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

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Abstract

This paper evaluates 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 evaluation introduces and 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: (1) efficient only if the return on poor-country infrastructure exceeds the return on poor-country private capital; and (2) financeable through private rich-country savings only if the return on poor-country infrastructure exceeds 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—five 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

The slow recovery of the American economy following the Great Recession revived interest in the recurrent—roughly vicennial—but empirically unsubstantiated notion that a higher rate of infrastructure investment offers an ongoing and neglected route to greater national prosperity. Following the 1990–91 recession, for example, policymakers pointed to Aschauer (1989) as justification for higher levels of infrastructure spending (U.S. Conference of Mayors 1992; Rohatyn 1992). But Munnell (1992) and others demonstrated that Aschauer's estimates of the impact of infrastructure investment on aggregate output were implausibly large, with Fernald (1999) concluding that "the data seem consistent with a story in which 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...." While selective refurbishment of roads and other American hardscape may be in order and have a modest impact on output, Gramlich's (1994) observation that the surge of interest in U.S. infrastructure is "all out of proportion to its likely long run importance" creates a déjà-vu moment at a time when talk of secular stagnation (Eichengreen 2015; Gordon 2015; Summers 2015) has prompted yet another debate about the merits of a big push.

Indeed, if there is a plausible argument for an increased focus on infrastructure as a path to significant long-run output gains, the case hangs not on the U.S., or even other advanced countries, but rather on emerging and developing economies (EMDEs), in which: (1) Latin America has 1/4th the infrastructure capital per worker of North America; (2) Emerging and Developing Asia have less than 1/5th the infrastructure capital per worker of Advanced Asia; and (3) some estimates suggest that Africa's growth rate of GDP *per capita* would increase by 2.6 percentage points per year if its infrastructure endowment were equal to South Korea's (Foster

and Briceno-Garmendia 2010). These large discrepancies in infrastructure per worker are on course to widen in the decade ahead, because the working-age population in advanced economies is stagnant or falling while it continues to grow in developing nations like Nigeria, whose population ranks seventh globally and will expand between 2.6 and 3 percent per year from now until 2030. Additionally, a number of large, heavily populated countries in Africa and Asia (e.g., Egypt, Bangladesh, India, Pakistan, and the Philippines) will experience similar rates of labor-force growth during this time frame (Lam 2014). All told, between now and 2030, a systemically important subset of the least developed countries will add an average of 1.7 million new workers per month to their labor force—more than one and a half times the 1.1 million per month that China added during its unprecedented episode of economic growth 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, delivering a positive-sum outcome for the world economy. Furthermore, without rapid and sustained infrastructure investment in certain parts of the developing world, the demographic shift underway will portend, instead, increased pressure on immigration-averse advanced nations to absorb an ever-greater exodus of workers from a group of developing countries whose economies will lack the productive capacity to generate jobs for their local populations.

But fundamental as it is to recognize that the potential welfare gains from greater infrastructure investment in EMDEs outstrip those in the developed world, it is equally important to acknowledge that, like the U.S., emerging markets are susceptible to the perils of recurring fads about the promise of infrastructure (Estache and Fay 2007). To illustrate the point, consider

the McKinsey Global Institute's (MGI) definition of its widely cited "global infrastructure gap": the trillion-dollar difference between the quantity of investment in infrastructure that is scheduled to take place globally between 2015 and 2030 and the amount of investment that MGI says will be needed to achieve the projected growth rate of global GDP over that time frame (McKinsey Global Institute 2016; World Bank 2016; World Economic Forum 2016). Scarcity in developing countries notwithstanding, this definition of an infrastructure gap oversimplifies the challenge of capitalizing on cross-country differences in infrastructure, because it does not acknowledge that the discrepancy between scheduled and "needed" infrastructure spending represents an equilibrium outcome of the interactions between savers and investors given the opportunities and incentives they face.[1]

In failing to recognize explicitly the connection between incentives and investment, the "global infrastructure gap" bears an unfortunate similarity to its intellectual antecedent—the "financing gap" of Harrod-Domar (Domar 1946) that gave birth to the field of development economics in the 1950s. Much 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), this implies a financing gap equal to the difference between the two quantities. Armed with the intellectual framework of the financing gap, donors (multilateral and bilateral) from advanced countries tried to help poor nations grow by filling the gap with foreign aid (Easterly 2001). Their efforts failed and resources were squandered, because with a myopic focus on the gap donors failed to ask whether filling the gap with "needed" investment would actually correct some market failure, incentivize private production, and endogenously

[1]As discussed in Section 2 of the paper, Rozenberg and Fay (2019) offer a complementary critique of the global infrastructure gap that argues for defining "needs" in terms of specific infrastructure objectives (e.g., meeting the infrastructure-related Sustainable Development Goals) instead of general infrastructure spending targets (e.g., $1 trillion per year from now until 2030).

raise incomes in equilibrium.

Moving beyond the specific failure of aid, Figure 1 provides a sobering reminder that more general expenditures on infrastructure in the developing world have an underwhelming track record. The graph, which plots, for all EMDEs, the growth rate of the public capital stock (an imperfect proxy for infrastructure whose limitations are discussed in Sections 3 and 5 of this paper) against the growth rate of productivity, demonstrates that the growth of spending on public capital increased from an average of about 4 percent per year in the 1960s to almost 7 percent per year in the 1970s and early 1980s. In contrast, productivity growth slowed precipitously during this period, and actually turned negative in the early 1980s.

While there were exogenous shocks during the 70s and 80s that negatively impacted productivity in developing countries—an oil crisis and a major recession in the advanced economies, for example—two things must be acknowledged: First, the increase in expenditure on infrastructure did not have the intended impact on output per worker. Second, the rapid rise in developing country governments' expenditure was almost surely a contributing factor to the onset of the Third World Debt Crisis in a number of the countries from which the data are comprised. Given the International Monetary Fund's (IMF) recent warning about the rising risk of financial distress in African countries that have taken on non-concessional loans to finance infrastructure projects, summarized in the Brookings Institution's *Africa in Focus* blog (Signé 2018), and outright default by some countries on Chinese loans under the One Belt One Road Initiative, Figure 1 underscores the potential for another era of wasted resources, protracted debt workouts, and possibly worse if we blindly resurrect gap reasoning.

And yet, the fact remains that 940 million people in the developing world lack access to electricity, and 1 billion live more than two kilometers from an all-season road (Fay and

Rozenberg 2019a). Because the absence of electricity is particularly acute in precisely those developing countries where the working-age population is expanding most rapidly—their per capita generation capacity is 1/40th that of advanced economies—it is a real possibility that the scarcity of power infrastructure in certain emerging economies is a first-order bottleneck to global growth. World Bank Enterprise Surveys, conducted on 47,179 firms in 108 economies from 2006 to 2010, indicate that 41 percent of managers consider a lack of access to electricity to be a "major or very severe" obstacle to their operations and the biggest challenge to their business, ahead of crime, access to finance, and an inadequately educated labor force (Geginat and Ramalho 2015). Flooding EMDEs with loans or free grids will not cure their shortage of electricity, but it also strains the imagination to maintain that the combination of a plethora of people plus a paucity of power and roads will yield GDP outcomes that lie on the production possibilities frontiers of countries in the developing world.

2. Contribution

There has not been a critical review of the literature on infrastructure in a leading academic journal since the contributions of Munnell and Gramlich. Furthermore, those reviews focus exclusively on the U.S. and do not mention emerging and developing economies (EMDEs). There are studies of the impact of infrastructure on economic efficiency and growth in emerging economies (Calderón 2009; Fay et al. 2017). But this work does not systematically connect the research on infrastructure in developing countries to the broader forces at work such as demographics, urbanization, and premature industrialization that have critical implications for the rate of return on infrastructure investment in EMDEs and its potential impact on employment and growth in both developing and developed countries.

In contrast, this paper provides a critical synthesis of the literature that is relevant to the imbalances in the global distribution of infrastructure and the economic implications for advanced and developing countries that follow from their existence given other forces at work. By pulling together a wide and previously disparate set of intellectual threads, the paper weaves a narrative that will catalyze future research at the intersection of these areas and treads 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. The paper argues that if a globally efficient allocation of infrastructure (and the savings needed to finance it) is the goal, then, instead of looking at infrastructure "gaps," research devoted to understanding the prevalence of cross-country differences in the rate of return on infrastructure, as well as their causes and consequences, will be more fruitful.

Specifically, the paper presents a simple framework for evaluating the productive potential of investing in infrastructure that explicitly and simultaneously compares the social rate of return on infrastructure in emerging economies with the rate of return on alternative investment opportunities in: (a) the local environment, and (b) advanced economies. This dual-hurdle rate framework yields a unique classification that sorts countries into quadrants according to their potential for efficient investment in infrastructure. The quadrant-based classification flows naturally from a simple but powerful result: adding to a given country's stock of infrastructure capital is both economically efficient and potentially financeable through a market-based allocation of foreign savings only when the return on doing so exceeds the return on all capital (infrastructure and non-infrastructure) in both the local economy and the developed world.

The paper applies this result, and the framework from which it is derived, to what is, to

the best of my knowledge, the only explicit set of estimates of the social rate of return on infrastructure (paved roads and electricity-generating capacity) in a comprehensive set of developing countries (Canning and Bennathan 2000). There are a total of 53 developing countries, 26 of which have data for the return on paved roads and 49 for the return on electricity generating capacity (EGC), yielding a total of 75 country-infrastructure-return observations. Of these 75 observations, 71 exceed the mean return on the corresponding type of infrastructure in advanced economies, and the returns differ, on average, by a factor of 21 in paved roads and a factor of 6 in EGC. In spite of this reality, however, opportunities for efficient investment in the infrastructure of EMDEs are not nearly as widespread as the large prospective return differentials would otherwise seem to suggest.

Just 39 of the 75 observations (distributed across 32 developing nations) clear both the cross-country and within-country hurdle rates for efficient investment. This means that 21 of the 53 countries, or roughly 40 percent, do not clear the dual hurdle for either type of infrastructure and are therefore not obvious candidates for additional investments in paved roads or electricity generating capacity. Furthermore, of the 32 countries with projects that clear the dual hurdle, only 7 are places where it is efficient to engage in additional investments in both kinds of infrastructure. The reality that the data from less than one-seventh of the countries present a clear case for investment in both roads and electricity raises questions about the wisdom of big-push approaches to infrastructure in the developing world.

The “Lucas Paradox” (Lucas 1990) cannot explain these findings, because the average rate of return on all capital for the 53 developing countries is 1.4 times as large as the average return on all capital for advanced economies, and 35, or roughly two-thirds, of the developing countries in the sample have higher rates of return than the advanced economy average. The

results, instead, are driven by two additional facts.

First, developed countries are over-invested in infrastructure relative to their other forms of capital. This has driven down their return on infrastructure to the point where the yield on another dollar invested in the infrastructure of advanced economies is less than their overall return on capital. Accordingly, the binding constraint for market-driven cross-border investment from developed countries into emerging-economy infrastructure is actually not the return on infrastructure in developed markets but rather the return on all capital in developed markets, and there are fewer developing countries whose returns on infrastructure clear this more stringent hurdle rate.

Second, in order for additional investment in infrastructure in a given developing country to be efficient, its rate of return on infrastructure must exceed its own return on all capital. The imposition of this second hurdle rate renders still fewer countries as candidates for efficient investment in infrastructure.

In addition to providing a more discriminating lens through which to judge the potential for productive outcomes, the dual-hurdle framework reveals that efficient investment in emerging-market infrastructure depends on a rich set of interactions between international and domestic optimality conditions, yielding some counterintuitive results. For instance, a country whose return on all capital is less than that of advanced economies can nonetheless be an efficient destination for advanced-economy savings to finance infrastructure if: (a) the return on investing in that country's infrastructure exceeds the return on all capital in advanced nations, and (b) the country's return on infrastructure exceeds its own return on all capital.

