# THE INSTITUTIONAL ENVIRONMENT FOR TELECOMMUNICATIONS INVESTMENT

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This paper demonstrates that a structurally derived, internationally comparable index of checks and balances on executive discretion created by variation in political structures and party systems affects relative rates of basic telecommunications infrastructure deployment in 147 countries during the period 1960–1994. Models of infrastructure investment that omit the political characteristics of a prospective host country confound countries whose economic and demographic characteristics point to rapid demand growth for infrastructure services with those that create a potential trap for investors due to a higher probability of arbitrary change in the policy environment. The econometric analysis exploits both cross-sectional and temporal variation in the panel. A robust covariance-matrix estimator based on that developed by Newey and West is used to compute valid standard errors in the presence of heteroskedasticity and within unit-serial correlation, two common characteristics in the error-term structure of panel datasets.

### 1. INTRODUCTION

In this paper we investigate the institutional determinants of the diffusion of basic telecommunications infrastructure across 147 countries during the period 1960–1994. The specific question that we seek to answer is, how do cross-national differences in the level of checks

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and balances on executive discretion created by variation in political structures and party systems affect relative rates of basic infrastructure deployment? We begin by briefly reviewing the received wisdom in three bodies of scholarly literature that relate to this question. The combined insights from these literatures suggest that stronger constraints on executive discretion should lead to more rapid infrastructure deployment, *ceteris paribus*. We test this hypothesis using a structurally derived, internationally comparable measure of political constraints, in combination with relevant economic variables and allowing for country and temporal fixed effects, to predict crossnational variation in the growth rate of basic telecommunications infrastructure.<sup>1</sup> Econometric analysis demonstrates strong empirical support for our theory.

Our findings are salient for academics, policymakers, and practitioners alike. While empirical economic studies have recently begun to demonstrate the long-purported theoretical link between political institutions and economic outcomes, these studies have primarily examined the impact of "macro" measures of the institutional environment on macroeconomic accounting measures.<sup>2</sup> Our paper takes a step toward unpacking which political institutions matter and the mechanisms through which they affect the specific economic activity of telecommunications infrastructure deployment, which is itself of strong interest due to its scale, central role in the economic development process, and high media profile.

The main lesson to be drawn from the paper involves the central role played by political institutions in the investment process. Prospective investors in the telecommunications sector must realize that a low penetration level relative to the level of economic development in a country may not signify untapped market potential, but rather a large risk of expropriation by the state. An enhanced understanding of the political foundations of a strong investment regime should therefore be of substantial interest to a wide audience.

### 2. THEORY

The scholarly literature that underpins our hypotheses falls into three broad categories: catch-up, institutions and commitment, and publicsector organization. We begin by summarizing the primary insights from each body of literature as they relate to the expected pattern of basic infrastructure deployment in the telecommunications sector.

<sup>1.</sup> For related studies of the determinants of telecommunications investment see Antonelli (1993), Greenstein, McMaster and Spiller (1995), and Roller and Waverman (2000).

<sup>2.</sup> A notable exception is Levy and Spiller (1994).

# 2.1 CATCH-UP

There exists a voluminous literature on cross-country technological diffusion and economic convergence.<sup>3</sup> The fundamental insight of this literature is that in the presence of large technological gaps among countries, those countries that exhibit a lower level of economic and technological development may imitate and thereby catch up with the leaders. This result derives from the assumption of diminishing marginal returns to capital (see Mankiw et al., 1992). Put simply, if laggard countries enjoyed all of the characteristics of the countries with the most developed telecommunications infrastructures other than high levels of infrastructure penetration, the laggards would experience faster penetration growth than the leaders would, due to higher marginal returns on their smaller capital stock.

In particular, we seek to apply the logic of the macroeconomic growth model presented in Solow (1956) and Koopmans (1965) to the telecommunications sector. Our application of the model to this sector yields the result of a steady-state level of telecommunications infrastructure per capita for a given set of demand and cost characteristics. When the demand structure or factor costs in a country change in a way that increases the long-run steady-state level of infrastructure penetration for that country, the growth rate of penetration increases during a long transition interval until the new steadystate level is attained. The model applied in the telecommunications sector thus implies that penetration growth rates in a given period depend on demand and cost characteristics. Furthermore, under the assumption of diminishing marginal returns to capital, countries with lower initial levels of infrastructure penetration are expected to experience more rapid infrastructure penetration growth, ceteris paribus. The model does not predict any simple correlation between growth rates and existing penetration levels, but rather between growth rates and existing penetration levels after taking into account demand and cost characteristics.

The underlying assumption of diminishing marginal returns to capital that drives this result is reasonable in the context of basic telecommunications.<sup>4</sup> First consider intertemporal comparisons within a given country. If capital investments are made sequentially and the total available returns in the individual territories in which a utility makes its successive investments vary, then the utility will rationally choose to invest first in those territories that promise the highest returns per unit of investment. These high-return territories are likely

<sup>3.</sup> For a summary, see Fagerberg (1988).

<sup>4.</sup> However, the core arguments regarding the effect of political institutions on infrastructure deployment do not rest on this assumption.

to be urbanized regions with large, dense populations of consumers. Subsequent investments in rural regions yield lower returns because these areas are more sparsely populated, and their populations typically have lower demand for services.

Now consider a cross-sectional comparison. Ceteris paribus, utilities in countries with low existing penetration levels enjoy higher marginal returns to infrastructure investment than do those in countries with high existing levels, both because they have not yet penetrated the most lucrative service territories, and because the costs of the best-practice technologies deployed in leader countries have typically fallen dramatically since the utilities in these countries initially deployed such technologies themselves. Moreover, utilities in leading countries are likely to have engaged in learning by doing, the diffusion of which benefits utilities in laggard countries. Additionally, because telecommunications infrastructure assets are longlived, utilities in countries with low existing infrastructure stocks may also be able to leapfrog early adopters, as they need not anticipate replacement of nearly as much existing infrastructure and are generally less bound by prior complementary investments in old technologies (Antonelli, 1993). The upshot is that there should exist an inverse relationship between the existing penetration level and the penetration growth rate both within and among countries.

