SUMMARY OF BACKGROUND PAPER 11

AFRICA INFRASTRUCTURE COUNTRY DIAGNOSTIC

Unit Costs of Infrastructure Projects in Sub-Saharan Africa

Africon

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About AICD

This study is part of the Africa Infrastructure Country Diagnostic (AICD), a project designed to expand the world's knowledge of physical infrastructure in Africa. AICD will provide a baseline against which future improvements in infrastructure services can be measured, making it possible to monitor the results achieved from donor support. It should also provide a more solid empirical foundation for prioritizing investments and designing policy reforms in the infrastructure sectors in Africa.

AICD will produce a series of reports (such as this one) that provide an overview of the status of public expenditure, investment needs, and sector performance in each of the main infrastructure sectors, including energy, information and communication technologies, irrigation, transport, and water and sanitation. The World Bank will publish a summary of AICD's findings in spring 2008. The underlying data will be made available to the public through an interactive Web site allowing users to download customized data reports and perform simple simulation exercises.

The first phase of AICD focuses on 24 countries that together account for 85 percent of the gross domestic product, population, and infrastructure aid flows of Sub-Saharan Africa. The countries are: Benin, Burkina Faso, Cape Verde, Cameroon, Chad, Congo (Democratic Republic of Congo), Côte d'Ivoire, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia. Under a second phase of the project, coverage will be expanded to include additional countries.

AICD is being implemented by the World Bank on behalf of a steering committee that represents the African Union, the New Partnership for Africa's Development (NEPAD), Africa's regional economic communities, the African Development Bank, and major infrastructure donors. Financing for AICD is provided by a multi-donor trust fund to which the main contributors are the Department for International Development (United Kingdom), the Public Private Infrastructure Advisory Facility, Agence Française de Développement, and the European Commission. A group of distinguished peer reviewers from policy-making and academic circles in Africa and beyond reviews all of the major outputs of the study, with a view to assuring the technical quality of the work.

This and other papers analyzing key infrastructure topics, as well as the underlying data sources described above, will be available for download from www.infrastructureafrica.org. Freestanding summaries are available in English and French.

Inquiries concerning the availability of datasets should be directed to vfoster@worldbank.org.

Summary

Public services and infrastructure are inseparable facets of economic and human development—so much so that it is hard to picture one without the other. To plan the investments in infrastructure that growing societies and economies need, governments and financial institutions must know how much those investments will cost and how those costs are determined—in detail. Ultimately, the cost of every project will reflect many purely local circumstances and requirements, but a comprehensive database on the cost of the components of standard infrastructure interventions is an essential instrument for planners. It can provide a helpful frame of reference within which to assess the validity of the proposals and estimates submitted in response to requests for bids on infrastructure projects. It can also shed light on the factors that account for cost variations across projects. Indeed, without such information, how is one to know whether the people have received value for their money?

Procurement officers, planners, and others needing information on unit costs typically work with the cost estimates prepared by engineers in the course of project design. A handful of standard unit-cost parameters are widely used for such purposes across the infrastructure sectors, although their exact origin and relevance often are no longer clear. Moreover, being design estimates, such costs tend not to reflect the peculiarities of the local setting, nor do they include any indication of the likely spread around the central parameters.

For all of these reasons, the development of a unit-cost database for the infrastructure sectors—transport, energy, and water—is an important goal. Building one, however, is methodologically challenging, for conceptual and empirical reasons alike. The conceptual challenge lies in finding a way to strip out extraneous cost elements so that each cost element is pared to a standardized core that is readily comparable across specific projects. The empirical challenge lies in locating, analyzing. and capturing the essence of extensive and complex contractual documents that record the actual costs of implementation.

The objective of our study was to design, generate, and analyze a database of the unit costs of infrastructure projects in Sub-Saharan Africa over the past decade. Our plan was to gather actual unit costs from recently completed projects, which meant obtaining documentation on projects procured some years back. But in recognition of practitioners' concerns about a escalation in unit costs for infrastructure development in Sub-Saharan Africa, we added to our plan a more focused exercise to understand the evolution of unit costs—from design to procurement—for road projects during the period 2005–06. The results complement the historic database by shedding light on recent cost trends and their likely explanations.