The potential for this kind of counterintuitive outcome is more than a theoretical curiosum. Ten of the 32 countries whose social rates of return on infrastructure justify greater

investment in paved roads or electricity generating capacity have rates of return on all capital that fall below the rate of return on all capital in the developed countries. There are poor countries with badly functioning private sectors where infrastructure investment can, in principle, be productively deployed.

While the opportunities for efficient investment in infrastructure are not ubiquitous, they do exist and can be quite large. For example, of the 39 country-infrastructure-return observations that suggest opportunities for efficient investment, 21 are in paved roads where the average (median) social rate of return is 10.2 (5.99) times larger than the return on capital in advanced economies. The average (median) prospective return for the 18 efficient investment opportunities in electricity generating capacity are more modest: 2.2 (1.87) times as large as the return on capital in advanced economies. In addition to the opportunities for efficient investment in EGC being substantially smaller than in the case of paved roads, another notable difference is that the potential for efficient investment in EGC manifests primarily in low-income countries—particularly those in Africa—whereas the opportunity in paved roads falls mainly to middle-income developing nations. To place the magnitude of the potential for efficiency gains in both paved roads and electricity in context, prior to the liberalization of restrictions on foreign ownership of domestic stocks in the late 1980s and early 1990s, the expected return on publicly traded emerging-market equity was roughly 1.7 times greater than the expected return on the S&P 500. The order of magnitude of the potential in paved roads is thus 6 times this size; in electricity, it is a less eye-popping 1.3 times as large.

Reviewing the literature through the lens of the dual-hurdle framework complements the important work of Rozenberg and Fay (2019), who push the global infrastructure debate away from a myopic emphasis on more money toward an approach of more efficient spending.

Specifically, Fay and Rozenberg (2019a) argue that instead of setting general targets for expenditure, countries should establish specific infrastructure needs and objectives 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; (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, 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 were to maximize productive efficiency—achieving an allocation of capital that equalizes the social rate of return on infrastructure in LMICs with the return on all capital in those countries, as well as with the return on all capital in advanced economies. 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 a vision of the infrastructure that countries need—it is instructive to let the data on capital returns speak to what the market (i.e., consumers, firms, savers, and investors) demands, and to whether that demand is being met.

Now, 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 incentivize supply to meet excess demand, 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 all capital at home or abroad. Nevertheless, the magnitude of the return differentials 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 the extent that needs-based approaches to guiding the allocation of infrastructure are broadly consistent with considerations of productive efficiency, we should see, on average, the highest prospective return on infrastructure in precisely those sectors identified as "high need." Low prospective returns on investment in high-need sectors, on the other hand, raise questions about the economic sustainability of identified priorities. While they need not prove dispositive, social returns on infrastructure in an area identified as high need that are lower than in other sectors should raise yellow flags about targeted investment in the given area.

Just as investigating the efficiency of prospective infrastructure investments through a framework of returns provides a complementary check on needs-based approaches, it can also serve as a useful bound on the optimism for the potential of private-sector gains to drive future supply responses through the creation of market mechanisms that currently do not exist. To the extent that the existing return differentials are large enough to absorb the frictional costs of overcoming the obstacles to creating new markets and leave sufficient surplus to still incentivize productive arbitrage, cautious optimism may be justified. If, on the other hand, the orders of magnitude of the return differentials are small, it may be unrealistic to expect them to catalyze meaningful private participation in the market for infrastructure.

Previous work has implicitly considered the importance of returns by using panel data regressions to estimate the elasticity of GDP with respect to various measures of infrastructure

investment (Bougheas, Demetriades, and Mamuneas 2000; Esfahani and Ramirez 2003). But this work does not compute the explicit returns on infrastructure investment implied by their estimated elasticities. While Canning and Bennathan (2000) take this line of work a step further and do compute the social rate of return on infrastructure in a given country and compare it to the rate of return on all capital in the domestic economy, they do not systematically compare the return on infrastructure to the return on all capital in advanced economies, much less apply the simultaneous domestic-and-foreign hurdle rate framework articulated in this paper.

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. These issues notwithstanding, a consensus has emerged that: (a) these econometric challenges are manageable with careful attention to regression techniques and thoughtful interpretation of the estimated parameters, and (b) investment in infrastructure does, in fact, have a causal impact on growth (Estache and Fay 2007).

Keeping in mind the limitations of making inferences about the efficiency of prospective infrastructure investments on the basis of return calculations subject to the preceding caveats, the proposed article will draw on insights from a wealth of individual country studies (e.g., Donaldson 2018; Allcott, Collard-Wexler, and O'Connell 2016), microeconomic studies (e.g., Dinkelman 2011; Lee, Miguel, and Wolfram 2016), and the project evaluation literature from the World Bank (Estache and Fay 2007; Shafik 2005; Briceño, Estache, and Shafik 2004) to augment the aggregate data. In turn, the aggregate estimates complement the microeconomic and project evaluation literature, because the economic rate of return on an individual project can

miss important country-wide externalities (Canning and Bennathan 2000; Estache and Fay 2007).

More important than any particular estimate, the dual-hurdle lens through which this paper reviews the literature provides a simple and rigorous framework for objective evaluation. Rather than delivering a definitive verdict about those countries where additional investment in infrastructure is efficient versus those where it is not, this framework brings positive analysis and the discipline of equilibrium to a global infrastructure debate that has so far been largely normative. In doing so, it also provides a template—a first step toward the kind of tractable yet discriminating analysis that can be easily replicated on better and more recent data as they become available in the future.

The rest of this paper proceeds as follows: Section 3 briefly reviews the economics of infrastructure, provides an overview of the geographic distribution of infrastructure capital per capita, and makes the case for returns over gaps. Section 4 revisits the Lucas Paradox in the context of its implications for the global infrastructure debate. Section 5 presents and examines the data on infrastructure returns in developed and developing countries. Section 6 introduces the dual-hurdle framework and the quadrant classification of countries that flows from it. Section 7 discusses potential explanations for the persistence of differences in the return on infrastructure between certain developed and developing countries and asks what, if anything, can be done to allow private markets to bring about more efficient outcomes. Section 8 concludes with some thoughts on the implications for investment in infrastructure of premature deindustrialization, disruptive technologies, and urbanization, along with a few other speculative topics.

3. Infrastructure: Basics, Geographic Distribution, and the Case for Returns over Gaps

While often treated as an implicit variable in the Cobb-Douglas representation of the aggregate production process, infrastructure capital is a fundamental complement to labor and non-infrastructure capital inputs, and can be modeled explicitly through the following reformulation that exhibits the standard mathematical properties of a production function:

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

where A is total factor productivity, K is the stock of non-infrastructure capital, X is the stock of infrastructure capital, and L is the stock of labor.

In its broadest sense, the term "infrastructure" encompasses two categories of land-use-intensive physical assets: (1) social infrastructure (e.g., schools and hospitals) and (2) economic infrastructure (e.g., energy, transportation, telecommunications, and water). This paper focuses on economic infrastructure, which affects productivity and output directly as a part of GDP formation (e.g., building a road) and indirectly as an input to the production function of other sectors.

In the absence of infrastructure, there is little incentive for firms and entrepreneurs to engage in systematic, large-scale production and the accumulation of knowledge and private capital necessary to drive it. Poor roads, for example, inhibit the overland transport of goods from producers to consumers, and substandard ports effectively cut off domestic producers from foreign markets. Similarly, if a country has an inadequate water supply, public health suffers and the labor force is less productive and (effectively) grows more slowly, both of which are disincentives to production and investment.

These simple examples illustrate that infrastructure generates positive externalities, with the standard consequence that left to its own devices the market will provide less infrastructure than is socially optimal. For this reason, governments have traditionally played a significant role

in providing infrastructure services by investing in and operating infrastructure capital. An important issue, therefore, is the extent to which alternative institutional arrangements that internalize the externalities by enabling the private supply of infrastructure capital—and the private appropriation of the returns from its contributions to GDP—could lead to a more efficient provision and allocation of infrastructure services within and across countries.

3A. Geographic Distribution of Infrastructure Capital Per Capita

As an initial step toward addressing this issue it is useful to take a closer look at geographic endowments of infrastructure capital—as a whole, as well as by sectors and regions. The challenge in doing so, however, is that comprehensive data on infrastructure are shockingly scarce (Estache and Fay 2007; Fay and Rozenberg 2019a). Because data on the stock of infrastructure capital are not readily available for a number of developing countries, the IMF (2014) constructed a cross-country time series on the stock of public capital. Although a significant fraction of the public capital stock in most countries is infrastructure, and the government is the principal underwriter of those assets, the public capital stock includes land, administrative buildings, and other non-infrastructure components. Therefore, to check the suitability of public capital as a proxy for infrastructure, the IMF also constructed a synthetic index of infrastructure capital per capita for all countries with the requisite data. The elements of the index are: power, roads, and telephones. Over the period from 2005 to 2011, the correlation between the infrastructure index and the public capital stock per capita is 0.77, and a one-percentage-point increase in public capital per person is associated with a 0.73 percentage-point increase in infrastructure per capita.

Because the correlations suggest that the public capital stock is a reasonable, if imperfect,

proxy, the IMF reports the following figures for infrastructure capital per capita in 2005 purchasing power parity (PPP) dollars: Advanced Asia: $27,500; North America: $22,000; Advanced Europe: $13,000; Latin America: $6,000; Emerging and Developing Asia: $5,000; Sub-Saharan Africa: $1,250. Taken as a whole, emerging and developing economies (EMDEs) have 1/5th the infrastructure endowment of the advanced economies (AEs). For Africa, the number is 1/20th. Latin America has 1/4th the infrastructure endowment of North America; Emerging and Developing Asia have 1/6th that of Advanced Asia.

Moving from countries to sectors, the smallest infrastructure endowment in EMDEs is in the area of power. Per capita power generation capacity in low-income countries is 1/40th that of advanced economies, and the 48 countries of Sub-Saharan Africa (population 800 million) generate roughly the same amount of electricity as Spain (population 45 million).

3B. The Economic Case for Returns Instead of Gaps

The geographic variation in per capita endowments of infrastructure highlights that in addition to a myopic focus on the normative notion of how much countries should spend, at the expense of remembering the importance of equilibrium, the concept of a global infrastructure gap suffers from a second critical limitation. Namely, because the global infrastructure gap presents the estimated shortfall of annual infrastructure spending across countries as monolithic, overemphasizing a single number that ignores region- and country-specific heterogeneity, it therefore masks the most economically significant infrastructure disparity that exists—the one between the stock of infrastructure capital per capita in developing countries and that of the developed world.

Thinking about infrastructure from this perspective—one of relative scarcity—forces an

objective observer to confront what country-specific differences in stocks of infrastructure capital per capita imply for the incentive to allocate savings toward investment in an additional unit of infrastructure capital in the developing world versus deploying it elsewhere. In turn, the social rate of return on infrastructure investment is a natural metric for conducting the cost-benefit analysis of such tradeoffs. As a rubric for guiding decisions that will drive efficient behavior, the simple and intuitive principle of comparing the social return on infrastructure in an EMDE to the return on non-infrastructure-related investment in that country, as well as to the return on investment in advanced economies, has at least two advantages over gap thinking.

