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

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Abstract

This paper critically reviews the literature that claims poor countries have an infrastructure investment gap of roughly 1 trillion dollars per year and therefore possess widespread opportunities for productive spending on infrastructure. The review employs a simple framework that concludes this claim is invalid. The framework compares a poor country's social rate of return on infrastructure investment with: (a) the poor country's return on private capital, and (b) the average rich country's return on private capital. The dual comparison reveals 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 exceeds both the return on poor-country private capital and the return on rich-country private capital. This dual-hurdle rate framework suggests a two-by-two classification that sorts countries into quadrants according to their potential for efficient investment in infrastructure. The paper then applies the classification to the only existing, comprehensive cross-country estimates of the social rate of return on infrastructure (electricity and paved roads). The conventional wisdom is that there are ubiquitous opportunities for infrastructure investment that meet the two criteria. In fact, only 7 of 53 developing countries clear the dual-hurdle rate in both electricity and paved roads. Where it is efficient to invest, however, the potential for excess returns on infrastructure is quite large—six times larger, in fact, than the excess returns that existed, but have long since been arbitraged away, in emerging-market stocks when foreigners were first permitted to own shares. The framework thus implies a new definition of the infrastructure gap as the amount of investment required to close the difference between the return on infrastructure in poor countries and the return on private capital elsewhere. More importantly, the framework moves the discussion away from alarmism and exaggeration toward the clarity that economics can and should bring to any policy discussion.

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1. Introduction

A slow recovery after the Great Recession revived interest in the recurrent but empirically unsubstantiated notion that more infrastructure investment offers a route to faster growth in advanced economies. 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..." Refurbishment of roads and other hardscape may have a modest impact on U.S. GDP, but Gramlich's (1994) observation that the surge of interest in infrastructure is "out of proportion to its likely long run importance" creates 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; IMF 2015; Summers 2015).

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 poor ones, the emerging and developing economies (EMDEs), in which: (1) Latin America has $1/4^{th}$ the infrastructure capital per capita of North America; (2) Emerging and Developing Asia have less than $1/5^{th}$ that of Advanced Asia; and (3) Africa's GDP growth might increase by 2.6 percentage points if its infrastructure capital per capita matched South Korea's (Foster and Briceno-Garmendia 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 that will be 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 trivializes 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 an unfortunate similarity to its intellectual antecedent—the "financing gap" that 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. The donors failed, because they did not ask whether filling the gap with "needed" investment would actually correct some market failure, incentivize production, and endogenously raise incomes (Easterly 2001).

Beyond the failure of the 1950s aid agenda, Figure 1 provides a sobering reminder of the complex relationship between infrastructure and output in EMDEs. Growth of the public capital stock, a proxy for infrastructure whose limitations we discuss later, increased from 4 percent per year in the 1960s to almost 7 percent per year in the 1970s and early 1980s. Productivity growth, in contrast, slowed precipitously and actually turned negative. Although infrastructure spending

has a lagged impact on output, and exogenous shocks during the 70s and 80s (e.g., oil crises and recessions) negatively affected developing countries, the increase in public expenditure did not ultimately raise productivity and contributed to the Third World Debt Crisis (Rogoff 1991). Given the onset of financial distress in African countries that signed infrastructure loans under China's Belt and Road Initiative (Reinhart 2020; Signé 2018), as well as outright default by Sri Lanka, Figure 1 underscores the potential for another era of debt crisis and wasted resources if decision makers continue to adhere to gap thinking.

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 940 million lack access to electricity (Fay and Rozenberg 2019a). 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 lie on the production possibilities frontiers of developing nations.

This paper introduces a new framework for distinguishing the potential of a feasible and efficient global allocation of infrastructure from the wasteful one that is likely to result from the status quo. The paper does 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.

For a given poor country, the first comparison 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, in spite of serial campaigns touting the importance of infrastructure for development (World Bank 1994, 2005, 2007), World Bank leadership has not provided the information required to drive fact-based decisions about infrastructure investment in poor countries. The only comprehensive cross-country estimates of the return on infrastructure (paved roads, electricity) provided by the Bank are based on 1985 data. Second, contrary to conventional wisdom that poor countries contain ubiquitous opportunities for investment in publicly efficient and privately profitable infrastructure, applying the dual-hurdle framework to the data demonstrates that 7 of 53 poor

countries cleared 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 folly of allowing the normative infrastructure-gap narrative to proceed unchecked.

For countries that did clear the dual hurdles, however, the average return on infrastructure was 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 1.7 times greater than the expected return on the S&P 500. In other words, the excess-return multiple on poor-country infrastructure was 6-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.

