

# Infrastructure and Development: Evidence from Postal Systems\*

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January 31, 2017

## Abstract

Though economic development is commonly posited to depend on the quality of political institutions, empirical research focuses mostly on how the nature and design of economic institutions affects developmental outcomes. We argue that infrastructural projects play a key role in shaping economic development. While the theoretical case for infrastructure as a key element in development extends back to work in the modernization paradigm and more recent work on trade and geography, the empirical case for this argument has received relatively little attention. We test our argument in the context of postal systems, one of the most important infrastructural consequences of state-building activities around the world. We find demonstrate support for our argument across micro-level analyses conducted at the county level in the United States and macro-level analyses conducted at the cross-national level. The results are robust across a wide range of dependent variables, model specifications, and estimation strategies. Our findings are consistent with a central premise of institution-alist theory and have important implications for understanding how the provision of public infrastructure facilitates development.

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\*We thank Alex Bluestone, Michael Byrne, Christopher Gibson, Madeline Josel, Sophie Schuit, and Joe Sutherland for research assistance, and Boston University and Washington University in St. Louis for funding. We also thank Cameron Blevins, Fernanda Brollo, Dan Carpenter, Sean Gilmard, Peter Hall, Florian Hollenbach, Richard John, Carl Knutsen, Pablo Montagnes, and participants in the 2016 LSE-NYU Political Economy Conference and the 2016 annual meeting of the American Political Science Association for helpful comments.

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According to one well-traveled theory, the course of economic development is conditioned by the quality of political institutions (Acemoglu, Johnson and Robinson 2005; North 1990; Sokoloff and Engerman 2000). While the idea has received a good deal of support, questions about measurement (how does one operationalize good institutions?) and mechanisms (through what pathways do institutions affect growth?) persist, decades after the seminal work of Douglass North.

Insofar as the institutionalist narrative is correct, public infrastructure should play a key role. Infrastructure provides “physical networks through which goods, ideas, waste, power, people, and finance are trafficked” (Larkin 2013: 327); as such, infrastructure should serve as a handmaiden of economic development. Likewise, because infrastructure generally depends upon government support — regulatory, fiscal, or direct provision — the quality of infrastructure in a country may be regarded as a proxy measure for ineffable concepts such as “good institutions,” “state capacity,” and “public goods.” If infrastructure is adequate this is a sign that institutions are doing their job.

Despite a sizeable body of work, the empirical connection between infrastructure and growth remains uncertain. Results from studies focused on the impact of roads (Fernald 1999; Sanchez-Robles 1998; van de Walle 2002), railroads (Atack et al. 2010; Banerjee, Duflo and Qian 2012; Donaldson 2016; Hornung 2015), miscellaneous transport (Easterly and Rebelo 1993), dams (Duflo and Pande 2007), telecommunications (Aker and Mbiti 2010; Canning, Fay and Perotti 1994; Chakraborty and Nandi 2011; Easterly and Rebelo 1993; Qiang and Pitt 2004), sanitation (Ashraf, Glaeser and Ponzetto 2016), energy (Esfahani and Ramirez 2003; Sanchez-Robles 1998), and public capital investments (Aschauer 1989; Holtz-Eakin and Schwartz 1995; Garcia-Mila, McGuire and Porter 1996; Tatom 1993) are mixed. No one believes that infrastructure is inconsequential, but it is unclear how much impact it has on aggregate growth (Estache and Garsous 2012; Gramlich 1994; Munnell 1992; Pereira and Andrzej 2013; Romp and de Haan 2005).

A few generic problems of assessment may be briefly noted. Macro-level studies are sometimes based on a stylized model of a production function, which rests on numerous essentially untestable assumptions. They may also enlist regression analysis of countries or regions. As such,

they are prone to familiar problems of measurement, functional form, and causal identification — in particular, the potential endogeneity between infrastructure and growth (Straub 2011). Micro-level studies, focused on a specific policy intervention, provide more precise estimates of causal effects but are difficult to generalize from and of uncertain import with respect to aggregate, country-level outcomes. Both macro- and micro-level studies tend to focus on proximal relationships in the contemporary era, even though economic theory suggests that infrastructure should have distal causal effects on economic development and that these effects should have been greater in earlier periods of historical development, when stocks of infrastructure around the world were much lower.

In an effort to overcome some (though not all!) of these difficulties, we focus on postal systems as a measure of infrastructural development. We theorize that the establishment and/or expansion of government-run postal systems in the nineteenth century generated short- and long-run economic effects by (a) reducing transaction costs, (b) facilitating the diffusion of ideas and technology, and (c) strengthening social capital. We report results from two sets of analyses on the role of postal services in economic development. The first tracks the spread of post offices across counties in the United States from 1845 to 1896 drawing on annual publications of the United States Official Postal Guide. The second employs an original dataset tracking the spread of postal services in countries and colonies around the world from 1875 to 2007 drawing on annual publications of the Universal Postal Union.

In this fashion, we conduct parallel analyses at county and country levels, a multi-level approach to causal inference. Since our micro-level analysis is focused on counties within a single country, examined in an intensive fashion (and incorporating qualitative evidence from a voluminous secondary literature), this study also exemplifies the strategy of nested inference (Gerring 2007; Lieberman 2005). Our hope is that the cross-country analysis addresses problems of generalizability and also overcomes potential problems of spillover across units, while the within-country analysis addresses other problems of inference and sheds light on causal mechanisms.

Consistent with our argument, the results from our triangulated study provide strong evidence for the proposition that postal services played a central role in economic development over the past two centuries. In both county- and country-level analyses, the spread of postal systems is associated with positive economic outcomes. The data also demonstrate that these effects persisted over the long term, with the provision of postal services in the 19th century associated with more favorable economic outcomes in the 20th century. These results are robust across a wide range of dependent variables, model specifications, and estimation strategies. Our findings thus validate a central premise of institutionalist theory and have important implications for understanding how the provision of public infrastructure facilitates development.

In the first section, we theorize why, and how, postal services might matter for long-run economic development. In the second section, we outline the case for postal services as a measure of public infrastructure. In the third section, we compose a series of cross-national tests based on data from the Universal Postal Union. In the fourth section, we test the theory at county levels using data from the Official Postal Guide. A final section offers preliminary conclusions and suggestions for further research.

