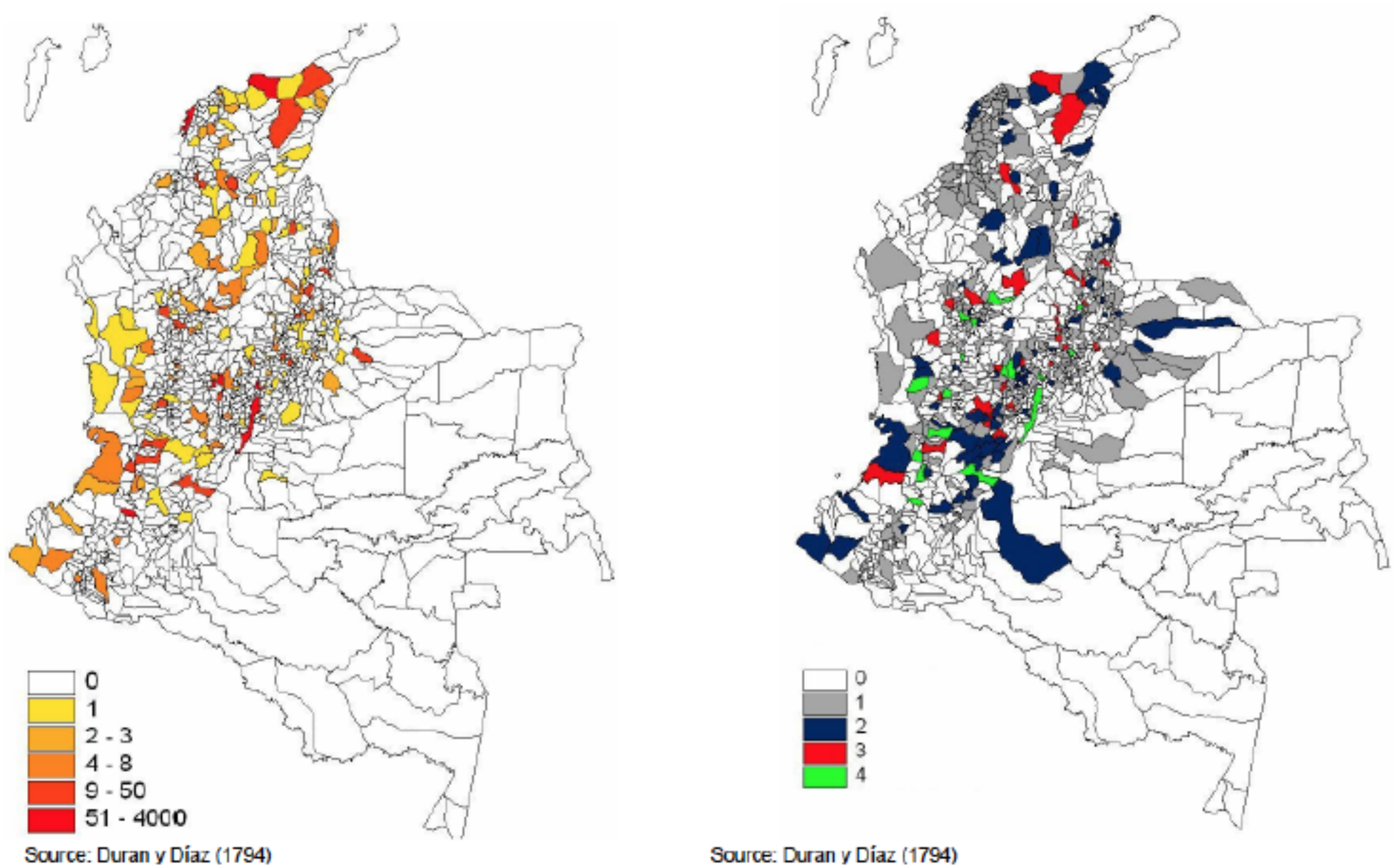
Figures

Figure 1: Colonial state presence, 1794

Number of crown employees | Number of state agencies (alcabalas, estancos, post offices)

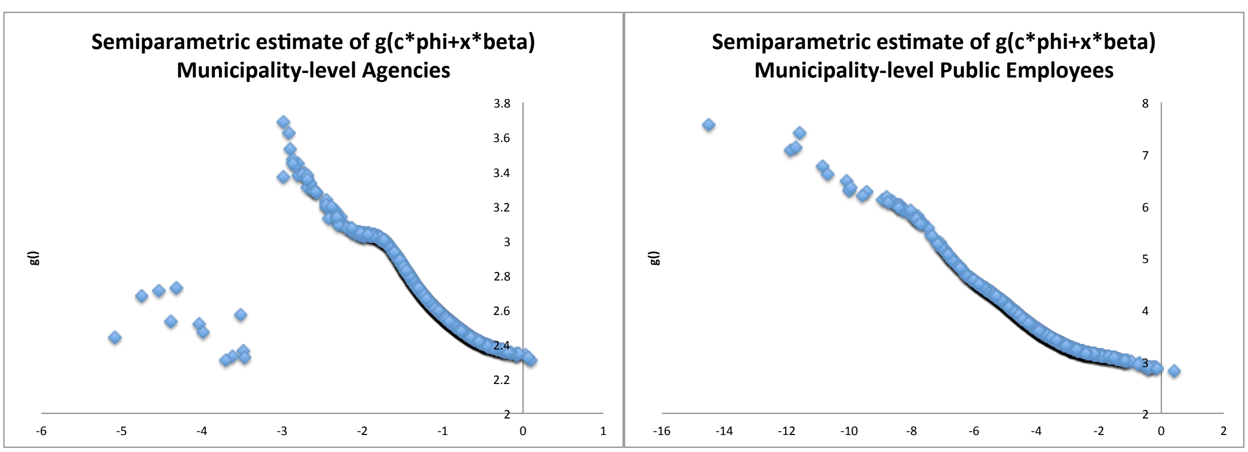


The left-hand-side figure presents the current municipality-level spatial distribution of Spanish crown employees in 1794. The right-hand-side figure presents the current municipality-level spatial distribution of the count of Spanish colonial state agencies in 1794, including *alcabalas*, tobacco and playing cards *estancos*, liquor and gunpowder *estancos*, and post offices.

