Comparative analysis of costs of some selected infrastructure components across Africa: Results from the 2011 International Comparison Program for Africa (ICP-Africa)

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Abstract

The key components of the infrastructure components that determine the direction and level of economic transformation include housing, water, electricity, gas, transportation, communication, and construction. Because of that, the AfDB and other regional economic commissions (RECs) are engaged in supporting Energy, Transport, Information and Communication Technologies (ICT) and Trans-boundary Water Resources sectors.. However despite these efforts, there seems to be a serious deficit in the three dimension of infrastructure namely, quantity, quality and access. The infrastructure investments represent only 4% of Africa's total GDP, as compared with 14% in China and much remains to be done to open up landlocked countries' economies, in order to link them to facilitate trade and social exchange and foster regional economic integration.

This paper analyzes the price levels of transport, energy, telecommunication, housing and water. Price level indices (PLIs) have been calculated to provide a comparison of and relationships among the costs of these infrastructure components across African countries. The paper uses the data collected from the 2011 round of the International Comparison Program (ICP) in Africa, covering 50 out of a total of 54 countries.

Key words: GDP, Price Level Index, Purchasing Power Parities, Infrastructure

1. Introduction

Economic development of any country is driven by and reliant on the set up of its infrastructure sector as well as the strategic positioning in the region and globally. Infrastructure deficit is a function of a number of variables including the economic and fiscal policies that a country puts in place. It plays a pivotal role in providing competitiveness, facilitating domestic and international trade, and enhancing regional integration into the global economy. Among the key components of the infrastructure components that determine the direction and level of economic transformation include housing, water, electricity, gas, transportation, communication, and construction. Unfortunately in Africa there seems to be a serious deficit in the three dimension of infrastructure namely, quantity, quality and access. For instance, power supply or a lack of it is Africa's greatest challenge to ensuring sustainable development and yet about 60% of Africa's hydroelectric potential is found in the Democratic Republic of Congo and Ethiopia. The two countries are classified as poor and therefore unable to raise the multi-billion dollar required to develop hydroelectricity to benefit the entire continent.

A similar trend is also observed in other infrastructure components such as Transport (railway, road, air, sea and inland waterway). According to the paper of the African Development Bank "Infrastructure Deficit and Opportunities in Africa – Economic Brief Volume 1 September 2010" Rail networks are the least developed in Africa. This poses serious hindrance to trade and transport of equipment required to enhance infrastructure development. The lack of or poor access to railway could lead to high prices of some of the components of infrastructure. It therefore becomes imperative to study price levels across the continent in order to provide a better understanding of the cost of each of the infrastructure component among countries. Generally prices levels provide a snapshot of prices at a given time.

This paper will not delve into the causes of infrastructure gaps but rather seeks to provide comparison of the cost of selected infrastructure components across countries using price level indices (PLIs), namely housing, water, electricity, gas, transportation, communication, and construction. These infrastructure components selected represent major drivers of an economy's development. The price level index (PLI) is defined as the ratio of PPP to a corresponding market exchange rate. The PPPs were calculated using the African average as the base, i.e., they were normalized with the average for Africa = 1.0. Price data collected from the 2011 round of the International Comparison Program (ICP) were used.

A descriptive analysis of each of the selected components of infrastructure price level indices (PLIs), housing, water, electricity, gas, transport, communication and construction is provided. Further, a canonical correlation analysis was performed to examine the relationships between two sets of variables: an energy and communication set (ECS) composed of PLIs of electricity, gas, transport and communication and a construction and other supplies set (COSS) comprising the PLIs of construction, housing and water. The first set was used as a predictor of the second set. The main interest of the study was how the set of ECS variables relates to the COSS variables, especially whether the ECS variables are predictive of the COSS variables. The paper concludes with a summary of results.

2. Infrastructure Components

The analysis is not using Price level indices to strictly rank countries but provide an indication of the order of magnitude of the price level in one country in relation to others. Interestingly, for some of the infrastructure components Prices levels of neighboring countries in some instances are not necessarily of the same magnitude as intuitively expected. Price level indices of the following infrastructure components, from the 2011 round of the International Comparison Program (ICP) were used in the analysis:

Transport: Transport includes passenger transport by railway, road, air, sea and inland waterway and other purchased transport services. The distribution of PLI varies moderately, resulting in a low relative variation (coefficient of variation) of 22.12%. The highest costs were in Mauritius with more than 50% above the Africa average, followed by Malawi, Zambia, Seychelles and South Africa and the least were in Egypt with about 47% below the Africa average followed by Algeria, The Gambia and Ethiopia.