Standardizing and categorizing the data

Our goal was to obtain accurate unit output costs—that is, the cost per unit of infrastructure (a water connection, for example) as opposed to the cost per unit of input (such as labor costs). Output costs are especially useful for planning; input costs, by contrast, are most useful at the design stage.

We obtained data from four development finance institutions, which we labeled Donor 1, Donor 2, Donor 3, and Donor 4. The central data source was the bill of quantities (BOQ) drawn up for each civil works contract. We also took great care to collect supporting documentation, including project appraisal and completion reports, procurement documents, and subsequent change orders.

Although we had intended to compile a representative sample of projects (with the target of 150 contracts per sector), practical constraints limited us to 115 road contracts, 144 water contracts, and 58 electricity contracts over a shorter period of time—approximately 2002 to 2006. These limitations skewed the data toward certain countries and activities in which donors were active and excluded certain activities that the study originally expected to cover.

We packaged the data into a template that we applied to all the infrastructure sectors. The template's general section covers context (contract name, country, key dates, donor, and so forth), while the specific section covers content (contract costs, units, and so forth). We also standardized input costs to ease comparisons of contracts within and among sectors. We then customized the specific template for each sector to accommodate infrastructure requirements.

Because the organization and content of BOQs differ widely, we had to convert data to the template as dictated by specific projects. We excluded certain cost categories—notably initial studies, taxes, and design and supervision. For roads, the study excludes certain major structures. Some contracts (especially in the water sector, and to a lesser extent in electricity) combine various infrastructure outputs in one contract. Our study separated those outputs, allocated nonspecific costs across them, and standardized the data to real 2006 U.S. dollar values. On this basis, unit costs could be calculated as the total contract cost relevant to a specific output, minus the excluded cost categories described above, divided by the units of output.

Selecting descriptive measures and exogenous variables

We needed descriptive measures to quantify the spread of data around a central point. Ideally, the measure of spread should not be affected by outlier values. So, rather than employing the more traditional statistical measures of mean, variance, and standard deviation, we used the median to indicate the center point, employing the interquartile range to describe the spread and excluding outlier values in the calculation of the range. We considered as outliers all data points more than 1.5 interquartile ranges from Q1 and Q3.

Some of the data sets reveal patterns in residual values—in particular, evidence of economies of scale in road contracts. For simplicity's sake, we differentiate small contracts are from big contracts and demonstrate the descriptive statistics for each separately.

Apart from a contract's intrinsic design characteristics (such as terrain, climate, design standard, and so forth), various external factors may contribute to differences in unit costs relative to otherwise similar contracts. For our study, we analyzed contract data by country (geographic region; access to sea vs. landlocked), main donor, procurement method, nationality of contractor, and time trends. The question of competition (number of bidders) was considered, but we had insufficient data to make conclusions in that regard.

Findings for the road sector

The study sampled 115 road projects, including 25 contracts to build new paved roads, 45 to rehabilitate paved roads, 8 to maintain paved roads, and 37 to regravel unpaved roads. The sample is heavily skewed towards a single donor (Donor 1), but the sample is widely spread across countries. The best-represented countries are Angola, Burkina Faso, Mozambique, and Uganda.

The resulting unit costs for road construction and maintenance are summarized in table A. There is strong evidence of a scale effect, with projects involving less than 50 kilometers of road costing significantly more than larger projects, particularly where new construction is concerned. Viewed against comparable values from the World Bank's ROCKS Database, the costs we arrived at tend to be substantially higher, except in the case of regraveling.