Figure 2: Distribution of prosperity outcomes

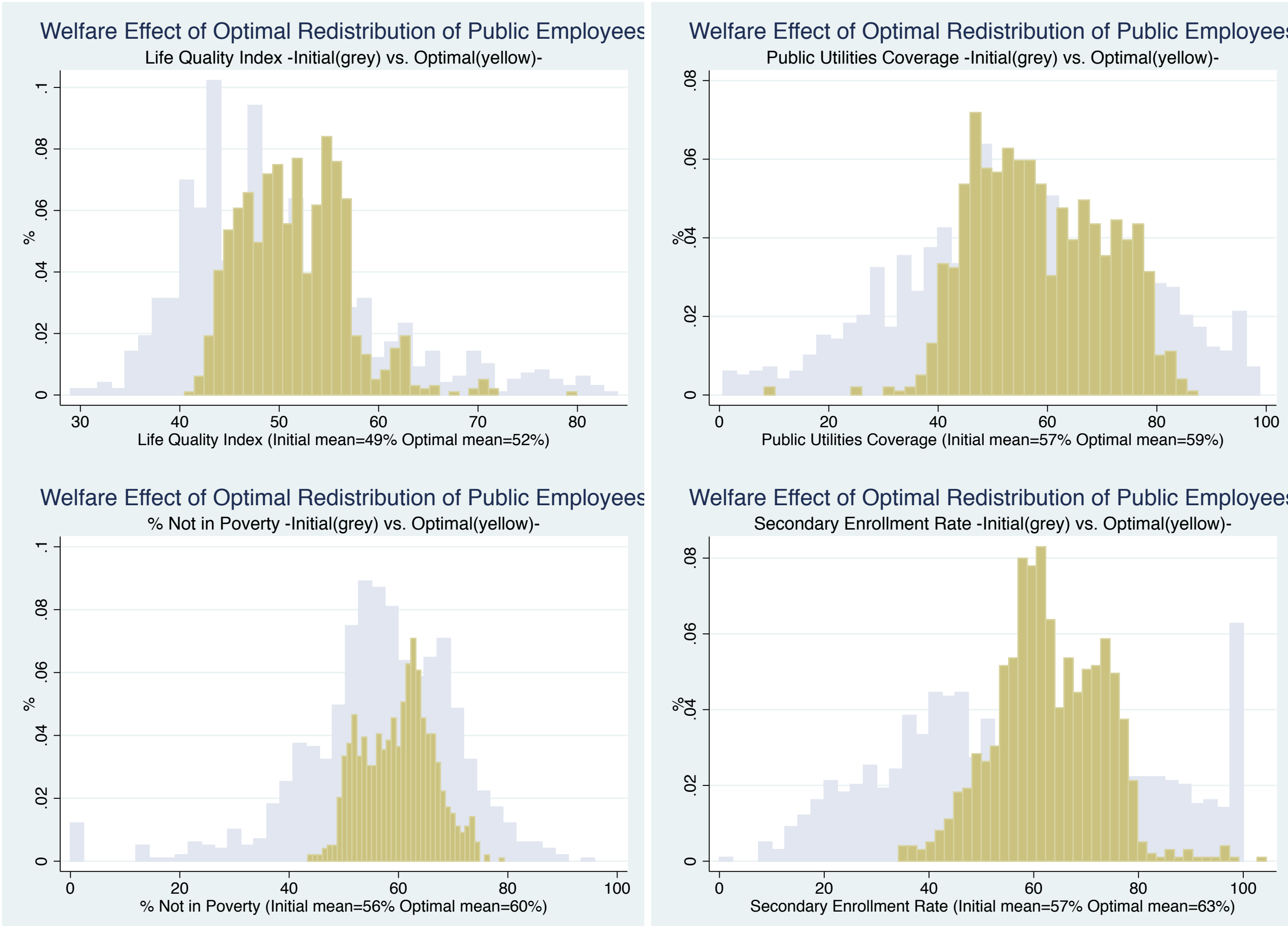
The figure plots the empirical distributions for the four prosperity outcomes in the sample of Colombian municipalities. The top left panel presents the distribution of the life quality index in 1998. The top right panel presents the distribution of the public utilities coverage (average of aqueduct, electricity, and sewage) in 2002. The bottom left panel presents the distribution of the fraction of the population above the poverty line in 2005. The bottom right panel presents the distribution of the average 1992-2002 secondary enrollment rate.

Figure 3: Estimated $g(\mathbf{c}_i\boldsymbol{\varphi} + \mathbf{x}_i\boldsymbol{\beta})$ function



The figure plots the semi-parametric index function estimate of g(.), the intercept of the best response equation, under the system GMM estimation strategy. The left-hand-side panel presents the estimate for the model using municipality-level agencies as the measure of local state capacity. The right-hand-side panel presents the estimate for the model using municipality-level public employees as the measure of local state capacity.

Figure 4: Change in the distribution of prosperity following the optimal reshuffling of bureaucracy



The figure plots the predicted (yellow) empirical distributions for the four prosperity outcomes in the sample of Colombian municipalities following a reallocation of local state capacity measured as the number of public employees that follows the optimal distribution according to the solution to the problem in (11), overlayed on the actual distributions (grey). The top left panel presents the distributions for the life quality index in 1998. The top right panel presents the distributions of the public utilities coverage (average of aqueduct, electricity, and sewage) in 2002. The bottom left panel presents the distributions for the fraction of the population above the poverty line in 2005. The bottom right panel presents the distributions for the average 1992-2002 secondary enrollment rate.

Tables

Table 1. Descriptive Statistics

	Variables	Mean	Median	Std. Dev.
State capacity	Local-level state agencies	21.6	10.0	105.1
	Local-level municipality employees	99.6	20.0	843.4
	National-level municipality employees	1038.9	220.0	7900.2
Prosperity	Life quality index	49.8	48.0	9.9
	Public utilities coverage rate	53.7	53.4	21.5
	Fraction of population above poverty line	56.4	57.2	14.3
	Secondary enrollment rate	56.9	56.4	23.5
	Primary enrollment rate	96.8	100.0	9.5
	Vaccination coverage rate	45.2	43.8	16.8
Historical variables	Colonial state officials	5.7	0.0	122.9
	Colonial state sagencies	0.6	0.0	0.9
	Distance to royal roads (Kms.)	26.1	13.8	34.6
	Population in 1843 (000)	2.9	2.9	2.1
Network variables	Number of neighbors (Degree)	5.5	5.0	1.8
	Geodesic distance to neighbors (Kms.)	27.8	22.7	17.7
	Geodesic variability in elevation to neighbors	0.8	0.7	0.5
	Betweenness Centrality	0.011	0.003	0.021
	Bonacich Centrality	86.4	74.3	67.2
	Local clustering coefficient	0.45	0.40	0.18
Covariates	Distance to current highway (Kms.)	3.1	1.5	6.5
	Longitude	-74.8	-74.8	1.5
	Latitude	5.6	5.5	2.4
	Surface area (sq. kms)	669.3	273.5	1425.1
	Elevation (mts.)	1206.7	1265.0	897.7
	Average annual rainfall (mm.)	1894.6	1630.5	1067.1
	Population (000)	37.4	13.8	200.5
	Number of municipalities			1019

Sample mean, median and standard deviation for our main variables. Please see the text for variable definitions and sources.

Table 2. Within-department Spatial Correlation of Historical State Presence Variables

	1	2	3	4	5	6	7	8	9
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						
4. Own colonial officials	-0.095	-0.072	-0.047	1.000					
5. Neighbors' average colonial officials	-0.146	0.039	0.060	-0.061	1.000				
6. Neighbors of neighbors' colonial officials	-0.044	0.063	0.072	-0.062	-0.070	1.000			
7. Own colonial state agencies	-0.135	-0.039	-0.017	0.545	-0.006	-0.002	1.000		
8. Neighbors' average colonial state agencies	-0.208	0.250	0.283	-0.053	0.490	0.008	0.022	1.000	
9. Neighbors of neighbors' colonial state agencies	-0.193	0.244	0.334	-0.036	0.031	0.408	0.078	0.289	1.000

Correlations reported are the average across-departments of the correlations for each department.

Table 3. Contemporary State Equilibrium Best Response

State capacity measured as log of:	Number of state agencies				Number of municipality employees			
Panel I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	IV	Sys. GMM	OLS	IV	IV	Sys. GMM
	Equilibrium best response							
ds_i/ds_j	0.016	0.017	0.019	0.020	0.021	0.022	0.022	0.016
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)
ds_i/dcolonial state officials$_i$	0.127	0.128	0.108	-0.040	0.129	0.130	0.105	0.087
	(0.031)	(0.031)	(0.033)	(0.050)	(0.043)	(0.043)	(0.047)	(0.069)
ds_i/dcolonial state agencies$_i$	0.003	0.001	-0.016	0.096	0.017	0.017	-0.002	0.085
	(0.033)	(0.033)	(0.033)	(0.055)	(0.058)	(0.059)	(0.060)	(0.085)
ds_i/ddistance to royal road$_i$	0.008	0.010	0.007	0.074	-0.035	-0.035	-0.038	-0.036
	(0.019)	(0.019)	(0.021)	(0.034)	(0.034)	(0.035)	(0.036)	(0.044)
Panel II	First stage for $N_i(\delta)s$							
Neighbors' colonial state officials		0.320	0.338			0.556	0.637	
		(0.096)	(0.100)			(0.143)	(0.155)	
Neighbors' colonial state agencies		1.275	1.242			1.673	1.631	
		(0.126)	(0.131)			(0.211)	(0.223)	
Neighbors' distance to royal road		-1.031	-0.992			-1.497	-1.456	
		(0.219)	(0.223)			(0.278)	(0.287)	
Neighbors of neighbors' colonial state officials		0.209	0.269			0.311	0.427	
		(0.170)	(0.177)			(0.240)	(0.258)	
Neighbors of neighbors' colonial state agencies		0.649	0.568			1.085	0.937	
		(0.181)	(0.190)			(0.264)	(0.281)	
Neighbors of neighbors' distance to royal road		0.178	0.172			0.268	0.296	
		(0.169)	(0.173)			(0.231)	(0.236)	
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	
Log population	Control	Control	Instrum	Instrum	Control	Control	Instrum	Instrum
Observations	975	975	975	963	1017	1017	1017	1003

