The Global Infrastructure Gap: Potential, Perils, and a Framework for Distinction

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Abstract

Poor countries lack infrastructure services: 1.2 billion people have no electricity, and 1 billion live more than 2 kilometers from an all-weather road. In 2015, the World Bank initiated a surge of interest in financing this need when it claimed that rich-country private capital could close the infrastructure services gap, make money, and achieve the sustainable development goals by moving from "billions to trillions" in infrastructure investment in poor countries. This paper assesses and challenges the prevailing gap thinking by introducing an equilibrium framework that distinguishes those poor countries in which the Bank's three-fold claim is tenable from those where it is not. The framework shows that additional investment in a poor country's infrastructure is efficient and financeable through private rich-country savings if and only if the return on poor-country infrastructure clears two hurdles: it must exceed both the return on poor-country private capital and the return on rich-country private capital. Applying the framework to the only existing, comprehensive cross-country estimates of the social rate of return on infrastructure reveals that just 7 of 53 poor countries clear the dual hurdles in both paved roads and electricity. Where it is efficient to invest, however, the potential for excess returns is large—seven times larger than the excess returns that existed in publicly traded emerging-market stocks when foreigners were first permitted to own shares. The dual-hurdle framework thus provides a template that can be used as new data become available, to prioritize poor-country infrastructure investments that have maximum potential to drive greater global growth, equity, and sustainability.

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1. Introduction

Since the mid-twentieth century, which saw the revolutionary expansion of and unprecedented economic gains brought by infrastructure investment during the Eisenhower Era, the United States and other advanced nations have repeatedly hung their hopes of future growth on domestic infrastructure projects. Following the 1990–91 recession, for example, American policymakers seized on Aschauer (1989) as justification for more infrastructure spending (U.S. Conference of Mayors 1992). But Munnell (1992) and others demonstrated that Aschauer's estimates of the infrastructure elasticity of output were implausibly large, with Fernald (1999) concluding that "the massive road-building of the 1950s and 1960s offered a one-time boost to the level of productivity, rather than a path to continuing rapid growth…". Even so, and despite Gramlich's (1994) observation that the surge of interest in infrastructure is "out of proportion to its likely long run importance," we have more recently experienced a déjà-vu moment at a time when talk of secular stagnation has ignited yet another debate over the merits of a big push (Eichengreen 2015; Gordon 2015; Summers 2015). The slow recovery after the Great Recession has clearly revived interest in the recurrent but empirically unsubstantiated notion that more infrastructure investment offers a route to faster sustained growth in advanced economies.

Although refurbishment of roads and other hardscape might have a short-run impact on U.S. GDP, if a plausible argument exists for more infrastructure spending as a means to significant output gains, the case hangs not on America or other rich countries, but on poor ones—the emerging and developing economies (EMDEs) in which: (1) Latin America has 1/4 the infrastructure capital per capita of North America; (2) Emerging and Developing Asia have less than 1/5 that of Advanced Asia; and (3) Africa's GDP growth might increase by 1.6

percentage points if its infrastructure capital per capita matched Chile's (IMF 2014; Calderón and Servén 2010).

Fundamental as it is to recognize that the potential gains from greater infrastructure investment in poor countries outstrip those in the rich world, it is equally important to acknowledge that, like the U.S., EMDEs are also susceptible to the perils of recurring fads (Estache and Fay 2007). Consider the widely cited "global infrastructure gap," defined as the trillion-dollar difference between the quantity of infrastructure investment scheduled to take place globally between 2015 and 2030 and the estimated amount needed to achieve the projected growth rate of global GDP over that time frame (McKinsey Global Institute 2016). Scarcity in EMDEs notwithstanding, the MGI definition minimizes the challenge of capitalizing on cross-country differences in infrastructure by not acknowledging that the discrepancy between scheduled and "needed" spending is an equilibrium outcome of the demand for infrastructure services, on the one hand, and, on the other, the willingness of savers and investors to supply infrastructure capital given the incentives they have to do so.

In failing to embrace the discipline of equilibrium, the notion of a "global infrastructure gap" bears a striking similarity to its intellectual antecedent—the "financing gap," which gave rise to the field of development economics (Domar 1946; Harrod 1939). Like the MGI conception, the Harrod-Domar Model asserts that a desired rate of growth requires a target level of investment. Given national savings (or scheduled investment in the case of MGI), target investment implies a financing gap equal to the difference between the two quantities. Armed with this framework, bilateral and multilateral donors from rich countries sought to help poor countries grow by filling the gap with aid. These donors failed, because they did not ask whether filling the gap with "needed" investment would actually correct a market failure, incentivize production, and endogenously raise incomes (Easterly 2001).[1]

Beyond the failure of the 1950s aid-driven growth agenda, Figure 1 provides a sobering reminder of the complex relationship between infrastructure and output in EMDEs. Growth of the public capital stock, a widely used proxy for infrastructure whose limitations are described in Fay, Lee, Mastruzzi, Han, and Cho (2019), increased from 4 percent per year in the 1960s to almost 7 percent per year by the mid-1970s. Productivity growth, in contrast, slowed precipitously and actually turned negative. Of course, we would not expect greater infrastructure spending to immediately increase productivity, public capital is an imperfect proxy for infrastructure capital, and exogenous shocks (e.g., 1979 Oil Crisis and 1980–82 Volker Recession) reduced output everywhere. Nevertheless, productivity did not begin rising in poor countries until the mid-1990s, a twenty-year lag that challenges even the most optimistic narrative about the delayed efficiency of increases in public capital.

There is an abundance of evidence, however, that the 1970s spike in poor-country expenditure on public capital precipitated the Third World Debt Crisis (Rogoff 1991). Given the recent onset of financial distress in countries that signed non-concessional infrastructure loan agreements under China's Belt and Road Initiative (Gallagher and Ray 2020; Reinhart 2020; Signé 2018), including defaults by Sri Lanka and Zambia, Figure 1 underscores the potential for another era of crises and wasted resources if decision-makers adhere to gap thinking. Defaults on BRI loans may have strategic value for China, but they are not consistent with the goal of Pareto-improving capital flows that are a pillar principle of the international financial system in the post–Bretton Woods Era.

[1]General aid does not lift growth; targeted aid improves health, water, and sanitation (Archibong, Annan, Ekhator-Mobayode 2020; Arslanalp and Henry 2004; Ndikumana and Pickbourn 2017; Ndikumana and Pickbourn 2018).

A naïve narrative about infrastructure gaps will likely result in an equally naïve allocation of resources into unproductive investments, but the fact remains that 1 billion people live more than two kilometers from an all-season road, and 1.2 billion have no electricity (Rozenberg and Fay 2019). Flooding EMDEs with grants or grids will not cure these shortfalls, but it also strains the imagination to maintain that a paucity of power and roads will yield GDP outcomes that capture the full production potential of poor nations.

This paper introduces a framework for distinguishing a feasible and efficient global allocation of infrastructure from the wasteful one that is likely to result from the status quo. The paper accomplishes this by turning from the exclusive focus on the demand for infrastructure services in poor countries championed by MGI to an equilibrium perspective that also incorporates the incentive that suppliers of capital have to finance the provision of those services, given the prospective return and risk on poor-country infrastructure. Because infrastructure is a public good, the social rate of return on infrastructure is the cornerstone of the analysis. Binding the analysis to this cornerstone requires a comparison of the social return on infrastructure in poor countries with two additional rates of return.

The first comparison for a given poor country is with its own rate of return on investment in private capital. When considering whether to direct a dollar of savings toward investment in infrastructure, or instead, allowing market forces to do the allocation, a welfare-maximizing government will invest the dollar in infrastructure only if the return to doing so—that is, the social return on infrastructure—exceeds the return on private capital. In effect, the poor country's return on private capital is a hurdle rate that its social return on infrastructure must clear to justify the diversion of savings from private to public investment.

The second comparison is less obvious, but equally important. By definition, the quantity of domestic savings in a poor country is small compared to that which the country's potential infrastructure projects could absorb. It is therefore relevant to ask whether the poor country could plausibly attract rich-country private savings to invest in its public capital. Given a dollar, a rich-country saver (or their asset manager) will allocate it to poor-country infrastructure only if the financial return from doing so exceeds that of investing it in rich-country private capital by a margin large enough to compensate for the risk of poor-country public capital. The return on rich-country private capital therefore constitutes a second hurdle rate for the poor country—one that its risk-adjusted social return on infrastructure must clear to attract rich-country savings.

Taking the dual-hurdle-rate framework to the data produces two revelations. First, despite serial campaigns emphasizing the importance of infrastructure for development, including a 2015 World Bank communiqué touting the opportunity for private capital to leverage multilateral resources and move the world from "billions to trillions" of investment in infrastructure to achieve the sustainable development goals (World Bank 1994, 2005, 2007, 2015), successive presidents and boards of the World Bank have failed to marshal the wealth of talent under their direction to produce a common and current repository of infrastructure return estimates that governments, savers, and investors can use to drive fact-based decisions about infrastructure investment in poor countries. The sole extant source of explicit, comprehensive cross-country estimates of the social return on infrastructure (roads and electricity) in poor countries is a paper commissioned by the Bank more than two decades ago that is based on 1985 data.[2] Second, contrary to the communiqué's message that poor countries contain an abundance of publicly efficient and privately profitable infrastructure investment opportunities, only 7 of 53 poor

[2]Infrastructure includes a wide range of physical structures that deliver services related to energy, health, schools, telecommunications, transportation, and water and sanitation. Data constraints focus our work on roads and electricity, but we discuss implications of our findings for investment in other types of infrastructure.

countries in the data set clear the dual hurdles in both roads and electricity. The reality that less than one in seven countries withstand the scrutiny of positive equilibrium analysis underscores the danger of allowing the normative infrastructure-gap narrative to proceed unchallenged.

For countries that clear the dual hurdles, on the other hand, the average return on infrastructure can be as large as 10.2 times greater than the return on private rich-country capital. It is useful to compare this infrastructure-excess return multiple with the excess-return multiple of a non-infrastructure class of poor-country assets, namely stock market shares, around the same time, and unrelated to the dual-hurdle test *per se*. Before restrictions on foreign purchase of domestic shares were liberalized in the late 1980s, the expected return on publicly traded stocks in poor countries was roughly 1.5 times greater than the expected return on the S&P 500 (Chari, Henry, and Reyes 2020). In other words, the excess-return multiple on poor-country infrastructure in 1985 was roughly seven-fold the excess-return multiple on portfolio equity in poor countries, which, once their stock markets were liberalized, presented an arbitrage opportunity large enough to fuel the rise of the emerging-market equity fund industry. Unlike the flood of savings that poured into emerging equity markets following liberalization, however, there are two reasons why significant quantities of private rich-country capital have not flowed to poor-country infrastructure.

First, the absence of tradable financial claims on infrastructure in the 1980s made it impractical to pursue private, rich-country financing of public, poor-country capital. Tradable contingent claims on poor-country infrastructure now exist, and the dual-hurdle analysis provides a framework for distinguishing those countries where the return differentials are large enough to incentivize the economically productive creation of further such claims, from those countries where they are not. Too much has happened since 1985 to draw any present-day conclusions on the basis of returns from that year, but the new analysis of old information in this paper: (a) provides a template to apply to updated, cross-country data on social rates of return; and (b) demonstrates the urgency of the World Bank generating, validating, and disseminating that information as soon as possible.

Second, to the extent that large return differentials remain today, they are a necessary but not sufficient condition for resource flows to occur. The key to sufficiency is appropriability. Foreigners must be able to appropriate a large enough share of the economic return on poor-country infrastructure—their private financial return—to induce them to undertake socially productive investments. Even when the economic return on infrastructure is high, uncertainty about appropriability may imply levels of risk that are simply too large to justify investment.

2. Private Versus Public Capital and the Dual Hurdle Framework

Panel A of Figure 2 presents a schematic illustration of the traditional approach to evaluating the efficiency of capital allocation across rich and poor countries: one type of non-differentiated capital, two rates of return (*r*-Rich and *r*-Poor), and an emphasis on the magnitude of *r*-Poor relative to *r*-Rich. Given that *r*-Poor is greater than *r*-Rich under standard neoclassical assumptions, a multitude of articles across the past three decades have focused on evaluating the four Lucas (1990) hypotheses—differences in human capital; human capital externalities; political risk; and restrictions on foreign investment—as a possible explanation for why capital does not flow from rich to poor countries to equalize incomes and rates of return.[3] Because evaluations of the Lucas hypotheses are predicated on a single type of capital, however, they are silent on the degree to which international disparities stem from an inefficient allocation of

[3] See Alfaro, Laura, Kalemli-Ozcan, and Vadym Volosovych (2008) and the references therein.

private versus public capital (e.g., infrastructure).

