# Investing in Africa's Infrastructure: Financing and Policy Options

Paul Collier[1] and James Cust[2]

[1]Blavatnik School of Government, University of Oxford, Oxford OX1 4JJ, United Kingdom

[2]Department of Economics, Oxford Centre for the Analysis of Resource Rich Economies (OxCarre), University of Oxford, Oxford OX1 3UQ, United Kingdom; email: jim.cust@economics.ox.ac.uk

Annu. Rev. Resour. Econ. 2015. 7:473–93

First published online as a Review in Advance on May 1, 2015

The *Annual Review of Resource Economics* is online at resource.annualreviews.org

This article's doi: 10.1146/annurev-resource-100814-124926



JEL codes: H54, O40

## Keywords

infrastructure, public investment, Africa

## Abstract

Africa has a severe shortage of infrastructure. Addressing this shortage involves both correcting the problems of poor maintenance and underinvestment that have caused it and raising the finance for a phase of remedial investment. We review evidence that substantiates the shortage, in terms of both stocks and the potential for high rates of return. We then turn to the range of options for attracting remedial finance, focusing in particular on how they relate to the region's endowment of natural resources. Governments will need to build the regulatory and technical capacities to tap into this opportunity for leveraged private capital flows by reducing the risks associated with large, capital-intensive projects. Furthermore, governments must build the authority necessary to manage both the challenges associated with deferred public consumption and the time consistency needed to support long-term ventures.

## 1. INTRODUCTION

Africa is judged to have a severe shortage of infrastructure. The World Bank estimates annual needs at US$93 billion and the financing shortfall at between US$31 and US$40 billion.[1] The underlying rationale for the notion of an infrastructure shortage is that additional infrastructure would unlock large gains in African factor productivity. African economies have opportunities: There is probably more potential for resource extraction than in any other region, and the African labor force is increasing and urbanizing more rapidly than any other region. However, these opportunities cannot be fully seized without the provision of infrastructure. Yet increasing the finance for infrastructure has acute difficulties. Domestic financing is constrained because Africa's fragile democracies are hungry for consumption. International public finance is constrained by the fiscal woes of OECD governments. International private finance is deterred because African infrastructure is encumbered by an array of political and organizational impediments that raise perceived risk to unacceptable levels. To break the impasse, each of these issues will need to be tackled. African electorates must be convinced that deferring gains in consumption would yield large benefits. Donors must restructure aid budgets so as to gear up other sources of finance. Governance reform of infrastructure projects must make them acceptable assets for patient international capital such as pension funds.

This article reviews the literature on the need for African infrastructure and what would be involved to address it. Section 2 sets out the evidence for a current infrastructure shortage. However, this shortage is the result of past decisions, and Section 3 explains how it has come about. Section 4 discusses how the remarkable expansion of resource extraction in Africa during the past decade is transforming the opportunities for financing infrastructure and why seizing these opportunities is not straightforward. Section 5 addresses four ways in which finance for infrastructure could be scaled up and their implications for capacities and governance. Section 6 concludes.

## 2. AFRICA'S INFRASTRUCTURE CHALLENGE

Africa faces a critical shortfall in public infrastructure. An estimated 600 million people still have no electricity connection, more than 80% of the road network remains unpaved, and only 56% of the population have access to an improved water source (Banerjee et al. 2008, Foster & Briceño-Garmendia 2010, IEA 2013). Furthermore, infrastructure deficits are being addressed more slowly in Africa than elsewhere in the developing world. The differences are particularly large for paved roads, telephone main lines, and power generation. For all three, Africa has been expanding stocks at a lower rate than have other developing regions, so unless something changes, the gap will continue to widen (Pierce et al. 2008).

According to Teravaninthorn & Raballand (2009), the overall African road stock is actually contracting. The World Bank (2014) data show that paved roads for sub-Saharan Africa represent just 15% of total road networks in 2011, down from 18% in 2003. Electricity consumption is not much better. Consumption levels—530 kWh per person per year for 2009—have been largely stagnant for the previous decade and are down slightly from 560 kWh in 1997. Rail continues to be a significant challenge for the continent, with more than 80% of the 69,000-km network in a dilapidated, nonoperational state in 2009. Even when lines are running, transit times can be excessive; the 3,000-km trip from Kolwezi, Democratic Republic of the Congo (DRC), to Durban,

[1]World Bank's Africa Infrastructure Country Diagnostic (AICD) (World Bank 2010).

South Africa, takes 38 days, an effective speed of 4 km/h, according to Foster & Briceño-Garmendia (2010).

Infrastructure is of critical importance to economic output and human development. It complements a wide variety of private investments and types of economic activity. Furthermore, the provision of infrastructure services is typically an important contributor to welfare provision and therefore to human development outcomes. According to World Bank estimates, successfully closing the infrastructure gap could yield social dividends of US$17 billion a year (World Bank 2010).

The infrastructure deficit in Africa has wide-reaching consequences beyond the implications for economic growth. Limited infrastructure means that Africa will fail to meet the Millennium Development Goals for water and sanitation. The Africa Infrastructure Country Diagnostic (AICD) (World Bank 2010) estimates a persistent annual infrastructure investment need of approximately US$93 billion. This number represents almost double the estimated levels of annual investment across the continent at present.

Infrastructure can be defined in various ways. Typically, it refers to large, capital-intensive natural monopolies, such as highways, other transportation facilities, water and sewerage, power utilities, and communications (Gramlich 1994). Social infrastructure, such as schools, hospitals, prisons, and public housing, is sometimes included in this categorization. In Africa, these types of infrastructure have usually been publicly financed, owned, and operated, but some are held privately, and in other cases the absence of their provision leads to smaller-scale, private solutions (such as on-site power generation).

## 2.1. Quantifying the Importance of Infrastructure Investment

Researchers have traditionally relied on two distinct methodological approaches to evaluate the importance of infrastructure investments. The first, cost-benefit analysis, takes a project-level view, attempting to compute all the costs and benefits and their implied rate of return. Additionally, assessments may attempt to quantify the external effects of the project, although these effects are notoriously challenging to capture. The alternative takes a macro view of public investment within the aggregate production function. Here, as Arrow & Kurz (1970) propose, infrastructure can be captured in the aggregate production function and can be considered a complement to other input factors: labor and private capital. A large body of empirical work explores the link between stocks of public capital or infrastructure and economic performance (see, for example, Aschauer 1989, Gramlich 1994).

More recent approaches move beyond these two methodologies to construct a more rigorous evaluation of the wider effects and benefits of infrastructure. Such approaches seek to estimate the impact of infrastructure investment by using historical series and econometric techniques. These methodological innovations utilize various sources of data, including trade statistics, firm- or household-level survey data, and regional economic data. Here economists can often exploit time and spatial variation or exogenous placement of infrastructure to identify causal effects of projects on the wider economy.

For transportation infrastructure, studies find that an infrastructure deficit can carry a heavy cost, whereas the social returns to new investments can be potentially very high. Limao & Venables (2001) show that poor infrastructure significantly reduces trade flows. Donaldson (2012) finds that colonial railroads in India decreased transport costs, increased trade, and raised real income levels. Mu & van de Walle (2007) show that rural roads can increase wages and develop local markets in poor communities in Vietnam.

Storeygard (2013) examines the role of road infrastructure and transportation costs in economic activity in Tanzania. Using new data on spatial patterns of economic activity derived from

satellite imagery of nighttime lights, he estimates the effect of an exogenous increase in transport costs induced by a rise in world oil prices. The results show that an oil price increase of the magnitude experienced between 2002 and 2008 induces cities close to a major port to become 6% larger than otherwise identical cities one standard deviation farther away.