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to current highway, and a department capital dummy. Columns (1)-(4) use the log number of local state agencies as the measure of state capacity, and columns (5)-(8) use the log number of municipality employees as the measure of state capacity. Panel I reports the estimates of the best response equation, and Panel II reports the first stage for the instrumental variables models of columns (2),(3), (6), and (7). In the models reported in columns (2) and (6), log population is treated as exogenous. In the models reported in columns (3), (4), (7), and (8), log population is instrumented using 1843 population. Models in column (4) are estimated as a system together with those reported in columns (4), (8), (12), and (16) of Table 4A. Models in column (8) are estimated as a system together with those reported in columns (4), (8), (12), and (16) of Table 4B. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. For models with more than one endogenous right-hand-side variable, the F-test is corrected following Angrist and Pischke (2009).

Table 4A. Prosperity and Public Goods Structural Equation

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

Dependent variable	Life quality index				Public utilities coverage			
Panel I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	IV	Sys. GMM	OLS	IV	IV	Sys. GMM
	Prosperity equation							
dp_i/ds_i	0.802	0.394	0.389	0.314	0.602	0.563	0.567	0.314
	(0.044)	(0.135)	(0.143)	(0.041)	(0.037)	(0.127)	(0.134)	(0.041)
dp_i/ds_j	0.015	0.024	0.025	0.025	0.022	0.020	0.020	0.027
	(0.004)	(0.006)	(0.006)	(0.004)	(0.004)	(0.006)	(0.006)	(0.003)
Panel II	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	
Log population	Control	Control	Instrum	Instrum	Control	Control	Instrum	Instrum
Observations	973	973	973	963	975	975	975	963

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

Dependent variable	Not in poverty				Secondary enrollment			
Panel I	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	IV	IV	Sys. GMM	OLS	IV	IV	Sys. GMM
	Prosperity equation							
dp_i/ds_i	0.520	0.342	0.353	0.314	0.515	0.178	0.223	0.314
	(0.038)	(0.141)	(0.147)	(0.041)	(0.049)	(0.179)	(0.186)	(0.041)
dp_i/ds_j	0.019	0.021	0.021	0.021	0.023	0.036	0.035	0.035
	(0.004)	(0.006)	(0.006)	(0.003)	(0.005)	(0.007)	(0.007)	(0.004)
Panel II	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	
Log population	Control	Control	Instrum	Instrum	Control	Control	Instrum	Instrum
Observations	975	975	975	963	965	965	965	963

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to current highway, and a department capital dummy. Panel I reports the estimates of the prosperity equation for each of the four outcomes, and Panel II reports the F-tests for joint significance of the excluded instruments in the first stages for the instrumental variables models of columns (2), (3), (6), (7), (10), (11), (14), and (15). The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In the models reported in columns (2), (6), (10), and (14), log population is treated as exogenous. In the models reported in columns (3), (4), (7), (8), (11), (12), (15), and (16), log population is instrumented using 1843 population. Models in columns (4), (8), (12), and (16) are estimated as a system together with those reported in column (4) of Table 3. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. For models with more than one endogenous right-hand-side variable, the F-test is corrected following Angrist and Pischke (2009).

Table 4B. Prosperity and Public Goods Structural Equation

State capacity measured as: log of number of municipality employees								
Dependent variable	Life quality index				Public utilities coverage			
Panel I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	IV	Sys. GMM	OLS	IV	IV	Sys. GMM
	Prosperity equation							
dp_i/ds_i	0.478	0.247	0.222	0.210	0.263	0.395	0.310	0.210
	(0.023)	(0.092)	(0.090)	(0.023)	(0.022)	(0.111)	(0.103)	(0.023)
dp_i/ds_j	0.015	0.020	0.022	0.020	0.020	0.013	0.017	0.019
	(0.003)	(0.005)	(0.005)	(0.003)	(0.002)	(0.005)	(0.005)	(0.002)
Panel II	First stage for s_i^2							
F-test for excluded instruments:		13.68	27.44			13.28	27.42	
F-test p-value		0.000	0.000			0.000	0.000	
First-stage R-squared		0.571	0.576			0.570	0.575	
First-stage linear model:	First stage for $N_i(\delta)s$							
F-test for excluded instruments:		351.3	459.4			344.4	457.4	
F-test p-value		0.000	0.000			0.000	0.000	
First-stage R-squared		0.759	0.758			0.759	0.758	
Log population	Control	Control	Instrum	Instrum	Control	Control	Instrum	Instrum
Observations	1014	1014	1014	1003	1017	1017	1017	1003

State capacity measured as: log of number of municipality employees								
Dependent variable	Not in poverty				Secondary enrollment			
Panel I	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	IV	IV	Sys. GMM	OLS	IV	IV	Sys. GMM
	Prosperity equation							
dp_i/ds_i	0.233	0.305	0.275	0.210	0.222	0.144	0.216	0.210
	(0.021)	(0.119)	(0.111)	(0.023)	(0.025)	(0.138)	(0.133)	(0.023)
dp_i/ds_j	0.019	0.013	0.014	0.016	0.020	0.024	0.022	0.024
	(0.003)	(0.005)	(0.005)	(0.002)	(0.003)	(0.006)	(0.006)	(0.003)
Panel II	First stage for s_i^2							
F-test for excluded instruments:		13.28	27.42			14.89	29.61	
F-test p-value		0.000	0.000			0.000	0.000	
First-stage R-squared		0.570	0.575			0.585	0.597	
First-stage linear model:	First stage for $N_i(\delta)s$							
F-test for excluded instruments:		344.4	457.4			378.2	495.3	
F-test p-value		0.000	0.000			0.000	0.000	
First-stage R-squared		0.759	0.758			0.767	0.768	
Log population	Control	Control	Instrum	Instrum	Control	Control	Instrum	Instrum
Observations	1017	1017	1017	1003	1006	1006	1006	1003

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to current highway, and a department capital dummy. Panel I reports the estimates of the prosperity equation for each of the four outcomes, and Panel II reports the F-tests for joint significance of the excluded instruments in the first stages for the instrumental variables models of columns (2), (3), (6), (7), (10), (11), (14), and (15). The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In the models reported in columns (2), (6), (10), and (14), log population is treated as exogenous. In the models reported in columns (3), (4), (7), (8), (11), (12), (15), and (16), log population is instrumented using 1843 population. Models in columns (4), (8), (12), and (16) are estimated as a system together with those reported in column (8) of Table 3. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. For models with more than one endogenous right-hand-side variable, the F-test is corrected following Angrist and Pischke (2009).

Table 5. Experiment: Implications of Moving All Municipalities below Median State Capacity to Median

Panel Ia	Linear model									
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
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%	

Panel Ib										
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	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%	

Panel IIa	Non-linear model (under SMM 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	52.8	53.3	58.5	57.1	63.5	56.6	59.7

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	19.4	48.0	61.0	53.3	66.2	57.1	73.5	56.6	67.2

This table reports results from an experiment which takes all municipalities below median state capacity to the median, using the estimated parameters of the models measuring state capacity as the number of local state agencies. Panel I reports the medians of the empirical and counterfactual distributions using the structural parameters of the linear model estimated using the system GMM. Panell II reports the medians of the empirical and counterfactual distributions using the structural parameters of the non-linear model estimated using SMM. Panels Ia and IIa report the medians for the partial equilibrium exercise where municipalities' best responses are held fixed. Panels Ib and IIb report the medians for the general equilibrium exercise where municipalities have best responded to the shock. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average.