Even in countries where excess returns were orders of magnitude greater than those of portfolio equity, however, the absence of tradable financial claims on infrastructure in the 1980s made it impossible to pursue private, rich-country financing of public, poor-country capital. Tradable claims on poor-country infrastructure still do not exist at scale, but the dual-hurdle analysis provides a framework for distinguishing those countries where the creation of tradable claims might be beneficial from those countries where it would not. Too much has happened since 1985 to draw any distinctions on the basis of data from that year, but the new analysis of old information in this paper: (a) provides a template that can readily be applied to updated, cross-country data on the social return on infrastructure; and (b) demonstrates the urgency of the World Bank collecting and disseminating that data as soon as possible.

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 over the past three decades have focused on evaluating the relevance of the four Lucas (1990) hypotheses—differences in human capital; human capital externalities; political risk; and restrictions on foreign investment—as to why capital does not flow from rich to poor countries to equalize incomes and rates of return.[1] 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 private versus public capital (e.g., infrastructure).

The private versus public distinction matters because recent work documents that the return on public capital varies much more than the return on private capital, and the variation in public returns is greater in poor countries than in rich ones.[2] 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 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

[1] Add citations.
[2] See Lowe, Papageorgiou, and Perez-Sebastian (2018)

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, instead of one return comparison required to assess allocative efficiency—*r*-Poor versus *r*-Rich—there are now four choose two: (i) *r*-Private-Poor vs. *r*-Public-Poor (ii) *r*-Private-Rich *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, and the other four can be 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 doomed from the start. 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. 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.[3] Similarly, let $K^*$and X^*denote the stocks of private and infrastructure capital in the rich country. With these definitions in place, Figure 3 visually depicts a new framework for evaluating, simultaneously, a poor country's potential for efficient investment in infrastructure and its ability to attract 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, 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

[3] In practice, the former is a subset of the latter. Our subsequent empirical analysis acknowledges the practical distinction.

has too much infrastructure relative to private capital; this does not necessarily mean that a 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 the figure 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 efficiently allocated 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., $\rho_x^{CC} > 1$).

The intersection of the within- and cross-country hurdles divides the $(\rho_x^{WC}, \rho_x^{CC})$ 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 governance caveats).

Quadrant III ($\rho_x^{WC} < 1,\ \rho_x^{CC} < 1$) consists of countries in which the return on infrastructure fails to clear both the within- and cross-country hurdles. 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 dollars finance it instead.

3. 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 in the 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 developing and 16 developed), and 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 the social rates of return on each type of infrastructure. Of the 53 developing 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.[4] 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 come from 1985 World Bank data, and therefore, so too, in effect, do their return estimates, a limitation we discuss in Section 4.

Panel A of Table 1 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. 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}; the third column lists the

[4] Need a double counting footnote

quadrant into which each country sorts given its values of ρ_x^{WC} and ρ_x^{CC}.

The most striking observation about the rich countries in Panel A is that they are overinvested in roads. Fourteen of 15 sort into Quadrant III; ρ_x^{WC} for the rich-country cluster has a mean (median) value of 0.48 (0.26) and is less than 1 in every country except Japan. 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 do not support the notion that these nations were teeming with opportunities for efficient and privately financeable infrastructure investment, even though that might appear to be the case at first blush. Panel A, for instance, 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, however, a much smaller fraction of poor countries—18 of 49—sorted into Quadrant I. Notably, 15 of the 18 countries that sort into Quadrant I for electricity were classified as "low-income." Accordingly, the case for 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.

Aggregating across roads and electricity, 39 of the 75 country-infrastructure return observations sorted into Quadrant I. The reality that 52 percent of the country-infrastructure-return observations cleared the dual-hurdles suggests that the potential for efficient and privately financeable investment in poor-country infrastructure was not at all ubiquitous. Indeed, 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 hurdle for either type of infrastructure and were therefore not obvious candidates for additional investments in either roads or electricity. Said another way, 40 percent of the 53 developing countries for which data are available had no returns-based case for investment in infrastructure. Digging deeper, of the 32 countries with projects that did clear the dual hurdle, there were only 7—Argentina, Bolivia, Honduras, Indonesia, Kenya, Malawi, and the Philippines—whose return ratios made a case for potential investment in both roads and electricity.

The truth 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 productive and profitable investment in both roads and electricity raises questions about the wisdom of the current "billions to trillions" approach to infrastructure in the developing world. Furthermore, for each of the 36 country-infrastructure-return observations that failed to sort into Quadrant I, it is far more likely that it was not efficient for the country associated with the observation to allocate relatively more resources to infrastructure—i.e., the country landed in Quadrant III (23 observations), or, Quadrant IV (12 observations)—than it was for the country to have efficient infrastructure opportunities for which there was no reasonable prospect of attracting private foreign capital. In fact, there was only 1 example of this latter case: Ghana (Quadrant II).