Communication: Communication includes postal services; telephone and telefax equipment; telephone and telefax services, costs of connection, internet, etc. They facilitate communication both for public and private enterprises within and between countries. Gabon, Zambia Comoros and Angola are among countries with the highest PLIs while The Gambia, Kenya, Ethiopia, Tunisia, and Tanzania have the lowest. Gabon is the most expensive with a price level index of 181.7% while The Gambia is the cheapest at 47.6%. The coefficient of variation is about 30.95%, depicting a relatively high price dispersion across countries.

Construction: Construction includes construction of residential buildings, non-residential buildings, and civil engineering works. PLIs vary among countries, with a coefficient of variation of 30.10%. PLIs for construction were lowest in Tanzania, Uganda, Ethiopia, and in Tunisia —Tanzania having the lowest PLI at 0.47. The highest PLIs were in Gabon, Congo Republic, Chad, Capo Verde, and Democratic Republic of Congo with costs more than 50% above the African average.

Housing: This component includes actual and imputed rentals for housing. The distribution of the PLIs for housing in Figure 4 shows that Namibia is, by far, the most expensive country with a PLI of 2.50 followed by Algeria, Gabon, and Botswana. At the other end of the scale, Guinea enjoys the lowest housing costs, followed by Egypt and Sierra Leone. The coefficient of variation for the housing PLI is 47.43%, revealing significantly high variation among countries.

Water: This includes water supply and miscellaneous services, such as sanitation and sewage. Also included are associated costs such as the hire of meters, the reading of meters, and standing charges. The cost excludes drinking water sold in bottles or containers, and hot water or steam supplied by distinct heating plants. The distribution of water PLIs shows high price dispersion across countries, indicated by a coefficient of variation of 57.26%. Water is most expensive in Botswana – large part being a desert, followed by South Africa (which largely imports water from Lesotho), Benin and Angola, while it is cheapest in Egypt, Ethiopia, The Gambia, and Algeria.

Electricity: The PLI for electricity includes associated costs, such as the hire and reading of meters and standing charges. There is a substantial price variation across countries, indicated by a coefficient variation of 64.46%. The cost of electricity in Angola is, by, far the highest, with prices 288% above the African average. The two countries with the next highest costs are South Africa and Liberia. The lowest electricity costs are in Egypt, Ethiopia, and Guinea.

Gas: The PLI for gas includes the costs of liquefied gas in containers for stove and gas cooker and of gas supply including all taxes and standing charges. It shows high price dispersion across countries, indicated by a coefficient of variation of 53.19%. Gas is most expensive Liberia, Comoros, Sao Tomé and Principes Rwanda, South Africa and Namibia. In these countries, prices are more than 80% above the African average. Gas is cheapest in Morocco, Egypt, Tunisia, and Togo.

3. Canonical Correlation Analysis

A canonical correlation analysis is a general case of multiple regression and correlation analysis. It examines the relationship between two sets **U** (with m variables) and **V** (with n variables) while in multiple regression the relationship between a single variable Y and a linear combination of a set of variables X is of interest. Canonical correlation analysis forms linear combinations **a'U** and **b'V** that maximizes the correlation between them. The two linear combinations are the first pair of canonical variates. Then a second pair of linear combinations having the next highest correlation possible under the constraint that they are uncorrelated with the preceding variates is sought and they are the second pair of canonical variates. The number of pairs of canonical variates is equal to the min (n, m).

The PLIs of infrastructure components under study were grouped into two sets: an energy and communication set (ECS) comprising electricity, gas, transportation, and communication and a second set with water, housing and construction which can be labeled construction and other supply set (COSS). A canonical correlation analysis using the two sets was performed to identify and measure the associations among the variables in the two sets, especially in how the set of ECS variables relates to the COSS variables. The main question of this study asked whether the ECS variables are predictive of the COSS variables. We are also interested in how many dimensions (canonical variables) are necessary to understand the association between the two sets of variables.

The intra and inter set correlation coefficients are presented in Table 1. The first number is the correlation coefficient and the second number in parentheses and in italics is the observed significance level (OSL) of the null hypothesis of a zero correlation coefficient.