Likewise, Baum-Snow & Turner (2012) estimate that Chinese transport infrastructure has a strong influence on the shape of the rapid urbanization process across the country. They find that railroad construction has supported the decentralization of production from traditional economic centers, whereas road construction has supported the decentralization of population. The pattern of road building within cities, namely the construction of ring roads, has supported the decentralization of both population and production. Casaburi et al. (2013), using road-level regression discontinuity design in Sierra Leone, study the impact of improvements in rural road infrastructure on crop prices in rural markets. They show that the improved roads reduced market prices of local crops.

The countries that need investment the most face the biggest barriers. Collier et al. (2015) find that unit costs vary substantially, being especially high in societies affected by conflict and corruption, and that costs are negatively correlated with provision. Countries such as South Sudan, where the population is highly dispersed but unit costs of roads are very high, may face a difficult choice between addressing the causes of high costs and radically reducing dispersion through accelerated urbanization.

Road investments can have strong economic persistence. Michaels & Rauch (2013) show that in Europe there is a significant legacy of Roman infrastructure investments for modern agglomeration and urbanization. This approach has also been applied in Africa to measure the effects of other types of transport infrastructure. A study of colonial railroads in Africa by Jedwab & Moradi (2012) provides evidence suggesting that railroad cities have persisted, even after the railroad has fallen out of use. Furthermore, this study finds evidence that railroad cities are wealthier than nonrailroad cities, suggesting that the agglomeration triggered by railroad connectivity is persistent and leads to the accumulation of other factors, thus having a long-term effect on economic growth.

A similar study of railroad construction in colonial Kenya (Jedwab et al. 2014) uses data at a fine spatial level. Here the authors show that railroads causally determined settler location, which in turn decided the location of the major cities at independence. The persistence of these urban centers, outlasting both the settlers and the railroads, served as a mechanism to coordinate investments in the postindependence period. Their work underscores the importance of choices of infrastructure investment as solutions to coordination problems, with persistent effects on spatial development.

Recent empirical estimates by Lowe (2014) seek to understand the impacts of African rail privatizations. The author finds preliminary evidence of improved outcomes of interest such as economic activity, proxied by nighttime lights. However, some evidence suggests a negative effect on subjective measures such as perceived living standards and political support. This study raises the puzzle that local narratives seemingly diverge from tangible outcomes. Meanwhile, the study provides tentative evidence that late-1990s privatizations have been a step in the right direction.

For power, Dinkelman (2011) measures the effect of the massive rollout of the electricity grid in rural South Africa on employment—and, most notably, on female employment and labor market participation. She finds that, via time-saving contribution to the household, access to grid power frees up females' time for increased employment—as much as 9 hours per week more in districts with an average improvement in power access.

Kosec (2014) examines the effect of private sector participation (PSP) in the water sector across Africa. The author employs micro-level panel data to measure the 35% decrease in diarrhea

prevalence among urban-dwelling children under the age of 5. The study identifies causality through exploiting the time variation in private water market share controlled by African countries' former colonizers. A placebo analysis reveals that PSP does not affect symptoms of respiratory illness in the same children, nor does it affect a rural control group untreated by PSP. In the context in which one in ten child deaths each year results from diarrhea, the author argues that PSP can be an important policy instrument for improving human development outcomes.

In an earlier study, Galiani et al. (2005) examine the effect of privatizing water provision across 30% of Argentina's municipalities. Because privatization was not randomly assigned, Galiani et al. rely upon a difference-in-difference approach to compare privatized municipalities with their nonprivatized counterparts. Although this approach cannot eliminate selection on unobserved characteristics, it does allow the authors to control for time-invariant effects. Their estimates find a striking 8% fall in child mortality in privatized areas, with a 26% decline in the poorest areas.

Water infrastructure services are also important for agriculture. Duflo & Pande (2007) find that the benefits of building a dam, as a major form of public infrastructure investment in India, accrue to downstream districts in the form of increased agricultural reduction and reduced rural poverty.

Various authors examine the effects of ICT and, in particular, the market effects of improved mobile phone connectivity. Both Jensen (2007) and Aker & Mbiti (2010) estimate the role of communications infrastructure in lowering search costs and reducing information frictions. These researchers find reduced price dispersion from mobile phones, more so if markets are connected by road.

The effects of infrastructure, including direct channels of welfare effects versus long-term agglomeration effects, can be complex. Infrastructure, as a complement to both other infrastructure and private economic activity, can provide a platform for diversification or can be a driver for agglomeration and urbanization. Although these effects can be hard to capture, whether through cost-benefit analysis or macro analysis, the long-run effects can be stark and persistent. Furthermore, in developing countries with significant shortfalls in the stock of public capital, understanding the relationship between infrastructure investment and growth, and the social rates of return on different types of infrastructure investment, is of critical importance to policy making. Evidence suggests that privatization can yield benefits but is no panacea. Furthermore, high unit costs and deferred or dispersed returns on investment create daunting hurdle rates for new projects.

## 2.2. Estimated Economic Rates of Returns of World Bank Infrastructure Projects in Sub-Saharan Africa

**Table 1** looks at the estimated economic rate of return of World Bank–financed projects across different sectors between 1979 and 2009 in sub-Saharan Africa (Warner 2010).[2] The observed economic rates of return doubled in 20 years, from a median of 12% in the late 1980s to 24% in 2008 (Warner 2010). If reflective of the larger group of projects, these statistics could signal a large rise in the effectiveness of development projects. However, these estimates should be interpreted cautiously and may constitute an upper bound. Nonetheless, they provide useful evidence of the range of infrastructure financing as well as the trends associated with different categories of infrastructure financing. For individual projects, very high rates of return are apparently possible across a range of conditions.

[2]The data are drawn from the World Bank report "Cost-Benefit Analysis in World Bank Projects" (Warner 2010).

**Table 1 Estimated rates of return (ERR) for World Bank–financed projects**

| Sub-Saharan African infrastructure projects[a] | ERR0 | | ERR1 | |
|---|---|---|---|---|
| | Number of projects | Average ERR% | Number of projects | Average ERR% |
| Energy and mining | 101 | 21.4 | 85 | 16.2 |
| Global information/communications technology | 30 | 22.5 | 29 | 20.6 |
| Transport | 294 | 31.0 | 241 | 27.2 |
| Urban development | 55 | 25.5 | 41 | 22.9 |
| Water | 51 | 12.9 | 47 | 8.0 |
| **All** | **531** | **26.4** | **443** | **22.2** |
| **Sub-Saharan African infrastructure projects[b]** | **ERR0** | | **ERR1** | |
| | Number of projects | Average ERR% | Number of projects | Average ERR% |
| Energy and mining | 80 | 20.3 | 80 | 15.6 |
| Global information/communications technology | 29 | 22.7 | 29 | 20.6 |
| Transport | 237 | 28.7 | 237 | 26.7 |
| Urban development | 39 | 24.8 | 39 | 23.5 |
| Water | 43 | 12.4 | 43 | 7.9 |
| **All** | **428** | **24.0** | **428** | **22.0** |

[a]Projects for which either ERR0 or ERR1 is available.
[b]Projects for which both ERR0 and ERR1 are available.
Adapted from the data set provided by Warner (2010). ERR0 describes the estimated rate of return at the beginning of the project. ERR1 is the estimate at approximately 5 years after the project started (not at the end of the project, as some say, because the projects can last for 25–30 years or more). Due to the categorization of the projects in the data set, each of the categories presented might also include other recurring projects (e.g., procurement of goods and services, project implementation costs). The report suggests there is a strong upward bias as a result of limited reporting from unsuccessful projects but that there is limited evidence as to an upward bias in the estimation of returns from individual projects, which made this information available.

## 3. REASONS FOR THE DEFICIT

Africa's infrastructure shortfall has a number of contributing factors. Historically, Africa has suffered from underinvestment in and deterioration of the inherited infrastructure stock such as colonial railroads. Although overall stocks at independence were roughly comparable with other developing countries, stocks have since fallen increasingly behind. According to the World Bank, Africa had levels comparable to those of South and East Asia in terms of roads in the 1960s, telephones in the 1970s, and power in the 1980s. The comparison with South Asia, which has similar per capita incomes, is particularly striking. In 1970, sub-Saharan Africa had almost three times the generating capacity per million people compared with that of South Asia. In 2000, South Asia had left sub-Saharan Africa far behind—with almost twice the generation capacity per million people. Additionally, in 1970, sub-Saharan Africa had twice the landline telephone density of South Asia, but by 2000, the two regions were even (World Bank 2010).