## **Postal Services and Economic Development**

Postal systems generate communication networks. Insofar as networks matter for economic development these effects should be manifested in the spread of modern postal services. To this extent, our theoretical account builds on existing studies of networks and development (Eagle, Macy and Claxton 2010; Granovetter 1973, 2005; Jackson 2010; Rauch and Casella 2001). However, communication technologies differ, and these differences presumably matter for causal effects they generate and the pathways by which those effects are achieved. In this section, we outline the distinctive ways in which the development of a postal service or the placement of a post office may have contributed to economic growth — at both national and local levels.

An impressive library of work addresses various aspects of the post office. General historical accounts relate the rise of postal systems in the United States (Blevins 2015; Cushing 1893; Fuller 1972; John 2012; Rich 1924; Roper 1917; Scheele 1970), Canada (Smith 1920), New Zealand (Robinson 1964), Japan (MacLachlan 2011), Britain (Austen 1978; Campbell-Smith 2012; Daunton 1985; Hemmeon 1912; Joyce 1893; Perry 1992; Robinson 1948), Ireland (Reynolds 1983), France (Langlois-Thiel 2014; Le Roux and Richez 2016; Vaille 2015), Russia (Alef 1967; Bazilevich 1927/1987), and other European countries (Le Roux 2014), as well as of the Universal Postal Union (Coddington 1964; Zacher and Sutton 1996: ch 6). Theoretically oriented studies focus on the post office as a regulatory arena (Coase 1961; Crew and Kleindorfer 1998; Priest 1975), a government bureaucracy (Carpenter 2000; Ellis 1958; Fowler 1943; Kennedy 1957; Kernell and McDonald 1999; Perry 1992; Rogers 1916; Rogowski 2015, 2016; Rogowski and Gibson 2015), an agent of political change (John 1998; Perlman and Schuster 2015), and a facilitator of technological innovation (Acemoglu, Moscona and Robinson 2016). No study that we are aware of has systematically examined the impact of postal services on economic development during the age of the industrial revolution.<sup>1</sup>

Postal systems, in one form or another, extended back to ancient times (Beale 1998; Gazagnadou 1994; Scheele 1970: Part 1; Silverstein 2007; Zilliacus 1956). However, they underwent a period of dramatic expansion in the nineteenth century as the responsibilities of the state increased (see citations above). This followed the widespread adoption of several principles of organization: government monopoly (partial or complete) over postal delivery, universal coverage of post offices throughout settled territories, and cheap pre-paid postage with uniform rates. Underlying these foundational principles was a new overall objective: to foster communication, and with it, commerce. This replaced older objectives: namely, to raise revenue and serve state

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<sup>1</sup>Although Acemoglu, Moscona and Robinson (2016) provide important evidence about the association between the postal system and patent applications in nineteenth-century United States, their study does not address the causal impact of patents on growth (rife with difficult to measure counterfactuals) or other ways in which postal systems might impact growth.

elites. In this fashion, state-run postal systems provided rapid and dependable written communication for anyone who could afford a postage stamp, a system that largely displaced longstanding private and ad hoc methods of correspondence.

Contemporary and secondary accounts emphasize the transformative impact of postal services on nineteenth-century politics and society (see citations above). We surmise that their impact on economic development was equally transformative. Consider the key role of communication networks in the industrial revolution (Lerner 1958; Pye 1963), and consider that the post was the dominant means of (non face-to-face) communication prior to the mid-twentieth century. In this light, it seems plausible that the extension of postal systems to mass publics in the nineteenth century served a catalytic role in the expansion of economic capacity. We argue that this role was carried out through three main channels: a dramatic reduction of transaction costs, the diffusion of new information, and the creation of social capital.

First, the development of a postal system reduced transaction costs, facilitating contracts and business relationships of all sorts. It allowed sellers to advertise their wares (e.g., through sales catalogs such as those produced by Sears Roebuck and Montgomery Ward) and to consummate sales (via postal money orders) without travel to and from urban centers by clients, salespersons, or delivery personnel. It provided a system of rural banking, remittances, and postal orders. It facilitated job searches between employers and potential employees during a period of wrenching economic transition, when labor market demands shifted quickly from one area to another, thus enhancing the productivity of human capital. It allowed investors to find opportunities for investment and to monitor those investments through time, enhancing the productivity of capital. This included farmers, who needed to keep careful track of commodity prices, as well as corporate investors.

It is worth emphasizing the degree to which the early post office served as a handmaiden of business. Blevins (2015: 10) reports that “Americans sent all manner of material through the mail that made up the commercial lifeblood of the nation, from bank-notes to commodity prices to

speculative rumors. Merchants and lawyers, plantation owners and mill operators — all relied on the mail to conduct their business.” Roper (1917: 258) writes: “The instruments of trade and banking pass through the countless postal channels, and can pass in no other way. In fact, the post office creates wealth in so many ways that it is futile to attempt to enumerate them.” Fuller (1972: 88) concludes that the US Post Office served as “the good right arm of business in antebellum America.”<sup>2</sup>

Second, the development of a modern post office facilitated the diffusion of new ideas and technology. Just as the printing press was the technological innovation allowing for the duplication of written documents (Eisenstein 1979), the postal service was the institutional innovation allowing written material to be widely disseminated (Fuller 1972: ch 4; John 1998; Kielbowicz 1989; Starr 2004: part I). Indeed, a principal motivation for government subsidy of the post was to spread useful information, thereby educating the masses and strengthening the bonds of nationhood. Nineteenth-century mail services were duly freighted with political and religious tracts. But they also carried newspapers (often at reduced fees), which included a potpourri of news and information on all matters, especially commercial matters. Mail services played an explicit commercial function by conveying commercial samples, seeds, industrial and agricultural circulars — including new methods of agricultural and industrial production — as well as (in the US) serving as a mechanism for the registration of patents (Acemoglu, Moscona and Robinson 2016). Insofar as diffusion serves as an agent of economic progress (Eaton 1999; Keller 2004; Rogers 2003; Spolaore and Wacziarg 2009), mail services must have played a key role in that process during their heyday in the nineteenth and early twentieth centuries.