First, because differences in the rate of return on infrastructure across developing and developed countries are a function not only of their endowments of infrastructure per capita but also of differences in the levels of their stocks of human capital (*L*), non-infrastructure capital (*K*), and total factor productivity (*A*—which is, in turn, a function of the economic efficiency of the policies and institutions in those countries), the dual-hurdle framework for evaluating prospective infrastructure investment introduced in Section 6 of the paper inherently incorporates the principles of scarcity and equilibrium. Second, positive cost-benefit analyses that reflect the intrinsic motivations of savers and investors and that explore, taking these motivations as given, whether it is possible for markets to internalize the social benefits of infrastructure are more likely to yield useful insights than normative approaches that ask if planned infrastructure investment is in line with a nebulous notion of need.

3C. Reservations about Returns

In spite of its advantages, the returns-rooted-in-scarcity approach to evaluating infrastructure investment requires caution, because relative to advanced economies, developing

countries also lack the human capital, non-infrastructure capital, institutions, and policies that are important for growth. This means that the optimal mix of sectoral investments will vary across countries, and the key to catch-up growth for the developing world is not simply "more infrastructure."

Indeed, estimating the elasticity of output per worker with respect to electricity and roads using a trans-log production function that allows for flexibility in rates of return on factor inputs across countries, Canning and Bennathan (2000) document rapidly diminishing returns to both roads and electricity when taken in isolation. They also find, however, that roads and electricity are complementary to physical and human capital. In other words, infrastructure investments on their own do not generate large changes in output, but they can be very productive in economies with sufficiently high levels of physical and human capital, and infrastructure itself raises the productivity of investments in both kinds of capital. Specifically, Canning and Bennathan examine whether the elasticity of output with respect to infrastructure is higher in countries that have higher levels of physical, human, and infrastructure capital per worker by calculating the elasticity of output with respect to electricity and roads for three fictitious countries: (1) a moderately poor country with each of the three factor inputs at the lower quartile for their sample of fifty-three countries; (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.

These elasticities are broadly in line with those reported by Calderón, Moral-Benito, and Servén (2011). Using a production function framework, a panel of 88 countries, and a synthetic index of infrastructure similar to the IMF's, the three authors estimate that the elasticity of output

with respect to infrastructure is between 0.07 and 0.1.[2] Additionally, by conducting a number of tests, they find that the elasticity of output does not vary systematically with countries' population, GDP per capita, or endowment of infrastructure per capita. This invariance is somewhat surprising, because most infrastructure is provided through networks, which are characterized by economies of scale and threshold effects and would suggest that the elasticity of output with respect to infrastructure 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. When a certain threshold of infrastructure is reached—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. 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.

Using panel data from Canning (1998), 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. Consistent with Calderón, Moral-Benito, and Servén (2011), however, Candelon et al. do not find evidence of threshold effects with respect to country income levels; the elasticity of output with respect to infrastructure is not significantly related to the level of GDP per capita.

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

Although there is no evidence that the elasticity of countries' output with respect to infrastructure varies with GDP per capita, the data do suggest that the elasticity of countries' output with respect to electricity and roads taken separately depends on the state of completion of each of those networks, as well as the country's per capita endowment of other productive inputs. Since we know that the state of electricity completion and the state of road completion varies across countries (as do per capita endowments of productive inputs), out of an abundance of caution, the analysis of infrastructure returns in the sections ahead will use the data on returns reported in Canning and Bennathan (2000) because those returns are calculated assuming that the elasticity of output with respect to both electricity and roads varies across countries.

3D. Illustrative Calculations

As a preview of the analysis to come, write (1) in intensive form

$$y = k^{\alpha} x^{\gamma}$$

so that output, capital, and infrastructure are all expressed in per capita terms, and the marginal product of infrastructure in a given developing country, *mpx*, is given by $mpx = \gamma \frac{y}{x}$; let $mpx^* = \gamma^* \frac{y^*}{x^*}$ denote the marginal product of infrastructure in the advanced world; and notice that the cross-country estimates of the infrastructure elasticity of output just reported in Subsection 3C provide a range of values for γ and γ^* that can be used to determine the conditions under which the marginal product of infrastructure in a given developing country will be higher than that in the advanced world. Specifically, $mpx > mpx^*$ if and only if

$$\frac{x^*}{x} > \frac{y^*}{y}\frac{\gamma^*}{\gamma} \qquad (2),$$

that is to say, if and only if the developed-to-developing country ratio of infrastructure per capita is greater than the developed-to-developing country ratio of output per capita times the

developed-to-developing country ratio of the infrastructure elasticity of output.

Starting with the left-hand side of (2), consider the case of electricity generating infrastructure in North America versus Sub-Saharan Africa (SSHA). According to the IMF infrastructure data, the value of $\frac{x^*}{x}$ (the ratio of kilowatts per 100 people in North America to SSHA) was roughly 40. Turning to the right-hand side of the inequality, in 2010 $\frac{y^*}{y}$ was 12.1 ($39,590 in North America divided by $3,280 in SSHA). As for the ratio of developed-to-developing country elasticities, take the Canning and Bennathan lower-quartile estimate of 0.06 as a proxy for SSHA and their upper-quartile estimate of 0.07 as a proxy for advanced economies. This yields a $\frac{\gamma^*}{\gamma}$ value of 1.17. Multiplying 12.1 by 1.17 gives a right-hand-side value of 14.1, which is much smaller than 40, so that (2) holds with ease. Indeed, given the values of $\frac{x^*}{x}$ and $\frac{y^*}{y}$ which are directly observable, $\frac{\gamma^*}{\gamma}$ would have to be greater than 3.31 in order for the inequality not to hold. This would require an electricity elasticity of output in developed countries of roughly 0.2, which lies above the upper bound of any estimates in the literature.

It is instructive to do the same back-of-the-envelope calculation for roads, this time comparing North America to Latin America and the Caribbean (LAC). Starting again with the left-hand side of (2), according to the IMF infrastructure data, the value of $\frac{x^*}{x}$ (the number of kilometers of roads per 100 people in North America divided by the corresponding figure for LAC) is roughly 4. Moving to the right-hand side of the inequality, in 2010 $\frac{y^*}{y}$ was 2.93 ($39,590 in North America divided by $13,500 in LAC). The value of $\frac{\gamma^*}{\gamma}$ is 0.8 (0.04 divided by 0.05). Multiplying 2.93 by 0.8 gives a value of 2.34, which is less than 4, so the inequality holds in this case as well, albeit by a smaller margin than in the case of electricity.

These simple calculations suggest that the marginal product of infrastructure in developing countries may be higher than in advanced economies, but the marginal product of infrastructure is only the numerator in the computation of returns, $\frac{mpx}{P_x}$, that is ultimately of interest. Since computing the rate of return on infrastructure requires dividing the marginal product of infrastructure by infrastructure's real price (P_x), we cannot infer that developing countries have higher returns on infrastructure without additional data. More generally, because infrastructure is a type of investment good, a meaningful returns-based analysis of its productive potential must consider the return on infrastructure in developing countries in the broader context of these countries' return on capital as a whole. At first blush, therefore, the Lucas (1990) observation that capital does not flow from rich to poor countries would seem to dismiss the notion that there are potential efficiencies to be gained through the flow of savings from advanced economies to fund infrastructure investment in the emerging world. This is the issue to which the paper now turns.

4. The Lucas Paradox Revisited

The dominant explanation of the Lucas Paradox is Lucas's own conjecture that the return to capital in poor countries is not really higher than in rich ones, because any apparent differences in capital-to-labor ratios disappear after adjusting for cross-country disparities in the average level of human capital. While Lucas's conjecture was grounded in his back-of-the-envelope calculations and anecdotal observations, he did not actually confront it with the data on capital returns. This paper does so in Table 1, which contains information from two independent sources on the rate of return on capital in developed and developing economies around the time Lucas's paper was published. Panel A presents figures on rates of return on all capital in 1985 in

69 countries taken from Canning and Bennathan (2000). The countries are divided into four different groups: Advanced Economies (of which there are 16), Latin America and the Caribbean (17), Africa (19), and Asia (17). The last three groups constitute the 53 countries in the sample that were considered "developing" at the time.

4A. Many Poor Countries Do Have a Higher Return on Capital Than Rich Countries

The data show that Lucas was not quite right. The developing countries have an average (median) rate of return on capital of 42.3 (40) percent, which is greater than that of the 16 advanced economies whose average (median) rate of return of 31.4 (30) percent seems, if anything, higher than one might have expected *a priori*. Since the central focus of inquiry in Table 1 is cross-country differences, however, the critical aspect of the returns are not their absolute levels in either the developed or the developing countries, but their relative magnitudes, which are best captured using ratios. The ratio of developing country returns to advanced economy returns in Panel A is 1.35 (42.3 divided by 31.4). Going beyond aggregate averages to look at the consistency with which the returns to capital are higher in the various subgroups of poorer countries, Panel A also shows that Africa is the only region of the developing world where the average (median) rate of return to capital—a level of 27.2 (24) percent and a ratio of 0.87 (0.80)—is less than in the advanced economies. The average (median) return to capital in Latin America and the Caribbean is 43.2 (40) percent with a ratio of 1.38 (1.33). In Asia, the average (median) return is 59.9 (56) percent with a ratio of 1.91 (1.87).

Turning from regions to individual nations reinforces the consistency of the basic observation. Thirty-five of the 53 developing countries in Panel A have a rate of return to capital that is higher than the advanced-country average. With the exceptions of Algeria, Argentina,

which was in the midst of hyperinflation in 1985, and Jamaica, which was recovering from a decade of nationalization, all of the developing countries whose rates of return are below the advanced-economy average—Bolivia, Central African Republic, Congo, Fiji, Gambia, Ghana, Kenya, Mali, Liberia, Mozambique, Nicaragua, Niger, Papua New Guinea, Uganda, and Zambia—are low-income countries. Indeed, splitting the sample of developing countries according to income throws the observation into relief. The low-income African countries have an average (median) return of 24.9 (24) percent and a ratio of 0.79 (0.80), while all other developing countries have an average (median) return on capital of 50.5 (46) percent and a ratio of 1.61 (1.53). Apparently, the Lucas Paradox is really only a paradox for a subset of the world's very poorest nations, and not for poor (i.e., developing) countries in general.

4A.1 Developing Countries' Higher Returns Are Not an Artifact of a Particular Dataset

To see if the facts about returns on capital in Panel A are peculiar to the specific data source from which they are drawn, Panel B presents another set of returns on capital. Using data on 68 developed and developing 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 rates of return on private capital, as well as on all capital, for 2005. Because the countries covered by Lowe et al. differ to some extent from those listed in Canning and Bennathan, Panel B takes care to present figures on returns only for the countries that are covered in both papers. For the developed countries, every country that appears in Panel A also appears in Panel B. For the developing countries, Panel B contains 29 of the 53 countries in Panel A.

As for the figures themselves, the ratios of the average returns on capital reported in

Panel B are on the same order of magnitude as those in Panel A, suggesting that the differences in developing and advanced country returns are not an artifact of either the data in Canning and Bennathan or the methodology they used to construct them. For all capital, the ratio of the developing-to-developed country returns in Panel B is 1.44 (19.2 percent for developing countries divided by 13.3 percent for advanced economies) in 1996, and 1.15 (17.2 percent for developing countries divided by 14.9 percent for advanced economies) in 2005 (Panel C). Furthermore, 22 of the 29 developing countries in Panel B have a return on all capital that is greater than the average advanced economy return on all capital. Turning to the data on private capital in Panel C, the ratio of developing-to-developed country returns is even higher than in the case of all capital—1.41 (27.4 percent for developing countries divided by 19.5 percent for advanced economies)—and 21 of 29 developing countries are above the advanced economy average.