The colonial legacy of infrastructure, which was focused on resource extraction, has exacerbated the challenge. Countries have had the wrong kind of infrastructure in the wrong places. Indeed, new work by Bonfatti & Poelhekke (2014) suggests that infrastructure investments motivated by resource extraction, such as mine-to-coast infrastructure, have diverted cross-border trade and regional interconnectivity. Furthermore, political instability and conflict have led to the pillage and dilapidation of public assets. The World Bank estimates that, following conflicts affecting the DRC, approximately 50% of infrastructure assets need rehabilitation (World Bank 2010).

Africa is characterized by low overall population density, low urbanization, and geographically dispersed economic activity. These characteristics reduce the potential returns to investment, either through lower utilization levels or through larger distances to traverse. For example, Africa has a much lower spatial density of roads than does any other region of the world: only 204 km of roads per 1,000 $km^2$ of land area, with less than one-quarter paved. In contrast, the world average is 944 km per 1,000 $km^2$, with more than one-half paved (Gwilliam 2011). Population dispersal has been exacerbated by political fragmentation: Notably, many countries are landlocked. Border crossing is costly and reduces the size of locally accessible markets. It also limits the opportunities to connect important economic centers.

Although all these underlying historical factors contribute to the challenge, domestic political economy often holds back countries from rectifying their investment deficits. African transportation networks are characterized by high freight tariffs. Research shows, however, that rather than being driven by higher costs, such tariffs are driven by the high profit margin and limited competition in Africa compared with other continents (Teravaninthorn & Raballand 2009). The limited competition is exacerbated by a highly regulated market. Furthermore, construction costs remain higher than in the rest of the developing world, and unit costs are particularly high in fragile or postconflict states. However, the failure of infrastructure can be attributed as much to failures of operation and maintenance as to insufficient investment.

Financing the deficit will require more than US$90 billion per year, although available domestic resources fall a long way short of that figure. Government revenues are estimated to contribute approximately US$60 billion per year to infrastructure investment, with US$22 billion per year made available via overseas development assistance (IMF 2014). The remainder will have to come from private financing, either in return for resource exports—so-called barter deals or resources for infrastructure—or from private financing models to build profitable projects.

The nature of the infrastructure challenge varies markedly between African country groups (Briceño-Garmedia et al. 2008). In fragile states, for example, infrastructure spending needs exceed 35% of GDP and attract little external finance. Although the challenge is lower in nonfragile states, the World Bank (2010) estimates that they must allocate on average approximately 23% of their GDP to build and sustain basic infrastructure. Resource-rich countries are, in principle, better placed to meet their infrastructure needs, although in practice they have not tended to do so (Bhattacharyya & Collier 2014, IMF 2014). Resource-rich countries could meet their infrastructure spending needs for only approximately 12% of GDP (World Bank 2010). Capturing the value of resource extraction, via tax and royalty payments, could in principle provide a key source of financing, but the accomplishment of this goal would depend upon revenues being collected effectively through taxation and then being spent appropriately.

The political economy of infrastructure provision has become the main impediment. At the international level, in the mid-1990s donors switched aid budgets from infrastructure to social spending on health and education. This shift was motivated partly by an exaggerated belief that international private finance would meet the need for infrastructure. Additionally, there was a perceived need to regain popular support for aid following both criticism from the political left

that infrastructure support was used to enforce socially damaging structural adjustment policies and criticism from the political right that it fueled corruption.

At the domestic level, there has been a bias against maintenance such that existing infrastructure has eroded. This trend is partly due to the greater opportunities for corruption presented by construction contracts and partly due to the bias in aid toward new construction (Briceño-Garmendia et al. 2008). Service provision has been dominated by public monopolies either inherited from colonial times or established in the heady atmosphere of postindependence state-led development. Once established, these entities acquired strong vested interests that have been defended through patronage. As with other African public services, these entities have failed to develop an ethic of service to the national interest.[3] The public monopolies have grossly underused infrastructure: For example, Nigeria has cumulatively spent approximately US$16 billion to purchase generating equipment, to little effect (Collier 2012). As a consequence, firms and households have invested in self-provision with massive sacrifices of scale economies: For example, most firms have private generators (Reinikka & Svensson 2002). Occasionally, new technology has enabled commercial provision to bypass the public monopolies; the most spectacular instance is the mobile phone, which, by virtue of being classified as a distinct product, has evaded the telecom monopoly. The exceptionally rapid take-up of mobile phones has been driven by the prior failure of public landline provision. Similarly, the associated development of e-banking in East Africa has been aided by the inadequacies of official payments mechanisms. There are hopes that solar power will become an equivalent technology for electricity generation, enabling cheap off-grid provision. However, to date, solar has needed complementary inputs such as maintenance and finance, the inadequacies of which have precluded mass adoption (Collier & Venables 2012).

Public monopoly provision is also handicapped by the politicization of pricing, resulting in subsidies that are affordable only if supply is acutely inadequate. Seemingly, there is an obvious political deal to be struck in which citizens accept higher prices in return for expanded provision. However, such deals face a time-consistency problem. Ministers of finance have authority over financing, whereas ministers of energy have authority over pricing. A minister of energy will share some of the kudos for expanded provision but will face criticism for raising prices. Because expanding provision takes time, if the two decisions are announced as a package, the minister of energy will face immediate criticism and may not survive to reap a share of praise. If, however, investment in expansion is undertaken before prices are increased, the minister of energy has no incentive to comply with such an undertaking. Seeing this, ministers of finance will not authorize investment. Nigeria and Guinea have been examples of this standoff.

## 4. THE NATURAL RESOURCE OPPORTUNITY

The resource boom of the past decade created an unprecedented opportunity to rectify this deficit in infrastructure. Directly, some infrastructure investment became necessary to enable the exploitation of newly profitable resource discoveries. Indirectly, the increased public revenues made infrastructure more affordable. However, each of these opportunities has proved to be difficult to harness.

### 4.1. Infrastructure for Resource Extraction

The price boom sharply increased the incentive for prospecting. For straightforward commercial reasons, such activity was concentrated in those regions that had previously had little search. As of

[3]See Collier (2015a).

2000, the value of known subsoil assets per square kilometer of sub-Saharan Africa was only US$22,700, or approximately one-seventh of that in the OECD.[4] This massive difference is unlikely to have reflected fundamentally less promising geology: Over two such large parts of the Earth's surface, the most reasonable presumption is that the random allocation of localized value would generate similar averages. Rather, this difference reflected the fact that there had been much less opportunity to prospect in Africa. For the quarter century prior to the boom, resource prices had been depressed. Prior to that, much of Africa had been politically risky as a result of recent decolonization and coups; the deterrence effect of weak governance is estimated to have been quite large for resource exploration over the past half century (Cust & Harding 2014). The decade of the resource boom was the first time during which price incentives were aligned with satisfactory governance. Following the fall of the Berlin Wall, much of Africa had transitioned to democratic political governance, whereas the conjunction of sustained International Monetary Fund (IMF) programs and Jubilee debt relief had transformed macroeconomic governance. As resource extraction companies recognized this opportunity, investment in search was ramped up, which has yielded many commercially viable discoveries. Given the size of the continent, it was inevitable that many of these discoveries would be far from the coast and indeed far from urban centers. Their exploitation therefore required large investments in infrastructure for transport and power. For example, the massive and high-quality iron ore deposits at Simandou in Guinea required investment in a new rail line. Furthermore, the shortest rail route to the coast involved a line through Liberia. This scenario has generated problems, discussed below, and so the government of Guinea sought a new rail line of more than 600 km and a new port. The cost of this new infrastructure substantially exceeds US$10 billion and is approximately double the capital costs of the mine itself. Despite this enormous cost, the deposit is so valuable that the returns on the total investment remain high. Currently, Rio Tinto, a major international mining company, and the government of Guinea are seeking to put together a consortium that could finance the project. Simandou illustrates both the opportunity for resource extraction to induce infrastructure investment and the difficulties involved.