Third, the development of postal services enhanced social capital. Prior to the advent of an affordable postal service, social ties were limited to those living in close proximity, or required costly and time-consuming (and often dangerous) voyages by land or water. Communities were,

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<sup>2</sup>For further discussion of the role of the postal service in the development of markets in nineteenth-century America see Demaree (1941), Kielbowicz (1989: ch 1), Pred (1973, 1980). For discussion focused on Japan see MacLachlan (2011: 54-55).

of necessity, isolated from the world, and even from neighboring communities that lay more than several days' journey away. With the introduction of a postal system it became possible to converse with members of one's extended family living in a nearby city or abroad, to form correspondence-based relationships ("pen pals"), and to follow events in farflung places. "The U.S. Post's far-reaching geography made it indispensable for a staggering array of organizations and connected more people in more places than any other single institution," writes Blevins (2015: 15), who calls it "the great spatial infrastructure propping up nineteenth-century society." In addition, post offices functioned as local meeting points, lending greater cohesiveness to those living in a township or county (John 1995: 161). We assume that those local and extra-local communication networks generated trust, fostered compliance with community norms, facilitated voluntary associations, political participation, and economic partnerships, furthering the development of "weak ties" (Granovetter 1973). And we assume that these features of social capital brought economic payoffs at micro- and macro-levels (Knack and Keefer 1997; Woolcock 1998).

The three causal mechanisms discussed here — transaction costs, diffusion, and social capital — overlap and are therefore difficult to distinguish empirically (a task we do not undertake in this study). Nonetheless, a strong *prima facie* case, based on economic theory and extant studies, can be made that the postal service stimulated these mechanisms and that these mechanisms, in turn, stimulated economic development.

## **Postal Services as a Measure of Public Infrastructure**

The composite theoretical account portrayed in the previous section is based on an ideal-typical model of what postal systems in their most successful incarnations might achieve, with particular focus on the US case. Evidently, there was considerable variation in the timing and the manner in which postal systems around the world did their work. Some postal systems were unreliable, expensive, or incapable of reaching citizens living in the hinterlands — or they achieved



universal coverage very late in their development. Postal systems around the world thus present a full range of organizational successes and failures, which we regard as an indication of the quality of political institutions more generally. In this section we comment on some of the advantages that the postal system offers as a test of the institutionalist thesis — vis-à-vis other types of infrastructure, e.g., roads, railroads, waterways, telephones, telegraphs, sanitation, and energy.

First, postal systems are generally run by public corporations or government agencies. Although private mail systems (e.g., Wells, Fargo and Co formerly, United Parcel Service latterly) sometimes challenged this monopoly, nowhere has the private sector displaced public systems of mail distribution. Moreover, postal systems were a mainstay of national bureaucracies in the nineteenth and early twentieth centuries, constituting a majority of public employees in the United States (Blevins 2015: 13; John 1998). As a measure of state activity or “infrastructural power” (Mann 1984; Soifer 2008), the post office is therefore well-suited. By contrast, the provision of other kinds of infrastructure requires less bureaucratic effort or is shared between public and private providers. Although tightly regulated, these infrastructural developments are less clearly tied to state activity.

Second, building a postal system is less dependent upon physical features of the land than other aspects of infrastructure. For example, the extent of a railway system, a system of waterways, or a system of power generation hinges heavily on geography and natural resources. Consequently, the development of these systems is not a direct measure of state capacity but rather of some mix of state capacity and physical characteristics of the land.

Third, when postal systems were introduced and/or expanded in the nineteenth century they represented a massive and rapid change in communicative capacity. Subsequent “revolutions” sponsored by the advent of the telegraph, telephone, radio, television, and internet also enhanced the speed and the reach of communication networks. But their impact was probably not as revolutionary as the initial shift from word-of-mouth and private courier to national mail service. Causal inference is enhanced when a treatment is large and can be distinguished from background

noise. Note that little noise is provided by alternate mechanisms of communication in the nineteenth century. (Of course, the expansion of postal services was accompanied by the expansion of transport infrastructure — e.g., roads, railroads, and shipping — factors that we must bear in mind as potential confounders.) In addition, communities were affected more evenly by the expansion of postal services than they were by the introduction of other communication technologies such as the telegraph, television, and the internet, where access is dependent upon physical features of the land and/or the financial resources of consumers.

Fourth, postal systems have proven to be an enduring system of communication, offering a lengthy period of observation extending across several centuries. By contrast, many other infrastructural developments were important for relatively short periods of time, or are recent inventions. Insofar as one wishes to understand long-term effects of an infrastructural development the postal service offers an ideal focus of study.

Fifth, postal systems can be measured at national and subnational levels and can be expected to register both macro- and micro-level effects. One can count the number of post offices at a country level or a county level, and both should have effects measurable at that level of analysis. By contrast, most infrastructural technologies do not offer the opportunity for multi-level analysis.

For these reasons, we feel more confident in arriving at unbiased and generalizable inferences about the causal role of public infrastructure in economic development when focused on postal services than we might if focused on some other aspect of infrastructure. Granted, we cannot entirely separate the causal effect of postal systems from the effect of other government-sponsored infrastructure projects since improvements in roads, railroads, harbors, bridges often occurred in tandem, and often in response to one another (e.g., the development of “postal roads” to carry government mail). Thus, we regard the estimated relationship between postal systems and development in subsequent tests as encompassing a pure postal effect along with an additional generic

infrastructural effect.<sup>3</sup>

## County-level Analysis

The U.S. post office is well-suited for studying the effects of infrastructure on a population. During the nineteenth century, it was “the only state organization that interacted with all citizens” (Carpenter 2001: 66; see also John 1995: vii), and the single largest source of federal employment. Indeed, for a period of time the post office employed more federal employees than all other departments combined. By 1895, its appropriations accounted for eighteen percent of the domestic federal budget (Stewart 1989: 67). The post office also nicely exemplifies the nature of American politics and statebuilding in the nineteenth century. Debates about the post office were intensely political due to the large number of patronage positions and the importance of patronage for partisan spoils. At the same time, the Post Office Department was home to a number of important initiatives in bureaucratic organization, and launched innovative programs including the postal inspector system (Carpenter 2001), city free delivery beginning in 1863, and rural free delivery (RFD) beginning in 1896 (Kernell and McDonald 1999).