Table 6. Placebo Exercise: Nationally Determined Prosperity and Public Goods Outcomes Structural Equation

State capacity measured as log of:	Number of municipality state agencies				Number of municipality employees			
Panel I	Primary enrollment		Vaccination coverage		Primary enrollment		Vaccination coverage	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Prosperity equation							
dp_i/ds_i	-0.049	0.198	0.015	0.260	-0.007	0.355	0.013	0.134
	(0.051)	(0.207)	(0.046)	(0.199)	(0.027)	(0.154)	(0.025)	(0.143)
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)
Panel II	First stage on s_i^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 $N_i(\delta)s$							
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

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to current highway, and a department capital dummy. Columns (1)-(4) report estimates for models using the number of municipality agencies as the measure of state capacity, and columns (5)-(8) report estimates for models using the number of municipality employees as the measure of state capacity. Panel I reports the estimates of the prosperity equation for each of the two placebo outcomes, and Panel II reports the F-tests for joint significance of the excluded instruments in the first stages for the instrumental variables models of columns (2), (4), (6), and (8). The primary enrollment rate is the 1992-2002 average, and vaccination coverage is for 1998. All prosperity outcomes are standardized. In the models reported in columns (2), (4), 6), and (8), log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. For models with more than one endogenous right-hand-side variable, the F-test is corrected following Angrist and Pischke (2009).

Table 7. Placebo Exercise: Current vs. Historical Prosperity

Correlation between current prosperity and instruments

Panel I	Life quality index	Public util. coverage	Not in poverty	Sec. enrollment
	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
	Reduced form			
Neighbors' colonial state officials	-0.286	-0.521	0.192	0.349
	(0.403)	(0.400)	(0.499)	(0.570)
Neighbors' colonial state agencies	1.779	1.316	1.819	1.654
	(0.540)	(0.564)	(0.526)	(0.757)
Neighbors' distance to royal road	-1.352	-1.645	-0.800	-1.634
	(0.362)	(0.342)	(0.307)	(0.473)
F-test for joint significance of instruments:	12.53	10.26	7.59	9.38
F-test p-value	0.000	0.000	0.000	0.000
Control for log population	Yes	Yes	Yes	Yes
Observations	683	683	683	683

Correlation between historical (1918) prosperity and instruments

Panel II	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

All reported estimates are average marginal effects. Panel I reports the estimates of a reduced form regression of the four prosperity outcomes on neighbors' colonial state, and Panel II reports the estimates of a reduced form regression of the historical (1918) prosperity outcomes on neighbors' colonial state. Models in Panel I include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to current highway, and a department capital dummy. Models in Panel II do not control for the distance to a current highway. In the models of columns (2) and (4) in Panel II, historical (1843) population is included as an additional control. All prosperity outcomes are standardized. All models use the restricted sample of municipalities for which 1918 data is available. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table 8. Prosperity and Public Goods "Naïve" Equation

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

Panel Ia	Life quality index		Public util. coverage		Not in poverty		Secondary enrollment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	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
	(0.044)	(0.096)	(0.035)	(0.083)	(0.038)	(0.096)	(0.051)	(0.118)
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)
Panel Ib	First stage on s_i							
F-test for excluded instruments:		65.40		65.17		65.17		67.70
F-test p-value		0.000		0.000		0.000		0.000
First-stage R-squared		0.427		0.426		0.426		0.429
	First stage on $N_i(\delta)s$							
F-test for excluded instruments:		625.5		625.9		625.9		678.5
F-test p-value		0.000		0.000		0.000		0.000
First-stage R-squared		0.770		0.770		0.770		0.773
Observations	973	973	975	975	975	975	965	965

State capacity measured as: log of number of municipality employees

Panel IIa	Life quality index		Public util. coverage		Not in poverty		Secondary enrollment	
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	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)	(0.069)	(0.022)	(0.067)	(0.023)	(0.074)	(0.028)	(0.092)
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)
Panel IIb	First stage on s_i							
F-test for excluded instruments:		44.88		44.61		44.61		47.97
F-test p-value		0.000		0.000		0.000		0.000
First-stage R-squared		0.438		0.437		0.437		0.451
	First stage on $N_i(\delta)s$							
F-test for excluded instruments:		529.0		526.9		526.9		571.5
F-test p-value		0.000		0.000		0.000		0.000
First-stage R-squared		0.758		0.758		0.758		0.768
Observations	1014	1014	1017	1017	1017	1017	1006	1006

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to current highway, and a department capital dummy. Panels Ia and IIa report the estimates of a linear-in-state-capacity prosperity equation for each of the four outcomes, and Panels IIa and IIb report the F-tests for joint significance of the excluded instruments in the first stages for the instrumental variables models of all even-numbered columns. Models in Panel I use the log number of state agencies as the measure of state capacity. Models in Panel II use the log number of municipality employees as the measure of state capacity. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models reported in even-numbered columns log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. For models with more than one endogenous right-hand-side variable, the F-test is corrected following Angrist and Pischke (2009).

Table 9. 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]

This table reports the correlation coefficients between the residuals of the benchmark IV models in column (3) of Table 3 and columns (3), (7), (11) and (15) of Table 4A (Panel I), and in column (7) of Table 3 and columns (3), (7), (11) and (15) of Table 4B (Panel II), with the Betweenness Centrality and the Bonacich Centrality network statistics. The associated p-values are in square brackets.

Table 10. Contemporary State Equilibrium Best Response

Controlling for national-level bureaucracy		
State capacity measured as log of number of:	Municipality state Agencies	Municipality employees
	(1)	(2)
	IV	IV
	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
	(0.032)	(0.008)
ds_i/ddistance to royal road$_i$	0.008	-0.010
	(0.020)	(0.004)
Observations	975	1017

All reported estimates are average marginal effects of the best response equation. All models include department fixed effects and in addition to the number of national-level public employees, the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Column (1) uses the log number of local state agencies as the measure of state capacity, and column (2) uses the log number of municipality employees as the measure of state capacity. The first stages of the instrumental variables models are omitted. Log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table 11. Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Controlling for national-level bureaucracy

Dependent variable:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Utilities coverage	Not in poverty	Secondary enroll.	Life quality index	Utilities coverage	Not in poverty	Secondary enroll.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation				Prosperity equation			
dp_i/ds_i	0.520	0.685	0.441	0.274	0.320	0.541	0.355	0.238
	(0.107)	(0.122)	(0.134)	(0.170)	(0.080)	(0.096)	(0.102)	(0.133)
dp_i/ds_j	0.018	0.017	0.018	0.032	0.017	0.011	0.012	0.021
	(0.005)	(0.005)	(0.005)	(0.007)	(0.004)	(0.004)	(0.004)	(0.005)
Observations	973	975	975	965	1014	1017	1017	1006

All reported estimates are average marginal effects. All models include department fixed effects and in addition to the number of national-level public employees, the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Panel I uses the log number of local state agencies as the measure of state capacity, and Panel II uses the log number of municipality employees as the measure of state capacity. The first stages of the instrumental variables models are omitted. Log population is instrumented using 1843 population. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table 12. Normative Exercise: Welfare Gains from an Optimal Redistribution of State Capacity

Experiment: Reshuffle municipality state capacity optimally

Panel I: Linear Model	Average Equilibrium change in:			
State capacity measured as log of municipality employees	Life quality index	Utilities coverage	% not in poverty	Secondary enroll.
Raw Average Change	0.18	2.79	2.73	4.04
Population-Weighted Average Change	1.82	4.56	3.5	5.6
Panel II: General Model	**Average Equilibrium change in:**			
State capacity measured as log of state agencies	Life quality index	Utilities coverage	% not in poverty	Secondary enroll.
Raw Average Change	1.04	2.26	1.55	2.31
Population-Weighted Average Change	0.76	1.65	1.14	1.67

This table reports the average equilibrium change (after municipalities have best responded to the shock) in each prosperity outcome across the sample of municipalities of an experiment that relocates municipality state capacity optimally according to equation (11) using the system GMM estimated parameters. Panel I presents the experiment results on the linear model using the number municipality public employees as the measure of local state capacity. Panel II presents the experiment results on the general model using the number of municipality agencies as the measure of local state capacity. In this case the optimal reallocation is first computed on the linear model. Then the predictions for **e** from the regressions on network statistics reported in Table A11 are used to shock the nonlinear best replies and a Newton-Raphson method is used to compute the equilibrium state capacity levels following the shock. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average.