First, Simandou requires an irreversible investment that is so large as to be wholly disproportionate to the size of the economy—more than double the GDP. The combination of irreversibility and uniqueness renders the investment subject to potential holdup by the sovereign polity. The loss of sovereign reputation inflicted by repudiation of contract may be regarded by a future government, and hence by prospective investors, as less costly than the gain generated so that undertakings are liable to be time inconsistent. For many years, this issue indeed deterred investment in the processing of Guinea's bauxite because even the billion dollar investment required would have been disproportionate to GDP.[5] This holdup problem is not confined to the extraction of minerals. Oil extraction in Chad required an investment of US$4.2 billion. Because the government of Chad was subject to criticism from NGOs with regard to its legitimacy and its potential use of the revenues, oil companies were reluctant to risk their reputations. The World Bank undertook the reputational risk by getting the government to commit to a specific use of revenues, with a substantial part being devoted to social spending enforced by a governance structure. This was sufficient protection for oil companies to go ahead with the investment. However, once the investment was made, the government invoked its sovereign right to withdraw from the undertaking and switched expenditures to armaments. It backed its new policy with the threat to transfer the investment to Chinese companies unless the initial owner continued

[4]Data are from the Changing Wealth of Nations data set (World Bank 2010).

[5]Personal communication from Paul O'Neill, a former CEO of Alcoa.

extraction. The undertaking was seen to be time inconsistent and was resolved by acquiescence on the parts of the investor and the World Bank. The holdup problem can also arise in power generation when the sole purchaser is a public entity; we take this topic up in Section 5.

Second, because the African land mass is divided into 54 different sovereign polities, the most efficient infrastructure investment will often be transnational. The resource problem extends beyond the extraction of ore, and two further examples illustrate the generic issue. Deep-sea gas was recently discovered off the coasts of both Mozambique and Tanzania. For the enormous costs of extraction to be covered, a substantial proportion of the gas will need to be sold in international markets, notably East Asia. This step requires conversion into liquefied natural gas (LNG), which requires massive investment in trains.[6] It might well be most economic for this investment to be shared between the two countries. The largest opportunity for electricity generation in Africa is Inga, which could harness the River Congo in the DRC. However, Inga would generate far more power than the DRC could use, and the only substantial market within transmission distance is South Africa. To reach this market, the electricity would need to be transmitted through Zambia, Zimbabwe, and Botswana. Both private investors and home governments are wary of such involvement of other sovereign polities because of the enhanced potential for holdup.

Third, there is an intrinsic tension between the interest of the government in regulating the infrastructure built for resource extraction and the interest of the investor. Prospecting for resources is inherently a sequential process: Not everything is discovered at once. The circumstances in which private investment in the infrastructure for extraction is viable arise only because some valuable resource has been discovered, but such discovery increases the prospect that further resources will be found in neighboring locations. If the company that makes the first discovery is permitted to invest in a transport connection that it owns and controls, it has a strategic advantage in the bidding for rights to all neighboring prospects. Only it would be able to use the transport connection at marginal cost; other companies would be willing to pay for usage rights at anything less than the cost of building their own dedicated infrastructure and would therefore be outbid. Unrestricted rights over the infrastructure would thus be tantamount to acquiring the rights to all further prospecting in the neighborhood at a heavy discount. In effect, because mining and transport are intrinsically interdependent, the competitive market structure that is imperative at the prospecting stage implies that regulation should guarantee competitive access to a transport link that has a natural monopoly. Yet such shared-use infrastructure has historically been rare in Africa. The first resource extraction companies to find resources sufficiently valuable to warrant investment in a rail line have effectively acquired monopoly rights over all subsequent resource finds served by the line. This, for example, is the situation in Guinea with respect to bauxite extraction via the railway line to Boke. In its negotiations over Simandou, the government of Guinea was determined to learn from this mistake of a previous government and insisted that the railway line be multiuser. In the limit, the government can require a complete separation in ownership between the rail company and the resource extraction company. Such a separation creates the potential for a further holdup problem. This possibility became apparent in Mozambique, where the company that owned the railway built to transport coal came into conflict with the coal mining company. The conventional solution is to regulate the price that can be charged by the railway. However, such regulation is considerably more difficult because it requires an irreducible degree of discretion, which is problematic in the context of potential corruption. In turn, this challenge complicates the task of raising finance for the rail investment. The challenge of multiuser

[6]A train in this context is the technical term for a gas liquefaction plant.

infrastructure is compounded if the government requires that it also be multifunctional—able to serve uses other than resource extraction. We return to this topic in Section 5.

## 4.2. Infrastructure Financed by Resource Revenues

The indirect effects of resource extraction on infrastructure are potentially even more positive than the direct effects. The public revenues generated by extraction can finance new infrastructure, and there is a powerful reason for them to be used for such a purpose: A substantial proportion of resource revenues should be used for asset accumulation (Halland et al. 2014). The reasons for this investment are partly the prospect of physical depletion and partly the prospect of technological obsolescence.

Resource extraction depletes a natural asset. Viewed from the perspective of permanent income, this depletion should be offset by the accumulation of other assets to the extent required for a sustainable increase in consumption. An elementary inference from the permanent income framework is that the shorter is the duration of depletion, the higher is the required savings rate from resource revenues. Many of the recent high-value resource discoveries in Africa are liable to be relatively short lived. For example, almost all the really large oil fields were discovered decades ago; those discovered during the past decade are consequently mostly small. Hence, physical exhaustion is often a serious prospect: Cameroon, an early African oil economy, is already approaching that limit. However, even where physical exhaustion is very distant, resource rents are vulnerable to technological innovation. New technology may cause a collapse in demand, as happened with nitrates due to the discovery of synthetics in 1920, or it may open new sources of abundant supply. For example, Zambia is heavily dependent upon copper. Although Zambia has a large endowment, the global demand for copper will collapse once an alternative to copper wire is developed for the transmission of electricity, and global supply will expand once new technologies are developed for extracting abundant copper from the seabed. Although technological innovation threatens all industries, resource extraction is distinctive because what is at risk is the rent that accrues from it. If a manufacturing activity declines to extinction, capital can redeploy into other activities, continuing to earn a normal return. But if resource extraction becomes unviable, the rents on the activity are lost.

The implication is that over the next two decades African governments should substantially increase their savings rates. In Section 5 we discuss why, in African conditions, using much of this new savings for infrastructure rather than for other assets would be appropriate. Here, we consider the prior issue of whether having a high savings rate from resource revenues is politically viable.

During the resource booms of 1973–1986, few African governments used revenues to accumulate assets. Nigeria is the totemic case. The heady increase in oil revenues following the price hike in 1974 triggered a large increase in public consumption, exemplified by a public sector wage increase of 75% in the following year. Although there was also a "big push" to increase expenditure on infrastructure, in the absence of public organizational capacity this effort resulted in exceptional levels of waste and corruption. For example, Nigerian agents bought so much cement on world markets that Lagos port was clogged for 3 years by what became known as the Cement Armada. Cameroon and Zambia provide important examples of completed cycles of resource depletion. Gauthier & Zeufack (2011) estimate that in Cameroon sustained asset accumulation was negligible. In Zambia, by 2002 known viable copper reserves had been exhausted; the industry was loss making; and the international owner, Anglo-American, had pulled out. As in Cameroon, the resource had been depleted without offsetting asset accumulation. Within Africa, the historic exception to this pattern of low savings from resource extraction is Botswana. The astute first

president of Botswana promoted patient use of diamond revenues through a national narrative that became widely known: "We're poor, and so we must carry a heavy load."