We begin by examining the distal effects of postal infrastructure on economic development at the county level in the U.S. Data on the number of post offices are reported in the United States Official Postal Guide. This feature is measured in 1896, prior to the advent of RFD. In the wake of RFD, many rural post offices were closed in preference for household mail delivery, meaning that the changing number of post offices in rural areas of the United States does not serve as an accurate proxy for postal infrastructure at-large during a period of several decades in the early twentieth century (Carpenter 2001: 140).

Figure 1 shows the distribution of post office locations in 1896.<sup>4</sup> Counties shaded with darker

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<sup>3</sup>This follows the strategy adopted by Acemoglu, Moscona and Robinson (2016: 62).

<sup>4</sup>Data are missing for approximately 450 counties. The map in Figure 1 is based on contemporary county boundaries because these are the boundaries for which we use economic data. Many of the counties with missing data had been consolidated with other local jurisdictions in the early or mid-twentieth centuries.

colors had greater numbers of post offices, and each color corresponds (roughly) to a different quantile. Counties with missing data are shown in gray. Overall, there were nearly 70,000 local post offices across the country, the vast majority of which were fourth-class post offices in rural locations.

The distribution of post offices varied widely. Counties in the northeast had large numbers of post offices, as one might expect, while fewer post offices were found on the frontier. The map shows some interestingly intraregional variation as well. For instance, the concentration of post offices per county was greater in Alabama than in Georgia, and greater in the Appalachian foothills of southeastern Ohio than in the farmland counties on the western side of the state.

**Figure 1 goes here.**

To estimate the impact of postal infrastructure on long-term economic development, we measure the former in 1896 and the latter in 2000, using data drawn from the decennial U.S. Census.<sup>5</sup> Of principal interest is median income, which we regard as a measure of overall economic development in a county.<sup>6</sup> This is supplemented with county manufacturing output (per capita), which measures a certain type of economic development. All variables of theoretical interest are transformed by the natural logarithm, generating a log-log model, with the assumption that variables on both right and left sides of the model exhibit decreasing marginal returns.

Figure 2 displays a scatterplot of post offices in 1896 plotted against our two chosen measures of economic development in 2000. A best-fit regression line accompanies the scatterplot. The bivariate correlation between logged number of post offices and logged median income ( $r = 0.29$ ) and the value of manufacturing output ( $r = 0.37$ ) are both positive and reasonably strong, offering preliminary corroboration of our theory.

**Figure 2 goes here.**

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<sup>5</sup>All dependent variables for the U.S. analysis were obtained from ICPSR study #2896 ("Historical, Demographic, Economic, and Social Data: The United States, 1790-2002").

<sup>6</sup>The Census reported median income at the household level for 2000 and at the family level from 1950 to 1990.

To further test the proposition we estimate cross-sectional analyses in which county-level development in 2000 is regressed on post offices in 1896 along with additional covariates, which might serve as common-cause confounders. Background factors include population (logged), population density (logged), population born outside the U.S. as share of total population (logged), railroad access, waterway access, and state fixed effects. All background factors are measured in 1896 except for railroad and waterway access, for which data is available only in 1860. Although other county-level features may also have affected economic development during this period (e.g., the varying impact of the growing military-industrial complex, localized effects of the Great Depression, subsequent rebuilding efforts undertaken as part of the New Deal, globalization, demographic changes, migration, and suburbanization), these factors may also have been affected by communications infrastructure, raising a problem of post-treatment confounding (Gelman and Hill 2007: 189).

Results from these analyses are presented in the first part of Table 1. Here, we find strong and consistent evidence that state infrastructure is associated with long-term economic benefits. Model 1 shows that counties with greater numbers of post offices in 1896 registered higher median incomes in 2000, while Model 2 shows that the prevalence of post offices in 1896 is associated with greater manufacturing output.

To gauge the substantive magnitude of these effects, we examine the predicted effect of a hypothetical increase in post offices per county in 1896 from one standard deviation below the mean (about 9) to one standard deviation above the mean (about 43), while holding values for other variables at their mean. Estimates from our models imply that this two standard-deviation increase in post offices is associated with a \$5,800 increase in median income and an increase in manufacturing output from \$133.5 to \$139.3 million.

The provision of U.S. post offices, however, was not random, and this may introduce bias into our analysis — despite our attempt to condition on potential confounders. Another approach to the problem attempts to model assignment into treatment by measuring factors that might

affect the allocation of post offices. To serve as an appropriate instrument the chosen factor must not have direct impact on long-term economic development and must not be associated with other factors that have a direct impact on economic development (unless those are conditioned in the model). Rogowski (2016) proposes that political factors, particularly the partisan alignment between the party of the president and a county’s congressional representative, could have played an important role in affecting where post offices were established. Accordingly, we instrument for the provision of post offices using the average county vote shares for the winning presidential candidate and for the congressional candidate who shared the incumbent president’s partisanship in the two presidential and congressional elections prior to 1896.<sup>7</sup> We must assume that other partisan-driven policies that might be correlated with post offices do not have lasting economic effects.

Model 3 in Table 1 shows results from the first-stage regression. The F-statistic is substantial (12.63), suggesting that the instruments are sufficiently strong to ameliorate concerns about biases from weak instruments. Second-stage results, shown in Models 4 and 5, are consistent with the OLS estimates and confirm that larger numbers of post offices in 1896 are associated with greater economic development in the subsequent century. We note, however, that the coefficients from the 2SLS models are significantly larger in magnitude than the OLS estimates.