Table 1: Intra and Inter correlation coefficients

	PLI Electricity	PLI Gas	PLI Transport	PLI Communication	PLI Water	PLI Housing	PLI Construction
PLI Electricity	1.000						
PLI Gas	0.2136 *(0.136)*	1.000					
PLI Transport	0.2395 *(0.094)*	0.1222 *(0.398)*	1.000				
PLI Communication	0329 *(0.019)*	0.0084 *(0.954)*	0.4596 *(0.0008)*	1.000			
PLI Water	0.3157 (0.025)	0.1321 (0.360)	0.2465 (0.084)	0.057 (0.694)	1.000		
PLI Housing	0.1363 *(0.345)*	0.0274 *(0.850)*	0.1661 *(0.249)*	0.1144 *(0.429)*	0.3167 *(0.025)*	1.000	
PLI Construction	0.2707 *(0.0573)*	0.1375 *(0.341)*	0.4055 *(0.0035)*	0.5785 *(0.00001)*	0.0655 *(0.651)*	0.0610 *(0.674)*	1.000

The correlation structure is weak within each set. In the ECS, Electricity and Transport are correlated with Communication while in the COSS only Water and Housing are correlated. For inter set correlations, Electricity is correlated with Water and slightly with Construction. Both Transport and Communication are correlated with Construction.

The analysis yielded three canonical correlations 0.6467, 0.3587 and 0.0275 leading to three possible canonical variates for each set (also known as canonical dimensions), which corresponds as expected to the number of variables in the smaller set. The full model (Functions 1-3) across all dimensions was statistically significant (Wilk's $\lambda = 0.506$ $F(12, 114.06) = 2.79$ with $p = 0.0023$). Functions 2 to 3 and Function 3, which was tested in isolation were not statistically significant with $F(6, 88) = 1.052$, $p = 0.398$ and $F(2, 45) = 0.017$, $p = 0.983$ respectively. Thus only one canonical dimension out of the three is statistically significant.

In order to interpret the first dimension which was the only significant one, we need to examine the standardized coefficients and the structure coefficients. They are presented in Table 2 for the first two dimensions along with the communality coefficients across the two dimensions for each variable. The statistics of the second dimension are represented in the table even though it is not statistically significant but it accounts for almost 13% of the variance shared by the two sets of variables.

Table 2: Statistics for Dimensions 1 and 2

Variable	Canonical Dimension 1			Canonical Dimension 2			h^2
	Coeff	r_s	r_s^2 (%)	Coeff	r_s	r_s^2	
PLI_Electricity	0.269	0.509	25.87	0.729	0.653	42.64	68,51
PLI_GAS	-0.270	-0.161	2.61	0.256	0.467	21.80	24,41
PLI_Transport	0.374	0.695	48.29	0.505	0.358	12,87	61,16
PLI_Communication	0.6301	0.888	78.91	-0.766	-0.292	8,51	87,42
$\mathbf{R_c^2}$			**41.82**			**12.86**	
PLI_Water	0.1672	0.274	7.52	0.982	0.912	83,17	90,69
PLI_Housing	0.1419	0.253	6.38	-0.008	0.286	8,19	14,57
PLI_Construction	0.9485	0.968	93.72	-0.276	-0.212	4,50	98,22