3A. Paucity of Prevalence and the Lucas Paradox

Given the underwhelming presence of efficient and profitable investment opportunities in roads and electricity, it is natural to ask whether this fact is new or simply an infrastructure-specific manifestation of the Lucas (1990) conjecture that after adjusting for differences in the

productivity of human capital the implied return on all capital in poor countries is not significantly higher than it is in rich ones. To examine the extent to which this 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 paradox, 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.

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

Turning 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} greater than 1. With the exceptions of Algeria, Argentina, which was in the midst of hyperinflation in 1985, and Jamaica, which was recovering from a decade of wide-scale nationalization of private industries, 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. Indeed, splitting the sample of poor countries by income throws the observation into relief. Thirty-five of the 38 poor countries that are not "low income" 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 all others is 1.61 (1.53).

The facts in Panel A are not peculiar to the Canning and Bennathan (2000) data from which they are drawn, Panel B of Table 2 presents another set 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 presents figures on returns only for the 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} 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, appear to exist. For instance, Of the 32 unique countries identified as having had Quadrant I opportunities for investment in infrastructure 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.[5] Furthermore, of the 7 countries that

[5] 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.

made it into Quadrant I for both roads and electricity, 3—Argentina, Bolivia, and Kenya—had returns on all capital below that of the rich-country average. There were, in other words, poor countries to whose private sectors rich-country capital had little incentive to flow that nonetheless had the potential to be efficient and profitable destinations for rich-country investment in infrastructure.

The counterintuitive fact 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 rich-country private capital into poor-country infrastructure is the rich-country return on private capital. 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 be an efficient destination for rich-country savings to finance infrastructure 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 an empirical reality.

3B. Magnitude and Welfare Implications

When Lucas observed in 1990 that capital had not been flowing to poor countries, his preferred hypothesis as to why was as follows: once properly adjusted for cross-country differences in human capital, the implied difference between *r*-Poor and *r*-Rich was not big enough to induce flows from rich countries. As it turned out, the human capital explanation was less relevant than another hypothesis proposed by Lucas: capital did not flow from rich to poor countries, because poor countries maintain barriers to private capital inflows. We know that

Lucas' barriers-to-private-capital-flows hypothesis was relevant, because, ironically, poor countries eased restrictions on foreign ownership of domestic stocks shortly after the publication of Lucas's article. Figure 4 documents the flood of capital from Private-Rich into Private-Poor that followed.[6] Liberalizing the access of Private-Rich savers to Private-Poor capital catalyzed 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). It is therefore natural to ask whether the potential for capital flows from Private-Rich to Public-Poor presents an opportunity for similarly large unrealized welfare gains.

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 *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 the excess-return multiple for roads is anywhere from to 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 private capital. Similarly, Panel B of Table 3 gives the values of ρ_x^{CC} for the 18 countries with Quadrant I opportunities for electricity generating capacity. The mean (median) value of ρ_x^{CC} for electricity—2.2 (1.87)—is

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

also bigger than the ratio of *r*-Private-Poor to *r*-Private-Rich. In this case, however, the excess return multiple is a less eye-popping 1.6 times larger than the excess return multiple for private capital.

We can also gauge the welfare consequences of the non-equalization of *r*-Public-Poor with *r*-Private-Rich versus 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 1.7 times greater than the expected return on the S&P 500. As this excess return was largely arbitraged away in the aftermath of liberalization, 1.7 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 4.8 (8.2 divided by 1.7) to 6 (10.2 divided by 1.7) 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-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. The magnitude of this inefficiency has increased over time and explains why the deadweight loss from the misallocation of public capital is 4.8 times larger than that which would come about from equalizing the marginal product of private capital; world GDP would be 9 percent higher than its current level if the marginal product of public capital was equalized across countries (Lowe, Papageorgiou, and

Perez-Sebastian 2018)

4. Plausibility, Foundations, and Limitations

The dual-hurdle framework brings the clarity of equilibrium, 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). 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 quality 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 private capital, *H* is human capital, *X* is infrastructure capital, and *L* is the stock of labor.[7] Reformulating (1) in intensive form, $y = k^{\alpha}h^{\beta}x^{\gamma}$, so that output,

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

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, $r_x = \frac{mpx}{P_x}$, 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 $r_{k^*} = \frac{mpk^*}{P_{k^*}}$, 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 US 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 ratio of poor country GDP per capita to developed country GDP per capita is roughly 1/5 (Maddison 2003, p. 234). Taking the US 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 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^*. By convention, α^*= 1/3. Arriving at a consensus for γ requires a more extensive review 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 roads today offer 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, the literature points to a value of γ that ranges from 0.07 to 0.1.[8] 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

[8] Bom and Lighthart (2008) conduct a meta-study in which they find an elasticity of 0.087.

numbers—crude bounds on what theory and the relevant literature tell us should be a kind of 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.[9] As the upper and lower bound 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, depending on which end of the range countries fall for certain parameters.