**Table 1 goes here.**

In Appendix A, we present several additional tests that probe the robustness of the relationship between postal infrastructure and long-term economic development. To see whether these results are affected by our choice of end-points, we re-estimate all models in Table 1 with indicators of economic development measured in 1960, 1970, 1980, 1990, and 2000 (the year of our original analyses). Results are posted for the key variable of theoretical interest — number of post

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<sup>7</sup>These data were obtained from ICPSR study #8611, “Electoral Data for Counties in the United States: Presidential and Congressional Races, 1840-1972.” States that had not been admitted as of 1892 were omitted from the analysis.

offices, logged — in Table A3, where it will be seen that the relationship remains robust regardless of the chosen end-point.<sup>8</sup>

To see whether results are sensitive to the choice of covariates, we include a battery of specification tests in Table A4. Beginning with the benchmark model, we remove additional measures of infrastructural development — railway and waterway access. Next, we add (to the benchmark model) additional covariates measuring manufacturing value and farm value in 1890 in order to account for the level of economic development attained by counties at the turn of the twentieth century. For each alteration in specification, both OLS and 2SLS models are re-estimated. Results track those reported in Table 1 closely, suggesting that the relationship between postal infrastructure and long-term economic development is not dependent upon a particular specification of the model.

In a second set of analyses, we explore the proximal effects of infrastructure on economic outcomes using data from a panel of approximately 2,700 counties. The provision of post offices is measured in 1855, 1867, 1876, 1886, and 1896 while economic outcomes are measured in 1870, 1880, 1890, and 1900.<sup>9</sup> Since estimates of median income (and similar measures) are unavailable prior to the mid-twentieth century, we focus on three indicators of local economic performance gathered from census reports: (a) farm values, (b) value of manufacturing output (as previously), and (c) capital investment in manufacturing — each calculated on a per capita basis.

To account for time-varying factors that might confound the relationship of interest we measure population, population density, and the percentage of the county population born outside of the U.S. We also include county fixed-effects to help account for invariant characteristics of counties and year fixed-effects to account for national-level changes through time. Standard errors are clustered on counties, as previously.

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<sup>8</sup>The association between postal systems (in 1896) and median income peaks in the final year (2000) while the association of postal systems with manufacturing demonstrates no consistent trend over time — though these apparent patterns may be stochastic rather than systematic.

<sup>9</sup>Data for 1855 and 1867 are drawn from Acemoglu, Moscona and Robinson (2016). Data for 1876, 1886, and 1896 are drawn from Rogowski (2015; 2016).

As previously, we present linear regression specifications along with instrumental-variable models, using the average of a county's vote share cast for the winning presidential candidate and the president's copartisan candidates in the two elections that preceded the year in which the number of post offices is measured. The instruments are again fairly strong, providing a first-stage F-statistic of 19.05. The results from these analyses are shown in Table 2. We find substantially similar results across each dependent variable. The coefficients for the number of post offices are consistently positive and statistically significant, indicating that increases in post offices contributed to increased economic development as measured by farm values, the value of manufacturing output, and the capital investment in manufacturing. Based on the OLS estimates, a 10 percent increase in the number of post offices is predicted to have increased the per-capita value of that county's farms by just under one percent, with somewhat smaller increases for manufacturing value and capital. It comes as no surprise that the estimated effects are quite a bit smaller than those shown for our long-term analyses above given the close proximity of predictors and outcomes.

We find similar results for our instrumental variables approach, in which the coefficients for the number of post offices are again positive and statistically significant. As with our earlier analyses, we again find that the magnitudes of the 2SLS coefficients are quite a bit larger than our OLS coefficients.

**Table 2 goes here.**

Analyses presented in this section suggest that government-run postal services generated short- and long-term economic benefits across U.S. counties. The relationship is robust across a variety of estimators, specifications, and temporal frames, and using a variety of measures of economic performance. Counties that received a higher allocation of post offices in the nineteenth century experienced greater economic development, an effect that has endured for a century and appears to be ongoing.



## Country-level Analysis

One may reasonably question whether the results presented in the previous section are generalizable to other settings. After all, no country developed as dramatically as the United States over the course of the past two centuries and the expansion of postal service in the western regions of the country amounted to an intervention from a very low base. One might anticipate that more modest interventions would attenuate the relationship between postal systems and economic development. To properly test the impact of postal services on economic development across the world we must move from the micro-level (i.e., county level) to the macro-level (i.e., country level). In so doing, we face additional problems of causal inference but also overcome a potential problem with micro-level data — the (possible) non-independence of units, as discussed. Country-level data on postal systems can be found in publications of the Universal Postal Union (UPU), which were drawn from archives at Harvard University, Boston University, University of Illinois at Urbana-Champaign, the United States Postal Service archives in Washington DC, and Bibliothèque Historique des Postes et Télécommunications in Paris. The main UPU statistical abstract, which carried a variety of titles, was published annually or semi-annually at the organization's headquarters in Berne, Switzerland, from 1875 to 1979, after which it was replaced by the UPU web site, which carries data up to 2007 (the most recent year in our sample). Data was digitized by hand and then cross-checked with the original copy to limit data entry errors. Forty-five variables pertaining to various aspects of postal administration — e.g., organization, finance, domestic and international mail — were collected in this fashion, all of which are available in an accompanying dataset, described in Gerring and Cojocaru (2016). Our focus here is on the number of post offices within a country or colony (aggregated by country-year). A post office, as defined by the UPU, includes all establishments where users can receive postal services with the exception of those that only sell stamps. The raw number of post offices is recalculated on a per capita basis to reflect the density of postal systems across sovereign and semisovereign terri-

tories. We regard this as the best overall measure of the provision of postal services throughout the world.<sup>10</sup> Missing data within a country time-series (generally for spells of just a few years) is linearly interpolated — a reasonable approach when dealing with highly trended data. The resulting variable is then transformed by the natural logarithm to account for the presumed declining marginal effectiveness (*vis-à-vis* economic development) of each additional post office within a national postal system. Finally, we construct a stock measure of this variable by calculating a country’s post office density from the first data point in the UPU dataset (1875 or later), with a low, one percent annual depreciation rate (following Gerring et al. 2005). This follows our theoretical expectation that the impact of postal infrastructure on national-level growth performance accumulates over a long period of time. A country with a long history of postal infrastructure should have stronger growth today than a country with a shorter history (*ceteris paribus*), even if their postal density is comparable in the contemporary period. Like many other institutional features, communications infrastructure is likely to be long-memored (Gerring et al. 2005). Table 3 explores the relationship between this predictor and economic development. Models 1 and 2 focus on the long-term effect of postal services on per capita gross domestic product (constant dollars, logged), provided by Angus Maddison and associates (Bolt and van Zanden 2014). For these analyses, the outcome is measured in 2000 and the predictors a century earlier — paralleling our analyses of U.S. counties in Table 1. Model 1 is a simple specification including only the lagged value of the dependent variable and per capita GDP (log), both measured in 1900. Model 2 adds several additional covariates — also measured in 1900 — that might serve as confounders: population (log), urbanization, democracy (measured by the Polity2 index), resource wealth, educational attainment, and literacy. Definitions and descriptive statistics for all variables