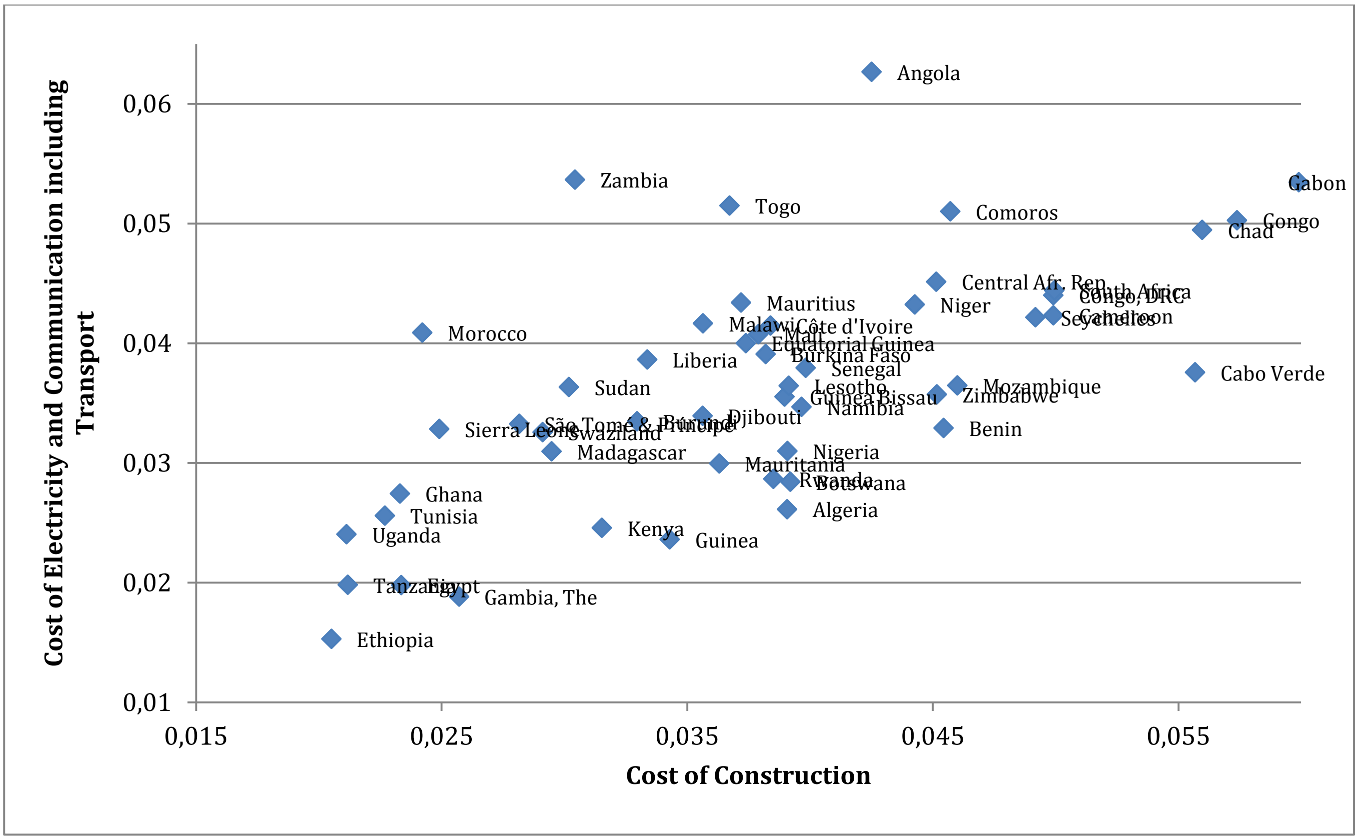
Note: *Coeff = standardized canonical coefficient, r_s = structure coefficient (correlation between the original and the canonical variate r_s^2 = squared structure coefficient*
h^2 = communality coefficient

Looking at the Dimension 1 coefficients, the relevant predictor variable was PLI_Communication followed by PLI_Transport and PLI_Electricity. This assertion was also supported by the structure coefficients. The covariate corresponding to the ECS set can therefore be labeled “*Cost of Electricity and Communication including Transport*”. For the COSS set in Dimension 1 the only relevant variable on the basis of Dimension and structure coefficients was PLI_Construction and thus the variate can be labeled *“Cost of Construction”*. The results were supportive of the expected relationships between cost of energy and communication including transport and of construction as the more expensive (cheaper) energy and communication including transport, the more expensive (cheaper) the construction should be.

Figure 1 presents countries’ projections in the plan of the two variates of Dimension 1. It indicates varying cost of Electricity, Communication and Transport and Construction, from cheapest to most expensive. At the lower end of Countries’ scatter of points we have Ethiopia, Egypt, The Gambia with lowest costs of Electricity, Communication and Transport and thus of Construction. The next group of countries with cheaper costs of these infrastructure components is composed of Uganda, Tunisia, Ghana, Kenya, Guinea and Algeria.

At the higher end of the scatter of points, we have Gabon, Congo, Chad Comoros and Angola with the most expensive costs of these infrastructure components. Most of these countries are oil producing countries, and this raised the question of the efficient use of oil revenues.

Figure 1: Country projections in the plan of the first Dimension



5. Conclusions

Most PLIs of the infrastructure components exhibited high variation with Electricity varying the most. The correlation structure is weak within both the ECS and COSS sets. In the ECS, Electricity and Transport are correlated with Communication while in the COSS only Water and Housing are correlated. For inter set correlations, Electricity is correlated with Water and slightly with Construction. Both Transport and Communication are correlated with Construction.

The relevant predictor of the cost of construction was the cost of Communication followed by costs of Transport and Electricity. The results were supportive of the expected relationships between cost of energy and communication including transport and of construction as the more expensive (cheaper) energy and communication including transport, the more expensive (cheaper) the construction should be. Ethiopia has the cheapest infrastructure cost. Surprisingly, Gabon, Congo, Chad and Angola, which are oil producing countries have the most expensive costs of energy and communication, and thus of construction.

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