The variation in these back-of-the-envelope calculations is 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 country-specific estimates of ρ_x^{CC}.

4A. Country-Specific Infrastructure Returns and Data Limitations

As part of their process for producing country-specific infrastructure returns, Canning and Bennathan (2000) explore how the infrastructure-elasticity of output across countries varies with their levels of physical, human, and infrastructure capital per worker. They do this by calculating elasticities (γ) for three fictitious countries: (1) a moderately poor country with each of the three factor inputs at the lower quartile for their 53-country sample; (2) an average country

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

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. On their own, infrastructure investments do not generate large changes in output, but they can be very productive in economies with sufficiently high levels of physical and human capital as they raise the efficiency of both. Said another way, the key to catch-up growth for poor countries is not simply "more infrastructure."

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 1990s as they implemented reforms and raised levels of total factor productivity, 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 in the 1990 data. Even if we stipulate that infrastructure growth in poor countries has not kept pace with growth in output, however, such a conclusion is 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 data and using it to replicate the Canning and Bennathan (2000) procedure to estimate country-specific values of γ.

Turning to the denominator of $\frac{mpx}{P_x}$ reveals similar limitations related to the age of the

available data. Canning and Bennathans's information on the cost of building roads and electricity in developing countries is from 1985. Yesteryear's roads and grids may not be today's infrastructure (Leifman, Fay, Nicolas, and Rozenberg 2019). 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. Again, the only way to resolve these and many other unanswered questions about infrastructure is through the compilation of more recent data (Estache and Fay 2007), and the institution best positioned to provide these data is the World Bank.

In spite of its age, however, 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 estimates represent the frontier of empirical knowledge about the social rate of return on infrastructure in developing 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 advanced economies, but Canning and Bennathan provide the only explicit and comprehensive estimates of the economy-wide rate of return on infrastructure in developing countries.

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 any 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).

A related exception to the paucity of estimates of the social return on infrastructure in developing countries is a small but careful body of individual country studies that document causal effects of infrastructure on various measures of output in developing countries. The introduction of the railroad in colonial India raised output levels by 16 percent (Donaldson 2018). Data from the modern era (1992-2010) in India indicate an important effect of power-related infrastructure on the efficiency of Indian manufacturing (Allcott, Collard-Wexler, and O'Connell 2016). As a complement to country-level studies, where the interpretation of even the most careful results are tempered by questions of causality, a number of articles conduct microeconomic analyses that demonstrate a positive impact of infrastructure, electricity in particular, on the economies of developing countries (Dinkelman, 2011; Lee, Miguel, and Wolfram 2016). In similar fashion to the microeconomic literature, World Bank project evaluations of 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). While micro studies and project evaluations provide helpful reality checks against which to benchmark aggregate estimates of the social rate of return, aggregate estimates are important to have because the economic rate of return on individual project can miss important 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 accurate 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 made accordingly actually delivered the expected results. A thorough examination of the 1985 data on prospective returns helps do that**.** Keeping in mind that social rates of return on infrastructure in developing countries may be quite different today than they were 35 years ago, the next section asks why the return differentials persist, and what, if anything, can be done about them.

5. Appropriability

The existence of social rates of return on infrastructure in certain developing countries that are far higher than the return on private capital in advanced economies gives rise to the following questions: (1) what are the factors that prevent the realization of the productive potential of these investment opportunities; and (2) what, if anything, can be done to mitigate those factors? Adequate answers to those questions require acknowledgment that although higher rates of return are a necessary condition for developing countries to be able to attract capital from abroad 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 social rate of return on infrastructure—their private return—to induce them to undertake socially productive investments in infrastructure. And even when the expected private 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 returns. Broadly speaking, however, all of these factors fall under one of the following categories: asymmetric information or moral hazard/agency problems. Consider

each category in turn.

Asymmetric information can inhibit foreign investors in two ways. First, potential foreign investors in infrastructure, who have limited knowledge of a given developing country, may worry about adverse selection or the "lemons" problem, wherein only countries with the lowest prospective returns on infrastructure offer them the opportunity to invest. The lemons problem can also take the form of developing 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 developing 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 implement projects in a way that makes private finance feasible. Public sector actions that make private finance feasible, such as setting a high enough price for the infrastructure service, can reduce the ability of potential users in poor countries to pay for the service.[10] Resolving this tension between feasibility and inclusivity requires local officials to have a set of skills that may not be easily observable by foreign investors, thereby causing them to under-invest.