Further evidence against broad applicability of the Lucas Paradox comes from data on the change that occurred to the flows of capital to developing countries and to the rates of return on capital in those nations following their easing of restrictions on foreign ownership of publicly traded capital assets (e.g, stocks) in the 1990s. When Lucas correctly observed that capital had not been flowing to developing countries, his assertion as to why that was the case—because returns there were not actually higher than in the developed world—failed to consider the alternative explanation that the paucity of flows was a result of legal restrictions in developing countries that had blocked those flows from occurring in spite of significant return differentials. Ironically, developing countries began easing those restrictions *en masse* shortly after Lucas's article was published in 1990. Figure 2 demonstrates what happened subsequently. Capital flows to developing countries soared, a systematic revaluation of assets (especially public equity) took

place in those countries, and a whole new class of savings vehicles—emerging-market country funds, for example—were created to take advantage of the changes afoot (Henry 2007; Stulz 1999; Van Agtmael 2007).[3]

The reality that capital did flow from rich to poor (if not abjectly poor) countries to exploit the arbitrage opportunity created by the easing of restrictions on foreign ownership gives rise to the following question: are there similarly unexploited opportunities with respect to infrastructure? The first step in answering this question is to compare the rates of return on infrastructure in developing countries with the rates of return in advanced economies. Of course, the returns on infrastructure are social not private, and there do not exist tradable assets that are claims on the incremental additions to GDP that are generated by building an additional mile of paved roads or installing another kilowatt of electricity generating capacity. This means that significant questions remain as to whether the social returns on infrastructure can be realized in practice. But since the existence of significant differences in the social rate of return on infrastructure across developed and developing countries is a necessary condition for the possibility of privately financed gains, the question of whether, in fact, such differences exist is the matter to which the paper now turns.

5. Infrastructure Returns in Developed and Developing Countries

Table 2 provides a qualitative and quantitative summary of the extent to which the countries in Table 1 have data that can be used to estimate rates of return on infrastructure (EGC and paved roads), as well as on all capital. Again, there are a total of 69 countries, broken into the same four groupings as in Table 1. For a given grouping and row in the table, each of the first 2 columns indicates "Yes" or "No," whether the country in question has data available for the

[3] Physical investment and wages also increased (Chari, Henry, and Sasson 2012).

type of capital named at the top of the column—paved roads and EGC. The third column indicates whether the country has data available for both paved roads and electricity. The last row of each grouping, labeled " 'Yes' Count," gives the total number of countries for which data are available. Three sets of remarks about the numbers are in order.

First, data for computing the return on all capital are available for every country. Second, 15 of the 16 advanced economies have the requisite paved road data, with Portugal being the only outlier. Availability in the case of EGC for the advanced countries is exactly flipped: Portugal is the only country for which data are available. Third, and most importantly, for the developing nations there are a total of 53 unique countries for which there are data on EGC and/or paved roads. Of these 53 countries, 49 have data on electricity generating capacity: 17 in Latin America and the Caribbean, 15 in Africa, and 17 in Asia. Of the same 53 countries, 26 have data on paved roads: 11 in Latin America and the Caribbean, 9 in Africa, and 6 in Asia. Only 21 developing countries have data on both types of infrastructure capital.

In accordance with the availability of data indicated in Table 2, Canning and Bennathan (2000) apply a three-step procedure to estimate the rate of return on infrastructure and the rate of return on all capital for the 69 developed and developing countries. First, using panel data from 1960 to 1990, and employing a variety of techniques to remove the effects of reverse causality, they estimate an aggregate production function with physical capital, human capital, and infrastructure as explanatory variables. The two infrastructure variables they employ are paved roads (PR) and electricity generating capacity (EGC); adequate information on other types of infrastructure was not available. Second, they use their estimates to calculate the marginal products of the aggregate capital stock, paved roads (PR), and electricity generating capacity (EGC) as their respective contributions to gross domestic product (GDP). Third, to compute rates

of return they divide the marginal product of each type of capital by its unit cost and subtract the rate of depreciation, which they assume to be constant (7 percent per year). They calculate unit costs for each country using observable data on the cost of infrastructure construction.

5A. Limitations of the Extant Data

All of Canning and Bennathan's cost data are from 1985, which means that the rates of return they compute are also for that year, and there are limitations to the current utility of examining thirty-four-year-old rates of return. Starting with the denominator, a key factor is the price of capital goods, which is higher in developing countries than in developed ones. The price of capital goods has fallen since 1980 (Eichengreen 2015). Furthermore, yesterday's roads and grids may not be today's infrastructure (Leifman, Fay, Nicolas, and Rozenberg 2019). To the extent that the cost of building paved roads and installing electricity generating capacity has fallen by more in developed countries than in developing ones, all else being equal, the rate-of-return gap will have decreased. The opposite is true if the price of capital has fallen by more in developing countries. If the price has fallen by the same amount for both sets of countries, there will have been no impact on relative returns. 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).

Turning to the numerator, a potentially important shortcoming is that the elasticity of output with respect to inputs is estimated using data that ends in 1990. Starting in 1994, the growth rates of developing countries accelerated relative to that of advanced economies (Chari and Henry 2014; Patel, Sandefur, and Subramanian 2018). In all likelihood, therefore, so have their elasticities of GDP with respect to the factors of production. Because the difference in

returns on private capital in developed and developing countries has narrowed since 1990, unless all of the increase in the growth of developing countries' national income has been captured by labor, the return on infrastructure capital in those countries has likely risen relative to the return on infrastructure in developed countries. Again, we need more recent data to understand precisely what has happened.

5B. Old Data, New Framework

In spite of the limitations just enumerated, there are at least three advantages of using the existing data to provide an in-depth comparison of the rate of return on infrastructure in developing countries with that in advanced economies.

First, surprising as it may be given the volume of discussion about infrastructure in academic, business, and public policy circles, the Canning and Bennathan (2000) estimates represent the frontier of empirical knowledge about the social rate of return on infrastructure in developing countries. While there are papers that compute the rate of return on infrastructure in advanced economies (e.g. Bivens 2017), to the best of my knowledge, Canning and Bennathan provide the only explicit and comprehensive estimates of the economy-wide rate of return on infrastructure in developing countries. One recent quasi-exception is Lowe, Papageorgiou, and Perez-Sebastian (2018) who employ the IMF data on public capital mentioned in the overview of this paper as a proxy for infrastructure and use it to calculate the rate of return on public capital. In the absence of better 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. To the extent that governments install public capital that does not fit the economic definition of infrastructure, the figures on the stock of public

capital will overstate the true level of the stock of infrastructure and therefore understate the prospective return on investments in infrastructure (Estache and Garsous 2012). Another exception to the paucity of empirical work that explicitly calculates the social rate of return on infrastructure in developing countries is the World Bank, which has produced numerous project evaluations of the economic return on individual infrastructure projects (e.g., Estache and Liu 2004; Herrera 2005). These studies provide helpful reality checks against which to benchmark aggregate estimates of the social rate of return, but individual project evaluations have the shortcoming of not capturing the potential externalities to the economy as a whole associated with investment in infrastructure (Estache and Fay 2007).

Second, 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.

Third, and most significantly, the paper uses the comprehensive and explicit nature of the Canning and Bennathan data to develop a new template that, in addition to classifying and evaluating the existing data, can be used to: (a) analyze updated data that become available in the future; (b) reveal the subtleties involved in evaluating the true potential for efficient investment in infrastructure; and (c) highlight the pitfalls of a blanket, gap-based approach to infrastructure that does not expressly incorporate the consideration of returns. The returns-based approach to evaluating infrastructure developed in this paper also highlights the urgency for new research that provides—using the template developed here, or still more innovative methods—additional disciplined examinations of the real possibilities for efficient infrastructure investment. Had

Canning and Bennathan used their data to overtly and systematically ask whether the rate of return on infrastructure is higher in developing countries than advanced economies, they might have developed such an approach, catalyzing a line of research that would have led to production of the more current estimates of infrastructure returns that are so sorely needed now. Since that question was not the focus of their paper, however, and thus they did not address it in depth, the next section of this paper builds on and repurposes their important data contribution to do just that.

5C. Cross-Country Differences in the Return on Paved Roads and Electricity

Table 3 provides relevant data on the rate of return on paved roads, arranged in three columns, for each grouping of countries. The first column gives the rate of return, and the bottom rows of the table list the corresponding summary statistics. The average return on paved roads for advanced economies is 12.9 percent with a median of 8 percent, similar to the 7 percent return on roads in the U.S. documented by Fernald (1999) and the 6 percent return on investment in U.S. infrastructure reported by the Economic Policy Institute (Bivens 2017).

Looking at the developing countries, one fact immediately leaps off the page. Their return on paved roads exceeds the return on paved roads in developed countries by an order of magnitude which swamps the difference that existed in the return on private capital across the two sets of countries prior to the era of open capital markets. Recall from Table 1 that for all capital the average developing-to-developed country ratio for rates of return ranged from 1.35 to 1.44. Given that the average rate of return on paved roads for the developing countries listed in

Table 3 is 265.4 percent,[4] the corresponding ratio for their paved road infrastructure capital is 20.6 (265.4 divided by 12.9)! This ratio is large for all three developing regions. The mean rate of return on paved roads in Latin America is 322.7 percent or 25 times that of the advanced economies. For Africa, the mean return is 64.5 percent, which is 5 times the advanced economy average. The return on paved roads in Asia is 464 percent or 36.0 times as large.

Furthermore, the differences in the return on paved roads between the developing regions and the developed world are not driven by a few developing countries with particularly high rates of return. The median return on paved roads in developing countries is 107.5 percent or 13.4 times as high as the 8 percent median return in advanced economies. For Latin America, Africa, and Asia the median rates of return are 197 percent, 54 percent, and 180.5 percent. While these numbers are not as large as the means, they are still higher than the median advanced economy return by factors of 24.6, 6.75, and 22.6. It is also striking that if we eliminate the highest rate of return in each group—Japan, Colombia, Cameroon, and Korea—the minimum return on paved roads in Latin America (39 percent) and Asia (52 percent) is greater than the maximum return in advanced economies (26.0 percent). Furthermore, every one of the 26 developing countries in the sample has a return on paved roads that exceeds the average return on paved roads in developed countries.[5]

Table 4 provides the same information and descriptive statistics for EGC that Table 3 provides for paved roads, but as noted in the second paragraph of Section 5: (i) there are EGC data for a greater number of countries; (ii) in spite of (i), there are countries for which there are

[4] The average rate of return for all LDCs is calculated using the sum of individual country returns divided by the total number of countries. Similarly, all calculations for means and medians for LDCs as a whole ("All LDC") are done by country rather than by group.

[5] It is also worth noting that the standard deviation of the return on roads in advanced economies is 15.3 percent, so the upper bound of a 95 percent confidence interval is 43.5 percent. Twenty one of the 26 developing countries in Table 3 have a return on roads greater than 43.5 percent.

paved road data but not EGC data, so that some developing countries appearing in Table 3 are not listed in Table 4. Also, Portugal, with a return of 7 percent is the only advanced economy for which there are EGC data. Still, Portugal is an important data point because its rate of return on EGC is notably of the same order of magnitude as the average rate of return on paved roads in advanced economies. Keeping that point in mind and looking at the data in more granular detail reveals that: (1) in 45 of the 49 developing countries in Table 4, the rate of return on EGC exceeds the return on EGC in Portugal; (2) the magnitude of the developing-developed country return differentials in EGC also swamps the differentials for the return on private capital, but they are not as large as in the case of paved roads. The mean (median) return on EGC in developing countries is 42.0 (35) percent, or 6.0 (5) times as large as the advanced economy return on EGC. By region, the mean (median) returns on EGC are: 35.1 (25) percent, or 5.01 (3.57) times as large in Latin America and the Caribbean; 50.5 (45) percent, or 7.21 (6.43) times as large in Africa; and 44.1 (40) percent, or 6.3 (5.71) times as large in Asia.