Indeed, given the benefits enjoyed by late adopters, it is worthwhile to ask why convergence in the penetration *level* of a given technology does not occur instantaneously and uniformly across laggard countries when such countries come to resemble technological leaders on all dimensions other than level of infrastructure penetration. In the context of telecommunications, the primary reason is the massive investment required to construct a telecommunications infrastructure, which constrains the rate of penetration growth possible during any period of time that is less than the long run. Extending a copper network to every home, adding fiber-optic cable to a copper system, or moving to electronic switching requires a multiyear commitment of funds often in excess of one percent of a nation's gross domestic product. Moreover, even if an adequate amount of investment capital were suddenly to become available for a truly massive deployment project, it is still unlikely that the necessary physical resources (i.e., labor and capital assets) could be reallocated rapidly enough to make convergence attainable in the short run. As a result, the advantages enjoyed by laggards show up as relative increases in rates of penetration growth, ceteris paribus.

# 2.2 INSTITUTIONS AND COMMITMENT

As discussed above, the catch-up literature can be summarized by the hypothesis that countries lagging in infrastructure deployment should exhibit higher growth rates of penetration, *ceteris paribus*. In contrast, the literature on institutions and commitment emphasizes a critical factor that is missing from the catch-up model. Specifically, the extent to which the political institutions in place support political actors' commitments not to expropriate the property or rent-streams of investing firms increases the incentives of telecommunications firms to invest. We posit two effects of the institutional environment on the growth rate of basic telecommunications infrastructure.

**HOLD-UP.** First, the absence of a credible commitment<sup>5</sup> by 2.2.1 the political actors at the helm of the state not to expropriate capital assets or the returns generated thereby increases the risk associated with investment in assets that are largely sunk-i.e., that cannot be redeployed without significant loss of value and therefore have large quasi-rents (Goldberg, 1976; Spiller, 1993). The components of a basic telecommunications infrastructure provide a classic example of nonredeployable assets. Moreover, as Levy and Spiller (1994) argue, economies of scale in and massive consumption of telecommunications services create an inherent political interest in telecommunications pricing, and may therefore provide a government seeking to curry favor with the electorate with a strong incentive to expropriate a telecommunication company's returns once the telecommunication company has deployed infrastructure in the ground. The confluence of economic opportunity and political motivation therefore creates an inherent contracting problem in the provision of telecommunications services [as demonstrated, for example, by the case studies assembled in Levy and Spiller (1996) or the more formal analysis provided by Sidak and Spulber (1997)]. The fact that the life span of an investment in this case is measured in decades, and thus may extend over several elections (leadership changes), compounds the problem.

Given the existence of such a contracting problem, investors will only believe government pledges regarding future pricing and regulatory policy to the extent that they are credible. Credibility, in turn, depends on the extent to which institutional safeguards that increase the costs of reneging on previous policy commitments are in place. When such safeguards are absent, the cost to the government of overturning prior decisions falls, and the likelihood that the short-term gains to a reelection campaign or popular support from a policy reversal will yield positive net present value to political actors rises. As a

<sup>5.</sup> We define "credible" as incentive-compatible in an intertemporal sense, or "time-consistent."

result, firms operating in laggard countries in which constraints on policy change are low should be less likely to capitalize on laggard status and thus exhibit a diminished sensitivity to existing penetration levels, relative to firms operating in laggard countries where constraints on policy change are high. Despite the fact that firms in laggard countries can use less expensive technologies and more efficient techniques developed abroad to expand their infrastructures more rapidly than those in countries with higher existing penetration rates can, the difficulties that the former experience with underdeveloped political institutions in surmounting political contracting hazards relegates them to continued laggard status.

**2.2.2 RENT SEEKING.** The second effect of the institutional environment on the growth rate of basic telecommunications infrastructure involves rent seeking. In countries with more easily manipulated political regimes, the attainment of substantial economic returns depends more heavily on political activities. The assignment of licenses for monopolies over new technology, quotas for imports of certain products, and lucrative contracts from the public sector typically involve both political and economic logic. As the role of politics in these assignments increases, substantial financial and managerial resources are diverted from economic activity to political rent seeking.<sup>6</sup> This shift in resource allocation implies lower investment in tangible economic infrastructure and greater investment in gray- and black-market activity.

**2.2.3 SUMMARY.** Essentially, we are adding the political environment to the list of determinants of the long-run steady-state level of penetration of basic telecommunications infrastructure. If the political environment in a country changes in a way that increases the steady-state level of penetration for that country, the growth rate of penetration increases for the duration of a long transition interval, *ceteris paribus*.

# 2.3 PUBLIC-SECTOR ORGANIZATION

In the case of private providers of infrastructure services, the commitment problem described above is usually conceptualized and modeled as a principal-agent problem between a government desiring reelection and a profit-maximizing firm. Despite the fact that the incentives and constraints faced by a state-employed manager differ somewhat from those faced by his or her private-sector counterpart, we argue that this basic result for private-sector investment can be generalized

<sup>6.</sup> See Krueger (1974) and Shleifer and Vishny (1994).

to the more common traditional mode of provision of telecommunication services: state-owned enterprises.<sup>7</sup> In the remainder of this section, we present arguments drawn from the theoretical literature on public-sector organization that elucidate the parallels between the private- and public-sector cases and thereby support our claim of generality.

**2.3.1** HOLD-UP. The analysis of the hold-up problem for public sector managers necessarily derives from a specific model of managerial behavior. The public telecommunications firm manager (like his or her private-sector counterpart) is an agent in a game where a government is the principal. Public-sector managers also engage in subgoal pursuit, in particular, the maximization of discretionary income. To be sure, both private- and public-sector managers face mechanisms that limit the extent to which they can pursue their subgoals at the expense of their respective principals. However, in both cases, these mechanisms are imperfect and leave managers with substantial latitude to pursue subgoals.

The significance of this latitude in the current context is the relatively large range of capital allocations from which the public-sector manager may choose without eliciting a strong disciplinary response from his or her political principals. The public-sector manager exploits the size of this range in maximizing the present value of his or her stream of discretionary income. Thus, unless the government is controlled by an "omniscient, omnipotent, and benevolent dictator" (Dixit, 1996), it must still provide incentives to the public-sector telecommunications firm manager to arrive at the level of investment that it desires.