Whereas asymmetric information about the quality of projects or the public sector's implementation 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. In the context of private financing of infrastructure, where the government does not issue its own debt obligations, willingness to pay can be interpreted as the extent to which the government is committed to honoring the terms of the underlying operating agreement, such as the pricing

[10]Reducing the cost of resolving insolvency makes it easier to achieve greater private financing and lower price for service, suggesting that improved creditor rights facilitate private finance (Fay, Martimort, and Straub 2018).

arrangement for infrastructure services. Even if the government wants to undertake good projects with high social rates of return and has the capacity to implement those projects, its ability to attract private financing requires a demonstrated willingness to repay, which cannot be taken for granted given considerations of domestic political economy (Stulz 2005).

Elections, for example, may present short-run political benefits of nonpayment to the party in power that outweigh any costs, 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 (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, no-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: (a) they experienced a significant increase in the flow of foreign capital to their private sectors in the late 1980s and early 1990s **(**World Bank 1997; Stulz 1999**)**, and (b)

there was no commensurate increase in the flow of private foreign capital into infrastructure; as of 2017, public private partnerships (PPPs) accounted for at most 10 percent of all infrastructure investment in developing countries (Fay, Martimort, and Straub 2018). Taken together, (a) and (b) suggest that whatever institutional changes were responsible for unleashing a surge of capital from the private sector of rich countries into the private sector of poor countries (e.g., removal of capital controls), these changes were not sufficient to trigger transformational flows of capital from the private sector of rich countries into the infrastructure sector of poor ones.

Drawing on the new dataset compiled by Fay, Lee, Mastruzzi, Han, and Cho (2019), the World Bank database on private participation in infrastructure (World Bank 2017), and the literature on capital flows to the private sector of developing countries (e.g., Henry 2007), this section of the paper will provide the first systematic synthesis of the facts outlined in the previous paragraph. Because infrastructure capital is a complement to private sector capital, the observation that policies that lead to increased foreign investment in the private sector of developing countries do not necessarily increase private participation in developing-country infrastructure has important implications for growth.

Therefore, in contrast to previous work that focuses on the general reasons why capital flows to developing countries fall short of what theory predicts, future research would do well to examine the infrastructure-specific impediments to capital flows described above and ask whether any of these impediments constitute market failures that could usefully be addressed by changes in policy. In the process of doing so, this research should consider: (1) reasons why the promise of PPPs has failed to materialize (Engel, Fischer, and Galetovic 1997, 2013); (2) the empirical validity of claims that regulatory changes in the aftermath of the global financial crisis have further hindered markets' ability to allocate private capital to infrastructure in developing

countries; and (3) the importance of strengthening institutions versus encouraging more creative financial engineering as a way of incentivizing flows of capital into infrastructure investment in developing countries.

6. **Conclusion**

Because the working-age population in advanced economies is stagnant or falling, the large discrepancies in infrastructure per worker are on course to widen in developing nations like 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 developing 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 combination of a boom in the developing world's working-age population and a reallocation of savings from slower-growing rich countries to the financing of productive infrastructure investments in poor countries has the potential to boost both global growth and the return on savings in aging rich countries, ease the global savings glut, and delivering a positive-sum outcome for the world economy. Without rapid and sustained infrastructure investment in certain parts of the developing world, however, the demographic shift underway will portend, instead, increased pressure on immigration-averse advanced nations to absorb an ever-greater exodus of workers from 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 (self-evidently) Pareto optimal.

Given that there do not yet exist tradable financial claims on the incremental additions to GDP generated by building another kilometer of roads or installing another kilowatt of electricity generating capacity, the social return on infrastructure must exceed the financial return on rich-country capital by a margin large enough to absorb the costs of creating such claims while leaving sufficient surplus to incentivize productive arbitrage. The data suggest that there were—and still may be—places with surpluses potentially this large. For countries that cleared the dual hurdles for roads in 1985, the excess-social-return multiple on poor-country infrastructure was 6-fold the excess-financial return multiple that existed on portfolio equity in poor-countries before foreigners were legally permitted to own shares.

Unlike the flood of savings that poured into emerging equity markets in the aftermath of capital market liberalization in the 1990s, appreciable quantities of private capital have not flowed from rich countries to poor-country infrastructure, because the return differentials that exist are a necessary but not sufficient condition for flows to occur. The key to sufficiency is appropriability. Foreigners must be able to appropriate a large enough share of the social return on infrastructure—their private return—to induce them to undertake socially productive investments. Even when the expected private return on infrastructure is high, uncertainty about appropriability may imply levels of risk that are simply too large to justify investment.