Table 13. Stuctural Parameter Estimates

National-level state capacity:	Predetermined	Endogenous
	Estimates (system GMM)	Estimates (simulated GMM)
Parameter	(1)	(2)
Ψ1	0.009	0.007
	(0.003)	(0.0036)
Ψ2 (Life quality index)	0.305	0.264
	(0.114)	(0.042)
Ψ2 (Public utilities)	0.335	0.288
	(0.122)	(0.039)
Ψ2 (Not in poverty)	0.266	0.219
	(0.101)	(0.038)
Ψ2 (Secondary enrollment)	0.462	0.393
	(0.171)	(0.053)
θ	0.056	0.070
	(0.020)	(0.055)
E[κi]	0.005	0.008
	[0.0004]	[0.0005]
η		0.218
		(0.014)
π1 (Historical electoral variability)		0.252
		(0.029)
π2 (Betweenness centrality)		0.384
		(0.029)
π3 (Bonacich centrality)		-0.139
		(0.022)
π4 (Local Clustering)		(0.194)
		(0.053)
CES parameters		
α	0.500	
	-	
σ	0.631	
	(0.187)	
τ	7.774	
	(0.366)	
Observations	963	962

The table reports structural parameter estimates of the non-linear model, using the log of the number of municipality agencies as the measure of local state capacity. Column (1) presents the system GMM estimates of the model that takes national-level state capacity as predetermined. Column (2) presents the simulated GMM estimates of the model where national-level state capacity is endogenous. The CES composite parameters are estimated from the system GMM together with the parameters in column (1), and imposed on the estimation of column (2). Analytic standard errors in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. Estimates in square brackets are standard deviations across the sample of municipalities.

Appendix

Proofs

Slope of the best response equation (7):

Implicitly differentiating equation (7) with respect to $\mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}$ yields

$$\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}} = \alpha\sigma\frac{\phi}{\theta}\frac{1}{(\sigma+1)\left[\frac{l_i}{s_i}\right]^{\frac{1}{\sigma}} - \alpha\left[\frac{l_i}{s_i}\right]}.$$

First note that when $\alpha = 1$, $\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}} = \frac{\phi}{\theta}$.

More generally, denominator of this expression is strictly positive since $\sigma \geq 0$ and $\alpha \in (0,1)$. In particular,

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

or equivalently

$$\sigma + 1 > \frac{\alpha l_i^{\frac{\sigma-1}{\sigma}}}{\alpha l_i^{\frac{\sigma-1}{\sigma}} + (1-\alpha)(\tau b_i)^{\frac{\sigma-1}{\sigma}}}.$$

Thus,

$$\text{sign}\left(\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}}\right) = \text{sign}(\phi).$$

Also notice that equation (19) implies $\frac{\partial l_i}{\partial \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s}} = \frac{\phi}{\theta}$ when $\alpha = 1$.

Optimal Reallocation of State Capacity

Recall that the optimization problem is

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

subject to

$$\sum_i e_i = 0$$

and

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

Define $\mathbf{M} \equiv \left(I - \frac{\phi}{\theta}\mathbf{N}(\boldsymbol{\delta})\right)^{-1}$. Recall that for a given equilibrium vector of state capacities $\mathbf{s}$, equilibrium prosperity is given by

$$p_i^j = \theta s_i^2 + \gamma^j \mathbf{N}_i(\boldsymbol{\delta})\mathbf{s} + \mathbf{x}_i\tilde{\boldsymbol{\beta}} + \tilde{\zeta}^D + \epsilon_i^j$$

So the problem above can be rewritten as

$$\max_{\mathbf{e}} \sum_i w_i \left\{ \theta \left[\mathbf{M}_i \left(\frac{1}{\theta} \boldsymbol{\kappa} + \mathbf{e} \right) \right]^2 + \bar{\gamma} \mathbf{N}_i(\boldsymbol{\delta}) \mathbf{M} \left(\frac{1}{\theta} \boldsymbol{\kappa} + \mathbf{e} \right) + \mathbf{x}_i \tilde{\boldsymbol{\beta}} + \tilde{\varsigma}_i^D + \epsilon_i^j \right\} + \lambda \left(0 - \sum_i e_i \right)$$

where λ is the Lagrange multiplier on the constraint and $\mathbf{M}_i$ represents the i'th row of matrix $\mathbf{M}$. The FOC of this problem with respect to some e_t can be shown to take the form:

$$2 \left[\mathbf{1}_N Diag\left(\mathbf{M}_t\right) \mathbf{M} \boldsymbol{\kappa} + \theta \mathbf{1}_N Diag\left(\mathbf{M}_t\right) \mathbf{M} \mathbf{e} \right] + \bar{\gamma} \mathbf{1}_N \mathbf{N}(\boldsymbol{\delta}) \mathbf{M}_t' - \frac{\lambda}{w_i} = 0 \tag{18}$$

where $\mathbf{1}_N$ is a size-N row vector of ones, and $Diag\left(\mathbf{M}_t\right)$ is an $N \times N$ matrix with $\mathbf{M}_t$ in its diagonal and zeros off diagnonal. Thus we have a system of $N+1$ linear equations (the N first-order conditions plus the budget constraint) on $N+1$ unknowns (the N e_i's plus λ).

Define the scalar $g_t \equiv 2 \cdot \mathbf{1}_N Diag\left(\mathbf{M}_t\right) \mathbf{M} \boldsymbol{\kappa}$, and $\mathbf{g} \equiv [g_1, g_2, ..., g_N]'$. Also define the scalar $h_t \equiv \bar{\gamma} \mathbf{1}_N \mathbf{N}(\boldsymbol{\delta}) \mathbf{M}_t'$, and $\mathbf{h} \equiv [h_1, h_2, ..., h_N]'$. Finally define the $1 \times N$ vector $\mathbf{q}_t \equiv 2\theta \mathbf{1}_N Diag\left(\mathbf{M}_t\right) \mathbf{M}$, and $\mathbf{Q} \equiv [\mathbf{q}_1', \mathbf{q}_2', ..., \mathbf{q}_N']'$.