Compare the capital allocation decision of a manager in a stateowned telecommunications firm in a strong institutional environment (i.e., one in which credible commitments by the government to a given price and regulatory structure can be secured) with that in a weak institutional environment. Assume that the relationship between the current cost of construction and expected future demand under the existing price and regulatory environment is such that choosing to invest in new infrastructure provides a stream of income with a positive net present value to the manager of the telecommunications firm. Given the informational advantage of the manager over the finance minister and the regulatory authority and the imperfect monitoring and enforcement of agency problems, this stream of income can provide substantial future discretionary income to the manager. If the

 $<sup>7.\ 748</sup>$  of 819 country-years in our sample are characterized by this form of ownership.

government cannot alter the existing price and regulatory environment (an extreme assumption made for expository purposes), the manager chooses to invest in new infrastructure.

In contrast, if the government can easily change the price and regulatory environment in the future, the telecommunications manager realizes that he or she will repeatedly have to make a case for a given price and regulatory structure and also defend the telecommunications firm's budget. Capital already sunk in the ground provides a poor basis on which to lobby political actors, because the government maximizes its political benefits from enhanced infrastructure capacity and telephone service by lowering service prices once lines have been deployed. The anticipated future stream of discretionary income available from capacity expansion is therefore smaller than what might be attained in the presence of a credible commitment. Recognizing the government's incentives and inability to commit to prices that cover his or her opportunity cost of infrastructure deployment, the publicsector manager faces a reduced incentive to allocate current budget to infrastructure deployment. As a result, the manager finds it more attractive at the margin to spend the current budget on consumption of discretionary items in the current period.<sup>8</sup> Conversely, when commitments are more credible, the public-sector manager views the trade-off as more favorable to infrastructure deployment.

**2.3.2 RENT SEEKING.** Public-sector managers, like private-sector managers, are also likely to exhibit rent-seeking behavior. The objective of such behavior by public-sector managers is the attainment of political influence, stature, and external economic rewards available from manipulation of the political system. The weight placed on such nonpecuniary rewards produces a real diversion of resources away from the provision of telecommunications services, and thus lowers infrastructure deployment. This tendency is likely to be more pronounced in countries with more easily manipulated political regimes, where rent-seeking behavior in general is more prevalent.<sup>9</sup>

8. Savedoff and Spiller (1999) suggest that, in weak institutional environments, one likely alternative to expenditure on infrastructure deployment is the hiring of additional workers. While the firm receives no economic benefit from such a strategy, a large payroll may serve as a hostage against future government expropriation, especially in the case of a state-owned enterprise. Budget cuts that threaten employment are politically more costly to the government. Workers can thus provide additional perquisites for public-sector managers both in the present and in the future.

9. Whether the severity of the agency problem—and thus the relative magnitude of the holdup hazards and consequent effects of the institutional environment on telecommunications investment—is more or less pronounced in the public sector than in the private sector is an issue requiring a more microanalytic treatment that we leave for future research. Here we simply seek to point out the parallels.

# 2.4 HYPOTHESES

The literatures on catch-up, institutional commitment, and publicsector organization provide important insights into the likely pattern of growth of infrastructure penetration across countries. Taken alone, the catch-up literature suggests that we should observe higher rates of infrastructure growth in countries that are relative laggards, *ceteris paribus*.

*H1:* Conditional on characteristics of costs and demand, and under the assumption of diminishing returns to capital, countries with lower initial levels of infrastructure penetration should experience more rapid penetration growth, *ceteris paribus*.

The literature on institutions and commitment, however, suggests that the investment needed by laggard countries to catch up—which is largely nonredeployable—is more likely to occur in the presence of an institutional environment that provides credible safeguards against arbitrary or capricious changes in the policy or regulatory environment. Furthermore, institutional environments that are unable to provide such commitments promote increased rent-seeking behavior, which creates an additional channel through which political institutions can affect the growth of infrastructure. The literature on publicsector organization suggests that these effects should occur in public- as well as private-sector organizations.

*H2*: The rate at which infrastructure penetration grows is positively related to limits on the feasibility of policy change (constraints on political discretion), *ceteris paribus*.

# 3. KEY VARIABLES

In accordance with the theory summarized in the previous section, the key variables in our analysis measure a country's level of penetration of basic telecommunications infrastructure, the growth rate of this penetration level, and the level of constraints on executive discretion. Data on the former were acquired from International Telecommunications Union (1997), and on the latter from Henisz (2000). We summarize the key variables in turn.

# 3.1 TELECOMMUNICATIONS INFRASTRUCTURE

Following standard practice, we measure infrastructure penetration (LINESPC) as the number of main lines per 10,000 inhabitants. A main line is defined as "a telephone line connecting the subscriber's terminal equipment to the switched public network and which has a

dedicated port in the telephone exchange equipment" (International Telecommunication Union, 1997, p. 9). The ITU has compiled data on main lines as part of its World Telecommunications Indicators database. The database is derived from various other compiled sources, and in its entirety covers up to 167 different countries during the period 1960–1995.

### 3.2 POLITICAL CONSTRAINTS

The measure of political constraints (POLCON) comes from Henisz (2000) and reflects the extent to which the structure of a nation's political institutions and the preferences of the actors that inhabit them constrain any one political actor from effecting a change in government policy. Unlike commonly used measures of the political system, this measure was constructed to address the specific issue of concern to investors: the credibility of the policy regime. It has a number of advantages over several more commonly used measures. For example, consider indexes measuring the degree of democracy vs. autocracy. De jure democracies with ineffective de facto checks and balances or homogeneity of party preferences (e.g., post-reform Russia or pre-1998 Mexico) do not necessarily provide stronger assurances to investors than do certain business-oriented autocracies with high policy stability (e.g., Singapore). For another example, consider measures of executive turnover. Investors may far prefer environments where the party or politicians in power change with great frequency but whose *policies* are relatively stable due to an effective system of checks and balances (e.g., Italy) to countries in which the politicians or parties in power are highly stable but safeguards against policy change are absent (e.g., Zaire under Mobutu).

The measure adopted here also offers several advances upon recent work that employs subjective risk ratings based on managerial surveys. While these indexes are targeted at the question of interest to investors, they are only indirectly linked to the structure of a country's political institutions. Demonstrating that investor perception of political risk is correlated with investment behavior does not permit one to unpack which political institutions matter or to assess how institutions affect both investor perceptions and investment. Furthermore, as these indexes are available for only the past 15–20 years, they either require the use of limited panel datasets or, if indexes for later periods are used to predict prior investment (under the assumption that these indexes vary little over time), introduce endogeneity problems into the analysis.