During the boom of the past decade, African governments were well aware of this history. The sentiment that "we won't make the mistakes of Nigeria" was widespread. However, whereas the previous resource boom was generally managed by autocracies, most African polities are now democratic. What governments understand no longer matters; rather, what citizens understand, and what they trust governments to do, is critical. Ghana is generally rated as being at the forefront of both democratization and economic improvement in the region, but the policy response to its discovery of oil in 2007 has not been encouraging. A close and intense political contest triggered competitive commitments to public consumption and wage increases, resulting in an overall decline in the public savings rate. By 2014, after only 3 years of oil revenues, the government had to call in the IMF. Similarly, in Zambia, also a closely contested democracy, by 2014 the copper boom had been sufficiently fiscally destabilizing to require IMF involvement. In Nigeria in 2012, the population resisted, through mass strikes, an attempt to redirect the use of oil revenues from a scam-prone petrol subsidy to the development budget. Underlying this resistance was a suspicion of government so deep that it could not credibly commit to spending revenue in ways that would benefit only the future. In effect, most governments lack commitment technologies.

## 5. OPTIONS FOR FINANCING INFRASTRUCTURE, AND THE ROLE OF NATURAL RESOURCE EXTRACTION

We now consider four ways, each related to natural resources, in which new finance can be raised for African infrastructure. **Table 2** presents an overview of recent estimates of financing for infrastructure arising from different financing sources. Although these historic levels are insufficient to meet the present financing challenge, various sources can be leveraged to help meet the shortfall.

### 5.1. The Almost-Free Lunch

The most straightforward way in which resource extraction can meet Africa's infrastructure needs is if the infrastructure required to facilitate extraction can be designed and regulated in such a way as to be multifunctional. This setup is distinct from a multiuser setup, which concerns the competitive access of resource extraction companies to each other's infrastructure.

For example, a railway whose primary use is for the transportation of ore to the coast can become either a quasi-wall across the country, traversed only by ultralong ore trains, or a transport corridor that opens up the interior for commercial agriculture. The resource extraction company has little direct interest in making such a facility multifunctional. Running such a railway would constitute a noncore business and would involve the risk of reducing the efficiency of extraction, which depends upon synchronizing the arrival of trains with the arrival of ships. Furthermore, there are few rents in commercial agriculture so that such users would be unable to pay much more than marginal costs. Similar considerations apply to the ports, power generation, and water supply needed for resource extraction.

However, whereas the resource company has little to gain from multifunctional infrastructure, the society has much to gain. Although the benefits of a transport corridor may be realized only after many years, they can be considerable. For example, Lusaka, the capital city of Zambia, was initially merely a coaling station on the railway line from the coast to the copper belt.

These divergent interests can be resolved if the government requires, as part of the extraction rights, that the infrastructure be designed to be multifunctional and priced for nonresource users at marginal cost. The company will then factor in the increased costs generated by the requirement in

**Table 2 Estimated spending by key financing source (annualized flows)**

| Country type | O&M (US$ billions) | Capital expenditure (US$ billions) | | | | | |
|---|---|---|---|---|---|---|---|
| | Public sector | Public sector | ODA | Non-OECD financiers | Private | Total capital expenditures | Total |
| Africa, total | 20.4 | 9.4 | 3.6 | 2.5 | 9.4 | 24.9 | 45.3 |
| Resource rich | 2.5 | 3.4 | 0.5 | 1.4 | 3.8 | 9.1 | 11.7 |
| Middle income | 10.0 | 3.1 | 0.2 | 0.0 | 2.3 | 5.7 | 15.7 |
| Low-income nonfragile | 4.4 | 1.6 | 2.5 | 0.6 | 2.1 | 6.7 | 11.1 |
| Low-income fragile | 0.8 | 0.2 | 0.4 | 0.3 | 0.5 | 1.4 | 2.1 |

Adapted from the AICD (Foster & Briceño-Garmendia 2010). Aggregate public sector covers general government and nonfinancial enterprises. Numbers are extrapolations based on the 24-country sample covered in AICD phase 1. Totals may not add exactly because of rounding errors. Abbreviations: O&M, operation and maintenance; ODA, official development assistance; private, private participation in infrastructure and household self-finance of sanitation facilities.

its bid for the rights. Because the cost to the company will usually be much less than the gain to the society, the small reduction in government revenue will be a cheap price for getting a lot of public infrastructure. Both African governments and international companies are now beginning to recognize the upsides of this policy (Collier 2011). For example, after initial opposition in the context of the Simandou project, Rio Tinto adopted the global principle that infrastructure should normally be multifunctional.

## 5.2. Resources as Collateral

Africa is highly unusual in its urgent need for urban infrastructure. Africa is the least urbanized region, and its rural population is now rapidly shifting to cities. Furthermore, Africa's total population is still rising rapidly. In conjunction, population shift and growth are expected to triple Africa's urban population by 2050: Two-thirds of Africa's future cities are yet to be built. It is far cheaper for this infrastructure to be built in advance of settlement rather than retrofitted in arrears, yet to date public investment has not kept pace with urbanization—hence the standard phenomenon of sprawling shanty towns. African governments therefore need urgently to ramp up their expenditures on urban infrastructure.

Urban infrastructure is distinctive in that its cost can potentially be recovered by socializing the consequent appreciation in land values. Because the infrastructure can benefit only those who live or work near it, the benefit is reflected in higher land values. If the land does not appreciate sufficiently to cover the cost, then the infrastructure was not worth installing. The appreciation can be socialized either by taxing it or, more directly, by the government taking ownership of a proportion of the land. China is the exemplar of this self-financing strategy for urban infrastructure, some Indian states have adopted it, and in Africa Ethiopia is following it.

Although such infrastructure is ultimately self-financing, it poses a challenge to cash flow: Infrastructure must be built before the value of land can increase. Nor is the prospect of land appreciation likely to be satisfactory collateral for an international lender. The appreciation of the land value is contingent upon a loan being spent on well-implemented infrastructure. Furthermore,

the land appreciation generates domestic currency, whereas loans to Africa are likely to be in foreign currency. The future revenues from natural resource extraction provide a much safer form of collateral, and so loan rates can be lower.

To take a current example, Tanzania is one of the least urbanized countries in the world. Dar es Salaam, its main city, is set to grow from 5 million to approximately 15 million by 2050. To preempt settlement, much of the infrastructure for this extra 10 million people needs to be built during the coming decade on land currently used for farming. The government cannot finance this scale of infrastructure from its existing resources. However, in 2012 Tanzania discovered offshore gas. Although this resource will not start to generate revenues until at least 2022, by 2016 the international companies involved will decide whether to make the large investments necessary to bring it to market. Once this decision is taken, and with it the associated contracts for LNG sales, the government will be in a position to borrow, using the prospective gas revenues as collateral. Such a use need not preempt the future use of gas revenues, because the land belongs to the state subject to compensation for existing usage rights. The debt could thus be repaid from the appreciation of the requisitioned farmland.

## 5.3. Infrastructure as an Offset to Resource Depletion

Almost all African countries are chronically short of social and economic infrastructure. Some services generated by investment in this infrastructure could in principle be recovered by charging users, and we discuss this in Section 5.4. But many of the services generated by valuable infrastructure could not be appropriated. For example, the cost of enforcing tolls on rural roads would most likely exceed the revenues collected, and charging for water has sometimes proved to be politically unacceptable. There are isolated examples of tolls on new major roads, but even in such cases public opposition has proved to be much stronger than anticipated. For social infrastructure, such as health clinics and schools, attempts during the 1990s at cost recovery have generally been judged to be mistakes due to the strong discouragement of usage among poorer households.