The private versus public distinction matters because recent work documents that: (a) the return on public capital varies much more than the return on private capital, and (b) the variation in public returns is greater in poor countries than in rich ones.[4] Furthermore, the variation in poor-country returns has been rising over time. Between 1990 and 2005 the standard deviation of the marginal product of all capital in poor countries remained roughly constant, even as the standard deviation of the marginal product of private capital fell. This fact implies that the standard deviation of the return on public capital in poor countries rose, both in absolute terms and relative to the standard deviation of the return on private capital. Accordingly, world GDP would be approximately 9 percent higher than its current level if the return on public capital were equalized across countries—a gain that is about 4.8 times as large as that which would accrue from equalizing cross-country differences in private returns (Lowe, Papageorgiou, and Perez-Sebastian 2018).

Because public returns vary more than private returns, with large attendant welfare implications, it is important that analyses of allocative efficiency distinguish explicitly between private and public capital. Accordingly, the schematic in Panel B of Figure 2 augments the traditional approach by treating private and public capital as separate stocks. The augmented treatment brings some complexity. In contrast to Panel A, Panel B contains four types of capital—Private-Poor, Public-Poor, Private-Rich, Public-Rich—and four rates of return: *r*-Private-Poor, *r*-Public-Poor, *r*-Private-Rich, and *r*-Public-Rich. With four rates of return and two countries, now instead of one return comparison required to assess allocative efficiency (*r*-Poor versus *r*-Rich), there are four choose two: (i) *r*-Private-Poor vs. *r*-Public-Poor; (ii) *r*-Private-Rich

[4] See Lowe, Papageorgiou, and Perez-Sebastian (2018)

vs. *r*-Public-Poor; (iii) *r*-Private-Rich vs. *r*-Public-Rich; (iv) *r*-Public-Poor vs. *r*-Public-Rich; (v) *r*-Private-Poor vs. *r*-Private-Rich; and (vi) *r*-Private-Poor vs. *r*-Public-Rich. In principle, all six country-sector-return comparisons have efficiency implications, but there are compelling reasons to focus on the first two, with the other four set aside through a practical process of elimination.

Comparison (i) is indispensable because any analysis of the efficiency of infrastructure investment in poor countries that does not ask whether the benefit to them of investing a dollar in public capital exceeds the benefit of investing it in private capital is destined to fail. Comparison (ii) is central to determining whether the World Bank's presumption that private savers in rich countries have an incentive to finance public capital in poor ones is an empirical reality or an article of faith. Comparison (iii) is known: *r*-Public-Rich is almost everywhere less than *r*-Private-Rich, which means that (ii) rather than (iv) is the binding consideration for rich-country savings to have an incentive to finance Public-Poor capital.[5] Comparison (v) is also known: *r*-Private-Poor largely converged to *r*-Private-Rich after restrictions on capital flows into poor countries were eased in the early 1990s (Henry 2007). Taken together, comparisons (iii) and (v) render (vi) a non-binding consideration.

2A. The Dual-Hurdle Framework

Acknowledging the importance of the distinction between private and public capital, let K denote the stock of private capital for a given poor country, and X the stock of public capital, which, for simplicity of theoretical exposition, we assume is the same as the stock of infrastructure.[6] Similarly, let K^* and X^* denote the stocks of private and infrastructure capital in

[5] Table 1 provides evidence that the return to private (i.e., business capital) is greater than the return on public capital in rich countries. See also, Caballero, Farhi, and Gourinchas (2017.)

[6] In practice, infrastructure is a subset of public capital. Our subsequent empirical analysis acknowledges the practical distinction.

the rich country. With these definitions in place, Figure 3 visually depicts a framework for evaluating, simultaneously, a poor country's potential for efficient investment in infrastructure and its ability to attract private foreign savings to finance it. Specifically, Figure 3 compares the country's social return on infrastructure (*r*-Public-Poor) with: (a) its own return on private capital (*r*-Private-Poor) and (b) the return on private rich country capital (*r*-Private-Rich).

For a given poor country, and category of infrastructure (e.g., paved roads or electricity generating capacity), the horizontal axis measures the ratio of *r*-Public-Poor to *r*-Private-Poor. Call this ratio the within-country ratio of the return on infrastructure, denote it $\rho_x^{WC} = \frac{r_x}{r_k}$, and consider the implications of ρ_x^{WC} for efficiency. If capital is allocated efficiently within the poor country, then the return on infrastructure will be the same as the return on private capital and $\rho_x^{WC} = 1$. If the country has too little infrastructure, then its social return on infrastructure will exceed its return on private capital so that $\rho_x^{WC} > 1$. If, on the other hand, $\rho_x^{WC} < 1$, then the country has too much infrastructure relative to private capital; this does not necessarily mean that the country has stellar infrastructure, but it does imply that infrastructure is not the most efficient choice for additional public expenditure given the country's mix of other inputs (private capital, technology, policies, institutions, and labor). The vertical dashed line on the figure, defined by the locus of points for which $\rho_x^{WC} = 1$, is the domestic hurdle; it is efficient for the country to increase its rate of investment in infrastructure (relative to private capital) if the within-country ratio falls strictly to the right of this line (i.e., $\rho_x^{WC} > 1$).

The vertical axis of Figure 3 measures the ratio of *r*-Public-Poor to *r*-Private-Rich. Call this ratio the cross-country ratio of the return on infrastructure and denote it $\rho_x^{CC} = \frac{r_x}{r_{k^*}}$. If capital is allocated efficiently across the poor country and the rich country then ρ_x^{CC}=1, and there is no incentive for capital to flow from the private sector of the rich country to infrastructure in the poor one. If ρ_x^{CC}>1 then it is efficient for capital to flow from the rich country's private sector to investment in poor-country infrastructure. The opposite is true if ρ_x^{CC}<1. The horizontal dashed line on the figure, defined by the locus of points for which ρ_x^{CC}=1, constitutes the cross-country hurdle; it is feasible, in theory, for the poor country to finance infrastructure through rich-country private savings if its cross-country ratio lies above this line (i.e., $\rho_x^{CC} > 1$).

For a variety of reasons ranging from the fact that infrastructure is a public good with an absence of tradable securities that privately capture its social benefits and thereby incentivize savers to provide the supply of capital needed to meet the demand for infrastructure services, to governments that actively pursue policies that prevent the marginal product of capital from converging across sectors or borders, we should not actually expect the social return on infrastructure in a given country to equal the return on private capital at home or abroad. Accordingly, the prevalence and magnitude of the return differentials across sectors and countries can provide a powerful signal about the extent to which the stock of infrastructure capital in place and the attendant flow of services it provides are meeting demand, or whether there are opportunities for a more efficient allocation of scarce resources.

To that end, the intersection of the within- and cross-country hurdles divides the (ρ_x^{WC}, ρ_x^{CC}) plane into four quadrants that sort countries according to their potential for publicly efficient and privately profitable investment in infrastructure.

Quadrant I ($\rho_x^{WC} > 1$, $\rho_x^{CC} > 1$) consists of countries in which the return on infrastructure exceeds both the within- and cross-country hurdle rates for investment. Countries in this quadrant are ripe for more investment in infrastructure and, in principle, can also attract Private-Rich capital to finance it.

Quadrant II ($\rho_x^{WC} > 1$, $\rho_x^{CC} < 1$) consists of countries in which the return on infrastructure clears the within-country hurdle but falls short of the cross-country threshold. Countries in this quadrant stand to benefit from more rapid investment in infrastructure but cannot attract Private-Rich financing. Instead, they must rely on domestic savings and concessional foreign financing (subject to the usual caveats about foreign aid).

Quadrant III ($\rho_x^{WC} < 1,\ \rho_x^{CC} < 1$) consists of countries in which the return on infrastructure clears neither the within- nor the cross-country hurdle. Countries in this quadrant do not warrant additional infrastructure expenditure (domestic or foreign) relative to other investment. Countries in this quadrant can also look quite different. A country with an excellent private investment climate and therefore high returns on private capital may land here because it is so well capitalized in infrastructure that the marginal benefit of installing another unit is not attractive from the perspective of either a welfare maximizing government or foreign investors. It is equally possible for a country to land in this quadrant because it has an abjectly poor investment climate that renders low the return on private investment, even as it remains relatively overcapitalized in infrastructure.

Quadrant IV ($\rho_x^{WC} < 1,\ \rho_x^{CC} > 1$) consists of countries in which the return on infrastructure fails to clear the within-country hurdle, but exceeds the cross-country threshold. For countries in this quadrant, it would be efficient for governments to stop appropriating domestic savings for infrastructure and let foreign savings finance it instead.

3. The Prevalence and Magnitude of Infrastructure Opportunities

Table 1 (Panels A and B) applies the dual-hurdle framework to the data by presenting 75 ordered pairs of country infrastructure returns ($\rho_x^{WC},\ \rho_x^{CC}$) for poor countries. The source of the data used to construct Table 1 is Canning and Bennathan (2000). The authors estimate a trans-log production function on panel data from 1960 to 1990 for 69 countries (53 poor and 16 rich), and employ a variety of techniques that control for reverse causality, to obtain the country-specific elasticities of output with respect to electricity generating capacity and paved roads required to compute social rates of return on each type of infrastructure.

Of the 53 poor countries in the sample, 26 have data with which to estimate elasticities for paved roads, and 49 for electricity generating capacity, yielding a total of 75 country-infrastructure-return observations. For all of the countries in the sample, data are available to estimate country-specific elasticities of output with respect to the aggregate capital stock. Canning and Bennathan use their estimated elasticities to produce rates of return in two steps.

First, they calculate each of the marginal products associated with roads, electricity, and the aggregate capital stock.[7] Second, they compute rates of return by dividing the marginal product of each type of investment good by its unit cost (calculated for each country using observable data on the cost of infrastructure construction) and subtracting the rate of depreciation (assumed to be 7 percent per year). Canning and Bennathan's information on the cost of building roads and electricity comes from 1985 World Bank data, and therefore, in effect, so do their return estimates—a limitation we discuss, along with other limitations, in Sections 3A and 4.

Table 1, Panel A, presents the 26 country-infrastructure-return ordered pairs for paved roads. Panel B presents the 49 country-infrastructure-return ordered pairs for electricity generating capacity. For each panel, the data are broken into a cluster of rich countries, plus three geographic clusters of poor countries: Latin America and the Caribbean, Africa, and Asia. For each country cluster, the first column lists ρ_x^{WC}; the second column lists ρ_x^{CC}; and the third column lists the quadrant into which each country sorts, given its values of ρ_x^{WC} and ρ_x^{CC}.

[7] Canning and Bennathan's returns calculations adjust for double-counting of capital and infrastructure.

The most striking observation about the rich countries in Panel A is their overinvestment in roads. All except Japan sort into Quadrant III, and ρ_x^{WC} for the rich-country cluster has a mean (median) value of 0.48 (0.26). As the return on another dollar invested in the infrastructure of rich countries in 1985 was less than the return on investing it in private capital, the binding constraint for market-driven cross-border investment from rich countries into poor-country infrastructure was not *r*-Public-Rich, the return on infrastructure in rich countries, but *r*-Private-Rich. For that reason, we use the average value of *r*-Private-Rich as the denominator of ρ_x^{CC} throughout the table.

Turning to the poor countries, the data in Table 1 present a mixed picture about the extent to which these nations contained opportunities for publicly efficient and privately profitable infrastructure investment. Panel A, on the one hand, indicates that for paved roads 21 of 26 countries landed in Quadrant I—all 11 countries in Latin America and the Caribbean, 6 of 9 in Africa, and 4 of 6 in Asia.

Moving to electricity in Panel B, on the other hand, a much smaller fraction of poor countries—18 of 49—sorted into Quadrant I. Notably, 15 of the 18 countries that sorted into Quadrant I for electricity were classified as "low-income." Accordingly, the case for publicly efficient and privately financeable investment in electricity appeared strongest in Africa, home to 9 of the nations listed in Quadrant I. Just 3 of 17 countries in Latin America and the Caribbean, and 6 of 17 in Asia, sort into Quadrant 1.

3A. Electricity, Roads, and the Rural-Urban Distinction

The absence of widespread evidence for the aggregate economic benefits of increased investment in electricity infrastructure for poor countries is consistent with Lee, Miguel, and

Wolfram (2020a) who, using a randomized control trial, document minimal social gains of household electrification in rural Kenya and conclude that providing electricity to rural households may not be an economically productive, high-return activity in the world's poorest countries.[8] Although Table 1 indicates that Kenya is, in fact, among the limited number of countries that sort into Quadrant I for electricity, the figures in Table 1 are based on the estimated impact of increased electrification to countries as a whole, not just to rural households.