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<sup>10</sup>Granted, it is prey to measurement error in the early twentieth century as postal systems adopted door-to-door delivery services that reduced the need for post offices in diffusely settled areas (as noted). To overcome this issue, we take a similar approach to our U.S. analysis, measuring the prevalence of post offices at the end of the nineteenth century. In time-series analyses we include year dummies, which should help to account for the replacement of post offices with door-to-door delivery, a development that occurred more or less simultaneously throughout the world in the early twentieth century.

are presented in Appendix B. For both models we impute missing data for background covariates using the Amelia algorithm (Honaker, King and Blackwell 2011). We do not extend the imputation to include countries for which there is missing data for the variable of theoretical interest — post offices — since this seems to stretch the bounds of imputation beyond reasonable limits. This preserves a full sample of 72 countries, observed across a century-long period. (Estimates obtained without imputed data on smaller samples are consistent with those displayed in Table 3, and also statistically significant ( $p < .10$ ).) Estimates across minimal and “full” specifications (Models 1 and 2) are similar, though the latter is somewhat attenuated and attains significance only at the 85% level. Cross-sectional analyses of distal causal relationships thus provide some preliminary corroboration for our hypothesis that postal systems have enduring effects on economic development. However, because of the small size of the sample and numerous potential confounders we turn to additional tests that focus on change through time. Remaining tests in Table 3 capitalize on the detailed, historical data available from the UPU, which extend back to 1875 for some countries. Here, we adopt growth, the percentage change in per capita GDP (based on the Maddison project), as a dependent variable, shifting the weight of the analysis to within-country changes over time. Note that because the independent variable of interest measures the cumulated stock of postal system provision since 1875, the analysis estimates the proximal effect (on annual or five-year periods of growth) of a country’s postal history. The stock variable thus captures both distal and proximal causal effects (discounting the former with a slow depreciation rate). The benchmark time-series analysis aggregates data at five-year periods. This is motivated by the fact that variables in our model are not measured annually for all countries and years for which data is available. Likewise, our theoretical interest is focused on longer-term effects, making annual changes less interesting. Thus, unless otherwise stated, the following panels measure smoothed variables every five years from 1875 (or the first year available) to 2005. The benchmark specification includes per capita GDP (logged) on the right side to control for convergence effects. We also include country fixed-effects to minimize potential specification problems and

year fixed-effects to control for changes over time that are global in nature. Right-side variables are lagged one period (i.e., five years) behind the outcome. Results from this benchmark model, shown as Model 3 in Table 3, suggest that a stock measure of postal infrastructure produces a strong short-term effect on growth performance. In Model 4, this analysis is replicated with annual data. Results are almost as strong, despite the added noise and measurement error. Model 5 replicates this specification with imputed data, following the procedure described above. This increases the number of countries (from 155 to 193) and observations (from 1,879 to 3,042). Reassuringly, there is little change in the estimated coefficient for our key variable of theoretical interest. Model 6 is a minimal specification, excluding all covariates except country fixed effects. Here, we find an attenuated (though highly significant) relationship between postal infrastructure and economic performance. Model 7 is a maximal specification, building on Model 3 but also including population (log), urbanization, regime-type (Polity2), resource wealth (per capita), educational attainment, literacy, and year of independence (measuring the length of time a country has been in existence). Here, we find a somewhat stronger estimated relationship between postal infrastructure and economic performance relative to our benchmark growth model (Model 3). Model 8 returns to the benchmark but with a longer lag imposed on the variable of theoretical interest — twenty years, rather than the usual five years. The longer lag appears to have little or no impact on the relationship between postal infrastructure and economic performance, mitigating concerns about simultaneity between right and left sides of the model. Model 9 introduces several lags of the dependent variable into the model — one at T-1 and the other at T-2. Again, the estimated coefficient for post office stock is stable, and highly significant. Finally, we conduct a generalized method of moments (GMM) test, displayed as Model 10 in Table 3. This “system GMM” estimator, regarded as appropriate for studying sluggish variables (Blundell and Bond 1998), includes level and differences regressions, and accounts for endogenous regressors by using lags of levels to instrument for differences and lags of differences to instrument for levels. We allow 2 lags for instrumentation, producing 191 instruments — slightly above the number

of cross-sectional units (155), often regarded as a rule-of-thumb threshold (Roodman 2009). Post offices and per capita GDP are treated as endogenous. The AR(2) test rejects autocorrelation in the first differences at the 5% level ( $p=0.13$ ) and the Hansen J-test p-value is 0.99, suggesting that Model 10 provides consistent estimates. The estimated (short-term) effect of postal infrastructure on growth is slightly weaker than for our benchmark time-series test (Model 3).

**Table 3 goes here.**

These ten tests offer strong confirmation of the thesis that postal infrastructure affects economic development. Both distal (Models 1-2) and proximal (Models 3-10) effects are estimated, and results are robust to a variety of specifications and estimators. Moreover, the estimated coefficient for our post office stock variable is remarkably stable. It would appear that micro-level effects found in our county-level analyses of the United States can be replicated in other countries across the world, including countries at various stages of industrialization.

## Conclusion

That political institutions might have an important effect on economic development is highly plausible. Yet, measuring this effect, and identifying the specific institutions that impact growth, has proven difficult.

This study regards postal systems as a key element of public infrastructure in the nineteenth and twentieth centuries. The post office was among the first and most visible imprints of the state. Insofar as states shepherded development during the age of the industrial revolution post offices were well-positioned to play a key role. Postal systems (a) reduced transaction costs, which facilitated financial exchange and opened new markets; (b) contributed to the diffusion of information and ideas, creating more informed citizens, incentives for innovation, and economic competition; and (c) enhanced social capital by connecting and integrating residents of local communities with family members, friends, and firms located close by and far away.