However, although citizens seem to expect such infrastructure to be financed by government taxation, the share of GDP captured through taxation is usually less than 20% and so is too low for this approach to be viable. If one supposes that the social rate of return on African infrastructure lies in the range of 15–25%, with only a fifth of this captured by taxation, the financial return is therefore only approximately 3–5%. This rate is far below the borrowing costs faced by any African government: A typical real rate in the sovereign bond markets is currently approximately 6%. The IMF recently developed a tool to help governments to evaluate whether debt finance of infrastructure is sustainable (Berg et al. 2013). The tool takes into account the linkage between investment and growth and makes assumptions on the rate of return on public capital. One reason why Africa is so short of infrastructure is that commercial borrowing would usually be unviable.

However, were the infrastructure to be financed out of savings from resource revenues, the pertinent comparison would not be between this financial return and the cost of borrowing, but between the social return and the return on foreign financial assets. Given that world risk-free real interest rates for depositors are currently close to zero, nearly all the real interest rate that African governments pay on their commercial borrowing is a risk premium: There is a large wedge between their borrowing and lending rates. Hence, infrastructure yielding 5–20% is far superior to foreign financial assets offering negligible yield.

Some African governments are now adopting this strategy. In 2010 Guinea received a US$700 million windfall as part of the Simandou negotiations. The finance minister ring-fenced US$200 million of this into a fund to be spent on infrastructure. However, it has also become fashionable

for resource revenues to be earmarked to a sovereign wealth fund, influenced by the Norwegian model, in which assets are held abroad: Africa has become the fastest-growing region for such funds. An offshore fund is reasonable for Norway because it has already invested more domestic capital per member of the labor force than has any other country in the world, and the government has also already paid down its domestic debt to zero. However, there are two important weaknesses with such a model for Africa. First, as discussed above, the return on foreign financial assets is likely to be far below that on infrastructure. Second, the establishment of a fund can create the illusion that resource revenues are being saved when in fact the opposite is happening. For example, Ghana has paid approximately US$200 million into an offshore heritage fund while over the same period raising almost US$2 billion from sovereign bond issues. Clearly, being a saver while also being a borrower merely incurs the costs of the substantial wedge between the borrowing and savings rates facing African governments.

The Chinese business practice in Africa of linking resource extraction directly to the provision of infrastructure and finance in a single deal simulates the approach of using the revenues from resource rents to finance infrastructure. Future resource extraction becomes the collateral for the advance provision of infrastructure. During the past decade, such Chinese deals have rapidly increased, although data remain limited. Such deals have been estimated at approximately US$0.5 billion per year in 2001–2003, US$1.5 billion in 2004–2005, and at least US$7 billion in 2006 (Foster et al. 2009). The finance was mainly through resource-backed loans from the Export-Import Bank of China (Cust & Zhang 2014). These Chinese packages have three potential advantages over contractual separation.[7] They can be negotiated and implemented quickly and, in particular, within an electoral cycle that is often on the horizon for African governments; the control of collateral reduces default risk and thus borrowing costs; and the packaging of infrastructure and resource extraction provides a valuable commitment technology. Otherwise, even if a finance minister obtained prior cabinet approval to earmark resource revenues for infrastructure, he or she may be outvoted by spending interests once revenues arrive. However, these packages also have important weaknesses. As they are packages, they are opaque, so determining whether they are good value is difficult. Because China is the only entity offering them, they are not disciplined by like-for-like competition. Hence, they have acquired the reputation for being poor value.

## 5.4. Private Finance for Infrastructure

As Africa continues to grow, helped by resource extraction, the demand for infrastructure services is increasing. FDI to Africa, for example, has increased by a factor of five since 2000, increasing from US$10 billion to US$50 billion in 2012 (Blas 2013, UNCTAD 2013). This development is increasing the potential for private investment in utilities. However, to date such projects are rated as highly risky, and few have been completed (Eberhard et al. 2011). Success depends upon reducing perceived risk. Currently, private finance seeks sovereign guarantees. For example, this solution was proposed by African-born Tidjane Thiam, who in 2011, when he was then CEO of Prudential, was commissioned by the G20 to devise ways of scaling up private financing. However, in view of the limited borrowing capacity of African sovereigns, it is important not to preempt this capacity with projects that could be commercially viable as free-standing entities. Indeed, properly structured, such projects can be less risky than sovereign debt because, although they lack the

[7]Indeed, the Chinese packages recall an earlier literature on interlinkages in rural factor markets in poor countries (Braverman & Stiglitz 1982).

backing of the general tax base, they gain a dedicated source of revenue that cannot be preempted for other uses. For example, when the government of Côte d'Ivoire defaulted on its sovereign debt during the civil war, the debt of the Azito project, the first major private power project in Africa, continued to be serviced.

Private risks can be reduced in part by the expansion of donor-provided risk capital and political risk insurance. Currently, the World Bank requires its risk capital arm, the International Finance Corporation (IFC), to cross-subsidize its concessional aid program, the International Development Association (IDA). Yet for aid to gear up private finance for infrastructure, it would be more appropriate for IDA funds to be used to cross-subsidize first-loss equity stakes held by the IFC. Similarly, until recently the Multilateral Investment Guarantee Agency (MIGA) of the World Bank had only a small African portfolio. Yet due to the considerable soft power of its parent group, MIGA has been able to recover on all but two of its 750 projects so that it is more akin to a commitment technology than an insurance agency. A strategic way for aid to gear up private infrastructure finance would be to subsidize the political risk insurance of projects. Donors are now recognizing that for aid to maintain significance it will need to be redirected to gearing up private finance for infrastructure, in contrast to the full financing model of the past.

Risks can also be preempted by redesigning the governance of projects (Collier 2015b). Conceptually, a project can be split into three phases: negotiation, building, and operating. Currently, the pipeline of bankable projects is limited, suggesting a failure at the first stage. Many negotiations drag on for years: Each project is treated as idiosyncratic, and time inconsistencies are not addressed up front. There are few private dedicated teams with the combination of technical and political expertise necessary to catalyze projects because appropriating a share of the gains is difficult for them. There is a good case for aid agencies to subsidize such teams. The British aid agency the Department for International Development now provides such subsidies through AfriCo and the new Africa50 fund of the African Development Bank. But the approach could be scaled up through IFC and its bilateral counterparts. The traditional mode of operation of IFC and its bilateral counterparts has usually been to wait passively for private sector proposals to be submitted, rather than to catalyze them. There is also scope for greater standardization to reduce delays and address time consistencies at the onset of negotiations.

The build stage requires large, irreversible investments facing high risks. It therefore requires high-return, equity capital, but unless this capital has an exit strategy upon completion, the resulting cost of infrastructure services financed by private equity will be far above world levels. Hence, a critical step is to provide a credible exit strategy for high-risk capital once the utility is operating.

Once operating, African infrastructure needs to be classified by international investors as a utility rather than as a frontier investment and thus made suitable for pension funds. Therefore, a reputable international operator has to be attracted. In turn, both foreign operators and government need reassurance that they will not be subject to holdup by the other party. Operators could get some reassurance by being allowed to sell directly to firms. For example, the need for sales to a public electricity grid could be eliminated by contracts that used the grid only for transmission, matching input with offtake. Resource extraction companies could sometimes serve as anchor clients for private infrastructure operators. However, an anchor client potentially creates a new risk of holdup. For example, in Mozambique, on World Bank advice, mining and rail were designed as independent private activities, but the investors in coal mining complain of inadequate capacity installed by the rail company on which they are dependent. More generally, investor and government reassurance requires credible regulation. But regulation requires discretion, and in the high-corruption environment of the African public sector, it is therefore distrusted, posing a new risk of holdup. For private finance of infrastructure to meet Africa's needs,

regulation will therefore need to be transformed so that regulators come to be seen as independent of government while subject to the conventions and norms of an international profession.

## 5.5. Implications for Government Decision Processes

If government and private finance is forthcoming to scale up African infrastructure, the technical capacities for public investment will need to be augmented and the political authority over infrastructure redesigned. Doing so has implications for a range of government decision processes.