Distinguishing between rural and aggregate electrification matters. In contrast to the evidence that rural electrification yields minimal consumer benefits, consider the impact of electrification on industrial and urban production. Results from World Bank Enterprise Surveys, conducted on 47,179 firms in 108 countries from 2006 to 2010, indicate that 41 percent of managers consider lack of access to electricity a "major or very severe" obstacle to their operations and the biggest challenge to their businesses—ahead of crime, access to finance, and an inadequately educated labor force (Geginat and Ramalho 2015).[9] If the return to increased electrification for industrial and urban production is high, then the cost-benefit trade-off associated with aggregate electrification may be positive, even as the costs of electrification for rural consumption outweigh the benefits.

The rural–aggregate electrification distinction applies to all 18 countries that sort into Quadrant I for electricity, and its importance is thrown into relief by another set of facts regarding trends of demographics and urbanization: Between 2000 and 2030, cities in poor countries, African countries in particular, will double their population from 2 billion to 4 billion

[8] Earlier studies documented the benefits of rural electrification for increases in labor supply (Dinkelman 2011; Grogan and Sadanand 2013), school attainment (Khandker et al. 2014, Akpandjar and Kitchens 2017), and respiratory health (Barron and Torero 2017). More recent studies find the impact of rural electrification economically and statistically significant (Foster and Rana 2020; Lee, Miguel and Wolfram 2020b).
[9] Aberese (2020) and Aberese, Ackah, and Asuming (2021) estimate the impact of electricity shortages on firm-level investment and productivity in Ghana.

and triple their land area, making preparation for ongoing urbanization a common priority (Angel 2008; United Nations 2016). Urbanization is inevitable, but poor countries' maximization of productivity gains from the process is not.

Good jobs—ones in which workers learn more and experience faster increases in productivity—arise naturally in large urban areas with both a local platform that facilitates rapid inter-city connections and links to the global system of production. The creation of such platforms requires intra-city infrastructure such as roads, water, and sanitation, in addition to power (Bertaud 2018; Romer 2018). Cities make workers and firms more productive when urbanization increases the effective size of the labor market, and the effective size of a city's labor market is a function of both its population and the speed with which people can travel from home to work (Prud'homme and Lee 1999). Because the average number of jobs per worker that are reachable within a one-hour, one-way commute is an effective proxy for a city's productivity, policies that maximize that number have profound potential to impact growth (Bertaud 2018).

There are 22 poor countries with data for social returns on both electricity and paved roads. Of these, the dual-hurdle framework indicates that it would have been efficient to increase investment in paved roads for 21 of them, whereas increased investment in electricity would have been efficient for only 7. Plainly stated, in 1985 it was 3 times more likely that greater investment in roads in a given poor country was publicly efficient and privately profitable than greater investment in electricity. To the extent that in subsequent decades the cost of constructing roads has changed relative to the cost of installing electricity, so too has the three-fold difference in likelihoods. Whether it remains current or not, however, the difference in likelihoods underscores the importance of comparing the social return on investing in roads to that of investing in electricity (or other infrastructure, such as hospitals, schools, water and sanitation) in order to prioritize large-scale expenditure on public capital in a way that maximizes growth, given equity considerations.

The more general point about any change in relative cost since 1985, of course, is that yesteryear's roads and grids may not be today's infrastructure, and they are even less likely to be tomorrow's transportation and power solutions (Foster and Rana 2020). The rapid evolution of technology in conjunction with the immutable nature of infrastructure—it is extremely costly to move a bridge once built—gives rise to non-trivial challenges in thinking about when and how to implement public investments to maximize their future economic return. Leifman, Fay, Nicolas, and Rozenberg (2019) elaborate on the complexities involved in trying to forecast the exact configuration of the infrastructure of the future and sketch a range of possible outcomes, but given the uncertainty and quasi-permanence of infrastructure, the most efficient course of action for leaders is to retain the option, but not the obligation to make decisions about the installation of public capital (Dixit Pindyck 1994). Maximizing the future value of building roads in response to the ongoing process of urbanization provides a tangible example.

Accordingly, Angel (2008) articulates a powerful real-options strategy for urban roads that distinguishes between infrastructure capital (materials for building roads) and land for infrastructure (the intra-city arterial dirt grid upon which future roads will be built).[10] His approach focuses on the essential function of arterial roads to minimize commute time and maximize the number of reachable jobs per worker per hour. Executing the strategy requires governments to make just one up-front commitment: obtaining the land to lock in the rights-of-way for trunk infrastructure in advance of urban development. The sooner rights-of-way are secured, the lower their cost and therefore the higher the benefit-cost ratio of securing them.

[10]An arterial grid is a network of the major arterial roads that typically carry intra-urban traffic, public transportation, and trunk infrastructure.

Importantly, because the strategy rises above the tactical complexity of questions like what type of vehicles will drive on the roads (e.g., autonomous or traditional), or what type of material will be used for paving, it requires no knowledge at the time of commitment about the future path of technology. Indeed, from a real-options perspective, Angel's central insight is that the highest return on roads in poor countries may come not from pouring asphalt, *per se*, but rather from the foresight to acquire land now that enables cities to engage in low-cost adaptation to the transportation realities of the future.

Speaking of foresight, past infrastructure spending was efficient when it provided the labor-abundant countries of East Asia with the transportation and power infrastructure they needed to convert their comparative advantage in low-wage labor into export-led manufacturing growth strategies (Kuroda, Kawai, and Nangia 2007). Today, other nations have positioned themselves as next in line to reap the benefits of infrastructure-enabled, labor-abundance-driven industrialization: wages in Vietnam, for example, are half what they are in China, and wages in Ethiopia are half those of Vietnam (Dinh et al. 2012; Standard Chartered Global Research 2016). But automation continues to reduce the share of labor in the cost of manufacturing—thereby eroding poor countries' advantage of a vast, low-wage workforce (Basu 2016)—and the technological changes afoot, in combination with premature de-industrialization (Rodrik, 2016), beg the question of whether investment in infrastructure will remain a high-return proposition in countries that pass the dual-hurdle test.

That said, a number of poor countries will continue to have a comparative advantage in traditional export-led industrialization (Hallward and Nayyar 2018). Others will reinvent themselves for a niche in the manufacturing-cum-services value chain. And some may pursue a radically different path that heavily leverages information and communications technology (ICT) and the digital economy. But even if the power infrastructure of the future looks very different than that of the past, without electricity it is not possible to build e-commerce platforms for growth using ICT. The point is fundamental, because faster internet connections in Sub-Saharan Africa, for example, increase innovation, employment and productivity (Akpan, Chuku, and Simpasa 2019; Hjort and Poulsen 2019).[11] The question, therefore, is less whether properly screened investments in infrastructure will still bring efficiency gains in a world of automation and premature de-industrialization, than how, given scarce resources, changes in the manufacturing landscape will alter the ordering of infrastructure priorities in the years ahead.

3B. Joint Prospects for Roads and Electricity

Because strategically-laid-out roads and reliable electricity form the common denominator of maximally productive cities, interpreting data on the joint prevalence of opportunities for roads and electricity requires caution. Aggregating across roads and electricity in Table 1, for example, indicates that 39 of the 75 country-infrastructure-return observations (or 52%) sorted into Quadrant I. The fact that little more than half of all observations cleared the dual hurdles does not suggest ubiquitous potential for publicly efficient and privately financeable investment in poor-country infrastructure. Additionally, the 39 Quadrant I observations are distributed across 32 countries, meaning that 21 of the 53 poor countries in the sample did not clear the dual hurdles for either type of infrastructure and were therefore not candidates for additional investments in either roads or electricity. Said another way, 40 percent of the 53 poor countries for which data are available had no returns-based case for investment. Digging still deeper, of the 32 countries with projects that did clear the dual hurdles, there were only 7—

[11] For more on the challenges of infrastructure in Africa see Ajakaiye and Ncube (2010), Ndulu (2006).

Argentina, Bolivia, Honduras, Indonesia, Kenya, Malawi, and the Philippines—whose return ratios made a case for investment in both roads and electricity.

The reality that less than one in seven countries in the only comprehensive dataset of social rates of return on infrastructure in poor countries presented a data-driven case for investment in both roads and electricity in 1985 raises questions about the wisdom of the World Bank pushing a "billions to trillions" agenda in infrastructure three decades later without first charging its research department to update and validate the social-returns data required to distinguish those countries that have an economic case for greater infrastructure investment from those that do not.

On the other hand, because the classifications in Table 1 reflect average rather than marginal returns, it is possible that they understate the prevalence of efficient and profitable infrastructure projects that arise at the intersection of roads and electricity—particularly in cities—versus for countries as a whole. The nuances of interpretation that arise from the distinctions between rural versus urban infrastructure, and roads versus electricity, have important implications—both for poor-country governments trying to decide on economic priorities, and for rich-country savers deciding whether to fund investment in those priorities.

3C. Non-Economic Considerations

The discipline of data and the dual-hurdle framework notwithstanding, there are legitimate non-economic reasons for increasing infrastructure investment in poor countries. Rozenberg and Fay (2019), for instance, push the global infrastructure debate away from a myopic emphasis on more money, predicated on gap-thinking, toward an approach of more efficient spending for a given set of equity-related goals. Specifically, Fay and Rozenberg

(2019a) argue that instead of setting general targets for expenditure, countries should establish specific infrastructure objectives—some of which may be non-economic—and drive the most cost-effective means of achieving them. Building on that premise, the authors use extensive scenario analyses to demonstrate that there are feasible investment paths along which low- and middle-income countries (LMICs) can: (1) meet the infrastructure-related Sustainable Development Goals with investments of 4.5 percent of GDP while staying on track to limit climate change to 2°C; (2) accomplish (1) at a cost no greater than more-polluting alternatives; and (3) reduce by more than 50 percent the total life-cycle cost of these investments by making maintenance of infrastructure as high a priority as capital expenditure.

Important as it is to produce cost-efficient options for a given set of infrastructure objectives, however, it is also useful to know how the investments required to achieve those objectives compare to the investments that could be made if, instead, the goal was to maximize productive efficiency in LMICs. While there are legitimate reasons for setting some infrastructure objectives that are geared toward equity rather than efficiency—and there is certainly a role for judgment and practical experience in sketching an aspirational, carbon-neutral vision of countries' infrastructure—it is also instructive to let the data on economic returns speak. Indeed, to the extent that the Fay-Rozenberg objectives-based approach to guiding the allocation of equitably minded infrastructure is broadly consistent with considerations of productive efficiency, we should see, on average, the largest prospective economic returns on infrastructure in precisely those sectors identified as "high priority." While returns on infrastructure need not always prove dispositive, a pattern of prospective returns in high-priority sectors that are consistently lower than prospective returns elsewhere should raise yellow flags about the economic sustainability of the overarching objectives.[12]

3D. Paucity of Prevalence and the Lucas Conjecture

Turning back to strictly economic considerations, it is reasonable to ask whether the underwhelming presence of efficient and profitable poor-country investment opportunities, particularly in electricity, is not simply an infrastructure-specific manifestation of the Lucas (1990) Conjecture, which asserts that after adjusting for differences in the productivity of human capital, the implied return on physical capital in poor countries is not significantly higher than it is in rich ones. To examine the extent to which the Lucas Conjecture can explain the results in Table 1, define ρ_{ALL}^{CC} as the ratio of poor-country returns on all capital (not just infrastructure) to rich-country returns on all capital. If the modest occurrence of Quadrant I infrastructure opportunities documented in Table 1 is merely a variation on the Lucas Conjecture, then the values of ρ_{ALL}^{CC} , which are based on the Canning and Bennathan (2000) estimated elasticities that control for cross-country differences in human capital, should not differ systematically from 1.

Panel A of Table 2 demonstrates that this is not the case. The average (median) value of ρ_{ALL}^{CC} for the 53 poor countries in the Canning and Bennathan dataset is 1.36 (1.27). By region, the average (median) values of ρ_{ALL}^{CC} are: 1.36 (1.27) for Latin America and the Caribbean; 1.91 (1.78) for Asia; and 0.87 (0.76) for Africa, the only region where the average (median) value of ρ_{ALL}^{CC} is less than 1.

Moving from regions to individual nations reinforces the consistency of the observation. Thirty-five, or roughly two-thirds, of the 53 poor countries have a value of ρ_{ALL}^{CC} that is greater than 1. With the exceptions of Algeria, Argentina, which was in the midst of hyperinflation, and

[12]Again, as discussed in Section 3B, low average returns need not mean there are no good projects.