Table A The unit costs of road construction and maintenance

2006 US$

Type	Unit	Lower quartile	Median	Upper quartile
Construction (paved) <50km	US$/lanekm	349,523	401,646	613,929
Construction (paved) >50km	*US$/lanekm*	*209,427*	*290,639*	*344,135*
Rehabilitation (paved) <50km	*US$/lanekm*	*220,186*	*352,613*	*505,323*
Rehabilitation (paved) >50km	*US$/lanekm*	*194,679*	*299,551*	*457,714*
Periodic maintenance (Paved)	*US$/lanekm*	*81,854*	*158,009*	*235,157*
Regraveling	*US$/lanekm*	*12,835*	*15,625*	*19,490*

Note: Italicized text denotes sample sizes large enough to provide reliable unit-cost predictions

Findings for water and sanitation

The study sampled 144 water and sanitation projects, including 33 well contracts, 60 distribution main contracts, 14 reservoir contracts, 26 service connection contracts, and 11 public latrine contracts. The sample was drawn almost exclusively from Donor 1, and the country coverage is highly skewed, with more than 80 percent of the contracts coming from just five countries: Mozambique, Namibia, Nigeria, Tanzania, and Zambia. The water and sanitation unit costs are summarized in table B.

Table B Unit costs for water and sanitation projects

2006 US$

Type	Unit	Lower quartile	Median	Upper quartile
Wells—no pump	*US$/well*	*5 297*	*6 341*	*6 707*
Wells—electric pump	US$/well	14 112	37 492	54 701
Wells—electric and hand pump	*US$/well*	*11 288*	*13 959*	*14 896*
Pipe—small diameter	US$/m	14	26	40
Pipe—midsize diameter	US$/m	122	144	219
Pipe—mains	*US$/m*	*358*	*457*	*633*
Reservoir construction—steel	US$/kl	437	1 067	2 584
Service connection—yard	US$/conn	13	24	74
Service connection—standpipe	*US$/conn*	*177*	*282*	*363*
Latrines—public	US$/conn	14 014	19 659	29 662

Note: Italicized text denotes sample sizes large enough to provide reliable unit cost predictions.

Findings for the electricity sector

Table C Electricity unit costs

2006 US$

Type	Unit	Lower quartile	Median	Upper quartile
Generation—high speed diesel	US$/MW	451,153	822,864	1,363,835
Distribution <66kV	*US$/line km*	*4,885*	*8,278*	*9,608*
Transmission ≥66kV	*US$/line km*	*20,455*	*27,632*	*31,970*
Substations ≤50MVA	*US$MVA*	*177,945*	*205,682*	*234,762*
Substations >50MVA	US$MVA	48,474	68,865	110,166
Service connection	US$/conn	729	806	1,450
Service connection with street lighting	*US$/conn*	*493*	*609*	*658*
Street lighting	*US$/conn*	*1,261*	*1,767*	*2,428*

Note: Italicized text denotes sample sizes large enough to provide reliable unit cost predictions

We sampled 58 electricity projects, many fewer than for the other sectors. The main explanation for the paucity of power projects is the relatively low level of donor engagement in the sector during the study period. The sample includes 12 generation contracts, 12 transmission contracts, 12 substation contracts, 18 service connection contracts, and 4 street lighting contracts. The sample is heavily skewed toward Donor 1. Benin, Ethiopia, Tanzania, and Uganda together account for about half of the sample.

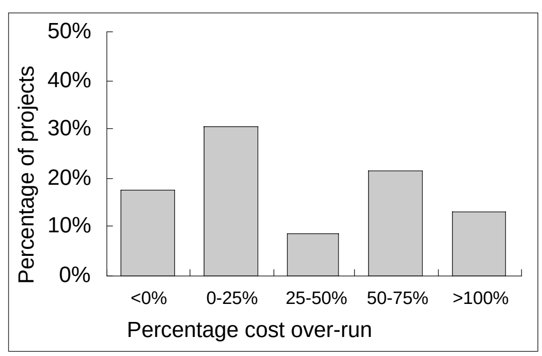
The main findings are reported in table C.

Understanding the recent spate of cost overruns

Cost overruns (relative to the original estimates at the time of project appraisal) have become increasingly common among road construction projects. They certainly were apparent in the projects in our database. Such escalations are creating serious problems in the implementation of development projects, since they significantly reduce the amount of infrastructure that can be purchased from a given funding commitment.