To test the hypothesized effect of postal infrastructure on economic development, we explore county-level data in the United States and at country-level data throughout the world. Micro and macro analyses span two centuries, capturing the modern era of economic growth. We find both proximal and distal causal effects on income, validating a central precept of institutional theory: government provision of public goods has a strong impact on economic performance.

These findings also have important implications for research on state-building and political development in the U.S. case. While most research on American state-building focuses on how it occurred (e.g., Carpenter 2001; Skowronek 1982), less attention has been paid to its economic consequences. Our results suggest that the expansion of the state in the nineteenth century supported and sustained the expansion of economic activity. Counties endowed with a greater density of post offices experienced higher income and manufacturing in the succeeding century.

While this study does not undertake to test other aspects of public infrastructure, several aspects of the methodology employed here may be translatable to other contexts. Specifically, we suggest that the impact of infrastructure on economic development requires a long-memoried empirical approach, one that counts time in decades rather than years and one that takes account of the accumulated stock of infrastructure. If infrastructure affects development this relationship is likely to unfold over a very long period of time. We also explore the value of combining micro- and macro-level analyses. Note that causal inference is generally enhanced when a relationship can be tested across multiple units of analysis. And the generalizability of theories is enhanced when they can be tested across a global sample. We note, finally, that this study has not attempted to test the stipulated causal mechanisms at work in the relationship between public infrastructure and economic development, an area we leave for future research.

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# Tables

**Table 1:** Distal Effects of Postal Infrastructure in U.S. Counties

	Median Income (2000)	Manufacturing Value (2000)	Post offices (1896)	Median Income (2000)	Manufacturing Value (2000)
<i>Estimator</i>	<i>OLS</i>			<i>2SLS</i>	
Post offices (ln), 1896	0.12** (0.01)	0.03** (0.01)		0.54** (0.12)	0.06* (0.03)
Population density (ln), 1896	0.10** (0.01)	0.01** (0.01)	−0.33** (0.02)	0.24** (0.04)	0.02** (0.01)
Population (ln), 1896	−0.10** (0.01)	0.02** (0.01)	0.81** (0.03)	−0.44** (0.10)	0.00 (0.02)
Foreign-born (%), 1896	0.30** (0.09)	0.23** (0.03)	−1.88** (0.22)	1.07** (0.27)	0.26** (0.06)
Railway access, 1860	0.12** (0.01)	0.02** (0.01)	−0.10** (0.02)	0.17** (0.02)	0.02** (0.01)
Waterway access, 1860	0.04** (0.01)	−0.01* (0.01)	−0.03** (0.02)	0.05** (0.01)	0.00 (0.00)
Presidential vote, 1896			−0.02 (0.07)		
Congressional vote, 1896			0.24** (0.06)		
N (counties)	2,009	1,658	1,887	1,887	1,564
State fixed effects	✓	✓	✓	✓	✓
<i>F</i> (first-stage)			12.63		

Entries are regression coefficients and standard errors, clustered by county. The dependent variables are the logged values of the outcomes listed at the top of each column.

\*\* indicates  $p < 0.05$  and \* indicates  $p < 0.10$  (two-tailed tests).

**Table 2:** Proximal Effects of Postal Infrastructure in U.S. Counties, 1850-1900

<i>Estimator</i>	Farm value		Manufacturing value		Manufacturing capital	
	<i>OLS</i>	<i>2SLS</i>	<i>OLS</i>	<i>2SLS</i>	<i>OLS</i>	<i>2SLS</i>
Post offices (ln)	0.08** (0.01)	0.51** (0.14)	0.03** (0.02)	1.31** (0.30)	0.04** (0.01)	1.39** (0.31)
Population density (ln)	0.40** (0.09)	0.15* (0.08)	0.10 (0.10)	0.10 (0.17)	0.15 (0.10)	0.21 (0.18)
Population (ln)	-0.03 (0.10)	-0.07 (0.11)	0.44** (0.11)	0.16 (0.19)	0.28** (0.10)	-0.02 (0.21)
Foreign-born (% , ln)	-0.04** (0.01)	-0.07** (0.02)	0.22** (0.02)	0.11** (0.03)	0.24** (0.02)	0.17** (0.04)
N (observations)	12,930	8,147	12,608	7,974	12,608	7,974
N (counties)	2,684	2,217	2,655	2,177	2,655	2,177
County fixed effects	✓	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓	✓

Entries are regression coefficients and standard errors, clustered by county. The dependent variables are the logged values of the outcomes listed at the top of each column.

\*\* indicates  $p < 0.05$  and \* indicates  $p < 0.10$  (two-tailed tests).