Turning from means and medians to measures of dispersion, looking at the variation in returns on both paved roads and EGC provides two useful insights about the productivity of capital in the developed and developing world. First, infrastructure capital is allocated less efficiently than private capital in both developed and developing countries. For developed countries, the standard deviation of the return on all capital is 7.1 percent while the standard deviation of their return on paved roads is 15.3 percent.[6] The standard deviation of the return on infrastructure in developing countries—369 percent in paved roads (260 percent excluding the extreme outlier of Korea) and 30.2 percent in electricity generating capacity—is also higher than the standard deviation of their return on all capital, which is 23.2 percent. The observation that

[6] The standard deviation of EGC for the advanced economies (0) is not meaningful because Portugal is the only advanced economy for which there is EGC data.

the return to infrastructure exhibits greater variation than the return on all capital is consistent with the findings of Lowe, Papageorgiou, and Perez-Sebastian (2018) who document that in a sample of 68 countries the ratio of output to public capital is more highly dispersed than the ratio of output to private capital, suggesting that public capital is less efficiently allocated.

Second, although infrastructure capital is allocated more inefficiently than private capital in all countries, the inefficiency is greater in the developing world. This point comes through clearly in a cross-country comparison of the relative variation in returns on infrastructure and on all capital reported in Tables 3 and 4. In developed countries, the standard deviation of the return on paved roads is 2.2 times as large as the standard deviation of the returns on all capital (15.3 divided by 7.1). In contrast, for developing countries the standard deviation of the return on paved roads is 15.9 times as large as the standard deviation on all capital (369 divided by 23.2).[7] The realization that infrastructure inefficiencies are greater in developing countries than developed ones raises another salient point of consideration.

5C. Within-Country Differences in the Return on Infrastructure and on All Capital

Critical as it is to know whether infrastructure in developing countries is more productive than infrastructure in developed countries, it is equally vital to ascertain whether a dollar invested in a developing country's infrastructure yields a greater incremental impact on its GDP than a dollar invested in the country's other forms of capital. Accordingly, the second column in each country grouping of Tables 3 and 4 lists the rate of return on all capital. The third column gives the ratio of the first column to the second and measures, therefore, how efficiently capital

[7] The ratio of the standard deviation of EGC to the standard deviation of all capital for developing countries is 1.30 (30.2 divided by 23.2). Again, Portugal is the only advanced country with EGC data, so its standard deviation is 0 (see previous footnote).

in a given country is allocated between infrastructure and the economy as a whole. If capital is allocated efficiently, the return on infrastructure will equal the return on all capital, giving a within-country ratio of the return on infrastructure to the return on all capital of 1. If a country has too little infrastructure, the rate of return on infrastructure will exceed the return on all capital, giving it a within-country ratio greater than 1.

A within-country ratio less than 1, on the other hand, implies that a country has too much infrastructure relative to other forms of capital; it does not necessarily mean that a country has stellar infrastructure, but it does suggest that infrastructure is not the most efficient priority for additional expenditure given the mix of other inputs (non-infrastructure capital, technology, policies, institutions, and labor) in the economy. This is strikingly the case for the advanced economies whose mean (median) ratio of return on infrastructure to return on all capital is 0.48 (0.26) for paved roads and 0.14 (0.14) for EGC. In stark contrast, for developing countries, the mean (median) ratio of the return on infrastructure to the return on all capital is 6.8 (2.4) for paved roads and 2.07 (5.71) for EGC.

Furthermore, on a regional basis, the difference in the within-country ratio between advanced and developing countries is remarkably consistent. For instance, all of the advanced economies except Japan have a within-country ratio of paved roads less than 1, strongly suggesting that, if anything, they are overinvested in roads. Formally, under the null hypothesis that the return on paved roads equals the return on all capital, the p-value of seeing 14 out of 15 advanced countries with a ratio below 1 is less than 1 percent. In contrast, 0 of 11 countries within Latin America and the Caribbean have ratios below 1; again, the two-tailed p-value of this outcome is virtually 0. The story is quite different in Africa and Asia, where the data do not suggest the same degree of underinvestment in paved roads. African countries have a mean

(median) within-country ratio of 2.3 (1.29) and 3 of 9 have ratios less than 1. Two of 6 countries in Asia have ratios less than 1, and without the outlier of Korea, the Asian mean (median) is 4.8 (2.03).[8] Taking all developing countries as a whole, just five of twenty-six countries have within-country paved road ratios less than 1, an outcome with a p-value of less than 1 percent.

For electricity generating capacity, the regional pattern of within-country ratios flips. Latin America and the Caribbean, where 14 of 17 countries have a within-country ratio less than 1 and the mean (median) ratio is 1.05 (0.56), does not appear to be underinvested in electricity. African countries, on the other hand, with a mean (median) ratio of 5.25 (2.16) and only 5 of 15 nations with ratios below 1, do seem to be underinvested in EGC. It is also interesting to note that two of the three Latin American countries with an EGC ratio greater than 1 (Honduras and Bolivia) are low-income nations as are all 10 of the African nations that appear to be underinvested in EGC.

Differences in the variation of the within-country ratio of the return on infrastructure to the return on all capital are equally illuminating as the ratios themselves. In particular, the within-country ratio is much more variable in developing countries where the standard deviation of the ratio is 9.96 for paved roads—14 times as large as the 0.75 standard deviation of the ratio in advanced economies—and 5.71 for EGC. Lowe, Papageorgiou, and Perez-Sebastian (2018) find analogous results using the ratio of the marginal product of public capital to the marginal product of private capital in more recent data. In similar fashion to Tables 3 and 4 of this paper, they document that the within-country ratio equals 1 virtually nowhere, but that the dispersion of the ratio is higher in developing countries than in developed ones. Specifically, in their sample, the within-country ratio displays greater variation in the bottom half of the distribution of countries' GDP per capita than in the top half. Furthermore, the time-series data in the authors'

[8] With Korea, the mean (median) ratio in the region is 10.1 (2.24).

work suggest that the degree of inefficiency in developing countries has increased over time. Specifically, their work indicates that between 1990 and 2005 the standard deviation of the marginal product of all capital in developing countries remained roughly constant, even as the standard deviation of the marginal product of private capital fell. This implies that the standard deviation of the return on public capital in developing countries rose, both in absolute terms and relative to the standard deviation of the return on private capital.

5C.1. The Binding Constraint for Advanced Economies is their Return on All Capital

The reality that the return on paved roads for advanced economies is uniformly lower than their return on all capital implies that when considering cross-country questions of efficiency the right comparison is not the return on infrastructure in advanced economies versus the return on infrastructure in emerging economies, but rather the return on all capital in advanced countries versus the return on infrastructure in emerging economies. Said another way, when analyzing whether there are untapped gains to be had from reallocating savings from developed countries to investment in the infrastructure of the emerging world, the binding constraint is not the developed-country return on infrastructure of 12.9 percent, but instead the 31.4 percent developed-country return on all capital. This means, for example, that the most relevant rule of thumb for potential efficiency gains from investment in developing country paved roads is not that they are 20.6 times as large as the return on developed country roads (265.4 divided by 12.9), but rather that they are 8.8 times as large as the return on all capital in developed countries (265.4 divided by 31.4). Nevertheless, 8.8 is still a big number—five-fold greater than the ratio of the return on emerging market equity to the return on developed market equity prior to the advent of stock market liberalization.

Similarly, the observation that the return on EGC in Portugal is low, both in absolute terms and relative to its return on all capital, suggests that in EGC, as in paved roads, the binding cross-country comparison for developing countries is the return on all capital in advanced economies. Again, the data suggest that, on average, the potential benefits from cross-border investment in EGC are more modest than in paved roads—just 1.33 times as large as the return on all capital in advanced countries (42.0 divided by 31.4).

6. The Dual-Hurdle Approach to Classifying Countries' Potential for Efficient Investment

Taken together, the dual constraints of cross- and within-country return comparisons make it clear that, for a given developing country, additional infrastructure investment is efficient and (potentially) financeable through a market-based allocation of foreign savings only when the return to doing so exceeds both: (a) the return on all capital within the country, and (b) the return on all capital in advanced economies.

Figure 3 provides a visual illustration of this dual-hurdle framework for evaluating the potential for efficient investment in infrastructure. For a given country and category of infrastructure (e.g., paved roads or electricity generating capacity), the x-axis of the graph measures the within-country ratio of the return on infrastructure to the return on all capital. The y-axis measures the cross-country ratio of the return on infrastructure to the return on all capital in advanced economies. The dashed vertical line defined by the locus of points for which x=1 denotes the domestic hurdle rate, and it is optimal for the country to increase investment in infrastructure if the within-country ratio falls strictly to its right. Similarly, the dashed horizontal line defined by the locus of points for which y=1 denotes the cross-country hurdle rate, and it is feasible, in theory, for the country to finance infrastructure through a market-based provision of

foreign savings if its cross-country ratio lies above that line. The intersection of the two dashed lines divides the (x,y) plane into four distinct quadrants.

Quadrant I consists of countries in which the rate of return on infrastructure exceeds both the cross-country and within-country hurdle rates for investment. Countries in this quadrant are ripe for more investment in infrastructure and, therefore, could also benefit from public sector efforts aimed at making tradable the untapped potential gains from cross-border investments in infrastructure.

Column 1 of Table 5 shows that just 18 of the 49 developing countries with data on EGC make it into Quadrant I. This is striking because the rate of return on EGC in 45 of these countries exceeds the advanced economy return on EGC, underscoring the importance of the return on all capital in advanced economies as the binding, cross-country efficiency constraint (per the discussion in Section 5C.1). It is also clear that both the cross- and within-country ratios for measuring allocative efficiency play a significant role in screening out more than 60 percent of the countries in question. Twenty countries fail to clear the cross-country hurdle rate, and another 11 fall short of the within-country benchmark.

Notably, 15 of the 18 countries that do make it into Quadrant I are classified as "low-income." Accordingly, the case for efficient investment in EGC is strongest in Africa, home to 9 of the nations listed in Quadrant I. Turning to paved roads, 21 countries make it into Quadrant I even though all of the 26 countries for which there are paved roads data have a return on roads in excess of the average return on roads in advanced economies. Aggregating across electricity generating capacity and paved roads underscores the extent to which the dual-hurdle framework provides a more discriminating assessment of the true potential for efficient investment in infrastructure than any single metric. Of the 75 country-infrastructure-return observations, just

39 fall into Quadrant I.

It is also noteworthy that of the 32 unique countries identified as having Quadrant I opportunities for investment in infrastructure, 10 of them—Algeria, Argentina, Bolivia, Central African Republic, Fiji, Kenya, Liberia, Mali, Uganda, and Zambia—have a return on all capital that is less than the return on all capital in advanced economies. There are, in other words, poor countries (Argentina was *sui generis* with hyperinflation) to whose private sectors there is little incentive for capital to flow from advanced economies but have the potential to be efficient destinations for cross-border investment in infrastructure nonetheless.

Quadrant II consists of countries in which the return on infrastructure falls short of the cross-country threshold but clears the within-country hurdle. Countries in this quadrant stand to benefit from more rapid investment in infrastructure but are unlikely to be able to attract private capital from abroad to finance it. Such countries will need to mobilize domestic savings to finance infrastructure and are sensible candidates for concessional financing from multilateral development institutions (subject to all of the usual governance caveats). Across both types of infrastructure, only 1 country, Ghana in the case of EGC, falls into Quadrant II.