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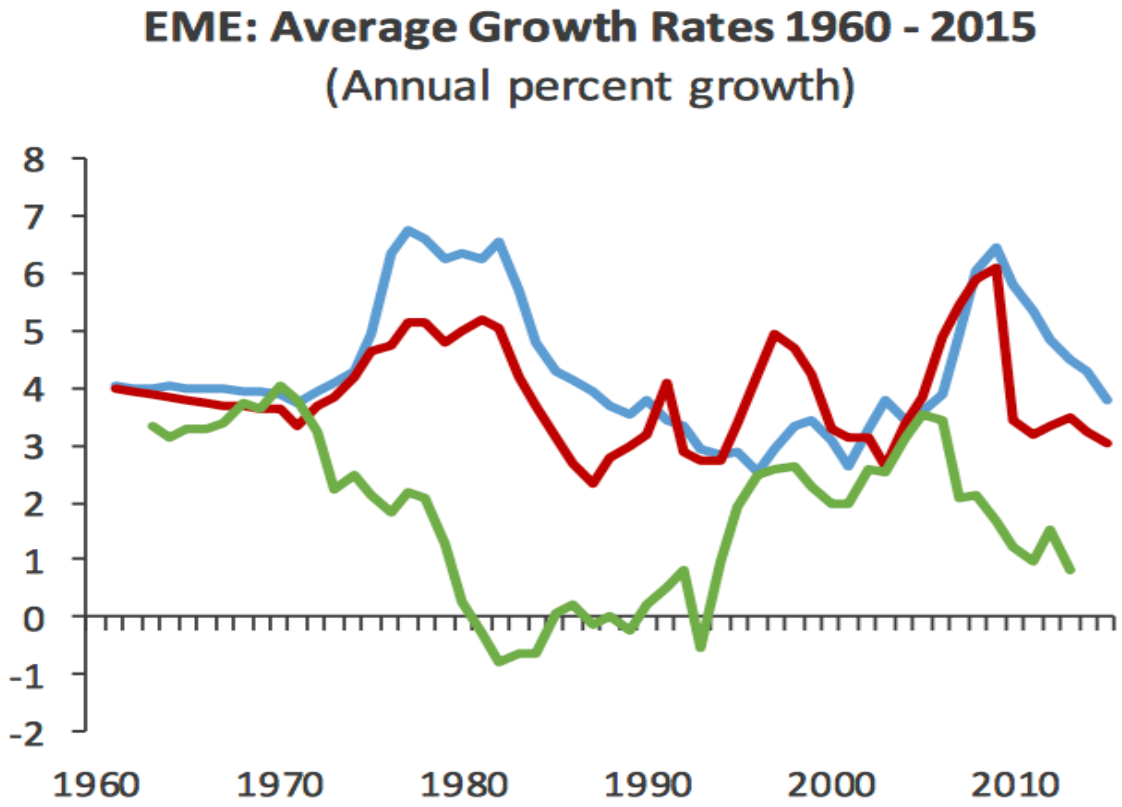
Figure 1. The sharp increase in the growth rate of the public capital stock in emerging-market economies in the 1970s was accompanied by a steep decline in their growth rate of productivity. Public capital Stock (blue), output per worker (green), and private capital stock (red).



Source: International Monetary Fund (2017)

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

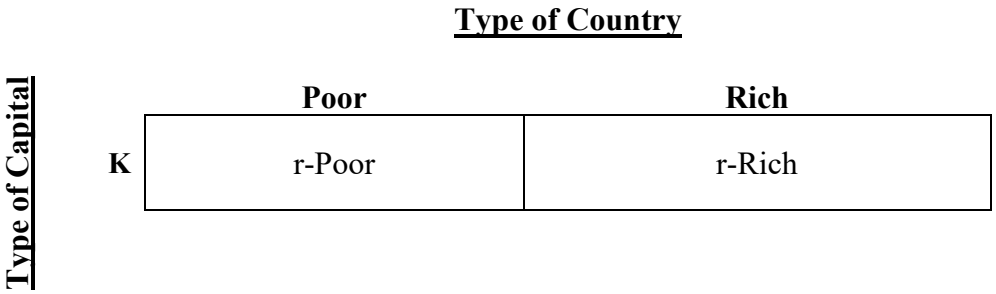


Figure 2, Panel B. The Infrastructure-Augmented Approach to Cross-Country Efficiency