We can express the N FOCs in matrix form as:

$$\mathbf{Q}\mathbf{e} - \tilde{\mathbf{w}} \lambda = -\mathbf{g} - \mathbf{h}$$

where $\tilde{\mathbf{w}}$ is the vector of inverse population weights. We can include the budget constraint equation to the system above:

$$\begin{bmatrix} 0 & 1 \quad 1 \quad \ldots \quad 1 \\ -\tilde{w}_1 & \\ -\tilde{w}_2 & \\ . & \mathbf{Q} \\ . & \\ . & \\ -\tilde{w}_N & \end{bmatrix} \begin{bmatrix} \lambda \\ \mathbf{e} \end{bmatrix} = \begin{bmatrix} 0 \\ -\mathbf{g} - \mathbf{h} \end{bmatrix}$$

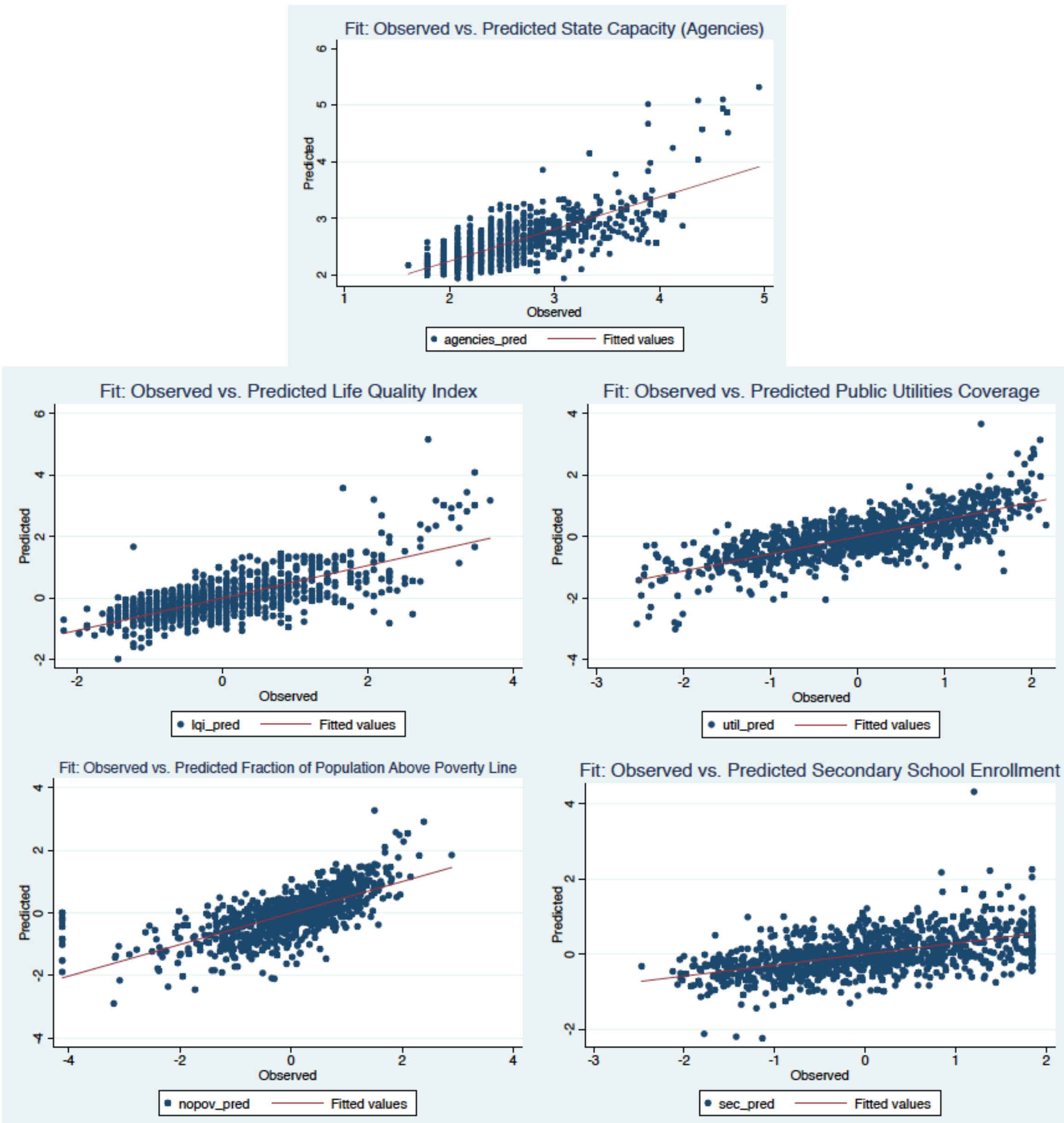
Defining the matrix of the LHS as $\mathbf{B}$, the solution to this system is

$$\begin{bmatrix} \lambda \\ \mathbf{e} \end{bmatrix}^* = \mathbf{B}^{-1} \begin{bmatrix} 0 \\ -\mathbf{g} - \mathbf{h} \end{bmatrix}, \tag{19}$$

Online Appendix for "State Capacity and Economic Development: A Network Approach"

Additional Tables and Figures

Figure A1: Fit Scatterplots Linear Model (System GMM estimates)



The figure plots the observed (x-axis) and predicted (y-axis) local state capacity (measured as the number of local agencies) and prosperity outcomes together with a linear fit line. The predicted values are based on the model with linear best responses with the parameter estimated using system GMM. The predicted local state capacity vector is obtained by inverting the system of linear best responses at the estimated parameters. The predicted prosperity outcomes are obtained using the predicted state capacity and estimated parameters on the prosperity equations.

Table A1. Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Panel I	Without controlling for distance to current highway							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.436	0.648	0.400	0.304	0.270	0.395	0.337	0.286
	(0.140)	(0.133)	(0.148)	(0.182)	(0.086)	(0.105)	(0.115)	(0.131)
dp_i/ds_j	0.025	0.020	0.022	0.035	0.021	0.015	0.013	0.020
	(0.006)	(0.006)	(0.006)	(0.007)	(0.005)	(0.005)	(0.005)	(0.006)
Observations	973	975	975	965	1014	1017	1017	1006

Panel II	Controlling by additional geographic covariates							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.288	0.443	0.198	0.189	0.189	0.259	0.210	0.096
	(0.146)	(0.143)	(0.155)	(0.192)	(0.097)	(0.106)	(0.115)	(0.138)
dp_i/ds_j	0.021	0.019	0.023	0.028	0.018	0.017	0.015	0.022
	(0.007)	(0.006)	(0.006)	(0.008)	(0.005)	(0.005)	(0.005)	(0.006)
Observations	960	962	962	952	999	1002	1002	991

All reported estimates are instrumental variables average marginal effects of the prosperity equation for each of the four outcomes. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, and a department capital dummy. Panel I reports the estimates of models that do not control for the distance to a current highway. Panel II reports the estimates of models that include the following as additional covariates: density of primary, secondary, and tertiary rivers, and the full distribution of land qualities (qualities 1-8), and types (under water, valley, mountain, hill, and plain). Columns (1)-(4) use the log number of municipality state agencies as the measure of local state capacity, and columns (5)-(8) use the log number of municipality employees as the measure of local state capacity. Estimates of the first stages for the IV models are omitted. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A2. Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Panel I	Using neighbors of neighbors of neighbors as instruments							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.617	0.763	0.479	0.318	0.411	0.423	0.330	0.222
	(0.111)	(0.115)	(0.126)	(0.161)	(0.066)	(0.079)	(0.088)	(0.102)
dp_i/ds_j	0.024	0.028	0.026	0.038	0.017	0.021	0.018	0.027
	(0.007)	(0.007)	(0.007)	(0.009)	(0.005)	(0.005)	(0.005)	(0.007)
Observations	973	975	975	965	1014	1017	1017	1006

Panel II	Defining links to include neighbors and neighbors of neighbors							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.519	0.693	0.375	0.365	0.374	0.331	0.296	0.226
	(0.114)	(0.115)	(0.129)	(0.164)	(0.069)	(0.080)	(0.095)	(0.107)
dp_i/ds_j	0.007	0.007	0.007	0.011	0.005	0.006	0.005	0.008
	(0.002)	(0.002)	(0.002)	(0.003)	(0.001)	(0.001)	(0.002)	(0.002)
Observations	973	975	975	965	1014	1017	1017	1006

Panel III	All municipalities linked to each other with decaying link strength							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.375	0.487	0.196	0.155	0.380	0.339	0.216	0.276
	(0.114)	(0.107)	(0.111)	(0.142)	(0.070)	(0.079)	(0.079)	(0.100)
dp_i/ds_j	0.039	0.051	0.063	0.052	0.021	0.038	0.041	0.028
	(0.011)	(0.012)	(0.012)	(0.015)	(0.009)	(0.010)	(0.010)	(0.012)
Observations	973	975	975	965	1014	1017	1017	1006