Quadrant III consists of countries in which the rate of return to infrastructure fails to meet both the cross-country and the within-country thresholds for efficient investment. Countries in this quadrant simply do not warrant a particular emphasis on additional expenditure (domestic or foreign) on infrastructure at a cost to other kinds of investment. Countries in this quadrant can also look quite different. A country with an excellent investment climate and high returns on all capital can land here simply because it is so well capitalized in infrastructure that the marginal benefit of installing another unit is not attractive from either the perspective of foreign investors or domestic public expenditure. 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 all investments, even as the country is still relatively overcapitalized in infrastructure. In the case of EGC, 20 countries fall into Quadrant III. For paved roads, the number is 3: Botswana, Tunisia, and Zimbabwe.

Quadrant IV consists of countries in which the return on infrastructure clears the cross-country hurdle but fails to exceed the within-country threshold. These are countries where the potential for efficiency gains from cross-border flows of savings to investment in infrastructure exist but are outstripped, at the margin, by the gains to be had from additional investment in other forms of capital. The efforts of governments of countries that fall into this quadrant are more effectively expended on policy changes to improve the climate for private investment rather than engaging in the extended efforts that will be required to make the prospective cross-border gains from infrastructure a tradable opportunity. For EGC, 10 countries fall into Quadrant IV. In the case of paved roads, there are only 2 countries: India and Pakistan.

Turning back to Quadrant I for a moment, it is important to recognize that not all efficient infrastructure opportunities are created equal. For all of the countries that land in Quadrant I, Table 6 (Panel A, electricity generating capacity, and Panel B, paved roads) ranks the overall magnitude of the infrastructure opportunity in descending order. For a given country and type of infrastructure, the magnitude of the opportunity is defined as the cross-country ratio multiplied by the within-country ratio. The most striking observations across both tables fall into two categories.

First, there is nothing in Table 6 that remotely suggests anything optimal about a broad-based "billions to trillions" drive for more infrastructure in all developing countries. Of the 22 countries for which there are data on returns for both PR and EGC, only 7—Argentina, Bolivia,

Honduras, Indonesia, Kenya, Malawi, and the Philippines—appear in both Panel A and Panel B. The reality that less than one-third of the countries for which we have data present a clear case for investment in both roads and electricity ought to give pause about big-push approaches to infrastructure in developing countries. There are also a total of 21 countries that do not appear in either panel. This means that almost 40 percent of the 53 developing countries for which data are available have no returns-based case for investment in infrastructure.

Second, when it is efficient to increase investment in infrastructure, the unexploited opportunities for gain can be massive—especially in paved roads. Even leaving aside the outlier of Korea, the return to building paved roads in emerging economies can easily be 2 to 25(!) times as large as the return on all capital in advanced economies.

Keeping in mind the caveats about the difference between infrastructure and public capital discussed in Section 5B, it is useful to note that the large return differentials documented in this paper are broadly consistent with the economic significance of the deadweight loss to public capital misallocation documented by Lowe, Papageorgiou, and Perez-Sebastian (2018) who tentatively conclude that world GDP would be 9 percent higher than its current level if the marginal product of public capital were equalized across countries. This gain is about 4.8 times as large as the one that would come about from equalizing cross-country differences in the marginal product of private capital.

7. Why the Return Differentials Persist, and What, If Anything, Can Be Done about Them

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.[9] 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 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

[9]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).

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 articles that synthesize research on the general reasons why capital flows to developing countries fall short of what theory predicts, this section of the article will both 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 it will explore: (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.

8. Automation, Premature Deindustrialization, and Other Speculative Considerations

Past infrastructure spending has proven efficient when it provided labor-abundant countries with the basic power and transportation they needed to convert their theoretical advantage in labor-intensive products into export-led manufacturing growth strategies (Kuroda, Kawai, and Nangia 2007). Accordingly, after witnessing the evolution of the Asian Tigers from poverty to high-income status, followed by China's rise from penury to middle-income, a variety of 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). In a static world, these facts would seem to suggest that Vietnam, Ethiopia, and other heavily populated developing countries have a manufacturing-led opportunity to grow between now and 2030 if they pass the dual-hurdle test and invest in infrastructure.

The industrial landscape, however, is anything but static. Automation, robotics, and other new technologies continue to reduce the share of labor in the overall cost of manufacturing and erode developing countries' competitive advantage of a vast, low-wage workforce (Basu 2016). An additional concern is that many developing countries whose transition from agriculture to manufacturing occurred after the first wave of industrial transformation have seen manufacturing output as a fraction of GDP peak at lower levels than the LDCs that were first to industrialize (Rodrik 2016). Because the growth rate of productivity in manufacturing has traditionally been higher than those in other sectors of the economy, the "premature" transition from manufacturing into services means that catch-up growth in countries that are just now undergoing the transition from agriculture to manufacturing might taper off more quickly than it did in East Asia. If these "second round" transition countries are on a trajectory toward a lower level of steady-state output per worker than those in the first round, then they will never fully catch up.

In light of the changes underway, and because the case for infrastructure is implicitly predicated, at least in part, on its importance as an input for export-led manufacturing, this section of the paper raises the following question: will infrastructure investment remain a high-return proposition in countries that pass the dual-hurdle test, or does an increasingly automated future mean that the export-led manufacturing path to prosperity has passed, and with it, therefore, the opportunity for infrastructure-fueled growth? Recent research suggests two reasons

why infrastructure will remain a priority for certain countries in spite of the changes afoot.

First, the jobs created by export-led manufacturing will not disappear overnight. Some industries will remain significant absorbers of low-skill labor and provide viable manufacturing entry points for countries that have not yet industrialized. These entry points consist of areas such as commodity-based process manufacturing (e.g., food, beverages, and agro-industry). Ninety-eight percent of agricultural products in advanced countries undergo industrial processing versus 30 percent in developing economies (Hallward and Nayyar 2018). While commodity processing offers a reasonable possibility of sustained job creation for workers with lower levels of education, the output from these sectors is less traded internationally, with attendant implications for long-term gains in productivity and wages. The output from industries such as textiles, garment making, and footwear, on the other hand, remain labor intensive because of limited automation to date and are highly traded internationally.

Second, manufacturing is becoming more like services. Because tariff barriers are significantly lower than they used to be in both advanced and developing countries, international trade is less about making a product in one country and selling it in another than it is about using value chains to coordinate across borders and time zones to reduce production costs and increase market coverage. As manufacturing continues to evolve into a series of nodes for particular tasks in a series of connections in global value chains, countries will need certain infrastructure investments to be viable destinations for any task in the node.

A number of countries will pursue opportunities still present in traditional export-led industrialization. Others will position themselves for a niche in the manufacturing-cum-services value chain. And some may pursue a radically different path that heavily leverages technology and the digital economy. But you can't build e-commerce platforms for growth without

broadband and electricity, even if the power infrastructure of the future looks very different than that of the past.[10] The question, therefore, is less whether properly screened investments in infrastructure will still bring efficiency gains, than how, given scarce resources, changes in the manufacturing landscape will alter the ordering of infrastructure priorities in the years ahead.

Given that one billion people will move from rural areas into cities between now and 2030 (United Nations 2016), preparation for ongoing urbanization will be a common priority for a wide range of countries. As virtually all this migration will take place in emerging economies, policies that impact the productivity of developing-country workers who move to urban areas will greatly influence global growth. While 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 intercity connections and links to the global system of production (Romer 2018), the creation of such platforms requires infrastructure such as roads, water, and sanitation, in addition to power. Therefore, the shortage of electricity in developing countries in combination with rapid urbanization has the potential to create a particularly acute bottleneck to growth.

[10] Leifman, Fay, Nicolas, and Rozenberg (2019) discuss the complexities involved in trying to forecast the exact configuration of the infrastructure of the future and sketch a range of possible outcomes.

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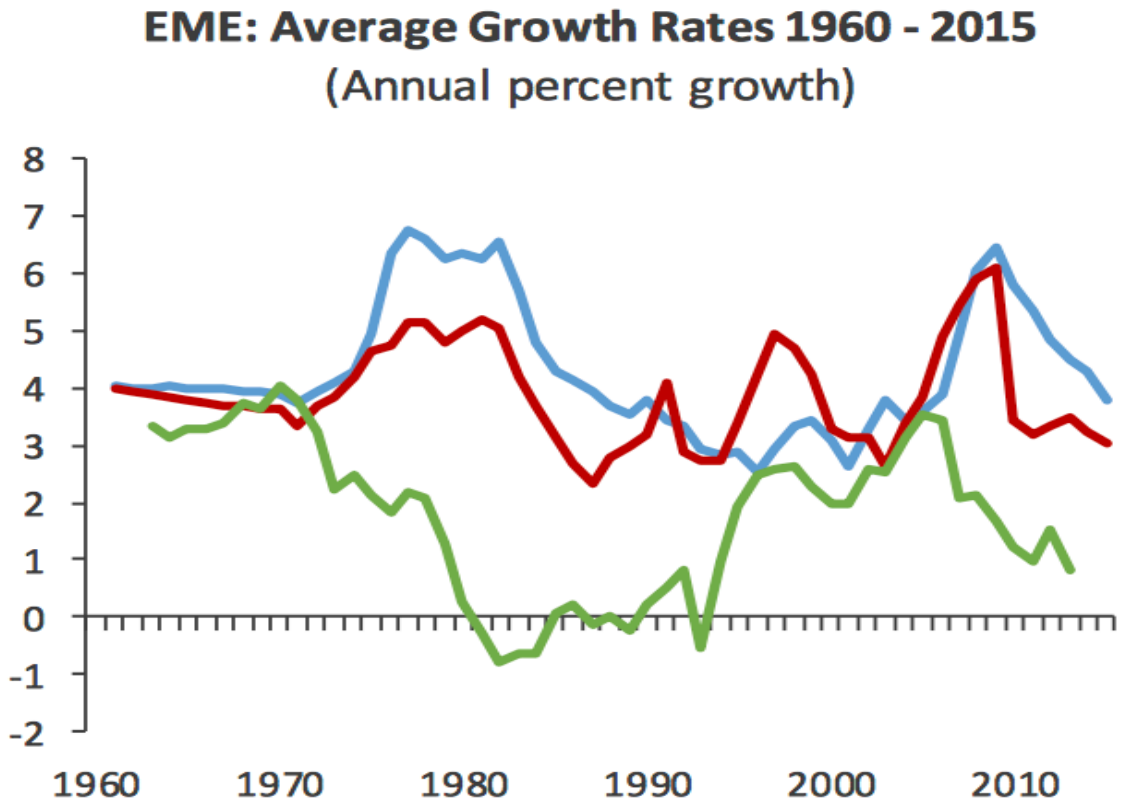
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Figure 1. The sharp increase in the growth rate of the public capital stock in emerging-market economies in the 1970s was accompanied by a steep decline in their growth rate of productivity. Public capital Stock (blue), output per worker (green), and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



Source: International Monetary Fund (2017)

Figure 2. 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.