**Table 3: Distal and Proximal Effects of Postal Infrastructure, Global Analysis**

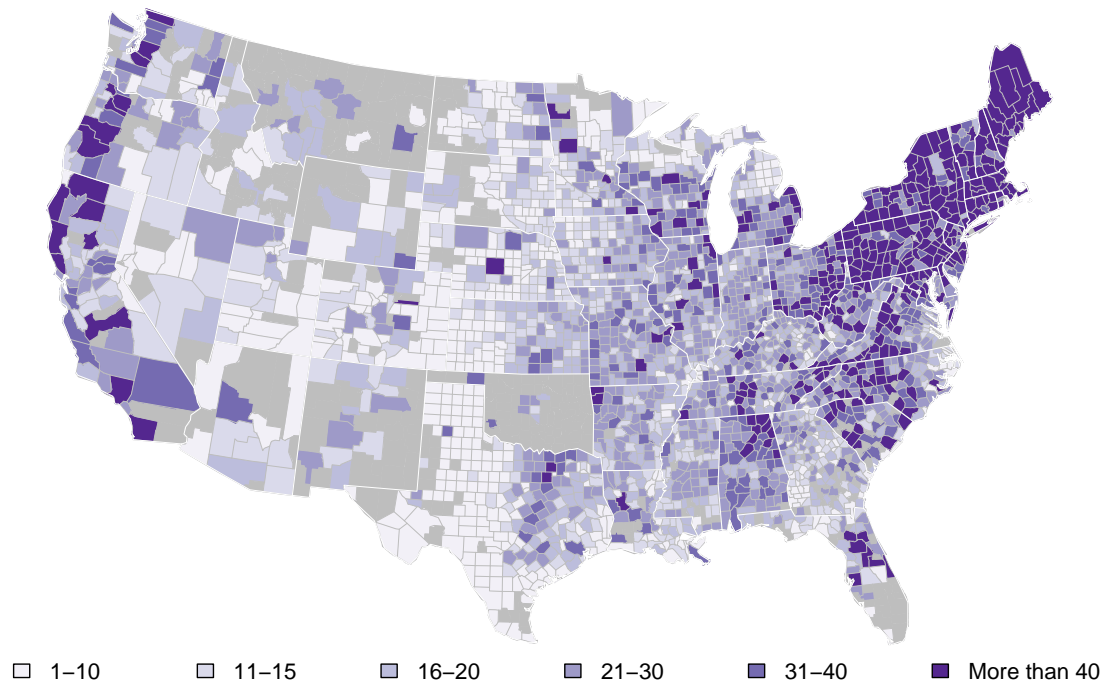
<i>Estimator</i>	GDP pc (ln)		GDP pc growth							
	<i>OLS</i> (1)	<i>OLS</i> (2)	<i>OLS</i> (3)	<i>OLS</i> (4)	<i>OLS</i> (5)	<i>OLS</i> (6)	<i>OLS</i> (7)	<i>OLS</i> (8)	<i>OLS</i> (9)	<i>GMM</i> (10)
Post offices (ln, stock)	0.007** (0.001)	0.004 (0.002)	0.014** (0.004)	0.012** (0.004)	0.011** (0.004)	0.002** (0.001)	0.023** (0.005)	0.017** (0.004)	0.016** (0.004)	0.003** (0.001)
GDP pc (ln)	0.811** (0.129)	0.511** (0.180)	-2.833** (0.387)	-1.983** (0.362)	-0.822** (0.431)		-3.679** (0.459)	-2.759** (0.388)	-3.483** (0.370)	-0.710** (0.285)
Population (ln)		0.040 (0.058)					-1.783** (0.624)			
Urbanization		0.911 (0.657)					-1.403 (2.700)			
Regime type (Polity 2)		0.005 (0.015)					0.029 (0.021)			
Resource wealth (pc)		0.000 (0.000)					0.000 (0.000)			
Educational attainment		0.026 (0.083)					-0.006 (0.012)			
Literacy		0.007 (0.006)					-0.028 (0.181)			
Independence							0.015* (0.008)			
GDP pc growth									0.037 (0.031)	0.145** (0.056)
GDP pc growth ( $T - 2$ )									0.077 (0.026)	
Trend										0.004 (0.003)
N (observations)	76	76	1879	10210	3042	1972	1491	1619	1777	1874
N (countries)	76	76	155	155	193	155	146	139	155	155
Country fixed effects			✓	✓	✓	✓	✓	✓	✓	
Year fixed effects			✓	✓	✓		✓	✓	✓	
# Panels	1	1	26	133	26	26	22	22	26	26

Entries are regression coefficients and standard errors, clustered by county. The dependent variables are the logged values of the outcomes listed at the top of each column.

\*\* indicates  $p < 0.05$  and \* indicates  $p < 0.10$  (two-tailed tests).

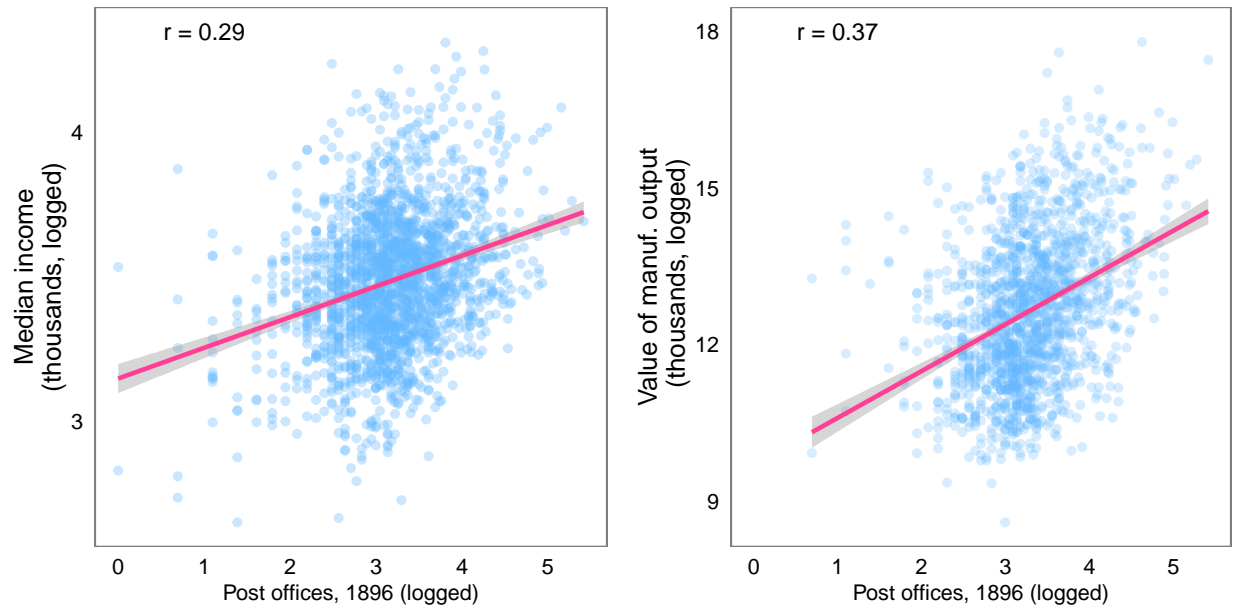
## Figures

**Figure 1:** Post Offices in U.S. Counties, 1896



Plot shows the number of post offices per county in 1896, where darker colors indicate larger numbers of post offices. The mean number of post offices was 25 (SD=20) and ranged from 1 to 225. Counties with missing data are shown in gray.

**Figure 2:** Post Offices in U.S. Counties, 1896



Plots show the number of post offices in 1896 plotted against economic outcomes — income (Panel a) and manufacturing (Panel b) — in 2000. Each circle indicates a county observation. Best-fit lines are accompanied by 95% confidence intervals.