The derivation of POLCON draws from the spatial modeling techniques of positive political theory to quantify the extent of the limitations imposed by the structure of a nation's political institutions and the preferences of the actors that inhabit them on the feasibility of policy change. In order to construct a measure that is comparable over a wide sample of countries and time periods, it is necessary to reduce the nature of the relevant political differences to a few analytically tractable dimensions. While not disavowing the importance of agenda-setting powers, decision costs, and relative political authority, the measure emphasizes the importance of the number of government branches with veto power over policy change (executive, lower and upper legislative chambers, judiciary, and subfederal institutions) and the distribution of party preferences across and within these branches.

The main results of the derivation (available in Henisz, 2000) are that (1) each additional veto point (branch of government that is both constitutionally effective and controlled by a party different from other branches) provides a positive but diminishing effect on the total level of constraints on policy change and (2) homogeneity (heterogeneity) of party preferences within an opposed (aligned) branch of government is positively correlated with constraints on policy change.<sup>10</sup>

The measure is computed annually and covers up to 157 countries during the period 1960–1998. Table I reports the average values of POLCON computed using this method for the 55 countries in our study for the period 1975–1994.<sup>11</sup>

### 4. EMPIRICAL ANALYSIS

The dataset excluding missing data contains 819 observations from 55 countries over 20 years.<sup>12</sup> Summary statistics for included (as well as excluded) country-years and a correlation matrix for variables included in the econometric analysis are provided in Appendix I.

### 4.1 CORE SPECIFICATION

The core specification for our econometric analysis follows from the theory discussion in Section 2. We also estimate several variants of this core specification, which we discuss in Section 4.2.

<sup>10.</sup> These results echo those produced in similar work by Tsebelis (1995) and Butler and Hammond (1997).

<sup>11.</sup> The dataset itself is available for downloading from http://www-management. wharton.upenn.edu/henisz/.

<sup>12.</sup> In addition to excluding individual observations with missing data, we exclude all of the observations for any country with fewer than five valid observations.

Country Name	POCLON	Country Name	POLCON	Country Name	POLCON
Algeria	.00	Honduras	.19	Oman	.00
Australia	.86	Hungary	.22	Panama	.00
Austria	.77	India	.45	Paraguay	.07
Botswana	.70	Indonesia	.00	Philippines	.21
Brazil	.76	Iran	.00	Senegal	.00
Bulgaria	.18	Jamaica	.29	South Africa	.27
Cameroon	.04	Japan	.80	Spain	.77
Chile	.20	Kenya	.04	Sri Lanka	.28
China, PR	.00	Korea	.15	Syria	.00
Colombia	.42	Kuwait	.00	Thailand	.47
Congo	.06	Malawi	.00	Togo	.00
Costa Rica	.73	Malaysia	.76	Trinidad & Tobago	.80
Cyprus	.30	Mauritius	.39	Tunisia	.00
Ecuador	.57	Mexico	.20	Turkey	.30
Egypt	.00	Morocco	.02	US	.86
El Salvador	.29	Netherlands	.80	Uruguay	.24
France	.79	New Zealand	.73	Venezuela	.77
Guatemala	.15	Norway	.76	Zambia	.00
		2		Zimbabwe	.04

TABLE I. AVERAGE VALUES OF POLCON FOR 55 COUNTRIES FOR 1975-1994

The core specification is

 $\Delta \text{LINESPEC}_{\ell} = \beta_0 + \beta_1 \ln \text{LINESPC}_{\ell-1} + \beta_2 \text{POLCON}_{\ell-1}$  $+ \beta_3 / \text{POLCON}_{\ell-1} \times \ln \text{LINESPC}_{\ell-1} /$  $+ \beta_4 \ln \text{INVESTPC}_{\ell-1} + \beta_5 \ln \text{RGDPPC}_{\ell-1}$  $+ \beta_6 \Delta \text{RGDPPC}_{\ell-1} + \text{COUNTRYDUM8}'$  $+ \text{YEARDUMy}' + \epsilon_{\ell}.$ 

For the sake of clarity, we include time subscripts but suppress the cross-sectional subscripts in this equation. We use the notation  $\Delta \mathcal{X}_{\ell}$  to represent the percentage growth in variable  $\mathcal{X}$  between time  $\ell$  and time  $\ell$  – 1, and the notation ln  $\mathcal{X}$  to represent the natural logarithm of  $\mathcal{X}$ . The right-hand side (RHS) variables in the core specification are all lagged one period to reflect the fact that changes in infrastructure penetration are expected to show up at least one year after deployment decisions based on the RHS-variable values are taken.<sup>13</sup>

<sup>13.</sup> As discussed below, the results are robust to the use of five-year moving averages.

We specify the left-hand side of the equation as the percentage change in the number of lines per 10,000 inhabitants between the end of the previous period and the end of the current period / $\Delta$ LINESPC,/. The existing level of infrastructure penetration, measured as the natural logarithm of lines per 10,000 inhabitants at the end of the previous period (ln LINESPC,\_\_1), appears on the RHS both alone and as part of a multiplicative interaction term. The coefficient in the former case measures the extent to which the existing level of infrastructure penetration affects penetration growth conditional on all of the other RHS variables (with the exception of POLCON,\_\_1). This coefficient represents the conditional catch-up effect, which we expect to be negative in sign (i.e., laggard countries experience higher growth, *ceteris paribus*).

The next variable appearing on the RHS is the political constraints index (POLCON<sub> $\ell-1$ </sub>). According to H2, stronger political constraints should be associated with more rapid rates of penetration growth. We therefore expect the coefficient on political constraints to be positive in sign. H1 and H2 together also suggest that the presence of strong political constraints may improve the ability of a laggard country to catch up. We thus include an interaction term in which the existing level of infrastructure penetration (ln LINESPC<sub> $\ell-1$ </sub>) is multiplied by the level of political constraints (POLCON<sub> $\ell-1$ </sub>). The interaction term allows for the possibility that in the presence of strong political constraints (high POLCON<sub> $\ell-1$ </sub>), a low penetration level (a small value of ln LINESPC<sub> $\ell-1$ </sub>) has a larger effect on penetration growth ( $\Delta$ LINESPC<sub> $\ell$ </sub>) than it does when political constraints are weak (low POLCON<sub> $\ell-1$ </sub>). Accordingly, we expect the estimated coefficient on the interaction term to be negative in sign.