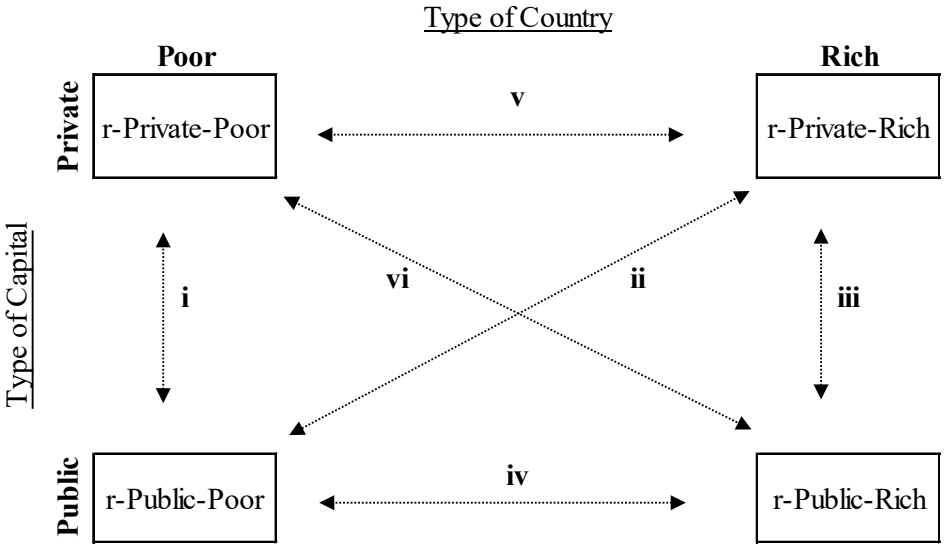


Figure 3. For each type of infrastructure, the dual hurdle rate framework sorts countries into one of four quadrants in accordance with their potential for publicly efficient and privately profitable investment.