Jamaica, which was recovering from a decade-long economic collapse, all of the poor countries for which ρ_{ALL}^{CC} is less than 1—Bolivia, Central African Republic, Congo, Fiji, Gambia, Ghana, Kenya, Mali, Liberia, Mozambique, Nicaragua, Niger, Papua New Guinea, Uganda, and Zambia—were classified as low-income nations by the World Bank in 1985. Indeed, splitting the sample of poor countries by income further weakens the empirical case for the Conjecture. Of the 38 poor countries that were not classified as "low income," 35 have a value of ρ_{ALL}^{CC} greater than 1. The average (median) value of ρ_{ALL}^{CC} for low-income African countries is 0.79 (0.80), while the average (median) value of ρ_{ALL}^{CC} for the other poor countries is 1.61 (1.53).

The facts in Panel A are not peculiar to the Canning and Bennathan (2000) dataset from which they are drawn. Panels B and C of Table 2 present additional sets of calculations of ρ_{ALL}^{CC}. Using data on 68 rich and poor countries from Monge-Naranjo, Sanchez, and Santaeulalia-Llopis (2016), Lowe, Papageorgiou, and Perez-Sebastian (2018) compute rates of return on all capital in 1996 and 2005. Because the countries covered by the Lowe *et al.* calculations differ to some extent from those listed in Canning and Bennathan (2000), Panel B and Panel C present figures on returns for only those countries that are covered in both papers. For the rich countries, every country that appears in Panel A also appears in Panel B (1996 returns) and Panel C (2005 returns). For the poor countries, Panels B and C contain 29 of the 53 countries in Panel A. As for the figures themselves, the values of ρ_{ALL}^{CC} reported in Panel B are similar to those in Panel A. For all capital, ρ_{ALL}^{CC} in Panel B is 1.29 in 1996, and 1.10 in 2005 (Panel C). Furthermore, 22 of the 29 poor countries in Panel B have a value of ρ_{ALL}^{CC} that is greater than 1. Eighteen of 29 countries in Panel C have a value of ρ_{ALL}^{CC} greater than 1.

In addition to the Lucas Conjecture's inability to account for the absence of widespread infrastructure opportunities in poor countries, the Conjecture is also at odds with a significant number of the efficient and profitable infrastructure opportunities that did, in fact, exist. For instance, of the 32 unique countries identified as having had Quadrant I opportunities for investment in either paved roads or electricity in 1985, 10 of them—Algeria, Argentina, Bolivia, Central African Republic, Fiji, Kenya, Liberia, Mali, Uganda, and Zambia—had a return on all capital that was less than the return on capital in rich countries.[13] Furthermore, of the 7 countries that sorted into Quadrant I for both roads and electricity, 3—Argentina, Bolivia, and Kenya—had a return on all capital below that of the rich-country average. There were, in other words, poor countries to whose private sectors rich-country private capital had little incentive to flow that nonetheless had the potential to be efficient and profitable destinations for Private-Rich investment in infrastructure.

The counterintuitive observation that infrastructure investment can, in principle, be productively and profitably deployed in countries with badly functioning private sectors is readily explained by the dual-hurdle framework. Because rich countries are overinvested in infrastructure, the binding constraint for market-driven flows of capital from Private-Rich to Public-Poor is *r*-Private-Rich. Therefore, a poor country whose return on all capital is less than the return on all capital of rich countries—and thereby satisfies the Lucas Conjecture—can nonetheless have infrastructure opportunities that provide a profitable and efficient destination for rich-country savings if: (a) *r*-Public-Poor exceeds *r*-Private-Rich and (b) r-Public-Poor exceeds *r*-Private-Poor. As demonstrated by the data in the previous paragraph, this kind of outcome is not a theoretical curiosum, but a practical reality that highlights the empirical relevance for future research of the distinction between private and public capital.

[13] The return on all capital is a weighted average of the return on infrastructure and the return on private capital. Therefore, if the return on all capital is less than the return on infrastructure, then the return on private capital is less than the return on all capital.

3E. Magnitude and Welfare Implications

When Lucas observed in 1990 that capital had not been flowing to poor countries, his preferred causal hypothesis ran as follows: once properly adjusted for cross-country differences in human capital, the implied difference between *r*-Poor and *r*-Rich was not large enough to induce capital flows from rich to poor. As it turned out, another hypothesis proposed by Lucas was just as relevant: capital did not flow from rich to poor countries, because poor countries maintained barriers to private capital inflows. We can affirm the relevance of Lucas's barriers-to-private-capital-flows hypothesis, because shortly after the publication of his article poor countries eased restrictions on foreign ownership of domestic stocks. Figure 4 documents the ensuing flood of capital from Private-Rich to Private-Poor.[14] Liberalizing the access of Private-Rich savers to Private-Poor capital sparked the creation of a new class of rich-country savings vehicles called emerging-market equity funds (Van Agtmael 2007) that: (a) induced a revaluation of poor-country corporate assets (Stulz 1999, 2005; Henry 2003, 2007), and (b) increased real investment and manufacturing-sector wages (Henry 2000b; Chari, Henry, and Sasson 2012). Thus it is reasonable to wonder whether the potential for capital flows from Private-Rich to Public-Poor presents an opportunity for unrealized welfare gains of similar significance.

To that end, Table 3 suggests that the welfare consequences of the non-equalization of returns between Private-Rich and Public-Poor are actually larger than those that resulted from the non-equalization of returns between Private-Rich and Private-Poor. For each of the 21 countries that sort into Quadrant I for roads, Panel A of Table 3 presents data on ρ_x^{CC}, the ratio of

[14] Stock market liberalizations were a subset of the broader process of capital account liberalization. See Stulz (1999), Henry (2000a), and the references therein.

r-Public-Poor to *r*-Private-Rich. Panel A indicates that ρ_x^{CC} has a mean (median) value of 10.2 (5.99). Even dropping the outlier of Korea, the mean (median) value of ρ_x^{CC} is 8.2 (5.1). In contrast, the largest value of the ratio of *r*-Private-Poor to *r*-Private-Rich is 1.36. This means that when it comes to roads, the excess-return multiple of *r*-Public-Poor relative to *r*-Private-Rich is anywhere from 6.0 (8.2 divided by 1.36) to 7.5 (10.2 divided by 1.36) times larger than the excess return multiple for *r*-Private-Poor to *r*-Private-Rich. Similarly, Panel B of Table 3 gives the values of ρ_x^{CC} for the 18 countries with Quadrant I opportunities for electricity. The mean (median) value of ρ_x^{CC} for electricity—2.2 (1.87)—is also bigger than the ratio of *r*-Private-Poor to *r*-Private-Rich. In this case, however, the excess return multiple for *r*-Public-Poor relative to *r*-Private-Rich is a less eye-popping 1.6 times as large.

We can also gauge the welfare consequences of the non-equalization of *r*-Public-Poor with *r*-Private-Rich versus the non-equalization of *r*-Private-Poor with *r*-Private-Rich by comparing the values of ρ_x^{CC} in Table 3 with the expected return that prevailed on portfolio equity in poor countries before they began easing restrictions on foreign ownership of shares of domestic corporations. Prior to easing, the expected return on emerging-market stocks was roughly 1.5 times greater than the expected return on the S&P 500.[15] As this excess return was largely arbitraged away following liberalization, 1.5 is a reasonable proxy for the pre-liberalization ratio of *r*-Private-Poor to *r*-Private-Rich. Using this emerging-market equity benchmark, the excess return multiple for *r*-Public-Poor relative to *r*-Private-Rich ranges from 5.5 (8.2 divided by 1.5) to 6.8 (10.2 divided by 1.5) times bigger than the excess returns multiple for *r*-Private-Poor relative to *r*-Private-Rich.

There is a simple reason why the potential welfare gains of capital flows from Private-

[15]The average earnings yield on emerging-market stocks in the five years prior to liberalization was 13.3; the average earnings yield on U.S. stocks over the same period was 8.6; 13.3 divided by 8.6 is 1.5.

Rich to Public-Poor are larger than those from Private-Rich to Private-Poor. The ratio of *r*-Public-Poor to *r*-Private-Rich divided by the ratio of *r*-Private-Poor to *r*-Private-Rich equals ρ_x^{WC}—the ratio of *r*-Public-Poor to *r*-Private-Poor. The dispersion of this ratio was greater for poor countries than for rich ones in 1985, which means that infrastructure was even less efficiently allocated in poor countries than in rich ones. Furthermore, the magnitude of this inefficiency has increased over time and may help explain why, as noted in Section 2, the global deadweight loss from the misallocation of public capital is 4.8 times larger than the deadweight loss from the misallocation of private capital.

4. Plausibility, Foundations, and Limitations

The dual-hurdle framework brings the clarity of equilibrium to the global infrastructure debate, but it also has limitations that are readily apparent from the literature. First and foremost, the economy-wide estimates of the elasticity of GDP with respect to infrastructure (and other factors of production), on which calculations of social rates of return on investment depend, are rightly subject to skepticism because of data constraints, endogeneity, and other potential concerns. A consensus has emerged that: (a) the econometric challenges of macroeconomic data are manageable with careful attention to regression techniques and thoughtful interpretation of the estimated parameters; and (b) infrastructure does, in fact, have a causal impact on growth (Estache and Fay 2007; Calderón and Servén 2010). Nevertheless, the calculations that determine the value of ρ_x^{CC}—the ratio of *r*-Public-Poor to *r*-Private-Rich—depend on the sensitivity of estimates of the infrastructure elasticity of output in poor countries, as well as on the availability of data. Deeper scrutiny of the fundamentals that determine whether ρ_x^{CC} is greater or less than 1 can, therefore, provide information about the precision of ρ_x^{CC} as a signal of the viability of rich-country financing of poor-country infrastructure.

Accordingly, because the numerator of ρ_x^{CC}, *r*-Public-Poor, and the denominator, *r*-Private-Rich, are functions of the marginal product of infrastructure and the marginal product of capital, for a given poor country it is useful to write:

$$Y = AK^{\alpha}H^{\beta}X^{\gamma}L^{1-\alpha-\beta-\gamma} \quad (1).$$

A is total factor productivity; *K* is the stock of private capital; *H* is the stock of human capital; *X* is the stock of infrastructure capital; and *L* is the stock of labor.[16] Reformulating (1) in intensive form, $y = k^{\alpha}h^{\beta}x^{\gamma}$, so that output, capital, human capital, and infrastructure are all expressed in per capita terms, it follows that the marginal product of infrastructure in the poor country is $mpx = \gamma\frac{y}{x}$, and its return to infrastructure is $r_x = \frac{mpx}{P_x}$, where P_x is the unit price of infrastructure in the poor country. Similarly, let $mpk^* = \alpha^*\frac{y^*}{k^*}$ denote the marginal product of private capital in the rich country, so that the rich-country return on private capital is $r_{k^*} = \frac{mpk^*}{P_{k^*}}$, where P_{k^*} is the unit price of private capital in the rich country. Using the definitions of r_x, r_{k^*}, and performing a little algebra, yields the following equation:

$$\rho_x^{CC} = \frac{r_x}{r_{k^*}} = \frac{k^*}{y^*}\cdot\frac{y}{x}\cdot\frac{P_{k^*}}{P_x}\cdot\frac{\gamma}{\alpha^*} \quad (2).$$

Moving in order from left to right, consider each of the four ratios on the right-hand side of (2).

The first ratio is $\frac{k^*}{y^*}$, the rich-country ratio of output to capital. Using the U.S. as a rich-country proxy gives a value of about 2.9 (Jones 2002).

For the second ratio, $\frac{y}{x}$, the poor-country ratio of output to infrastructure, we make a reasonable, if admittedly rough, inference about it by observing that $\frac{y}{x} = \frac{y}{y^*}\cdot\frac{y^*}{x^*}\cdot\frac{x^*}{x}$. For $\frac{y}{y^*}$, the

[16] The rich country production function is given by the parallel expression for Y* as a function of A*, K*, etc.

ratio of poor-country GDP per capita to developed-country GDP per capita is roughly 1/5 (Maddison 2003, p. 234). Taking the U.S. as a proxy for $\frac{y^*}{x^*}$ (the rich-country ratio of GDP to infrastructure), the ratio of GDP to nondefense infrastructure is roughly 4/3 (Fair 2019, Figure 4). Finally, for $\frac{x^*}{x}$, the stock of infrastructure per capita in rich countries is between 8 and 20 times that of poor countries (Dethier and Moore 2012, Table 1). Taken together, the three sets of numbers in this paragraph give low- and high-end figures for $\frac{y}{x}$ of 2.13 and 5.33.