The next variable included on the RHS of the core specification represents the telecommunication firm's investment budget and is measured as the natural logarithm of the real annual gross US dollar investment in telecommunications per 10,000 inhabitants (In INVESTPC<sub>*i*-1</sub>). It is important to recall that, in the vast majority of cases in our sample, the investment budget is not under the control of the managers of the telecommunications firms who make infrastructure deployment decisions, but instead represents a budget constraint set by the minister of finance, as discussed in Section 2.3. As the investment budget increases, we expect to observe higher growth rates of telecommunications infrastructure.

The core specification also includes RHS variables to measure (potential) demand. Consistent with the growth framework, the first of these is the natural logarithm of the level of real GDP per capita ( $\ln \text{RGDPPC}_{r-1}$ ). As discussed in Section 2.1, when the level of demand in a country increases, so too does the long-run steady-state level of

infrastructure penetration for that country. Consequently, the growth rate of penetration increases during a lengthy transition interval until the new steady-state level is attained. The growth rate of infrastructure penetration should therefore be positively related to the level of real GDP per capita.

The percentage change in real GDP per capita also appears as an independent variable ( $\Delta$ RGDPPC<sub>*i*-1</sub>). We want to control for demand as thoroughly as possible in order to ensure that the coefficients on the variables that are of central interest to us are not measuring omitted determinants of demand or, more precisely, expected demand. If demand is growing quickly, the level of real GDP per capita provides less information about the level of expected demand, because the level to which national income is converging is distant from the current level of income. That is, economies with high income levels and low income growth may have levels of expected future demand for telecommunication services that are similar to those of economies with lower current income levels but more rapid growth. The core specification allows for these two cases to be treated equivalently, whereas a specification that omits the income growth variable would be unduly restrictive.

The RHS also includes a vector of country dummy variables. Even with the GDP variables included on the RHS of the core specification, there may still be other omitted determinants of infrastructure penetration growth, such as colonial legacies; sociocultural divisions; the sectoral composition of output as determined by natural resource endowments; and deployment costs, which may differ based on geography, wages, and the real cost of equipment. Additionally, because we want to make sure that we have controlled for demand as thoroughly as is feasible, we employ variable rotation using a number of other possible determinants of demand, as described in our discussion of the estimation results in Section 4.2 below. Finally, we include a vector of year dummies in order to capture samplewide temporal effects such as technological innovation and increased globalization.

# 4.2 METHODS

We estimate the coefficients in the model using OLS. However, because our dataset is a panel, the error term exhibits within-group serial correlation and heteroskedasticity. We therefore estimate the standard errors using a robust covariance-matrix estimator based on that developed by Newey and West (Newey and West, 1987; Greene, 1997, pp. 503–506). This estimator is consistent in the presence of withinunit serial correlation up to a specified lag and heteroskedasticity of unknown form. It differs from the original Newey-West version in that it is constructed for use in a panel setting rather than a conventional time-series setting.<sup>14</sup> The lag window used to calculate the standard errors reported below is 5 years. The results are also robust to lag windows of 2 years and 10 years.

In addition to estimating the core specification described above, we estimate several variants of the core specification in order to assess the robustness of our results. The first of these specifications uses a five-year moving average of POLCON (from year  $\ell - 6$  to year  $\ell - 1$ ) rather than the annual point estimate for the previous year. Three additional variants retain the one-period lag structure but include other potential determinants of expected demand on the RHS of the equation. Additionally, we reestimate the core specification for different subsamples that exclude outliers, OECD countries, and countries with significant private-sector participation in telecommunications. We comment on each of these variants in our discussion of the estimation results in Section 4.3 below.

### 4.3 RESULTS

Column 1 of Table II reports the results from estimating the core specification. All of the RHS variables other than that for existing infrastructure penetration (ln LINESPC<sub>*i*-1</sub>) have individual p-values of 0.05 or less (the p-value for existing infrastructure penetration is 0.06). Joint tests of the country dummies and the time dummies against the relevant null hypotheses reject the null at a p-value of 0.01, and a joint

14. The conventional Newey-West covariance-matrix estimator is

$$\widehat{\mathbf{V}} = \mathscr{T} \mathbf{X}' \mathbf{X} / \mathbf{S} / \mathbf{X}' \mathbf{X} / \mathbf{S}^{-1},$$

where

$$\mathbf{S} = \mathcal{T}^{1}\left(\sum_{\ell=1}^{\mathcal{J}} e_{\ell}^{2} \mathbf{x}_{\ell} \mathbf{x}_{\ell}' + \sum_{\ell=1}^{\mathcal{J}} \frac{\ell}{\mathcal{J}} + 1 \sum_{\ell=\ell+1}^{\mathcal{J}} e_{\ell} e_{\ell-\ell} (\mathbf{x}_{\ell} \mathbf{x}_{\ell-\ell}' + \mathbf{x}_{\ell-\ell} \mathbf{x}_{\ell}')\right)$$

and X is the regressor matrix,  $\mathbf{x}_{t}$  is a vector representing row t of the regressor matrix,  $\mathcal{T}$  is the number of time-series observations,  $\mathcal{R}$  is the number of regressors,  $e_i$  is a consistent estimator of the disturbances, and  $\mathcal L$  is the lag truncation (i.e., the maximum order of autocorrelation to which the estimator is robust). The panel version is a straightforward extension of the conventional time-series version. Under the assumption that the  $\mathcal{N}$  cross-sectional units are independent,  $S_{\alpha}$  is constructed for each unit n, and the resulting  $\mathcal{N}$  values are then averaged to obtain a consistent estimator of S. See Driscoll and Kraay (1998) and Froot (1989). (Thanks are due to Aart Kraay for sharing his insights on this topic.) Compared with the alternative procedure of estimating one or more AR(n) terms, the use of the robust covariance-matrix estimator has two major advantages. First, it is computationally simpler, as it easily accommodates autocorrelation that is of higher order than one. Second, the robust covariance-matrix estimator does not rely on an assumption that the different cross-sectional units share a common autocorrelation parameter. Failure to make this assumption in the estimation of AR(n) models creates a need to estimate many additional parameters, which reduces the efficiency of the point estimator.