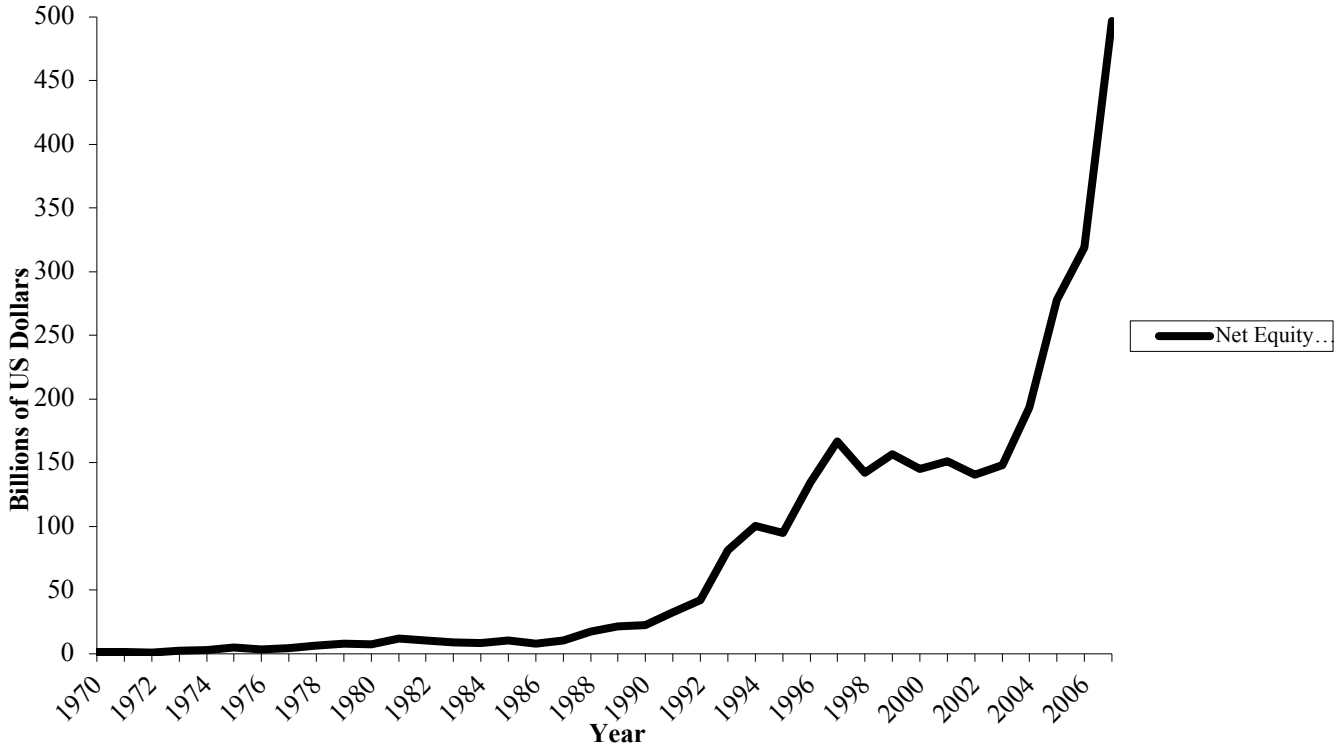


Figure 3. The dual-hurdle rate framework for evaluating efficient infrastructure investment sorts each country into one of four quadrants.

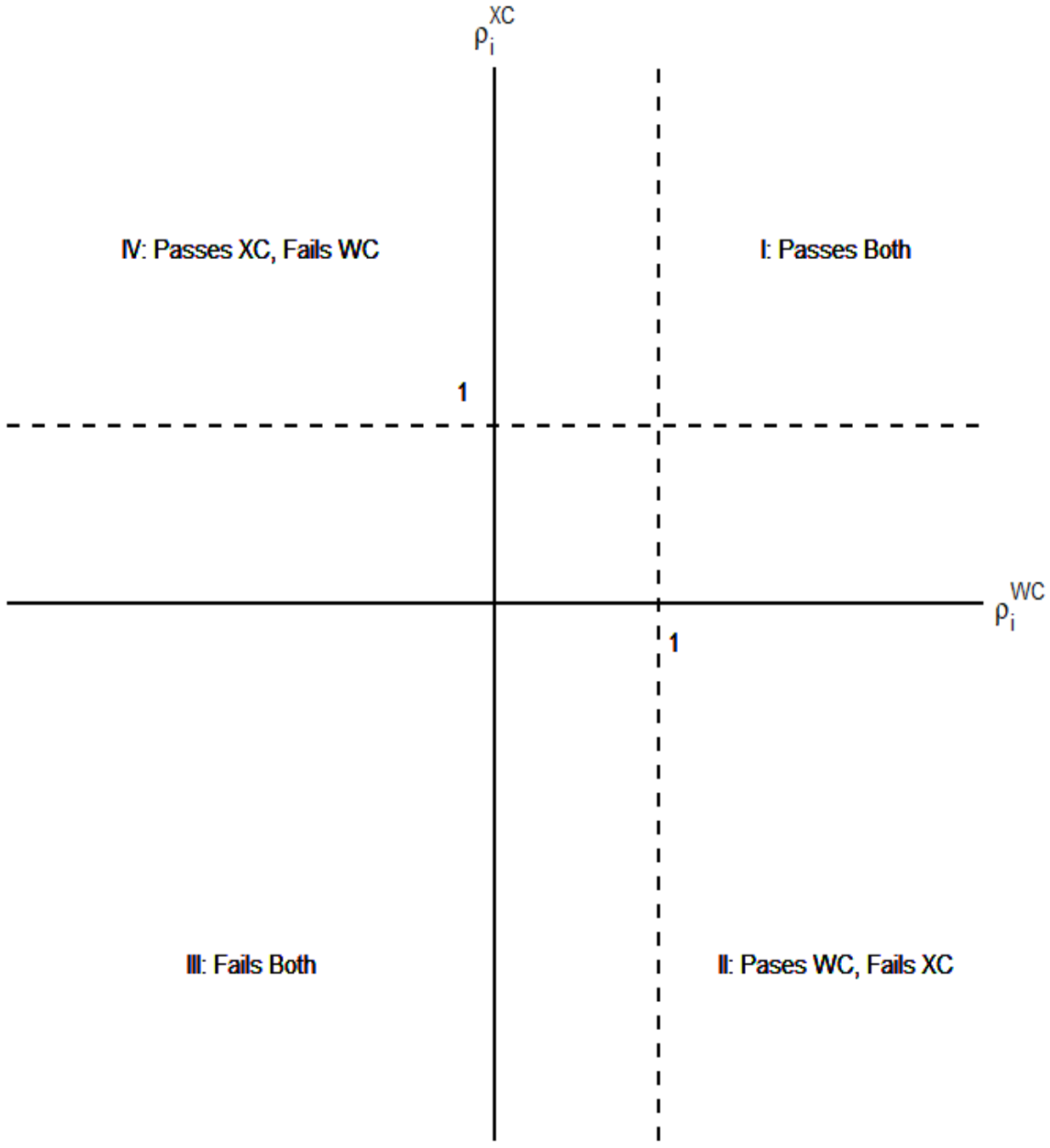


Table 1, Panel A. Return on All Capital in 1985

Advanced		LAC		Africa		Asia		All LDC[1]	Low-Income Africa[2]	Other
	All K		All K		All K		All K	All K	All K	All K
Australia	30	Argentina	29	Algeria	15	Bangladesh	80			
Austria	29	Bolivia	21	Botswana	58	China	41			
Belgium	40	Brazil	58	Cameroon	35	India	78			
Denmark	30	Chile	73	C.A.R.	12	Indonesia	83			
Finland	22	Colombia	55	Congo	25	Fiji	30			
Germany	29	Costa Rica	37	Egypt	50	Jordan	42			
Ireland	36	D.R.	61	Gambia	23	Korea	45			
Italy	34	Ecuador	51	Ghana	18	Malaysia	44			
Japan	20	El Salvador	47	Kenya	19	Myanmar	33			
Netherlands	32	Guatemala	38	Liberia	15	Nepal	56			
N. Zealand	36	Honduras	34	Malawi	40	Pakistan	117			
Norway	21	Jamaica	20	Mali	24	P.N. Guinea	24			
Portugal	46	Mexico	52	Mozambique	17	Philippines	40			
Sweden	29	Nicaragua	30	Niger	13	Sri Lanka	86			
U.K.	39	Panama	38	Senegal	45	Syria	80			
USA	29	Peru	40	Tunisia	37	Thailand	61			
		Uruguay	41	Uganda	2	Turkey	78			
				Zambia	24					
				Zimbabwe	45					
Min	20		20		2		24	2	2	15
Max	46		73		58		117	117	50	117
Median	30		40		24		56	40	24	46
Mean	31.4		43.2		27.2		59.9	42.3	24.9	50.5
St. Dev	7.1		14.5		15.1		25.5	23.2	12.7	22.5

[1] Includes all countries under LAC, Africa, and Asia.[2] Cameroon, C.A.R., Congo, Egypt, Gambia, Ghana, Kenya, Liberia, Malawi, Mali, Mozambique, Niger, Senegal, Tunisia, Uganda, Zambia, and Zimbabwe (Source: World Bank's 1985 World Development Report).

Table 1, Panel B. Return on All Capital in 1996

Advanced		LAC		Africa		Asia		All LDC[1]
	All K		All K		All K		All K	All K
Australia	12	Argentina	28	Cameroon	9	China	9	
Austria	11	Bolivia	2	Kenya	12	India	11	
Belgium	13	Brazil	34	Mozambique	25	Indonesia	21	
Denmark	14	Chile	26	Niger	14	Jordan	10	
Finland	12	Colombia	22	Senegal	17	Malaysia	26	
Germany	10	Costa Rica	15	Tunisia	14	Philippines	34	
Ireland	23	D.R.	30			Sri Lanka	14	
Italy	15	Ecuador	17			Thailand	19	
Japan	12	Guatemala	23			Turkey	35	
Netherlands	7	Honduras	9					
N. Zealand	10	Mexico	16					
Norway	11	Panama	15					
Portugal	19	Peru	24					
U.K.	14	Uruguay	26					
USA	16							
Min	7		2		9		9	2
Max	23		34		25		35	35
Median	12		22.5		14		19	17
Mean	13.3		20.5		15.2		19.9	19.2
St. Dev	3.91		8.67		5.49		9.98	8.56

[1]Includes all countries under LAC, Africa, and Asia.

Table 1, Panel C. Return on All Capital and Return on Private Capital in 2005

Advanced			LAC			Africa			Asia		All LDC[1]	
	All	Private		All	Private		All	Private		All	Private	All	Private
Australia	14	19	Argentina	19	22	Cameroon	10	12	China	12	29		
Austria	13	16	Bolivia	2	3	Kenya	8	13	India	16	28		
Belgium	15	18	Brazil	22	26	Mozambique	22	54	Indonesia	16	24		
Denmark	14	16	Chile	22	27	Niger	6	9	Jordan	15	28		
Finland	15	19	Colombia	19	34	Senegal	14	22	Malaysia	10	19		
Germany	14	17	Costa Rica	17	22	Tunisia	15	19	Philippines	20	27		
Ireland	22	30	D.R.	29	62				Sri Lanka	12	16		
Italy	16	20	Ecuador	14	27				Thailand	14	21		
Japan	13	20	Guatemala	19	33				Turkey	39	58		
Netherlands	14	18	Honduras	9	16								
N. Zealand	18	26	Mexico	24	33								
Norway	13	18	Panama	28	40								
Portugal	10	12	Peru	28	38								
U.K.	16	22	Uruguay	17	34								
USA	16	21											
Min	10	12		2	3		6	9		10	16	2	2
Max	22	30		29	62		22	54		39	58	39	62
Median	14	19		19	30		12	16		15	27	16	27
Mean	14.9	19.5		19.2	29.8		12.5	21.5		17.1	27.8	17.2	27.4
St. Dev	2.7	4.27		7.47	13.4		5.8	16.6		8.71	12.2	7.7	13.6

[1]Includes all countries under LAC, Africa, and Asia.