The third ratio on the right-hand side of (2) is the price of private capital in rich countries divided by the price of infrastructure capital in poor countries. We can make an educated guess about the average value of $\frac{P_{k^*}}{P_x}$ by noting that $\frac{P_{k^*}}{P_x} = \frac{P_{k^*}}{P_k} \cdot \frac{P_k}{P_x}$. Because the price of capital goods in poor countries is two to three times higher than in rich ones (Hsieh and Klenow 2007, p. 563), we know that $\frac{P_{k^*}}{P_k}$ ranges from 1/2 to 1/3. For $\frac{P_k}{P_x}$, the price of producer durables in poor countries is 1.34 times the price of construction (Lee 1995, Table 1, Column 3). From these two facts, a reasonable estimate of $\frac{P_{k^*}}{P_x}$ is a number between 0.447 (1/3 times 1.34) and 0.67 (1/2 times 1.34).

The fourth and final ratio on the right-hand side of (2) is the elasticity of output with respect to infrastructure in the poor country, γ, divided by the elasticity of output with respect to capital in the rich country, α^*. Historically, the data suggest that α^*= 1/3. Arriving at a consensus for γ requires a quick synthesis of the literature.

Using a panel of 88 countries and an index of infrastructure, Calderón, Moral-Benito, and Servén (2011) estimate an infrastructure elasticity of output that is between 0.07 and 0.1. They do not find that the elasticity varies systematically with population, GDP per capita, or endowment of infrastructure per capita. Candelon, Colletaz, and Hurlin (2013), employing panel data from Canning (1998), also find that the elasticity of output with respect to infrastructure is not significantly related to the level of GDP per capita. The invariance of γ with respect to country income levels is somewhat surprising, because most infrastructure is provided through networks, which are characterized by economies of scale and threshold effects, which would suggest that the infrastructure elasticity of output varies in a non-linear way with the development of the infrastructure network (for which population, GDP per capita, and infrastructure per capita serve as proxies).

Network effects imply that when the stock of infrastructure is extremely low, the marginal product of infrastructure will be the same as for private capital. After reaching a certain threshold, where the network is functional but not complete, the marginal product of infrastructure will exceed the marginal product of private capital. Once the network is complete, the marginal product of infrastructure will be no higher (and perhaps lower) than the marginal product of private capital. Roads are a classic example of a network, and accordingly, Fernald (1999) demonstrates that although the building of the interstate highway system in the U.S. during the 1950s and 60s generated abnormally large productivity gains, the data cannot reject the hypothesis that investment in roads today offers a normal (or even zero) rate of return. Candelon, Colletaz, and Hurlin (2013) find strong evidence of Fernald-like non-linearities in the marginal product of infrastructure as a function of the state of completion of electricity and road networks.

Although there is little evidence that countries' infrastructure elasticities of output vary systematically with GDP per capita, the data do indicate that countries' elasticities of output with respect to electricity and roads taken separately depend on the state of completion of each of those networks, as well as the country's per capita endowment of non-infrastructure productive inputs. All in all, and including the Bom and Lighthart (2008) meta-study which finds an elasticity of 0.087, the literature points to a value of γ that ranges from 0.07 to 0.1. This suggests that $\frac{\gamma}{\alpha^*}$ ranges from 0.21 to 0.3.

Taking the product of the complete set of permutations of all four ratios on the right-hand side of (2) yields a minimum value of ρ_x^{CC} of 0.580, and a maximum value of 3.1. These two numbers—crude bounds on what theory and the relevant literature tell us should be a workable poor-country average for ρ_x^{CC}—are not wildly out of line with the numbers in Table 1, where the mean (median) value of ρ_x^{CC} is 6.5 (2.9) for the 26 paved-road observations, and 1.3 (1.1) for the 49 observations of electricity.[17] As the upper and lower bounds on ρ_x^{CC} differ by a factor of 5.4 (3.1 divided by 0.58), they demonstrate that although it may be plausible for some poor countries to attract rich-country financing for investment in infrastructure: (a) it is not a foregone conclusion that all poor countries will clear the cross-country threshold of the dual-hurdle framework; and (b) ρ_x^{CC} is likely to vary widely, according to where countries fall (i.e., on which end of the range) for certain parameters.

The variation in these back-of-the-envelope calculations serves as an important reminder that relative to rich countries, poor ones vary widely in the extent to which they possess the private capital, human capital, institutions, technology, and policies that drive growth. This means that the optimal mix of sectoral investments will also vary widely from country to country. To that point, the next subsection describes the data challenges involved in producing and interpreting country-specific estimates of ρ_x^{CC}.

4A. Country-Specific Infrastructure Returns and Data Limitations

As part of their process for producing country-specific calculations for infrastructure

[17] The numbers for roads exclude Korea. With Korea, the mean (median) is 8.5 (3.4).

returns, Canning and Bennathan (2000) explore how countries' infrastructure elasticities of output vary with levels of physical, human, and infrastructure capital per worker. Specifically, the authors calculate elasticities (γ) for three fictitious countries: (1) a moderately poor country with each of the three factor inputs at the lower quartile for the 53-country sample; (2) an average country with each input at the median; and (3) a moderately rich country with each input at the top quartile. For electricity, the elasticity is 0.06 at the lowest quartile, 0.09 at the median quartile, and 0.07 at the top. For roads, the elasticity is 0.05 at the lowest quartile, 0.09 at the median, and 0.04 at the top. From these estimates, Canning and Bennathan conclude that roads and electricity exhibit rapidly diminishing returns when taken in isolation but are complementary to physical and human capital.[18] On its own, infrastructure investment does not generate large changes in output, but it can be very productive in economies with sufficiently high levels of physical and human capital, as infrastructure investment raises the efficiency of both. Said another way, the data are more consistent with an interpretation that a shortage of infrastructure constrains growth than one in which investment in infrastructure drives it.[19]

Traffic congestion in the city of Bangkok provides a powerful example of infrastructure-constrained growth. In the absence of an arterial grid of intra-city roads, the average one-way commute time to work in Bangkok is 90 minutes (Angel 2000), second worst in the world and 1.5 times the amount Bertaud (2018) identifies as the maximum average commute time a city can have and remain maximally productive. Beyond Thailand, the Asian Development Bank estimates that Asian economies lose 2-5 percent of GDP every year due to road congestion and

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[18]Given that infrastructure spending on schools is likely to increase the stock of human capital, which then raises the return on roads and electricity, as well as that on private capital, this finding further cautions against monolithic pushes for more roads or electricity in isolation and redoubles the need for prioritization discussed in Section 3A.
[19] The data are also consistent with Mbekani (2010) who emphasizes the lack of infrastructure in Sub-Saharan Africa as a significant bottleneck to regional integration.

the attendant lost time and higher transportation costs.[20]

While the social rates of return to which we applied the dual-hurdle framework in Table 1 are based on country-specific estimates of γ that account for differences in human capital, physical capital, and other factors, the age of the data used in the computation of $\frac{mpx}{P_x}$ imposes limits on how to interpret the results in 2021. For instance, the numerator, mpx, equals $\gamma\frac{y}{x}$, and the time-series data used to estimate γ for each country in the sample ends in 1990. Because the growth rates of poor countries accelerated in the mid-1990s as they implemented productivity-enhancing reforms (Chari, Henry, and Reyes 2020; Chari and Henry 2014), it is tempting to conclude that mpx rose also, suggesting that the number of countries that contain productive infrastructure opportunities today is significantly greater than the number the dual-hurdle framework identified using the Canning and Bennathan (2000) returns. Even if we stipulate that the growth of infrastructure in poor countries has not kept pace with their growth of output, such a conclusion would be valid only if γ has been constant (or risen) within countries. It is not possible to know if this is the case without updating the underlying data and using it to replicate the Canning and Bennathan (2000) procedure to estimate current country-specific values of γ.

Turning to the denominator of $\frac{mpx}{P_x}$ reveals similar age limitations with respect to Canning and Bennathans's information on the costs of building roads and installing electricity generating capacity that we discussed in Section 3A. Holding mpx constant, to the extent that the costs of constructing paved roads and installing electricity generating capacity has fallen by more in developed countries than in developing ones over the past 35 years, ρ_x^{CC} will have decreased. The opposite is true if relative costs have moved in the other direction.

[20] See *Asian Development Bank Key Priorities*: https://www.adb.org/sectors/transport/key-priorities/urban-transport

Resolving these and other unanswered questions about infrastructure requires current data (Estache and Fay 2007), and Chapter 4 of Rozenberg and Fay (2019), for example, suggests that the World Bank has compiled numbers, as recently as 2017, on the cost of road construction in poor countries. Compilation, however, is not sufficient. The World Bank commissioned the Canning and Bennathan study in 2000 and then spearheaded the "billions to trillions" agenda in 2015 without producing updated estimates of social rates of return. Given these two facts, the Bank's leadership has a responsibility to charge its research department with the mission of using all available data—and collecting more if necessary—to keep the cross-country estimates of infrastructure returns current, have them independently validated, and make them publicly available. Doing so along the lines of what the Bank has done with its annual flagship (if not uncontroversial) *Doing Business* indicators would provide a timely and common repository of trusted cross-country infrastructure returns that governments, investors, researchers, and others could use to systematically and independently make informed savings and investment decisions. In the meantime, there are at least two benefits of using the existing data.

First, despite the volume of discussion about poor countries' infrastructure gaps, Canning and Bennathan's 1985-based estimates represent the frontier of empirical knowledge on social rates of return on infrastructure in poor countries. Bougheas, Demetriades, and Mamuneas (2000) and Esfahani and Ramirez (2003) implicitly consider the importance of returns by using panel data regressions to estimate the elasticity of GDP with respect to various measures of infrastructure, but they do not explicitly compute the returns on infrastructure implied by their estimated elasticities. More recent papers such as Bivens (2017) document a litany of studies on the return on infrastructure in rich countries, but Canning and Bennathan provide the only explicit and comprehensive estimates of the economy-wide rate of return on infrastructure in poor ones.

A recent quasi-exception is Lowe, Papageorgiou, and Perez-Sebastian (2018), who employ data on public capital as a proxy for infrastructure and use it to calculate rates of return in developing countries. In the absence of other data, public capital provides a useful proxy for gauging the flow of infrastructure investment, but there are limitations to its utility for capturing returns, because public capital includes all public structures, not just infrastructure. To the extent that governments install public capital that does not fit the economic definition of infrastructure, figures on the stock of public capital will overstate the true stock of infrastructure and therefore understate its prospective rate of return (Estache and Garsous 2012; Fay, Lee, Mastruzzi, Han, and Cho 2019).[21]

As a complement to panel data approaches, a number of individual country studies that document significant effects of infrastructure on various measures of output provide relevant, if indirect, evidence on the social return on infrastructure in poor countries. The introduction of the railroad in colonial India, for example, raised output levels by 16 percent (Donaldson 2018). Data from the modern era in India indicate an important effect of power-related infrastructure on the efficiency of Indian manufacturing (Allcott, Collard-Wexler, and O'Connell 2016; Rud 2012; Aberbese 2017). At a more micro level, World Bank project evaluations suggest that the economic return on individual infrastructure projects exceeds the cost of capital (Estache and Fay 2007; Shafik 2005; Briceño, Estache, and Shafik 2004; Estache and Liu 2004; Herrera 2005). Although micro project evaluations provide helpful reality checks against which to benchmark aggregate estimates of the social rate of return, aggregate estimates are also important

[21] For an extensive discussion of the limitations of the use of public capital as a proxy for infrastructure, see Fay, Lee, Mastruzzi, Han, and Cho (2019). Suárez-Alemána, Serebrisky, and Perelman (2018) find that the data on total stock of infrastructure and IMF data on public capital are highly correlated.

because the economic rate of return on individual projects can miss significant country-wide externalities (Canning and Bennathan 2000; Estache and Fay 2007).

The second benefit of using existing estimates of the social return on infrastructure is that history matters. Understanding the optimality of investments in infrastructure today requires information about the extent to which past infrastructure investments were guided by their prospective rates of return, and information about the extent to which investments so made actually delivered the expected results. An examination of the 1985 data on prospective returns can provide important clues to that effect. India, for example, had no Quadrant I opportunities for roads or electricity in 1985. Consistent with the attendant diagnosis that a shortage of infrastructure was not a bottleneck to development at that time, India's well-documented acceleration in GDP growth that commenced circa 1992 was not triggered by an accelerated accumulation of public capital. The country's real average annual growth rate of public capital was 6.8 percent per year from 1980–85 and then slowed consistently in each of the three subsequent five-year increments: 5.7 percent from 1986–91; 4.1 percent from 1992–97; and 3.3 percent from 1998–2003. Keeping in mind that social rates of return on infrastructure in India and other poor countries may be quite different today than they were 35 years ago, the next section explains why it matters if the return differentials still persist, and discusses what can be done, if anything, to capitalize on the unrealized opportunities they embody.