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TABLE	

**ESTIMATION RESULTS** 

Variable	(1)	(2)	(3)	(4)	(2)	(9)	(2)	(8)	(6)	(10)	(11)	(12)
Q	- 0.73	- 0 <b>.</b> 89	- 0 <b>.</b> 73	- 0 <b>.</b> 79	- 0 <b>.</b> 79	- 0 <b>.</b> 72	- 0 <b>.</b> 71	-0.32	- 0.40	- 0 <b>.</b> 83	- 0.82	- 0 <b>-</b> 52
	0.04	0.02	0.04	0.03	0.03	0.05	0.05	0.19	0.18	0.03	0.02	0.12
Existing penentration level,	- 0.05	-0 <b>.</b> 04	- 0 <b>.</b> 05	-0 <b>.</b> 04	-0.04	- 0 <b>.</b> 05	- 0 <b>.</b> 05	- 0 <b>.</b> 06	- 0 <b>.</b> 08	- 0 <b>.</b> 05	- 0.05	- 0 <b>.</b> 12
In LINESPC,1	0.06	0.23	0.11	0.09	0.12	<i>0.05</i>	0.05	0.00	0.00	<i>0.06</i>	0.09	0.00
Political constraints,	0.42	0.00	0.42	0.41	0.00	0.46	0.38	0.33	0.32	0.46	0.46	0.29
POLCON <sub>6-1</sub>	0.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.05
Existing penetration level	- 0.06	-0.10	- 0 <b>.</b> 06	-0 <b>.</b> 06	- 0 <b>.</b> 06	- 0 <b>.</b> 07	- 0 <b>.</b> 06	-0.05	- 0.05	- 0 <b>.</b> 07	- 0 <b>.</b> 07	- 0.05
× political constraints	0.01	0.01	0.02	0.02	0.01	0.01	0.02	0.03	0.03	0.01	0.00	0.07
Real telecommunications investment, In INVESTPC <sub>6-1</sub>	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.03
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Log real per capita GDP,	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.06	0.08	0.10	0.10	0.15
In RGDPPC, 1	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.06	0.04	0.01	0.01	0.00
Growth in real GDP:	0.11	0.11	0.11	0.11	0.12	0.15	0.10	0.11	0.11	0.15	0.13	$0.04 \\ 0.41$
% change in RGDPPC,1	0.03	0.02	0.03	0.04	0.02	0.01	0.05	0.04	0.06	0.01	0.02	
Rotated variables: Urban population (%)			0.05 0.76									
Log rural pop. density				0 <b>.</b> 03 0.36								
V.A. in services (%)					0.11 0.36							

Variable with outliers removed:												
Existing penetration level						×						
Political constraints							×					
Real telecom. inv.								×				
Log real per capita GDP Growth in real GDP									×	×		
Notes <sup>b</sup>		(i)									(ii)	(iii)
Time dummies	×	×	×	×	×	×	×	×	×	×	×	×
Country dummies	×	×	×	×	×	×	×	×	×	×	×	×
N	819	746	819	819	789	757	757	760	688	796	748	645
Adjusted $\mathscr{R}$	0.33	0.35	0.33	0.33	0.33	0.34	0.31	0.32	0.29	0.35	0.34	0.33
Log likelihood	1155	1058	1155	1155	1111	1067	1052	1108	096	1137	1057	872
<sup>a</sup> Dependent variable is growth in infr reported.	rastructure pen	etration. Va	lues listed	ure coefficie	nt estimate	s with p-val	lues in italic	s. Coefficie	nts for cou	ntry and ye	ar dumnies	are not

(III) Sample andurpe Ē ÷ 2 0 Ē erage 2 E E -year i ve naggen ŝ "(1) Political constraint index calcurestricted to non-OECD countries. test of all of the RHS variables against the null rejects the null at a p-value of 0.01. The adjusted  $\mathscr{R}$  figure is 0.33.

Of central interest are the coefficients on the existing penetrationlevel variable by itself (ln LINESPC<sub> $\ell-1$ </sub>), the political-constraints variable by itself (POLCON<sub> $\ell-1$ </sub>), and the interaction term (POLCON<sub> $\ell-1$ </sub> × ln LINESPC<sub> $\ell-1$ </sub>). The negative coefficient estimate on the first of these terms implies that H1 does have some purchase, i.e., that there is a systematic negative association between existing penetration level and penetration growth rate, even when political constraints are the weakest possible according to the POLCON measure (i.e., POLCON = 0). However, the negative coefficient estimate on the interaction term implies that this catch-up effect is larger when political constraints are stronger and, together with the positive coefficient estimate on the political constraints variable (POLCON<sub> $\ell-1$ </sub>), provides support for H2.

A more formal test of the two hypotheses comes from examining the total slopes (Table III) with respect to existing penetration level and political constraints while holding the other variable constant at its minimum, mean, maximum and mean plus and minus one standard deviation.<sup>15</sup> Consistent with H1, the slope with respect to the existing infrastructure penetration level is everywhere negative. The associated p-value is 0.06 when the political constraints variable (POLCON) is at its minimum, and 0.00 at the other levels of existing infrastructure penetration for which the total slope coefficients are reported. The slope coefficients range in magnitude for - 0.05 to - 0.10. The coefficient of - 0.07 at the mean value of political constraints implies that a country with an average level of political constraints and an existing penetration level one standard deviation below the sample mean penetration level (77 lines per 10,000 population) would exhibit infrastructure growth 11 percentage points greater than an otherwise identical country with an existing penetration level equal to the sample mean penetration level (365 main lines per 10,000 population).<sup>16</sup>

Consistent with H2, penetration growth has a stronger negative association with the existing infrastructure penetration levels for countries that provide stronger constraints on political discretion. Specifically, the absolute magnitude of the slope with respect to existing penetration level nearly doubles when the political-constraints measure is one standard deviation above its mean, relative to when it is

<sup>15.</sup> The total slope with respect to  $\ln \text{LINESPC}_{\ell-1}$  is  $\beta_1 + \beta_3 \text{POLCON}_{\ell-1}$ . The total slope with respect to  $\text{POLCON}_{\ell-1}$  is  $\beta_2 + \beta_3 \ln \text{LINESPC}_{\ell-1}$ .