All reported estimates are instrumental variables average marginal effects of the prosperity equation for each of the four outcomes. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Panel I reports the estimates of models that use neighbors of neighbors' colonial state presence as instruments following Bramoulle et al. (2009). Panel II reports the estimates of models where the network structure defines a link as existing between both neighbors and neighbors of neighbors. Panel III reports estimates of models where the network structure allows for links between all municipalities and decaying link strength. Columns (1)-(4) use the log number of municipality state agencies as the measure of local state capacity, and columns (5)-(8) use the log number of municipality employees as the measure of local state capacity. Estimates of the first stages for the instrumental variables models are omitted. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A3. Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Panel I	Excluding distance to royal roads as instruments							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.429	0.763	0.441	0.367	0.258	0.415	0.293	0.196
	(0.148)	(0.144)	(0.154)	(0.198)	(0.095)	(0.112)	(0.113)	(0.144)
dp_i/ds_j	0.019	0.018	0.024	0.033	0.018	0.015	0.016	0.025
	(0.007)	(0.006)	(0.007)	(0.008)	(0.005)	(0.005)	(0.005)	(0.006)
Observations	973	975	975	965	1014	1017	1017	1006

Panel II	Excluding colonial agencies as instruments							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.465	0.503	0.327	0.248	0.258	0.232	0.240	0.415
	(0.166)	(0.156)	(0.170)	(0.234)	(0.124)	(0.139)	(0.143)	(0.199)
dp_i/ds_j	0.023	0.022	0.023	0.035	0.020	0.019	0.015	0.016
	(0.007)	(0.006)	(0.006)	(0.008)	(0.005)	(0.005)	(0.006)	(0.007)
Observations	973	975	975	965	1014	1017	1017	1006

All reported estimates are instrumental variables average marginal effects of the prosperity equation for each of the four outcomes. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Panel I reports the estimates of models that exclude neighbors' distance to royal roads from the instrument set. Panel II reports the estimates of models that exclude neighbors' colonial state agencies from the instrument set. Columns (1)-(4) use the log number of municipality state agencies as the measure of local state capacity, and columns (5)-(8) use the log number of municipality employees as the measure of local state capacity. Estimates of the first stages for the instrumental variables models are omitted. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A4. Contemporary State Equilibrium Best Response

	Subsets of municipality agencies				
State capacity measured as log of the number of municipality:	All agencies	Health agencies	Regulation agencies	Services agencies	Education agencies
Panel I	(1)	(1)	(2)	(3)	(4)
	IV	IV	IV	IV	IV
	Equilibrium best response				
ds_i/ds_j	0.019	0.050	0.029	0.024	0.020
	(0.003)	(0.010)	(0.009)	(0.005)	(0.005)
Colonial state officials$_i$	0.108	0.151	0.040	0.060	0.130
	(0.033)	(0.045)	(0.035)	(0.048)	(0.042)
Colonial state agencies$_i$	-0.016	-0.054	0.0381	-0.072	0.006
	(0.033)	(0.044)	(0.039)	(0.034)	(0.043)
Distance to royal roads$_i$	0.007	0.012	-0.037	0.024	0.007
	(0.021)	(0.021)	(0.029)	(0.016)	(0.026)
Panel II	First stage for neighbors' state agencies				
Neighbors' colonial state officials	0.338	0.235	0.278	0.183	0.437
	(0.100)	(0.051)	(0.054)	(0.060)	(0.098)
Neighbors' colonial state agencies	1.242	0.363	0.517	0.596	0.887
	(0.131)	(0.054)	(0.066)	(0.067)	(0.115)
Neighbors' distance to royal roads	-0.992	-0.347	-0.460	-0.507	-0.743
	(0.223)	(0.077)	(0.083)	(0.109)	(0.184)
Neighbors' of neighbors colonial state officials	0.269	0.033	0.122	0.098	0.259
	(0.177)	(0.066)	(0.080)	(0.079)	(0.168)
Neighbors' of neighbors colonial state agencies	0.568	0.259	0.214	0.311	0.379
	(0.190)	(0.074)	(0.090)	(0.094)	(0.169)
Neighbors' of neighbors distance to royal roads	0.172	0.041	0.091	0.099	0.149
	(0.173)	(0.060)	(0.070)	(0.085)	(0.143)
First-stage R^2:	0.671	0.644	0.684	0.675	0.626
Observations	975	975	975	975	975

All reported estimates are instrumental variables average marginal effects of the best response equation. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Column (1) reproduces column (3) of Table 3 for comparison. Column (2) measures local state capacity as the log number of health agencies and health posts. Column (3) measures local state capacity as the log number of notary offices, jails, deeds registry offices, and tax collection offices. Column (4) measures local state capacity as the log number of Telecom offices, post offices, and fire stations. Column (5) measures local state capacity as the log number of public schools and libraries. Panel I reports the estimates of the best response equation, and Panel II reports the first stage for the instrumental variables models. In all models log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A5. Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Panel I	Excluding from the estimating sample municipalities above the 90th percentile of violence							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.401	0.569	0.307	0.322	0.184	0.284	0.212	0.240
	(0.139)	(0.132)	(0.140)	(0.189)	(0.099)	(0.117)	(0.114)	(0.141)
dp_i/ds_j	0.026	0.021	0.023	0.032	0.024	0.018	0.016	0.020
	(0.007)	(0.006)	(0.006)	(0.008)	(0.005)	(0.005)	(0.005)	(0.006)
Observations	850	852	852	842	887	890	890	879

Panel II	Excluding from the network municipalities above the 90th percentile of violence							
State capacity measured as:	Log of number of municipality state agencies				Log of number of municipality employees			
	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment	Life quality index	Public utilities coverage	Not in poverty	Secondary enrollment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IV	IV	IV	IV	IV	IV	IV	IV
	Prosperity equation							
dp_i/ds_i	0.663	0.778	0.386	0.772	0.355	0.379	0.266	0.400
	(0.145)	(0.148)	(0.151)	(0.210)	(0.107)	(0.125)	(0.125)	(0.157)
dp_i/ds_j	0.021	0.017	0.022	0.024	0.019	0.016	0.014	0.017
	(0.007)	(0.007)	(0.006)	(0.008)	(0.006)	(0.006)	(0.006)	(0.008)
Observations	850	852	852	842	887	890	890	879

All reported estimates are instrumental variables average marginal effects of the prosperity equation for each of the four outcomes. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Panel I reports the estimates of models excluding from the estimating sample all municipalities in the top 10th percentile of violence as measured by 1988-2004 paramilitary attacks. Panel II reports the estimates of models excluding from the network all municipalities in the top 10th percentile of violence as measured by 1988-2004 paramilitary attacks. Columns (1)-(4) use the log number of municipality state agencies as the measure of local state capacity, and columns (5)-(8) use the log number of municipality employees as the measure of local state capacity. Estimates of the first stages for the instrumental variables models are omitted. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A6. Prosperity and Public Goods Quadratic Equation

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

Panel I	Life quality index		Public util. coverage		Not in poverty		Secondary enrollment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Prosperity equation (extra quadratic term on neighbors' state capacity)							
dp_i/ds_i	0.807	0.456	0.594	0.477	0.515	0.295	0.516	0.143
	(0.043)	(0.145)	(0.037)	(0.137)	(0.038)	(0.145)	(0.049)	(0.206)
dp_i/ds_j	0.011	0.017	0.030	0.031	0.025	0.028	0.023	0.042
	(0.004)	(0.008)	(0.004)	(0.007)	(0.005)	(0.008)	(0.006)	(0.011)
Observations	973	973	975	975	975	975	965	965

State capacity measured as: log of number of municipality employees

Panel II	Life quality index		Public util. coverage		Not in poverty		Secondary enrollment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Prosperity equation (extra quadratic term on neighbors' state capacity)							
dp_i/ds_i	0.486	0.236	0.253	0.215	0.226	0.231	0.219	0.162
	(0.022)	(0.090)	(0.022)	(0.103)	(0.021)	(0.111)	(0.025)	(0.136)
dp_i/ds_j	0.010	0.019	0.027	0.032	0.024	0.021	0.022	0.031
	(0.003)	(0.006)	(0.003)	(0.006)	(0.004)	(0.007)	(0.004)	(0.008)
Observations	1014	1014	1017	1017	1017	1017	1006	1006

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Panels I and II report the estimates of aquadratic-in-state-capacity prosperity equation for each of the four outcomes Models in Panel I use the log number of state agencies as the measure of state capacity. Models in Panel II use the log number of municipality employees as the measure of state capacity. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models reported in even-numbered columns, log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text. For models with more than one endogenous right-hand-side variable, the F-test is corrected following Angrist and Pischke (2009). First stages are omitted.