5. Appropriability

To the extent that *r*-Public-Poor remains substantially higher than *r*-Private-Rich, there are big opportunities for private, rich-country investment in infrastructure in certain poor countries—particularly in green capital that would avoid further commitment to carbon-intensive technologies (Obstfeld 2021; Fay and Rozenberg 2019; Foster and Rana 2020; Stern 2015). Also, given record-low rich-country real interest rates due to slower productivity growth and demographics (Council of Economic Advisors 2015), a shortage of safe assets (Caballero, Farhi, and Gourinchas 2008), and the global savings glut (Bernanke 2005), a significant reallocation of savings from rich countries to the financing of profitable and efficient infrastructure investments in poor ones could raise both poor-country growth and rich-country returns. The reality that capital has not been flowing from Private-Rich to Public-Poor in great enough quantity to exploit these opportunities for positive-sum outcomes raises two questions: (1) what factors prevent those flows from occurring; and (2) what, if anything, can be done to mitigate them?

Adequate answers must acknowledge that although higher economic rates of return on Public-Poor capital are a necessary condition for poor countries to attract rich-country savings to finance infrastructure, they are not sufficient. The key to sufficiency is appropriability. Foreign investors must be able to appropriate a large enough share of the economic return on infrastructure—their private financial return—to induce them to undertake socially productive investments. And even when the expected private financial return is high, uncertainty about appropriability may imply levels of risk that are simply too large to justify investment.

Many factors may drive foreign investors' doubts about the extent to which they will be able to appropriate private financial returns, but broadly speaking, all of these factors fall under one of two categories: asymmetric information or moral hazard/agency problems.

Asymmetric information can inhibit foreign investors in two ways. First, potential foreign investors in infrastructure, who have limited knowledge of a given poor country, may worry about adverse selection, or the "lemons" problem, wherein only countries with the lowest prospective returns on infrastructure offer foreigners the opportunity to invest. The lemons problem can also take the form of poor countries with high prospective returns on infrastructure allowing foreigners to bid only on those projects that local government officials know to be less than stellar.

Second, even if all poor countries seeking infrastructure financing from abroad offer foreigners the opportunity to invest in good projects, foreign investors may not have the information they need to assess the public sector's capacity to govern in a way that makes private finance feasible over the long term. Public sector actions that make private finance feasible, such as permitting private suppliers to set a high enough price to be able to sustain quality provision of the infrastructure service, can also reduce the ability of potential users in poor countries to pay for the service. Resolving the tension between feasibility and inclusivity requires local officials to have a set of leadership skills that are scarce and may not be easily observable by foreign investors. Consider, as a tangible example, the case of Aguas del Illimani, a consortium owned by the French water and sanitation company, Suez, and a group of minority shareholders, including the International Finance Corporation. Aguas del Illimani bought the water and sewage system of the city of El Alto, Bolivia, during a July 1997 privatization sale, but the consortium's contract was terminated by Bolivian authorities in 2007 due to massive community protests that Aguas del Illimani was overcharging poor residents and failing to expand provision of service.

Whereas asymmetric information about the quality of projects or the public sector's leadership capacity creates doubt about the ability of a country to pay for the value of infrastructure services, moral hazard creates doubt about the government's "willingness" to pay. For governments with skilled leaders who initiate good projects with high social rates of return, their ability to attract private foreign financing nonetheless requires a sustained willingness to service the debt incurred to undertake the project, which cannot be taken for granted given considerations of political economy (Bulow and Rogoff 1989a,b; Stulz 2005).[22]

Elections, for example, may present (to the party in power) short-run political benefits of nonpayment that outweigh the costs, reputational or other—especially if those costs will not be borne until far into the future. And even if the party currently in power is willing to pay, the regime that succeeds it may not feel obligated to honor previous commitments. Either scenario would represent an abrogation of contract that will undermine appropriability. Faced with political uncertainties about long-run contract enforcement—also known as sovereign risk—foreigners will under-invest (Bulow 20002; Reinhart, Rogoff, and Savastano 2003).

Sovereign risk is just one example of the moral hazard risks that foreigners face when considering investments in countries with "deficiencies in the institutional environment regarding the rule of law, property rights, and enforceability of contracts […] that render the appropriability of the returns that private investment generates highly uncertain" (Montiel 2006). Measuring institutional quality as a composite political safety index—with components consisting of government stability, internal conflict, external conflict, non-corruption, militarized politics, religious tensions, law and order, ethnic tensions, democratic accountability, and bureaucratic quality—Alfaro, Kalemli-Ozcan, and Volosovych (2008) find that institutional quality is an important determinant of capital flows.

Although developing countries have lower institutional quality than developed countries, we also know that they experienced a significant increase in the flow of private foreign capital to their private sectors in the late 1980s and early 1990s (World Bank 1997; Stulz 1999). It is therefore natural to ask: was the structural change of capital account liberalization that unleashed

[22] In the case of infrastructure projects that are built and owned by a foreign investor (or consortium of investors), willingness to pay can be interpreted as the extent to which the government honors the terms of the underlying operating agreement, such as the pricing arrangement for infrastructure services.

a surge of capital from Private-Rich to Private-Poor sufficient to trigger an analogously transformational flow of capital from Private-Rich to Public-Poor, or were there additional impediments to infrastructure-specific capital inflows that prevented such a change from occurring?

The question is unresolved, but a comprehensive study by Foster and Rana (1990) documents that the private sector has accounted for slightly greater than 40 percent of new power generation in poor countries since 1990 and its share in renewable power generation is almost twice as high—between 70 and 80 percent. Looking beyond power to private investment in infrastructure more broadly, using data on public private partnerships (PPPs) from the Public Private Infrastructure Advisory Facility (PPIAF), Engel, Galetovic, and Fischer (2020) document that private investment in poor-country infrastructure increased from 1990 through 1997. We are unaware, however, of any systematic attempt to assess the statistical or economic significance of this increase in private infrastructure investment relative to its behavior before liberalization. An obstacle to such enquiry is that the PPIAF data only go back to 1990. It is not clear how to overcome this absence of historical information, but the importance of the question merits further investigation.

Whatever the pre-1990 data may show, a carefully constructed new dataset by Fay, Lee, Mastruzzi, Han, and Cho (2019) indicates that the private sector accounts for only 9 to 13 percent of total infrastructure investment in low- and middle-income developing countries. We can infer that this modest fraction is smaller than it is for rich countries, because Engel, Galetovic, and Fischer (2020) calculate that for the world as a whole, private investment makes up roughly 33 percent of total infrastructure investment, with PPPs accounting for roughly 3 percent of total world infrastructure spending and 8 percent of private infrastructure spending.

Modest as it is, the total value of PPPs in poor countries remains below its pre-Global Financial Crisis level, and a potential explanation for this fact may lie in the market for project finance. Beck (2018) points out that project finance lending to emerging economies did not recover following the Global Financial Crisis the way it did for advanced economies. He goes on to ask whether anticipation of implementation in 2019 of the Basel III regulations—particularly increased capital requirements for project finance lending and liquidity requirements under the Net Stable Funding Ratio and the Liquidity Coverage Ratio—may have made banks more reluctant to fund private investment in emerging-market infrastructure.

In a similar vein, Rojas Suarez (2018) documents that cross-border lending to emerging markets has continued to fall, even as it rebounded in advanced economies after 2013. She shows that as cross-border bank lending has fallen, cross-border issuance of debt securities by EMDEs has increased. From an appropriability perspective, the ability of poor countries to issue debt, particularly in local currency terms, is positive, but the rising levels of financial distress—even pre-COVID—outlined in Section 1 of this paper raises the age-old question of why so little external finance to poor countries is state contingent.

The case of equity shares for the Electricity Generating Authority of Thailand (EGAT) provides a useful example of state-contingent external financing that successfully addresses the question of infrastructure appropriability in the developing world. As the name suggests, EGAT generates electricity then sells it to electricity distribution companies. Officially part of the North Bangkok Power Plant Block 1 Infrastructure Fund (EGATIF), which trades on the Stock Exchange of Thailand (SET), EGAT went public through a partial state divestiture in July 2015 that was initially worth $600 billion. EGATIF’s three largest shareholders are EGAT (committed to hold 25 percent for at least five years), Thai Life Insurance (11.99 percent), and EGAT Saving and Credit Cooperative (8.34 percent). Foreigners currently hold approximately 3 percent of the Fund, and there is a 49 percent limit on foreign ownership.

One successful data point does not the case for appropriability make, but EGATIF is far from the only publicly traded infrastructure fund in the developing world. The S&P Emerging Markets Infrastructure Index, for instance, launched in 2007 to give savers exposure to 30 of the largest publicly traded companies in emerging markets whose core operations are in infrastructure. More than 40 percent of the index, however, is weighted to China, and it contains no African companies. Additionally, the world remains a long way from having publicly tradable financial claims on the incremental additions to GDP generated by building another kilometer of roads or installing another kilowatt of electricity generating capacity in poor countries.

As a bare minimum for the creation of such claims to occur, the social return on infrastructure in poor countries must exceed the financial return on rich-country capital by a margin large enough to: (a) absorb the administrative and institutional fixed costs of creating the claims, and (b) compensate savers for the appropriability and covariance risk of holding them, even while leaving sufficient surplus to incentivize productive arbitrage. The data examined in this paper suggest that there were—and still may be—places with surpluses potentially this large. If it is useful to take seriously the feasibility of GDP-linked bonds in rich countries[23], then the sheer magnitude of the economic return differentials potentially at stake in certain poor countries cries out for research on the risk-reward characteristics of their prospective publicly traded contingent claims (Walter 2017).

6. Conclusion

[23] See, for example, Kamstra and Shiller (2009) and Benford, Ostry and Shiller (2018).

In 2015 the World Bank, together with regional development banks and the International Monetary Fund, issued a communiqué which claimed that by leveraging multilateral resources, private capital in rich countries could alleviate the shortage of infrastructure in poor countries, achieve the sustainable development goals, and make money. Not to be outdone, in 2016 the McKinsey Global Institute launched its own claim—that of a trillion-dollar global infrastructure investment gap, which in turn has captured the imagination and sustained attention of institutions from JP Morgan Chase to the United States Treasury.[24]

While there is undoubtedly a shortage of infrastructure services in the developing world, the dual-hurdle framework demonstrates the importance of distinguishing between poor countries where the World Bank and MGI's claims are tenable from those where they are not. Furthermore, the dual-hurdle approach reveals the importance of many other infrastructure distinctions—roads versus electricity, urban versus rural, inter-city versus intra-city, and so on—that have significant implications for the setting of efficient and equitable investment priorities, as well as the criticality of the research needed to inform attendant decisions. In short, the dual-hurdle framework provides direction for the kinds of data required to enable more fruitful future analysis and decision making, as well as a template that can be applied to the very same data as they become available.

The distinctions highlighted in this paper matter greatly, because the working-age population in rich countries is stagnant or falling. This means that the large discrepancies in infrastructure per worker between rich and poor countries is on course to widen in places like

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[24] See https://www.jpmorgan.com/solutions/cib/investment-banking/2020-dfi-announcement

https://dialogochino.net/en/infrastructure/37481-what-is-america-crece-the-us-response-to-the-belt-and-road-in-latin-america/

Nigeria, whose population ranks seventh globally and will expand between 2.6 and 3 percent per year for the next decade (Lam 2014). All told, between now and 2030, a systemically important subset of poor countries (e.g., Egypt, Bangladesh, India, Pakistan, and the Philippines) will add 1.7 million new workers per month to their labor force—almost twice the 1.1 million per month that China added during its unprecedented growth episode from 1978 to 2012.

In principle, the reallocation of savings from aging rich countries to the financing of publicly efficient and privately profitable infrastructure investments in poor countries where the working-age population is booming has the potential to boost growth for the poor and returns for the rich. Without this reallocation, however, the demographic shift underway will portend increased pressure on immigration-averse rich countries to absorb an ever-greater exodus of workers from poor countries that will lack the productive capacity to generate jobs for their local populations. Achieving the positive-sum outcome will require policy, and the research that informs it, to tread a fact-driven path between the Utopian trap of financing and infrastructure gaps on the one hand and, on the other, nihilistic adherence to a view that regards the status quo as Pareto optimal.