<sup>16.</sup> The slope coefficient (-0.07) multiplied by a one-standard-deviation reduction in existing penetration levels (-1.56) yields a predicted increase in the dependent variable (growth in lines per 10,000 population) of 10.9 percentage points.

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# ESTIMATED SLOPE COEFFICIENTS WITH RESPECT TO EXISTING PENETRATION LEVEL AND POLCON<sup>a</sup>

								)	-			
Statistic	(1)	(2)	(3)	(4)	(5)	(9)	(7)	(8)	(6)	(10)	(11)	(12)
		Slo	pe with r	espect to	Existing	penetrati	on level					
POLCON( - 1):	- 0.05	- 0 <b>.</b> 04	- 0.05	- 0.04	- 0.04	- 0 <b>.</b> 05	- 0 <b>.</b> 05	- 0.06	- 0 <b>.</b> 08	- 0.05	- 0.05	- 0.12
Minimum & mean - 1 s.d.	0.06	0.23	0.11	0.09	0.12	0.05	<i>0.05</i>	0.00	0.00	0.06	0.09	0.00
Mean	- 0 <b>.</b> 07	- 0 <b>.</b> 07	- 0 <b>.</b> 07	- 0.06	-0.06	- 0 <b>.</b> 07	- 0 <b>.</b> 07	- 0.08	- 0.00	- 0.07	- 0 <b>.</b> 07	- 0.13
	0.00	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mean + 1 s.d.	- 0 <b>.</b> 09	- 0 <b>.</b> 10	- 0 <b>.</b> 10	- 0 <b>.</b> 09	- 0 <b>.</b> 08	-0 <b>.</b> 10	- 0.00	- 0 <b>.</b> 10	- 0 <b>.</b> 11	- 0.09	- 0 <b>.</b> 09	- 0 <b>.</b> 15
	- 0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	- 0 <b>.</b> 10	- 0 <b>.</b> 12	- 0 <b>.</b> 11	- 0 <b>.</b> 10	- 0 <b>.</b> 09	-0 <b>.</b> 11	- 0 <b>.</b> 10	- 0 <b>.</b> 11	- 0 <b>.</b> 12	- 0 <b>.</b> 11	- 0 <b>.</b> 11	- 0 <b>.</b> 16
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-			Slop	e with re	spect to I	OLCON						
Existing penetration level:	+ 0.25	+ 0.39	+ 0.24	+ 0.24	+ 0.24	+ 0.27	+ 0-22	+ 0.20	$^{+}$ 0.19	+ 0.27	+ 0.26	+ 0.16
Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.04
Mean - 1 s.d.	+ 0.14 0.00	+ 0 <b>.</b> 24 0.00	+ 0.14 0.00	$^{+}$ 0.14 $0.00$	+ 0.13 0.00	+ 0 <b>.</b> 14 0.00	+ 0.13 0.00	+ 0.12 0.00	+ 0.10 0.00	+ 0.15 0.00	+ 0.15 0.00	+ 0.09 0.04
Mean	+ 0 <b>.</b> 04	+ 0 <b>.</b> 09	+ 0 <b>.</b> 04	+ 0 <b>.</b> 05	+ 0 <b>.</b> 04	+ 0 <b>.</b> 04	+ 0.05	+ 0.05	+ 0.04	+ 0.05	+ 0 <b>.</b> 04	+ 0 <b>.</b> 04
	0.11	0.07	0.12	<i>0.08</i>	0.15	0.10	0.05	0.06	0.07	0.08	0.12	0.14
Mean + 1 s.d.	-0.06	- 0 <b>.</b> 06	- 0 <b>.</b> 06	- 0.05	-0 <b>.</b> 06	-0 <b>.</b> 05	-0 <b>.</b> 04	- 0 <b>.</b> 02	- 0 <b>.</b> 02	- 0 <b>.</b> 06	- 0 <b>.</b> 07	- 0 <b>.</b> 02
	0.30	0.51	0.31	0.37	0.20	0.29	0.42	0.55	0.64	0.31	0.08	<i>0.55</i>
Maximum	-0.13 0.11	- 0 <b>.</b> 17 0.22	-0.12 0.13	- 0.11 0.15	-0 <b>.</b> 13 0.07	-0.13 0.09	-0.11 0.14	-0.08 0.21	- 0 <b>.</b> 07 0.25	- 0 <b>.</b> 13 0.11	- 0.15 0.01	- 0.10 $0.17$

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one standard deviation below its mean. That is, a laggard country with an existing penetration level one standard deviation below the sample mean but political constraints one standard deviation above the mean exhibits penetration growth that is close to twice as fast—14%—as the 8% growth rate exhibited by a laggard country that is identical in all other respects except that its political-constraints level is one standard deviation below the sample mean.<sup>17</sup>

Also consistent with H2 are the positive and statistically significant slope estimates with respect to political constraints for countries with existing infrastructure penetration levels at or below the mean. A country with an existing penetration level one standard deviation below the mean level, for example, could expect to increase infrastructure growth by 5 percentage points by increasing its level of political constraints by one standard deviation.<sup>18</sup> Countries with existing penetration levels above the mean are found to have statistically insignificant slopes with respect to political constraints. We are exploring the foundations for this result in subsequent research by paying special attention to other factors such as the strength of interest-group competition that may moderate the impact of political hazards in these countries (Zelner and Henisz, 2000).<sup>19</sup>

In more concrete terms, our results suggest that national telecommunications firms that face both relatively low penetration rates and low levels of political constraints, such as those in Ghana, Malawi, and Nigeria (as of 1994), are unlikely to exhibit high penetration growth rates in the near future. In contrast, firms in countries such as Slovenia and Mauritius previously had relatively low penetration rates and faced weak political constraints, but improvements in political regimes led to a 200% and 100% increase in the average annual growth rates of telecommunications penetration (from 0.5% to 1.5% in the case of Slovenia and from 1.5% to 3.9% in the case of Mauritius).