To explore the causes underlying the escalations, we analyzed 24 ongoing road-building projects. Ongoing projects were chosen because they provide the best indication of current market conditions. Our objective was to reveal the magnitude of cost overruns and to find possible explanations. The average project in the sample of 24 experienced a cost overrun of 35 percent (figure A). For a third of the sample, overruns exceeded 50 percent and reached 100 percent in a few cases.

Figure A. Frequency distribution of percentage cost overruns



Source: AICD Unit Cost Database, 2008.

We investigated several hypotheses for the recent escalations. The first was that delays in project implementation exposed the projects to the recent upswing in global prices of inputs needed in road construction, notably petroleum products. The second hypothesis was that tight market conditions in the global construction industry have exerted upward pressure on contractors' prices. The third is that the lack of effective competition has permitted higher markups.

Hypothesis 1: rising input prices

Nearly all of the projects in the sample experienced delays in implementation from the date anticipated in the project appraisal reports. The delays ranged from one to five years but averaged 22 months for the sample as a whole. Donors' project appraisal reports nearly always assume a best-case scenario under which the project will be completed quickly. In particular, they tend to assume that the procurement process will be completed within four to five months. But of the projects reviewed, *only two* were concluded in the time frame allowed; in both cases, procurement had largely preceded appraisal.

The longer it takes to procure materials and execute a project, the greater the chance that costs and prices will increase. We investigated the effect of both general price inflation and changes in the prices of specific inputs, notably oil. Oil prices affect road construction through two channels: the cost of direct inputs and the cost of transportation.

The price of bitumen (asphalt), a key material in road construction, tracks the price of petroleum very closely. Since 2002, international cost indices show increases of 80 to 120 percent in the price of bitumen, hot mix, paved concrete, and other key materials used in road construction. Increases became particularly steep during 2005–06.

With regard to the cost of transportation, higher oil prices are now reflected in the price of diesel in domestic African markets, which previously had been insulated by subsidies from price movements. Now, 60 percent of the countries we studied have passed on at least three-quarters of the oil price hike to their domestic diesel prices. In these countries it is plausible that higher transportation costs could have contributed to project cost overruns.

Figure B The ratio of increases in oil and diesel prices to project cost increases

For projects with overruns of greater than 10 percent

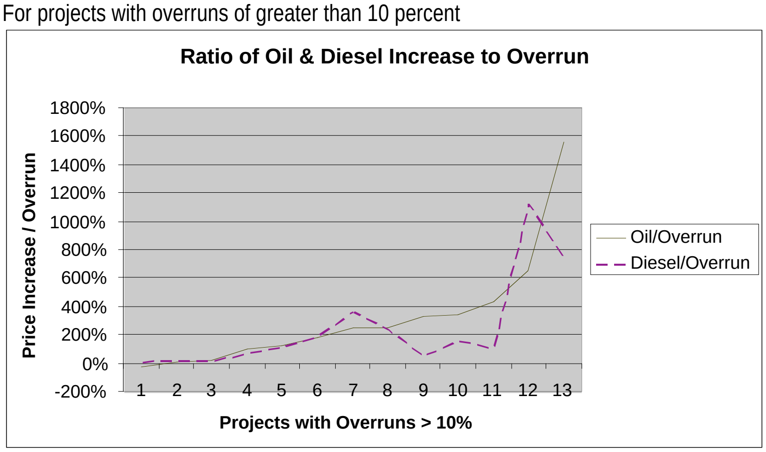
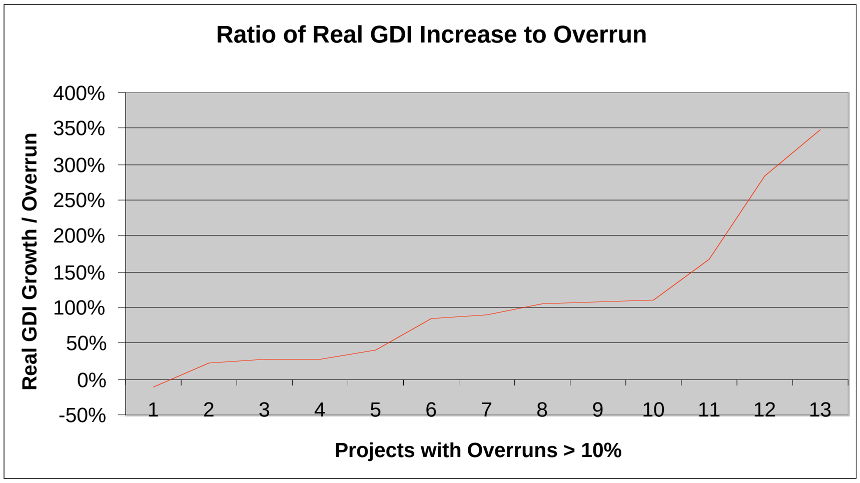