Table 2. Data Availability: Paved Roads (PR) and Electricity Generating Capacity (EGC)

Advanced				LAC				Africa				Asia			
	PR	EGC	Both		PR	EGC	Both		PR	EGC	Both		PR	EGC	Both
Australia	Yes	No	No	Argentina	Yes	Yes	Yes	Algeria	No	Yes	No	Bangladesh	No	Yes	No
Austria	Yes	No	No	Bolivia	Yes	Yes	Yes	Botswana	Yes	No	No	China	No	Yes	No
Belgium	Yes	No	No	Brazil	Yes	Yes	Yes	Cameroon	Yes	No	No	India	Yes	Yes	Yes
Denmark	Yes	No	No	Chile	Yes	Yes	Yes	C.A.R.	No	Yes	No	Indonesia	Yes	Yes	Yes
Finland	Yes	No	No	Colombia	Yes	Yes	Yes	Congo	No	Yes	No	Fiji	No	Yes	No
Germany	Yes	No	No	Costa Rica	Yes	Yes	Yes	Egypt	No	Yes	No	Jordan	No	Yes	No
Ireland	Yes	No	No	D.R.	No	Yes	No	Gambia	No	Yes	No	Korea	Yes	Yes	Yes
Italy	Yes	No	No	Ecuador	Yes	Yes	Yes	Ghana	No	Yes	No	Malaysia	No	Yes	No
Japan	Yes	No	No	El Salvador	Yes	Yes	Yes	Kenya	Yes	Yes	Yes	Myanmar	No	Yes	No
Netherlands	Yes	No	No	Guatemala	Yes	Yes	Yes	Liberia	Yes	No	No	Nepal	No	Yes	No
N. Zealand	Yes	No	No	Honduras	Yes	Yes	Yes	Malawi	Yes	Yes	Yes	Pakistan	Yes	Yes	Yes
Norway	Yes	No	No	Jamaica	No	Yes	No	Mali	No	Yes	No	P. N. Guinea	No	Yes	No
Portugal	No	Yes	No	Mexico	No	Yes	No	Mozambique	No	Yes	No	Philippines	Yes	Yes	Yes
Sweden	Yes	No	No	Nicaragua	No	Yes	No	Niger	No	Yes	No	Sri Lanka	No	Yes	No
U.K	Yes	No	No	Panama	Yes	Yes	Yes	Senegal	Yes	Yes	Yes	Syria	No	Yes	No
USA	Yes	No	No	Peru	No	Yes	No	Tunisia	Yes	Yes	Yes	Thailand	No	Yes	No
				Uruguay	No	Yes	No	Uganda	No	Yes	No	Turkey	Yes	Yes	Yes
								Zambia	Yes	No	No				
								Zimbabwe	Yes	Yes	Yes				
# Countries	16				17				19				17		
"Yes" Count	15	1	0		11	17	11		9	15	5		6	17	6

Table 3. Ratio of the Rate of Return on Paved Roads to the Rate of Return on Capital

Advanced				LAC				Africa				Asia			
	Roads	All K	Ratio		Roads	All K	Ratio		Roads	All K	Ratio		Roads	All K	Ratio
Australia	-1.0	30	-0.02	*Argentina*	385	29	13.33	*Botswana*	20	58	0.34	*India*	74	78	0.96
Austria	0.00	29	-0.02	*Bolivia*	796	21	37.09	*Cameroon*	188	35	5.31	*Indonesia*	203	83	2.45
Belgium	6.0	40	0.14	*Brazil*	61	58	1.07	*Kenya*	53	19	1.51	*Korea*	1576	45	36.95
Denmark	12.0	30	0.4	*Chile*	524	73	7.15	*Liberia*	104	15	6.82	*Pakistan*	52	117	0.45
Finland	15.0	22	0.68	*Colombia*	947	55	17.53	*Malawi*	60	40	1.50	*Philippines*	719	40	17.99
Germany	16.0	29	0.55	*Costa Rica*	196	37	5.24	*Senegal*	48	24	2.0	*Turkey*	158	78	2.03
Ireland	6.0	36	0.15	*Ecuador*	197	51	3.85	*Tunisia*	16	37	0.36				
Italy	26.0	34	0.76	*El Sal.*	111	47	2.38	*Zambia*	65	24	2.69				
Japan	62.0	20	3.05	*Guatemala*	76	38	2.01	*Zimbabwe*	15	45	0.33				
Netherlands	15.0	32	0.46	*Honduras*	39	34	1.15								
N. Zealand	8.0	36	0.23	*Panama*	218	38	5.76								
Norway	2.0	21	0.08												
Sweden	6.0	29	0.21												
U.K.	13.0	39	0.32												
U.S.A.	7.0	29	0.26												
Min	-1.0	20	-0.02		39	21	1.07		15	15	0.33		52	40	0.45
Max	62.0	40	3.05		947	73	37.1		188	58	6.82		1576	117	37.0
Median	8.0	30	0.26		197	38	5.2		54	41.5	1.29		180.5	78	2.24
Mean	12.9	31.4	0.48		322.7	43.7	8.8		64.5	38.1	2.30		464	73.5	10.1
St. Dev	15.3	7.1	0.75		309.1	14.8	10.7		58.4	13.4	2.49		598	28.1	14.7
# Countries			15				11				9				6
# Below			14				0				3				2
P-value			0.999				0.0005				0.363				0.344

Source: Underlying data taken from Canning and Bennathan (2000: Table 7)

Table 4. Ratio of the Rate of Return on Electricity Generation to the Rate of Return on Capital

Advanced				LAC				Africa				Asia			
	Elec	All K	Ratio		Elec	All K	Ratio		Elec	All K	Ratio		Elec	All K	Ratio
Portugal	7.0	46.0	0.14	*Argentina*	46	29	1.59	*Algeria*	63	15	4.20	*Bangladesh*	61	80	0.77
				Bolivia	92	21	4.74	*C.A.R.*	40	12	3.25	*China*	54	41	1.31
				Brazil	10	58	0.16	*Congo*	114	25	4.58	*Fiji*	32	30	1.06
				Chile	41	73	0.56	*Egypt*	45	50	0.9	*India*	24	78	0.4
				Colombia	28	55	0.50	*Gambia*	105	23	4.49	*Indonesia*	106	83	1.7
				Costa Rica	25	37	0.69	*Ghana*	25	18	1.37	*Jordan*	40	42	0.96
				D.R.	25	61	0.42	*Kenya*	125	19	6.63	*Korea*	31	45	0.68
				Ecuador	45	51	0.90	*Malawi*	54	40	1.35	*Malaysia*	77	44	1.76
				El Sal.	17	47	0.40	*Mali*	51	24	2.16	*Myanmar*	34	33	1.03
				Guatemala	18	38	0.52	*Mozambique*	-7.0	17	-0.42	*Nepal*	40	56	0.72
				Honduras	95	34	3.56	*Niger*	12	13	0.92	*Pakistan*	18	117	0.19
				Jamaica	11	20	0.54	*Senegal*	6	24	0.25	*P.N. Guinea*	6	24	0.26
				Mexico	51	52	0.98	*Tunisia*	40	37	1.08	*Philippines*	44	40	1.25
				Nicaragua	20	30	0.67	*Uganda*	80	2	40.0	*Sri Lanka*	27	86	0.31
				Panama	21	38	0.55	*Zimbabwe*	5	45	0.14	*Syria*	35	80	0.44
				Peru	21	40	0.51					*Thailand*	42	61	0.69
				Uruguay	30	51	0.59					*Turkey*	32	78	0.45
Min	7	46.0	0.14		10	20	0.16		-7.0	2	-0.42		6	24	0.26
Max	7	46.0	0.14		95	73	4.74		125	50	46.3		106	86	1.76
Median	7	46.0	0.14		25	40	0.56		45	23	2.16		40	50.5	0.75
Mean	7	46.0	0.14		35.1	43.2	1.05		50.5	26.1	5.25		44.1	56.5	0.88
St. Dev	NA	NA	NA		25.1	14.5	1.22		40.8	14.8	11.5		24.7	20.9	0.48
# Countries			1				17				15				17
# Below			1				14				5				11
P-value			0.5				0.999				0.06				0.941

Source: Underlying data taken from Canning and Bennathan (2000: Table 7)

Table 5. Fifty-two percent of country-infrastructure return observations clear the dual hurdle for investment in electricity generating capacity or paved roads. Thirty-three percent clear the dual hurdle for both.

Quadrants		EGC	Paved Roads	Both
I	LAC	Argentina, Bolivia, Honduras	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Honduras, Panama	Argentina, Bolivia, Honduras
	Africa	Algeria, Central African Rep., Congo, Gambia, Kenya, Malawi, Mali, Tunisia, Uganda	Cameroon, Kenya, Liberia, Malawi, Senegal, Zambia	Kenya, Malawi
	Asia	China, Fiji, Indonesia, Malaysia, Myanmar, Philippines	Indonesia, Korea, Philippines, Turkey	Indonesia, Philippines
II	LAC			
	Africa	Ghana		
	Asia			
III	LAC	Brazil, Colombia, Costa Rica, Dominican Republic, El Salvador, Guatemala, Jamaica, Nicaragua, Panama, Peru, Uruguay		
	Africa	Mozambique, Niger, Senegal, Zimbabwe	Botswana, Tunisia, Zimbabwe	Zimbabwe
	Asia	India, Korea, Pakistan, Papua New Guinea, Sri Lanka		
IV	LAC	Chile, Ecuador, Mexico		
	Africa	Egypt		
	Asia	Bangladesh, Jordan, Nepal, Syria, Thailand, Turkey	India, Pakistan	

Quadrant I: Clears Cross-Country Hurdle and Clears Within-Country Hurdle; Quadrant II: Fails Cross-Country Hurdle but Clears Within-Country Hurdle; Quadrant III: Fails Cross-Country Hurdle and Fails Within-Country Hurdle; Quadrant IV: Clears Cross-Country Hurdle but Fails Within-Country Hurdle.

Table 6, Panel A. Rank Ordering of Opportunities for Efficient Investment in Electricity Generating Capacity

	Return on EGC/Return on K^*	Return on EGC/Return on K	Product
Uganda	2.55	40.0	102
Kenya	3.98	6.63	26.4
Congo	3.63	4.58	16.6
Gambia	3.34	4.49	15.0
Bolivia	2.92	4.74	13.9
Honduras	3.02	3.56	10.8
Algeria	2.01	4.20	8.44
Indonesia	3.38	1.70	5.75
Malaysia	2.45	1.76	4.31
Central African Republic	1.27	3.25	4.13
Malawi	1.72	1.35	2.32
Argentina	1.46	1.59	2.32
China	1.72	1.31	2.25
Mali	1.62	2.16	2.20
Philippines	1.40	1.25	1.75
Fiji	1.02	1.06	1.68
Tunisia	1.27	1.07	1.36
Myanmar	1.08	1.03	1.11

Table 6, Panel B. Rank Ordering of Efficient Investment Opportunities in Paved Roads

	Return on PR/Return on K*	Return on PR/Return on K	Product
Korea	50.2	37	1857
Bolivia	25.4	37.1	942.3
Colombia	30.2	17.5	528.5
Philippines	22.9	18.0	412.2
Argentina	12.3	13.3	163.6
Chile	16.7	7.15	119.4
Panama	6.94	5.76	39.97
Costa Rica	6.24	5.24	32.7
Cameroon	5.99	5.31	31.8
Ecuador	6.27	3.85	24.2
Liberia	3.31	6.82	22.6
Indonesia	6.46	2.45	15.8
Turkey	5.03	2.03	10.21
El Salvador	3.54	2.38	8.43
Zambia	2.07	2.69	5.57
Guatemala	2.42	2.01	4.86
Senegal	1.53	2.0	3.01
Malawi	1.91	1.50	2.87
Kenya	1.69	1.51	2.55
Brazil	1.94	1.07	2.08
Honduras	1.24	1.15	1.43