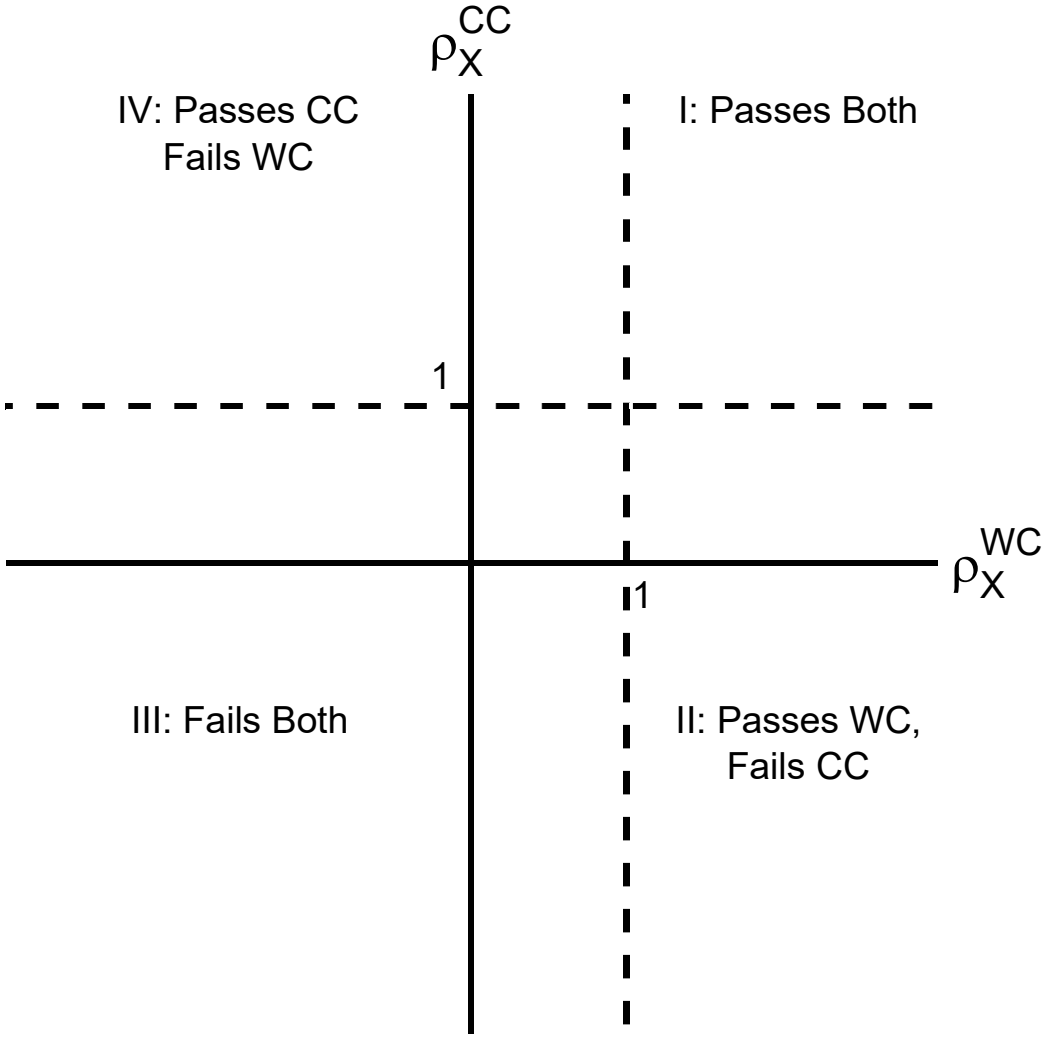


Figure 4. Net inflows of portfolio equity to developing countries soared after they eased restrictions on foreign ownership of domestic stocks in the late 1980s and early 1990s.

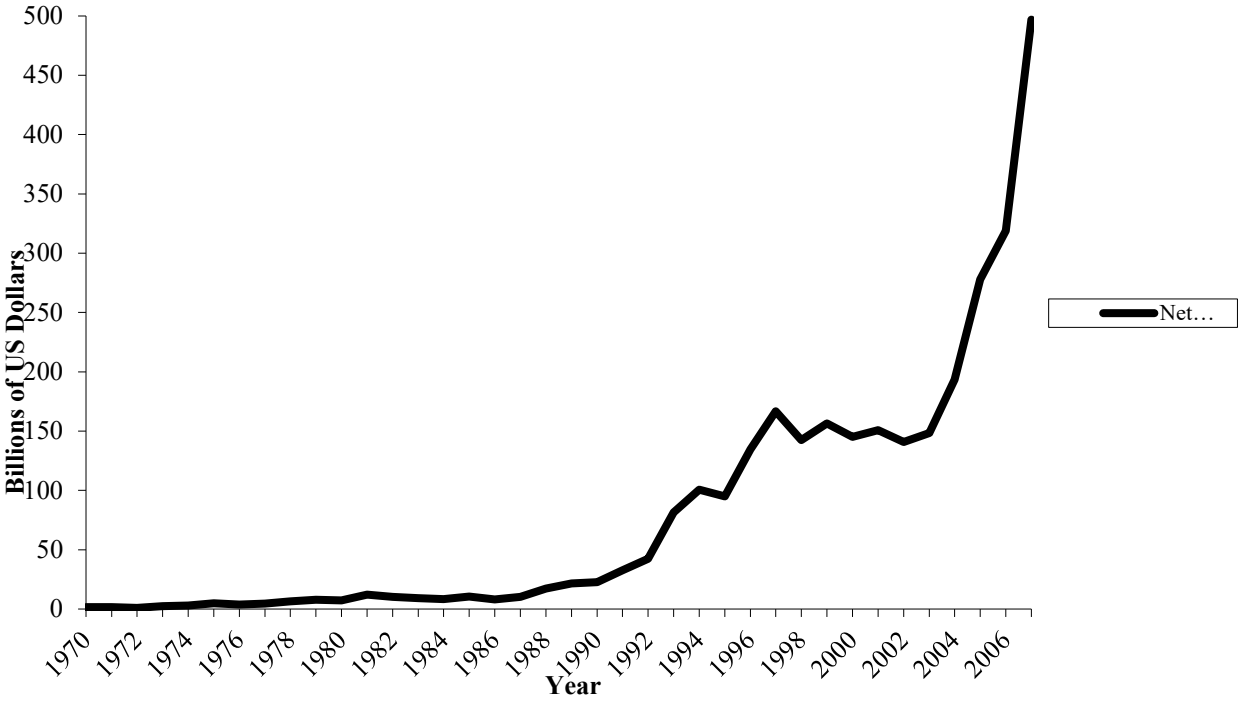


Table 1, Panel A. Within and Cross-Country Ratios of the Social Rate of Return on Paved Roads

Rich Countries				Poor 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

Rich Countries				Poor 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 Capital in 1985 in Poor and Rich Countries

Rich Countries			LAC			Africa			Asia			Poor Countries	
	ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}	ρ_X^{CC}	ρ_K^{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 Capital in 1996 in Poor and Rich Countries

Rich Countries			LAC			Africa			Asia		Poor Countries	
	ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}	ρ_X^{CC}	ρ_K^{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	
	ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}		ρ_X^{CC}	ρ_K^{CC}	ρ_X^{CC}	ρ_K^{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 the Opportunities for Efficient Investment in 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