Figure B illustrates the strong association between the magnitude of oil and diesel price hikes in a given country and the presence of cost overruns. By looking at the detailed content of each project, we were able to reach a more nuanced assessment of how the oil price hike might have contributed to the overrun. Our overall conclusion is that although this effect has been important, it is not nearly as dominant as generally believed. It played a role in only about half of the cases considered here.

Hypothesis 2: tight construction markets

The global construction business is substantially busier today than it was just a few years ago. When the market is busy and contractors' surplus capacity is absorbed, prices can be expected to rise. As a proxy for changes in demand for contractor services at the country level, we chose the rate of growth of real gross domestic investment (GDI), the component of the GDP that captures fixed capital formation. In the case of seven countries, real GDI increased by more than 50 percent from December 2002 to December 2006.

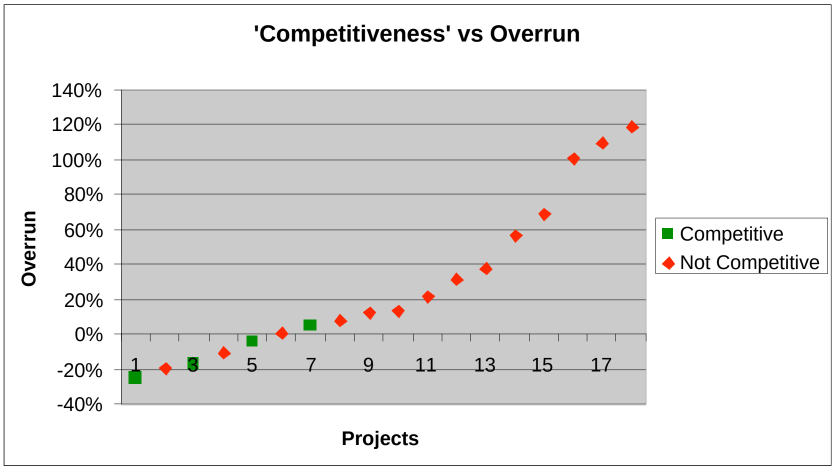
Figure C Ratio of increases in real GDI to increases in project costs



Movement in the ratio of real GDI growth to cost overruns is tracked in figure C. Our detailed project-by-project assessment concluded that market conditions in the construction industry appear to have played a role in explaining cost overruns in about a third of the cases considered here. Although GDI growth appears to be a relevant indicator of overruns, it is probably not as strong an indicator as are the increases in oil and diesel prices.