Enhanced capacities are needed to design, select, implement, and evaluate public projects. The IMF recently measured each such step in a public investment management index (Dabla-Norris et al. 2012). This index confirms that investment efficiency in sub-Saharan Africa lags behind that of other emerging markets and developing countries. However, there is considerable variation among the subcomponents, and so there is potentially scope for governments to learn from each other and perhaps even to combine capacities. For example, were each country of the West African Monetary Union able to attain its collective best scores, the countries in that group would rate among the best in the developing world in the index. Rwanda and Botswana have already built valuable capacities, the former in cost-benefit analysis and the latter in project implementation. Additionally, donor-provided technical assistance is now substantial. For example, Estache (2010) estimates that support for infrastructure capacities now accounts for 60% of the grant budget of the African Development Bank.

To address the failures of the past, political commitment technologies need to be built. Evidently, governments will build commitment technologies only once they have recognized the high costs of time inconsistency. The spread of independent central banking across the OECD demonstrates that governments do eventually learn. However, even when African governments recognize the advantages of being able to make credible commitments, doing so is especially challenging because the region abounds in isomorphic mimicry: entities that superficially copy international models but that are not intended to be effective. Typically, to be effective, a commitment technology that binds natural resource decisions will need three distinct components: a rule, a dedicated institution, and a critical mass of citizen support (Collier 2015c). The rule, which may be legislated or a publicly announced policy, guides repeated decisions and creates the potential for a newsworthy signal if a decision that breaches this rule is taken. A dedicated institution is a team of public officials with a mandate to implement the rule, with the technical capacity to do so, and with an organizational culture that internalizes its purpose. Citizen support defends the rule and the institution from the inevitable pressures of self-interested parties. The extent of such support necessary for effective defense—the critical mass—will vary between societies, depending upon the structure of political power.

One important commitment technology for infrastructure concerns project selection and implementation: The process needs protection from the influence of political patronage and prestige. Here a starting point is for parliaments to legislate rules that require the decision process to be transparent and to meet specified standards of due process. This process is by far the easiest of the three processes. Institutionally, a team of public officials must be built that has the capacity and motivation to act in the national interest. The capacity can be provided by donor-organized training, but motivation is more problematic. Public salary levels are often so low that refraining from opportunistic behavior would be quixotic. Even once salaries are reformed, which requires ring-fencing the vital institutions and placing their staff on distinct pay scales, this stage is highly dependent upon the selection of motivated people and may require politically sensitive actions. For example, when Tanzanian tax collection was reformed, existing tax officials were dismissed, and approximately one-third rehired into a new organization following screening for

skills and character. The final stage is building sufficient citizen understanding to provide effective defenses. Across Africa, citizens have become highly suspicious of government. As discussed below, such suspicion can be a two-edged sword, but the positive aspect is that the need for checks and balances on power is widely recognized.

A second commitment technology concerns infrastructure deals with foreign companies. This inevitably confronts the issue of national sovereignty, which remains a sensitive matter in Africa. Currently, a variety of ad hoc techniques, such as dispute settlement boards in which nominated panels adjudicate disputes, are negotiated. As discussed above, a more promising approach may be to radically scale up political risk insurance through international public agencies such as MIGA. The insurance nature of the arrangement is far less politically toxic than an overt surrender of sovereign power. Although credible dispute resolution is important, dispute avoidance may have more potential. African utilities could potentially be operated by reputable international utility companies that are subject to independent regulatory institutions genuinely benchmarked on established international practices and supported by international professional networks of expertise.

A third commitment technology concerns the need for a high rate of saving out of resource revenues. Ironically, the IMF, an institution usually committed to prudence, has historically opposed measures that would lock governments into using revenues for the accumulation of assets. Opposition has derived from maintaining the principle of integrated budgets that avoid any earmarking; the rationale is that marginal equivalences between all components of expenditure can be maintained. However, this principle ignores the severe time-consistency problems that African finance ministries often face. As the case of Ghana shows, there is already some appetite for legislated rules requiring saving out of resource revenues. The problem is that the intention of the rule can be readily overridden by offsetting decisions. Clearly, in Ghana what was lacking was a critical mass of citizens with sufficient understanding of the mechanics of saving and borrowing to recognize that the government was not actually accumulating assets and to hold institutions to account for not doing so. The pervasive suspicion of government is an impediment to prudential behavior. When citizens believe that government will embezzle resource windfalls, these individuals will rationally demand rapid pass-through to private consumption such as that achieved by spending the windfall on public sector wage increases. The end of the supercycle provides a rare opportunity for building such a critical mass across the region. As several African governments find themselves in fiscal crisis, citizens are beginning to recognize the enormity of the missed opportunity to accumulate assets. A respected African institution could usefully undertake a high-profile stocktaking of what the supercycle has delivered. Major mistakes are opportunities for social learning. Sometimes, as with hyperinflation in Germany, such mistakes immunize a society from repetition.

A fourth commitment technology concerns the proceeds of sovereign bond issues, which need to be ring-fenced from consumption. Here, the weight of responsibility should lie with creditors. Lending in the absence of a credible commitment technology deserves to face a high default risk. The IMF might usefully develop a rating system as part of its Article IV reviews to determine whether the moneys raised by sovereign bond issues were adequately protected from being diverted into consumption.

Finally, part of Africa's infrastructure deficit reflects inadequate maintenance, and so maintenance budgets need to be protected. Although potentially distorting, commitment devices such as road funds, which earmark some road usage–generated revenues for maintenance, may in practice be helpful (Gwilliam & Kumar 2002).

The practices of China in Africa have had ambiguous effects on the ability to make such binding commitments. Ready-designed Chinese infrastructure projects such as airports and stadiums are

often pitched directly to the president, bypassing conventional financial scrutiny and thus undermining the project selection process. However, by avoiding a revenue flow into the budget, the package structure of Chinese deals, in which resources are exchanged directly for infrastructure, provides a uniquely credible mechanism by which an African government can precommit to converting natural assets into infrastructure.

## 6. CONCLUSION

The infrastructure shortfall poses a major challenge for Africa. The economic costs of absent or limited infrastructure can be large and persistent, whereas the benefits are often dispersed, are hard to estimate ex ante, and are hard to recover. However, there is wide agreement that the economic returns can be significant; can be long lasting; and can serve as an important platform for urbanization, diversification, and growth.

The imperative, therefore, is to overcome barriers to source the necessary financing to build, operate, and maintain the next generation of infrastructure. Government faces a problem of both securing this financing and creating the political and regulatory environment to attract and protect the investments. To break the present impasse, each of these challenges will need to be tackled. Domestic financing is constrained because Africa's fragile democracies are hungry for consumption. International public finance is constrained by the fiscal woes of OECD governments. International private finance is deterred because African infrastructure is encumbered by an array of political and organizational impediments that raise perceived risk to unacceptable levels.

In the future, natural resource wealth presents policy options that can be leveraged to tackle these constraints, with the potential to unlock complementary infrastructure investments and to crowd-in additional private capital. Multifunctional resource infrastructure is rapidly becoming the preferred approach, but governments require better tools to evaluate and design these schemes. Resources can serve as collateral to secure, and commit to, long-term infrastructure investment. Packaging infrastructure for resources can overcome time inconsistency but can bring its own challenges of ensuring transparency and value. Private capital flows will necessarily play an important role. Finally, the technical capacities for public investment will need to be augmented and the political authority over infrastructure redesigned. Underpinning the reform of institutions is that African electorates must be convinced that deferring gains in consumption would yield large benefits.

## DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review.

## LITERATURE CITED


Aker JC, Mbiti IM. 2010. Mobile phones and economic development in Africa. *J. Econ. Perspect.* 24:207–32

Arrow KJ, Kurz M. 1970. Optimal growth with irreversible investment in a Ramsey model. *Econometrica* 38:331–44

Aschauer DA. 1989. Is public expenditure productive? *J. Monet. Econ.* 23(2):177–200

Banerjee S, Wodon Q, Diallo A, Pushak T, Uddin H, et al. 2008. *Access, affordability, and alternatives: modern infrastructure services in Africa*. Backgr. Pap., AICD, World Bank. **http://www.infrastructureafrica.org/system/files/BP02_Access_affordability_summary.pdf**

Baum-Snow N, Turner M. 2012. *Transportation and the decentralization of Chinese cities*. Unpub. Pap.