17. The slope coefficient for a country with political constraints one standard deviation below the mean (-0.05) multiplied by a one-standard-deviation reduction in existing penetration levels (-1.56) yields a predicted increase in the dependent variable (growth in lines per 10,000 population) of 7.8 percentage points. The same calculation for a country with political constraints one standard deviation above the mean (with an estimated slope coefficient of -0.09) yields a predicted increase in the dependent variable of 14.0 percentage points.

18. The slope coefficient with respect to political constraints for a country with existing penetration levels one standard deviation below the mean (0.14) implies that a one-standard-deviation increase in political constraints (0.34) would yield a predicted increase in the dependent variable equal to 4.8 percentage points.

19. As described below, the empirical results are robust to the exclusion of OECD countries (which account for the vast majority of cases with high existing infrastructure levels).

The results from the core specification are quite robust to a number of variations. In column (2) of Tables II and III, we employ a fiveyear moving average of political constraints rather than an annual value. While this reduces the sample size modestly (from 819 to 746), as not all countries have five years of political constraint data prior to the first year of observed infrastructure growth and economic data, the magnitude of the effect of political constraints increases dramatically. We prefer the core specification because it is less subject to the criticism that upward trends in political constraints are correlated with other, unobserved environmental variables that exaggerate the estimated effect of the political-constraints measure of central interest. The results presented in column (1) thus provide a conservative estimate of the effect of political constraints on infrastructure growth.

Despite the use of RHS variables measuring demand as well as country and temporal fixed effects, there may still be unobserved heterogeneity across observations in our sample to the extent that the structure of an individual economy varies across time in a way that influences infrastructure growth. We have addressed this potential concern to the extent possible in columns (3)–(5) by adding such demographic variables as the percentage of population in urban environments, rural population density, and value added in the services sector, all of which might vary within a country over time and consequently influence the demand for or cost of provision of telecommunications services. The failure of these variables to exhibit a statistically significant effect on telecommunications penetration growth provides added support for the validity of the core specification results reported in column (1).

We are also confident that influential data points for the variables included in the core specification are not unduly influencing the coefficient estimates reported in column (1). Columns (6)–(10) replicate the core specification estimated for samples in which observations containing independent variable values in the top or bottom 5% of the sample distribution of the relevant variable have been removed.<sup>20</sup>

As a final robustness check, we also estimate the core specification for specific subsamples. Column (11) reports the results for the subsample of country-years with public-sector provision of telecommunications services only. This subsample accounts for the majority of observations in the full sample, and the results are nearly identical to those reported in column (1). We do not report results for the sub-

20. Observations were excluded based on the distribution of the relevant independent variable in the full sample.

sample of country-years with significant private-sector participation in the provision of telecommunications services, because the number of observations in that subsample is so small.

Finally, because it is plausible that the nature of policymaking and demand for telecommunications services varies systematically between industrialized and developing countries, we also report results in column (12) for a subsample that excludes OECD countries. The results are qualitatively similar in this case to those reported in column (1), although the magnitude of the effect of political constraints is diminished.

### 5. CONCLUSION

Based on the insights of the catch-up literature, the literature on institutions and commitment, and the literature on public-sector organization, we have proposed that the ability of a laggard country to catch up with countries with more developed telecommunications infrastructure depends not only on economic characteristics but also on the ability of that laggard country's institutional environment to constrain arbitrary behavior on the part of government officials.

While the proposition that well-developed political systems that promote credible policy regimes are of primary importance in the process of economic development has become increasingly accepted by scholars in economics and business, no previous studies of which we are aware have attempted to quantify the effect of political institutions on infrastructure deployment. The telecommunications sector is ideally suited for studying this effect, due to the massive sunk investments required and the highly politicized nature of pricing deci-sions (Levy and Spiller, 1994). We also suggest, however, that similar effects can be expected to obtain in other sectors where data limitations make cross-national comparisons more difficult. Of course, the effect of political constraints on investment may be moderated by a number of factors. These include components of the policymaking process omitted from our analysis, such as agenda-setting power or appointment processes; firm-level characteristics, including political and regulatory experience; and the availability of technological alternatives that lessen the hold-up problem. We hope to build upon the current analysis to encompass these and other moderating effects in the telecommunications and other sectors of the economy.

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	Growth in Lines per 10,000 Pop.	Lines per 10,000 Pop.	Political Constraint Index	Real Telecom Investment	Real per Capita GDP	Real per Capita GDP Growth	Urban Pop. (%)	Log Rural Pop. Density	V.A. in Services
		I	ncluded in E $lpha$	pnometric Anal	ysis				
$\mathcal{N}$ Cross sections	819 55	819 55	819 55	819 55	819 55	819 55	819 55	819 55	789 54
Mean Median Maximum	0.08 0.05 0.70	5.90 5.86 8.66	0.36 0.34 0.88	11.27 11.15 14.97	7.48 7.27 10.31	0.02 0.20 220 220	0.53 0.51 0.93	5.36 5.26 9.65	0.51 0.50 0.73
Standard deviation	- 0.08 0.08	1.56	0.34	0.09 1.66	4.02 1.31	- 0.24 0.05	0.20	1.24 1.24	0.11
			All Ava	ilable Data					
J	2320	2486	2962	1527	2412	2281	2940	2586	2071
Cross sections	146	147	147	143	131	141	147	145	127
Mean	0.06	5.15 E 26	0.24	11.33	7.31	0.01	0.48	5.40 E 41	0.46
Maximum	0.0 <del>4</del> 1.05	90 8.8	0.00	15.20	7.00 10.33	0.91	0.40 1.00	9.70	0.40
Minimum	- 0.34	0.00	0.00	1.08	4.35	- 0.62	0.03	0.00	0.10
Standard deviation	0.09	2.30	0.33	1.92	1.47	0.07	0.24	1.22	0.12
Lines per 10.000 Pop.	- 0.14			CIM110/12					
Political Constraint Index	- 0.08	0.63							
Real Telecom. Investment	- 0.01	0.74	0.56						
Real per Capita GDP	-0.12	0.92	0.59	0.83	500				
Irban Pon. (%)	-0.15	0.02	0.50	- 0.0 1.68	0.01	- 0.07			
Rural Pop. density	0.20	- 0.39	- 0.30	- 0.28	- 0.29	0.09	- 0.46		
V.A. in Services	-0.16	0.64	0.44	0.55	0.59	- 0.08	0.53	- 0.43	

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