Hypothesis 3: inadequate competition

Figure D Competitiveness as an explanation of contract cost increases

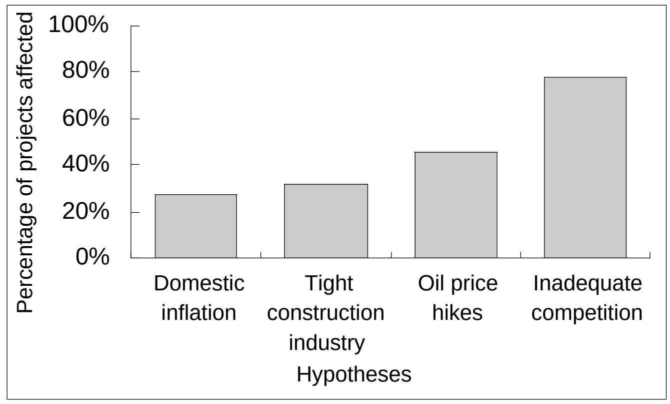


Assuming that engineers' estimates are reasonably accurate, competitive tenders should result in lower prices, and hence lower overruns. The intensity of competition can be measured along two dimensions: the number of bidders and the spread of the bids. It is generally agreed that at least three technically qualified bidders are needed to provide adequate competition, and that the price spread should be such that the lowest three bidders fall within a 10 percent range. Our analysis of the sample projects revealed that only half attracted a sufficient numbers of bids, and only half of those showed a spread that was tight enough that the bids could be considered truly competitive.

Combining both factors together into a competitiveness index (figure D), we see that competitive contracts are much less likely than noncompetitive ones to generate substantial overruns. When both factors are examined individually, the price spread criterion turns out to be a much stronger predictor of cost overruns than the actual number of bidders.

The balance of evidence

Figure E Percentage of projects affected by different explanatory factors



The cost overruns observed in recent road sector projects can be traced to various causes, including the three discussed above (figure E). Domestic inflation and currency appreciation affected several projects, but they show only weak causality, having played a part in only 27 percent of the observed overruns. The tightening of the construction industry is slightly more important, figuring in 32 percent of observed overruns. The increase in the international oil price and the knock-on to domestic diesel prices had a larger impact—affecting 45 percent of cases. The single strongest explanatory factor is the absence of meaningful tender competition, which affected 78 percent of projects.

These findings imply that there is no single solution to the problem of project cost overruns, but that any solution will need to address the different causes that have been identified here.

Conclusions

The benchmarking information provided in this report should prove useful for planning purposes and for obtaining value for money. Access to this type of information on a routine basis would help donors and policy makers better understand infrastructure costs and cost trends. Already, in a few cases, we saw evidence of scale economies that may repay further exploration. We also saw that exogenous factors (such as location, procurement method, time trend) rarely explain cost variations in a significant way.

It is likely that the broad ranges of unit costs found in our study chiefly reflect differences in project design. Unfortunately, the available information generally does not provide a basis for standardizing the infrastructure outputs being compared. Where this information is available, it takes the form of technical specifications that run into the hundreds of pages. The variability in the design of the outputs forced us to subdivide contracts into ever-smaller categories—something not conducive to making generalized conclusions. Standardizing contracts for comparability is therefore a major area for further work.

A number of specific recommendations can be offered in this regard. The first is to further refine the data template, with a focus on refining the specification of technologies and activities. The second is to develop clear cost-allocation rules to ensure that the same costs are allocated to standard categories. The third is to refine the description of physical units (that is, the size descriptors). In this regard, the roads sector is further ahead than the others, because valuable experience has been accumulated in the World Bank's ROCKS database. Similar attention needs to be paid to the power and water sectors.

The study did shed clear light on the recent phenomenon of cost overruns in the implementation of donor-funded infrastructure projects in Africa, particularly road projects. No single factor entirely accounts for this trend. Rather, a range of influences—among them escalation in the price of oil and oil-related inputs, such as bitumen), tight market conditions in the construction sector, and inadequate tender competition, all appear to have played a role. Sizable delays in project implementation relative to appraisal estimates, amounting to one or two years in most cases, increase exposure to these background trends.

Our study has demonstrated the feasibility of creating a standardized unit-cost database for different types of commonly financed infrastructure based on BOQs and other common contract and project documents. It also has illustrated many of the practical challenges involved in parsing and compiling such information. Not least of these is the difficulty of obtaining decentralized paper records of projects from donors. Even where electronic databases are maintained, locating and separating out the relevant data can be a challenge. Never is it a matter of simply pushing a button.

The samples that could be collected for this exercise were relatively small. Only in the case of roads (and some aspects of water and power infrastructure) did they begin to be large enough to provide reliable guidance on anticipated project costs. Nevertheless, with renewed efforts, sample sizes could be increased over time and the level of reliability gradually improved.