Berg A, Portillo R, Yang S-C, Zanna L-F. 2013. Public investment in resource-abundant developing countries. *IMF Econ. Rev.* 61(1):92–129

Bhattacharyya S, Collier P. 2014. Public capital in resource-rich countries: Is there a curse? *Oxf. Econ. Pap.* 66(1):1–24

Blas J. 2013. Offshore centres race to seal Africa investment tax deals. *Financ. Times*, Aug. 19. **http://www.ft.com/intl/cms/s/0/64368e44-08c8-11e3-ad07-00144feabdc0.html**

Bonfatti R, Poelhekke S. 2014. *From mine to coast: transport infrastructure and the direction of trade in developing countries*. Work. Pap. 4,170, CESifo

Braverman A, Stiglitz JE. 1982. Sharecropping and the interlinking of agrarian markets. *Am. Econ. Rev.* 72:695–715

Briceño-Garmedia C, Smits K, Foster V. 2008. *Financing public infrastructure in sub-Saharan Africa: patterns and emerging issues*. Backgr. Pap., AICD, World Bank. **http://www.infrastructureafrica.org/system/files/library/2009/11/BP15_Fiscal_costs_summary.pdf**

Casaburi L, Glennerster R, Suri T. 2013. *Rural roads and intermediated trade: regression discontinuity evidence from Sierra Leone*. SSRN Work. Pap. 2161643

Collier P. 2011. Building an African infrastructure. *Finance Dev.* 48:19–21

Collier P. 2012. *How to spend it: the organization of public spending and aid effectiveness*. Work. Pap. 2012/05, WIDER

Collier P. 2015a. Africa: new opportunities, old impediments. *Econ. Aff.* 35:169–77

Collier P. 2015b. Attracting international private finance for African infrastructure. *J. Afr. Trade* 1:37–44

Collier P. 2015c. *The institutional and psychological foundations of natural resource policies*. Unpub. Pap., Blavatnik Sch. Gov., Univ. Oxford

Collier P, Kirchberger M, Soderbom M. 2015. The cost of road infrastructure in developing countries. *World Bank Econ. Rev.* Forthcoming

Collier P, Venables AJ. 2012. Greening Africa? Technologies, endowments and the latecomer effect. *Energy Econ.* 34:S75–84

Cust J, Harding T. 2014. *Institutions and the location of oil exploration*. Discuss. Pap., OxCarre, Univ. Oxford

Cust J, Zhang Q. 2014. *Financing power infrastructure in Africa: the choice of methods*. Unpub. Pap.

Dabla-Norris E, Brumy J, Kyobe A, Mills Z, Papageorgiou C. 2012. Investing in public investment: an index of public investment efficiency. *J. Econ. Growth* 17(3):235–66

Dinkelman T. 2011. The effects of rural electrification on employment: new evidence from South Africa. *Am. Econ. Rev.* 101:3078–108

Donaldson D. 2012. *Railroads of the Raj: estimating the impact of transportation infrastructure*. NBER Work. Pap. 16487

Duflo E, Pande R. 2007. Dams. *Q. J. Econ.* 122(2):601–46

Eberhard A, Rosnes O, Shkaratan M, Vennemo H. 2011. *Africa's power infrastructure: investment, integration, efficiency*. Rep., World Bank, Washington, DC

Estache A. 2010. Infrastructure finance in developing countries: an overview. *EIB Pap.* 15(2):60–88

Foster V, Briceño-Garmendia C, ed. 2010. *Africa's infrastructure: a time for transformation*. Overv. Pap., AICD, World Bank. **http://siteresources.worldbank.org/INTAFRICA/Resources/aicd_overview_english_no-embargo.pdf**

Foster V, Butterfield W, Chen C, Pushak N. 2009. *Building Bridges: China's Growing Role as Infrastructure Financier to Sub-Saharan Africa*. Washington, DC: World Bank

Galiani S, Gertler P, Schargrodsky E. 2005. Water for life: the impact of the privatization of water services on child mortality. *J. Polit. Econ.* 113(1):83–120

Gauthier B, Zeufack A. 2011. Governance and oil revenues in Cameroon. In *Plundered Nations? Success and Failures in Natural Resource Extraction*, ed. P Collier, AJ Venables, pp. 27–78. Basingstoke, UK: Palgrave Macmillan

Gramlich EM. 1994. Infrastructure investment: a review essay. *J. Econ. Lit.* 32:1176–96

Gwilliam K. 2011. *Africa's Transport Infrastructure: Mainstreaming Maintenance and Management*. Washington, DC: World Bank

Gwilliam K, Kumar A. 2002. *Road funds revisited: a preliminary appraisal of the effectiveness of "second generation" road funds*. Discuss. Pap. TWU-47, World Bank
Halland H, Beardsworth J, Land B, Schmidt J. 2014. *Resource Financed Infrastructure: A Discussion on a New Form of Infrastructure Financing*. Washington, DC: World Bank
IEA. 2013. *World energy outlook 2013*. Rep., IEA. **http://www.worldenergyoutlook.org/publications/weo-2013/**
IMF. 2014. *Regional Economic Outlook: Sub-Saharan Africa: Staying the Course, October 2014*. Washington, DC: IMF
Jedwab R, Kerby E, Moradi A. 2014. *History, path dependence and development: evidence from colonial railroads, settlers and cities in Kenya*. Work. Pap. 2014-02, George Washington Univ.
Jedwab R, Moradi A. 2012. *Colonial investments and long term development in Africa: evidence from Ghanaian railroads*. Work. Pap., George Washington Univ.
Jensen RT. 2007. The digital provide: information (technology), market performance and welfare in the south Indian fisheries sector. *Q. J. Econ.* 122(3):879–924
Kosec K. 2014. The child health implications of privatizing Africa's urban water supply. *J. Health Econ.* 35:1–19
Limao N, Venables AJ. 2001. Infrastructure, geographical disadvantage, transport costs, and trade. *World Bank Econ. Rev.* 15(3):451–79
Lowe M. 2014. *Rail revival in Africa? The impact of privatization*. Presented at RES-SPR Conf. on "Macroeconomic Challenges Facing Low-Income Countries"
Michaels G, Rauch F. 2013. *Resetting the urban network: 117-2012*. Discuss. Pap. 9,760, CEPR
Mu R, van de Walle D. 2007. *Rural roads and local market development in Vietnam*. Policy Res. Work. Pap. 4,340, World Bank
Pierce J, Yepes T, Foster V. 2008. *Making sense of sub-Saharan Africa's infrastructure endowment: a benchmarking approach*. Work. Pap. 1, AICD, World Bank
Reinikka R, Svensson J. 2002. Coping with poor public capital. *J. Dev. Econ.* 69(1):51–69
Storeygard A. 2013. *Farther on down the road: transport costs, trade and urban growth in sub-Saharan Africa*. Policy Res. Work. Pap. 6,444, World Bank
Teravaninthorn S, Raballand G. 2009. *Transport Prices and Costs in Africa: A Review of the Main International Corridors*. Washington, DC: World Bank
UNCTAD (United Nations Conf. Trade Dev.). 2013. *Time series on inward and outward foreign direct investment flows, annual, 1970–2012*. Data Set, UNCTAD
Warner AM. 2010. *Cost-benefit analysis in World Bank projects*. Rep., World Bank
World Bank. 2010. *Africa Infrastructure Country Diagnostic*. Washington, DC: World Bank
World Bank. 2014. *World Development Indicators*. Washington, DC: World Bank. **http://data.worldbank.org/data-catalog/world-development-indicators**