Table A7. Contemporary State Equilibrium Best Response with Contextual Effects

State capacity measured as log of number of:	Municipality state Agencies	Municipality employees
	(1)	(2)
	IV	IV
	Equilibrium best response equation	
ds_i/ds_j	0.020	0.021
	(0.007)	(0.008)
ds_i/dcolonial state officials$_i$	0.101	0.092
	(0.031)	(0.047)
ds_i/dcolonial state agencies$_i$	-0.021	0.004
	(0.033)	(0.060)
ds_i/ddistance to royal road$_i$	0.017	-0.060
	(0.033)	(0.056)
Observations	975	1017

All reported estimates are average marginal effects of the best response equation. All models include department fixed effects, and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, contextual effects of all these covariates, and a department capital dummy. Column (1) uses the log number of local state agencies as the measure of state capacity, and column (2) uses the log number of municipality employees as the measure of state capacity. The first stages of the instrumental variables models are omitted. Log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A8. Prosperity and Public Goods Outcomes Structural Equation with Contextual Effects

State capacity measured as:	**Log of number of municipality state agencies**			
Dependent Variable:	LIFE QUALITY INDEX 1998	UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLL. 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
	Prosperity equation			
dpi/dsi	0.705	0.845	0.520	0.292
	(0.021)	(0.023)	(0.024)	(0.031)
dpi/dsj	0.004	0.006	0.013	0.042
	(0.002)	(0.002)	(0.003)	(0.003)
Observations	973	975	975	965
State capacity measured as:	**Log of number of municipality employees**			
Dependent Variable:	LIFE QUALITY INDEX 1998	UTILITIES COVERAGE 02	NOT IN POVERTY 2005	SECONDARY ENROLL. 92-02
	(1)	(2)	(3)	(4)
	IV	IV	IV	IV
	Prosperity equation			
dpi/dsi	0.441	0.501	0.347	0.221
	(0.014)	(0.016)	(0.016)	(0.020)
dpi/dsj	0.008	0.002	0.012	0.027
	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1014	1017	1017	1006

All reported estimates are average marginal effects. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, contextual effects of all these covariates, and a department capital dummy. Columns (1)-(4) use the log number of local state agencies as the measure of state capacity, and columns (5)-(8) use the log number of municipality employees as the measure of state capacity. The first stages of the instrumental variables models are omitted. Log population is instrumented using 1843 population. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley

Table A9. Contemporary State Equilibrium Best Response

Excluding capital cities from the network

State capacity measured as log of number of:	Municipality state Agencies		Municipality employees	
	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
	Equilibrium best response equation			
ds_i/ds_j	0.018	0.019	0.021	0.024
	(0.002)	(0.003)	(0.003)	(0.004)
ds_i/dcolonial state officials$_i$	0.104	0.091	0.140	0.112
	(0.036)	(0.039)	(0.0457)	(0.051)
ds_i/dcolonial state agencies$_i$	0.015	0.006	0.000	-0.020
	(0.034)	(0.033)	(0.057)	(0.060)
ds_i/ddistance to royal road$_i$	0.004	0.004	-0.051	-0.052
	(0.019)	(0.020)	(0.035)	(0.037)
Observations	949	949	991	991

All reported estimates are average marginal effects of the best response equation. All models include department fixed effects and in addition to the number of national-level public employees, the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Columns (1) and (2) use the log number of local state agencies as the measure of state capacity, and columns (3) and (4) use the log number of municipality employees as the measure of state capacity. The first stages of the instrumental variables models are omitted. Log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A10. Robustness Exercises: Prosperity and Public Goods Outcomes Structural Equation

Excluding capital cities from the network

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

Panel I	Life quality index		Public util. coverage		Not in poverty		Secondary enrollment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Prosperity equation							
dp_i/ds_i	0.848	0.833	0.737	1.096	0.590	0.646	0.844	0.429
	(0.078)	(0.179)	(0.070)	(0.165)	(0.072)	(0.183)	(0.087)	(0.235)
dp_i/ds_j	0.015	0.014	0.020	0.007	0.019	0.015	0.014	0.027
	(0.004)	(0.007)	(0.004)	(0.007)	(0.004)	(0.007)	(0.005)	(0.008)
Observations	947	947	949	949	949	949	939	939

State capacity measured as: log of number of municipality employees

Panel II	Life quality index		Public util. coverage		Not in poverty		Secondary enrollment	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
	Prosperity equation							
dp_i/ds_i	0.396	0.394	0.191	0.292	0.155	0.283	0.227	0.253
	(0.029)	(0.123)	(0.029)	(0.138)	(0.028)	(0.137)	(0.035)	(0.199)
dp_i/ds_j	0.018	0.016	0.024	0.018	0.022	0.014	0.021	0.019
	(0.003)	(0.005)	(0.003)	(0.005)	(0.003)	(0.005)	(0.004)	(0.007)
Observations	988	988	991	991	991	991	980	980

All reported estimates are instrumental variables average marginal effects of the prosperity equation for each of the four outcomes. All models include department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, and a department capital dummy. Panel I reports the estimates usingthe log number of municipality state agencies as the measure of local state capacity. Panel II reports the estimatesusing the log number of municipality employees as the measure of local state capacity. Estimates of the first stages for the instrumental variables models are omitted. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average. All prosperity outcomes are standardized. In all models log population is instrumented using 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A11. Regressions of Optimal Redistribution of State Capacity on Network Centrality Statistics

	Dependent Variable: Optimal allocation of state capacity							
State capacity measured as:	log of number of municipality agencies				log of number of municipality public employees			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
Betweenness Centrality$_i$	3.34			2.73	4.94			4.11
	0.36			0.33	0.48			0.46
Bonacich Centrality$_i$		1.85		0.92		2.67		1.26
		0.35		0.33		0.47		0.45
Local Clustering$_i$			0.15	0.12			0.19	0.14
			0.02	0.02			0.03	0.02
Actual state capacity$_i$	-1.17	-1.19	-1.11	-1.14	-1.18	-1.19	-1.14	-1.18
	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
R squared	0.71	0.69	0.68	0.74	0.81	0.78	0.77	0.82
Observations	962	962	962	962	988	988	988	988

All reported estimates are from OLS regressions. All models include a constant, department fixed effects and the following vector of controls: longitude, latitutde, surface area, elevation, annual rainfall, distance to a current highway, a department capital dummy, and 1843 population. Standard errors reported in parenthesis are robust to arbitrary heteroskedasticity and allow for arbitrary spatial correlation within the network following Conley (1996) adapted to the network structure as described in the text.

Table A12. Experiment: Implications of Moving the National-Level Weights of Municipalities 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	478.7	10	16.6	48	54.6	53.3	60.5	57.1	65.5	56.6	62.8
Percent change:											
117.6%		66.0%		13.8%		13.5%		14.7%		11.1%	

This table reports results from an experiment which takes all municipalities below median national state weights to the median, using the estimated parameters of the model. Local state capacity is measured as the number of local state agencies. National-level state capacity is measured as the number of national-level public employees. The table reports the medians of the empirical and counterfactual distributions using the structural parameters of the non-linear model estimated using SMM, in the general equilibrium exercise where both municipalities and the national level have best responded to the shock. The life quality index is for 1998, the public utilities coverage (aqueduct, electricity, and sewage) is for 2002, the fraction of the population above the poverty line is for 2005, and the secondary enrollment rate is the 1992-2002 average.