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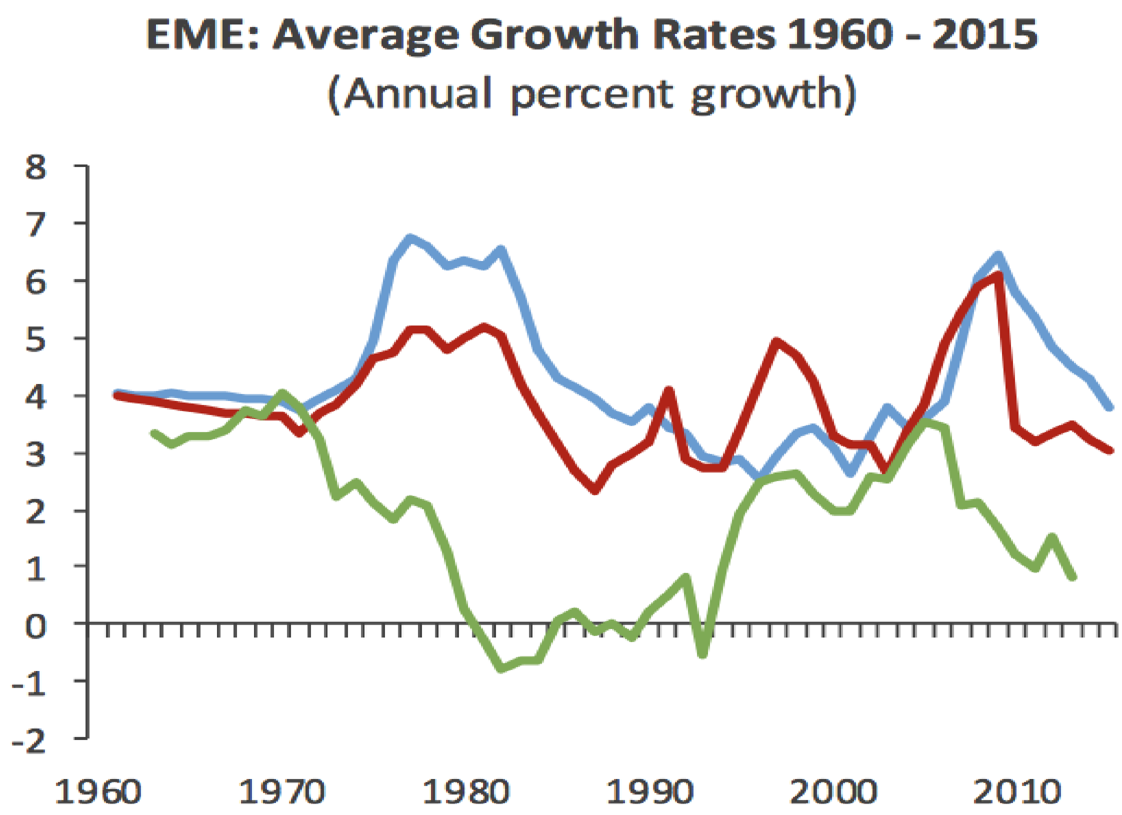
Figure 1. The sharp increase in the growth rate of the public capital stock in emerging-market economies in the 1970s was accompanied by a steep decline in their growth rate of productivity. Public capital stock (blue), output per worker (green), and private capital stock (red).



Source: International Monetary Fund (2017)

Figure 2, Panel A. The Traditional Approach to Cross-Country Efficiency

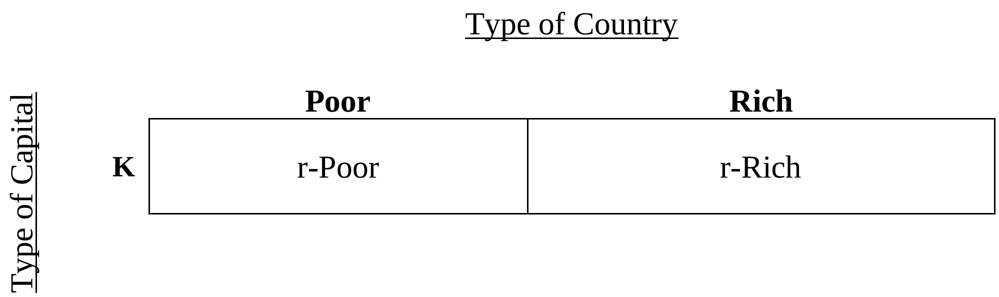


Figure 2, Panel B. The Infrastructure-Augmented Approach to Cross-Country Efficiency

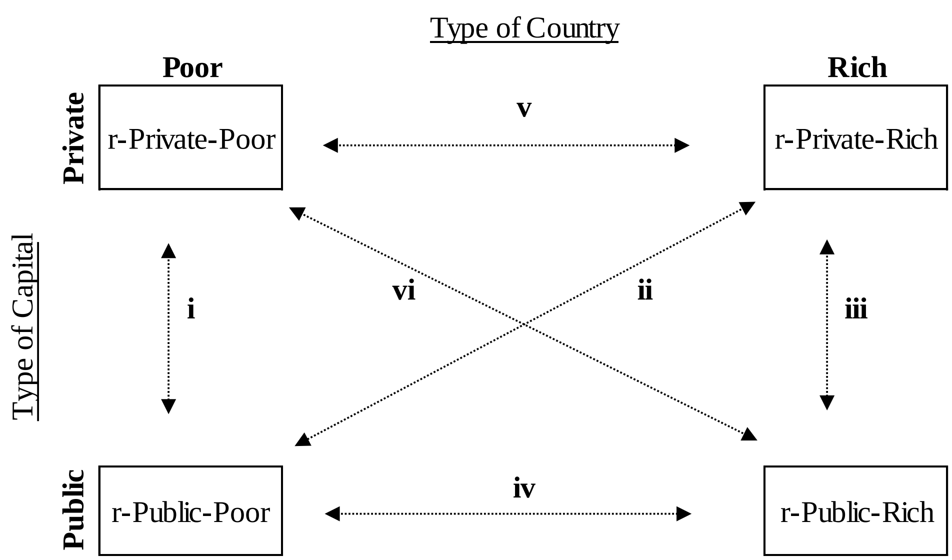


Figure 3. For each type of infrastructure, the dual-hurdle framework sorts countries into one of four quadrants in accordance with their potential for publicly efficient and privately profitable investment.

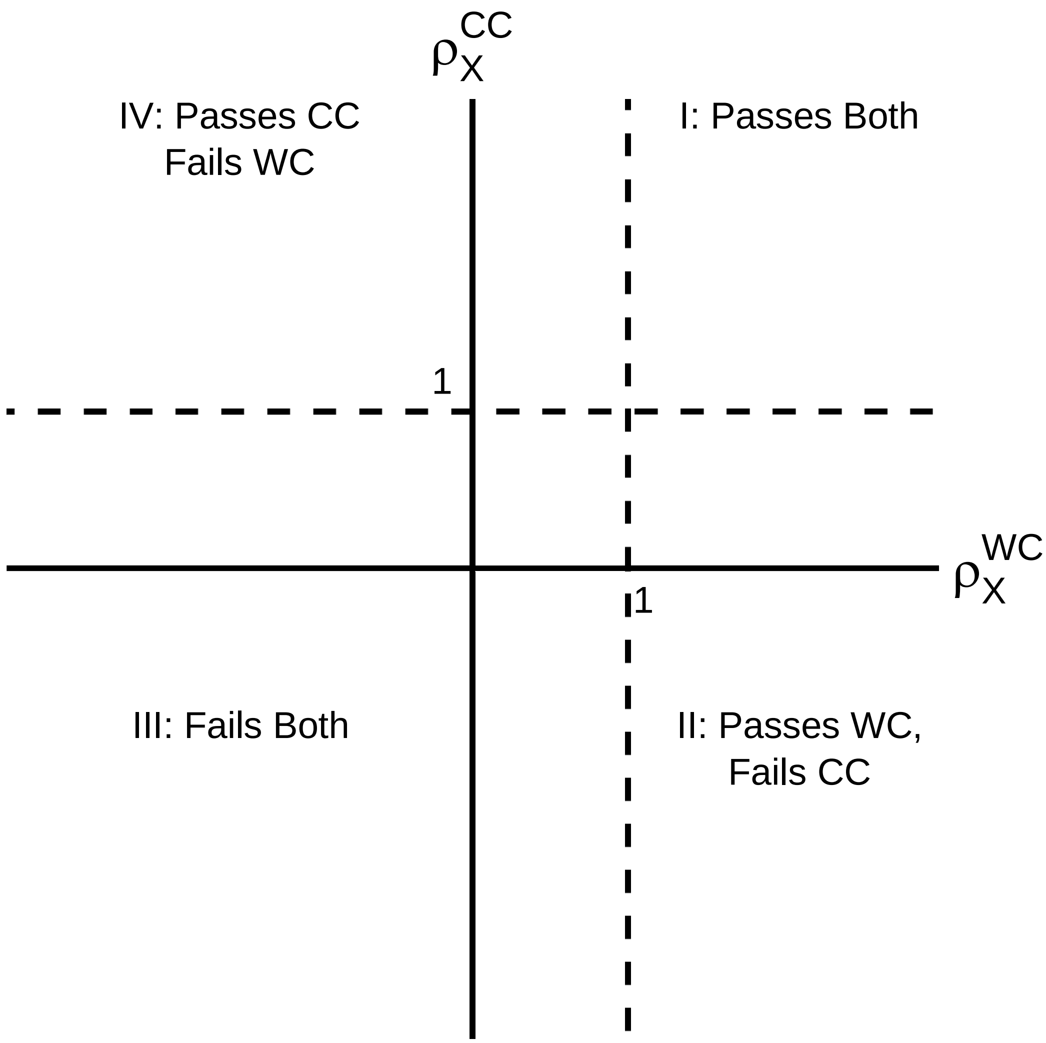


Figure 4. Net inflows of portfolio equity to developing countries soared after they eased restrictions on foreign ownership of domestic stocks in the late 1980s and early 1990s.

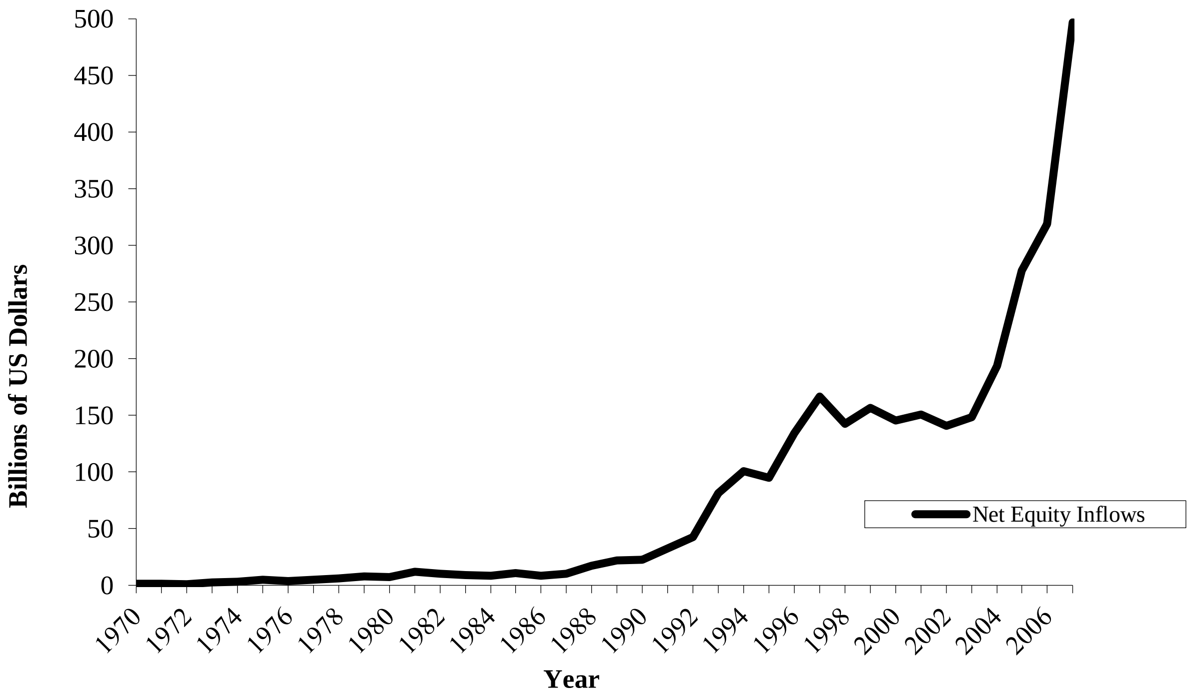


Table 1, Panel A. Within- and Cross-Country Ratios of the Social Rate of Return on Paved Roads

				Poor Countries											
Rich Countries				LAC				Africa				Asia			
	ρ_X^{WC}	ρ_X^{CC}	Quad.		ρ_X^{WC}	ρ_X^{CC}	Quad.		ρ_X^{WC}	ρ_X^{CC}	Quad.		ρ_X^{WC}	ρ_X^{CC}	Quad.
Australia	-0.02	-0.03	III	Argentina	13.3	12.3	I	Botswana	0.34	0.64	III	India	0.96	2.36	IV
Austria	-0.02	0.00	III	Bolivia	37.1	25.4	I	Cameroon	5.31	5.98	I	Indonesia	2.45	6.46	I
Belgium	0.14	0.19	III	Brazil	1.07	1.94	I	Kenya	1.51	1.69	I	Korea	37.0	50.2	I
Denmark	0.4	0.38	III	Chile	7.15	16.7	I	Liberia	6.82	3.31	I	Pakistan	0.45	1.66	IV
Finland	0.68	0.48	III	Colombia	17.5	30.2	I	Malawi	1.50	1.91	I	Philippines	18.0	22.9	I
Germany	0.55	0.51	III	Costa Rica	5.24	6.24	I	Senegal	1.07	1.53	I	Turkey	2.03	5.03	I
Ireland	0.15	0.19	III	Ecuador	3.85	6.27	I	Tunisia	0.36	0.51	III				
Italy	0.76	0.83	III	El Salvador	2.38	3.54	I	Zambia	2.69	2.07	I				
Japan	3.05	1.97	I	Guatemala	2.01	2.42	I	Zimbabwe	0.33	0.48	III				
Netherlands	0.46	0.48	III	Honduras	1.15	1.24	I								
N. Zealand	0.23	0.25	III	Panama	5.76	6.94	I								
Norway	0.08	0.06	III												
Sweden	0.21	0.19	III												
U.K.	0.32	0.41	III												
U.S.A.	0.26	0.22	III												
Countries		15				11				9				6	
Mean	0.48	0.41			8.77	10.29			2.21	2.01			10.15	14.77	
Median	0.26	0.25			5.24	6.27			1.50	1.69			2.24	5.75	
St. Dev	0.75	0.49			10.73	9.86			2.34	1.74			14.74	19.03	

Table 1, Panel B. Within- and Cross-Country Ratios of the Social Rate of Return on Electricity Generating Capacity

				Poor Countries											
Rich Countries				LAC				Africa				Asia			
	ρ_X^{WC}	ρ_X^{CC}	Quad.		ρ_X^{WC}	ρ_X^{CC}	Quad.		ρ_X^{WC}	ρ_X^{CC}	Quad.		ρ_X^{WC}	ρ_X^{CC}	Quad.
Portugal	0.14	0.22	III	Argentina	1.59	1.46	I	Algeria	4.20	2.01	I	Bangladesh	0.77	1.94	IV
				Bolivia	4.74	2.93	I	C.A.R.	3.25	1.27	I	China	1.31	1.72	I
				Brazil	0.16	0.32	III	Congo	4.58	3.63	I	Fiji	1.06	1.02	I
				Chile	0.56	1.31	IV	Egypt	0.9	1.43	IV	India	0.4	0.76	III
				Colombia	0.50	0.89	III	Gambia	4.49	3.34	I	Indonesia	1.7	3.38	I
				Costa Rica	0.69	0.80	III	Ghana	1.37	0.80	II	Jordan	0.96	1.27	IV
				D.R.	0.42	0.80	III	Kenya	6.63	3.98	I	Korea	0.68	0.99	III
				Ecuador	0.90	1.43	IV	Malawi	1.35	1.72	I	Malaysia	1.76	2.45	I
				El Salvador	0.40	0.54	III	Mali	2.16	1.62	I	Myanmar	1.03	1.08	I
				Guatemala	0.52	0.57	III	Mozambique	0.42	0.22	III	Nepal	0.72	1.27	IV
				Honduras	3.56	3.03	I	Niger	0.92	0.38	III	Pakistan	0.19	0.57	III
				Jamaica	0.54	0.35	III	Senegal	0.25	0.19	III	P. New Guinea	0.26	0.19	III
				Mexico	0.98	1.62	IV	Tunisia	1.08	1.27	I	Philippines	1.25	1.40	I
				Nicaragua	0.67	0.64	III	Uganda	40.0	2.55	I	Sri Lanka	0.31	0.86	III
				Panama	0.55	0.67	III	Zimbabwe	0.14	0.16	III	Syria	0.44	1.11	IV
				Peru	0.51	0.67	III					Thailand	0.69	1.34	IV
				Uruguay	0.59	0.96	III					Turkey	0.45	1.02	IV
Countries		1		Countries		17				15				17	
Mean	0.14	0.22		Mean	1.05	1.12			4.78	1.64			0.82	1.32	
Median	0.14	0.22		Median	0.56	0.80			1.37	1.43			0.72	1.11	
St. Dev	0	0		St. Dev	1.22	0.80			9.93	1.26			0.48	0.74	

Table 2, Panel A. Return on All Capital in 1985 in Poor and Rich Countries

Rich Countries			LAC			Africa			Asia			Poor Countries	
	r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}	r_K	ρ_{ALL}^{CC}
Australia	30	0.96	Argentina	29	0.92	Algeria	15	0.48	Bangladesh	80	2.55		
Austria	29	0.92	Bolivia	21	0.67	Botswana	58	1.85	China	41	1.31		
Belgium	40	1.27	Brazil	58	1.85	Cameroon	35	1.11	India	78	2.48		
Denmark	30	0.96	Chile	73	2.32	C.A.R.	12	0.38	Indo	83	2.64		
Finland	22	0.70	Colombia	55	1.75	Congo	25	0.80	Fiji	30	0.96		
Germany	29	0.92	Costa Rica	37	1.18	Egypt	50	1.59	Jordan	42	1.34		
Ireland	36	1.15	D.R	61	1.94	Gambia	23	0.73	Korea	45	1.43		
Italy	34	1.08	Ecuador	51	1.62	Ghana	18	0.57	Malaysia	44	1.40		
Japan	20	0.64	El Salvador	47	1.50	Kenya	19	0.61	Myanmar	33	1.05		
Netherlands	32	1.02	Guatemala	38	1.21	Liberia	15	0.48	Nepal	56	1.78		
N. Zealand	36	1.15	Honduras	34	1.08	Malawi	40	1.27	Pakistan	117	3.73		
Norway	21	0.67	Jamaica	20	0.64	Mali	24	0.76	P. New Guinea	24	0.76		
Portugal	46	1.46	Mexico	52	1.66	Mozambique	17	0.54	Philippines	40	1.27		
Sweden	29	0.92	Nicaragua	30	0.96	Niger	13	0.41	Sri Lanka	86	2.74		
U.K.	39	1.24	Panama	38	1.21	Senegal	45	1.43	Syria	80	2.55		
USA	29	0.92	Peru	40	1.27	Tunisia	37	1.18	Thailand	61	1.94		
			Uruguay	41	1.31	Uganda	2	0.06	Turkey	78	2.48		
						Zambia	24	0.76					
						Zimbabwe	45	1.43					
Min	20	0.64		20	0.64		2	0.06		24	0.76	2	0.06
Max	46	1.46		73	2.32		58	1.85		117	3.73	117	3.73
Mean	31.4	1.00		43.2	1.36		27.2	0.87		59.9	1.91	42.64	1.36
Median	30	0.96		40	1.27		24	0.76		56	1.78	40	1.27
St. Dev	7.1	0.22		14.5	0.46		15.1	0.48		25.5	0.81	22.95	0.73

Table 2, Panel B. Return on All Capital in 1996 in Poor j and Rich Countries

Rich Countries			LAC			Africa			Asia			Poor Countries	
	r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}	r_K	ρ_{ALL}^{CC}
Australia	12	0.90	Argentina	28	2.11	Cameroon	9	0.68	China	9	0.68		
Austria	11	0.83	Bolivia	2	0.15	Kenya	12	0.90	India	11	0.83		
Belgium	13	0.98	Brazil	34	2.56	Mozambique	25	1.88	Indonesia	21	1.58		
Denmark	14	1.05	Chile	26	1.95	Niger	14	1.05	Jordan	10	0.75		
Finland	12	0.90	Colombia	22	1.65	Senegal	17	1.28	Malaysia	26	1.95		
Germany	10	0.75	Costa Rica	15	1.13	Tunisia	14	1.05	Philippines	34	2.56		
Ireland	23	1.73	D.R	30	2.26				Sri Lanka	14	1.05		
Italy	15	1.13	Ecuador	17	1.28				Thailand	19	1.43		
Japan	12	0.90	Guatemala	23	1.73				Turkey	35	2.63		
Netherlands	7	0.53	Honduras	9	0.68								
N. Zealand	10	0.75	Mexico	16	1.20								
Norway	11	0.83	Panama	15	1.13								
Portugal	19	1.43	Peru	24	1.80								
U.K.	14	1.05	Uruguay	26	1.95								
USA	16	1.20											
Min	7	0.53		2	0.15		9	0.68		9	0.68	2	0.15
Max	23	1.73		34	2.56		25	1.88		35	2.63	35	2.63
Mean	13.3	1.00		20.5	1.54		15.2	1.14		19.9	1.50	19.2	1.29
Median	12	0.90		22.5	1.69		14	1.05		19	1.43	17	1.13
St. Dev	3.91	0.29		8.67	0.65		5.49	0.41		9.98	0.75	8.56	0.59

Table 2, Panel C. Return on All Capital in 2005 in Poor and Rich Countries

Rich Countries			LAC			Africa			Asia			Poor Countries	
	r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}		r_K	ρ_{ALL}^{CC}	r_K	ρ_{ALL}^{CC}
Australia	14	0.94	Argentina	19	1.28	Cameroon	10	0.67	China	12	0.81		
Austria	13	0.87	Bolivia	2	0.13	Kenya	8	0.54	India	16	1.07		
Belgium	15	1.01	Brazil	22	1.48	Mozambique	22	1.48	Indonesia	16	1.07		
Denmark	14	0.94	Chile	22	1.48	Niger	6	0.40	Jordan	15	1.01		
Finland	15	1.01	Colombia	19	1.28	Senegal	14	0.94	Malaysia	10	0.67		
Germany	14	0.94	Costa Rica	17	1.14	Tunisia	15	1.01	Philippines	20	1.34		
Ireland	22	1.48	D.R	29	1.95				Sri Lanka	12	0.81		
Italy	16	1.07	Ecuador	14	0.94				Thailand	14	0.94		
Japan	13	0.87	Guatemala	19	1.28				Turkey	39	2.62		
Netherlands	14	0.94	Honduras	9	0.60								
N. Zealand	18	1.21	Mexico	24	1.61								
Norway	13	0.87	Panama	28	1.88								
Portugal	10	0.67	Peru	28	1.88								
U.K.	16	1.07	Uruguay	17	1.14								
USA	16	1.07											
Min	10	0.67		2	0.13		6	0.40		10	0.67	2	0.13
Max	22	1.48		29	1.95		22	1.48		39	2.62	39	2.62
Mean	14.9	1.00		19.2	1.29		12.5	0.84		17.1	1.15	17.2	1.10
Median	14	0.94		19	1.28		12	0.81		15	1.01	16	1.01
St. Dev	2.7	0.18		7.47	0.50		5.8	0.39		8.71	0.58	7.7	0.44

Table 3, Panel A. Rank Ordering of Efficient Investment Opportunities in Paved Roads

	ρ_X^{CC}
Bolivia	25.4
Korea	50.2
Philippines	22.9
Colombia	30.2
Argentina	12.3
Chile	16.7
Liberia	3.31
Panama	6.94
Cameroon	5.99
Costa Rica	6.24
Ecuador	6.27
Zambia	2.07
Indonesia	6.46
El Salvador	3.54
Turkey	5.03
Guatemala	2.42
Senegal	1.53
Kenya	1.69
Malawi	1.91
Honduras	1.24
Brazil	1.94
Mean	10.20
Median	5.99
St. Dev	12.49

Table 3, Panel B. Rank Ordering of Efficient Investment Opportunities in Electricity Generating Capacity

	ρ_X^{CC}
Uganda	2.55
Kenya	3.98
Bolivia	2.92
Congo	3.63
Gambia	3.34
Algeria	2.01
Honduras	3.02
Central African Republic	1.27
Mali	1.62
Malaysia	2.45
Indonesia	3.38
Argentina	1.46
Malawi	1.72
China	1.72
Philippines	1.40
Tunisia	1.27
Myanmar	1.08
Fiji	1.02
Mean	2.28
Median	2.01
St. Dev.	0.95