Effectiveness of Infrastructure Project Investments in Africa[1]

Sandra Damijan*,
Simona Bovha Padilla,**

* University of Ljubljana, Slovenia
** European Investment Bank

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Abstract

This paper studies the impact of various types of infrastructure investment on GDP per capita growth conditional on institutional advancement and foreign co-financing in five African countries (Egypt, Morocco, Tunisia, Namibia and South Africa) for the period 1990-2010. Our results show that African countries with sustainable infrastructure projects are more likely to grow faster and achieve higher quality of living standards. Second, in a less corrupt environment infrastructure projects are long-term sustainable. In other words, with more advanced institutions infrastructure projects in the same sector can be expected to have longer sustainability than similar infrastructure projects in a more corrupt African country. This implies that institutional environment in individual countries matters and serves as a structural determinant of infrastructure projects sustainability and overall quality. These results, however, are significant only for investment into roads and railroads, but not for investments into fixed telephone lines and electric generation capacity. Finally, our results show that African countries that apply, at least partly, foreign private or institutional financing of infrastructure projects would more likely gain higher direct benefits and higher socio-economic spillovers. Both institutional advancement and foreign co-financing seem to mitigate the negative effects of miss-allocation of funds in countries where risk of corruption is high.

KEYWORDS: infrastructure, institutional quality, corruption, foreign private financing.

JEL Code: H41, H50, H54, K2, 010, 043.

1. Introduction

Infrastructure project investments have a direct impact on economic growth and employment, enhance institutional advancement and the quality of life. Investments in infrastructure, such as roads, railways and energy, have large positive effects on the production capacities of developing economies depending on the regional peculiarity. Moreover, infrastructural investments induce the integration of markets that were regionally and functionally separated before and thereby stimulate economic growth. There are also further socio-economic impacts, including accessibility, level and location of employment, improved environment and increased efficiency that will contribute to the regeneration of a particular region (OECD, 2002). Hence, improved access to basic infrastructure contributes positively to overall capacity building of regions and whole economies.

Nevertheless, such infrastructure investments may cause inefficiency if there is miss-allocation of funds and high levels of corruption. A low-end estimate suggests that the financial costs of corruption in infrastructure investment in developing countries might equal to $18bn per year (Kenny, 2006). For example, 25 percent of electricity production is lost due to illegal connections in India, as much as 24 percent of funds destined for road construction in a project in Indonesia 'went missing' and 7 percent of government contract values are paid in bribes according to survey respondents in Eastern Europe and Central Asia (Kenny, 2006). In other words, a substantial fraction of the invested money into infrastructure projects may be lost due to high-level corruption and/or mismanagement of the projects due to poor standards or low institutional capacities in developing countries.

Our research aims at exploring empirically the relationship between infrastructure projects investment and overall macroeconomic performance for selected African countries. We empirically study the effectiveness of infrastructure investments of African countries in terms of overall

macroeconomic growth. Moreover, we investigate how much does foreign co-financing of infrastructure project investments and overall institutional advancement of individual countries contribute to the overall effectiveness of infrastructure investments of selected African countries (Morocco, Tunisia, Egypt, South Africa and Namibia), divided as North and Southern Africa regions. Our prior is that countries with more advanced institutional systems and countries that apply foreign private or institutional financing of infrastructure projects will more likely gain higher direct benefits and higher socio-economic spillovers.

We empirically investigate these questions by using both the macro-level datasets (such as African Development Bank Group data, World Development Indicators and Africa Competitiveness Report by World Bank, Transparency International) and available specific information on infrastructure project financing for African countries from the World Bank and European Investment Bank. The period of study covers data for the period from 1990 to 2010.

Our findings confirm that institutional advancement and foreign co-financing contribute positively to reap the effects of infrastructure investment on public welfare as measured by the GDP per capita growth. Both institutional advancement and foreign co-financing seem to mitigate the negative effects of miss-allocation of funds in countries where risk of corruption is high.

The remainder of the paper is organized as follows. Section 2 provides an overview of related literature on infrastructure investments and institutional quality on the economic performance of selected African countries. Section 3 describes the data paper uses, as well as it presents some descriptive statistics. Section 4 describes the methodology and empirical models. Section 5 presents the results on effects of the effectiveness of infrastructure investments on the overall macroeconomic

performance for selected African countries, including foreign co-financing of infrastructure project investments and overall institutional quality contribution. Final Section concludes.

2. Theoretical background

Empirical research on the link between infrastructure investments and development outcomes has attained an increasing interest in recent scientific literature and economic research. The impact of infrastructure on development is analyzed from theoretical and empirical points of view, but estimations are difficult to generalize because authors analyze different geographical regions and include a number of different variables. Recent studies (including Aschauer, 1989; Prud'homme, 2004; Agénor and Moreno-Dodson, 2006; Yeaple and Golub, 2007; Baldwin and Dixon, 2008; Seethepalli, Bramati, and Veredas, 2008; Straub, Vellutini and Warlters, 2008; Canning and Pedroni, 2008; de Haan, Romp and Sturm, 2007; Grubesic, 2009, etc.) are based on various economic theories, estimate different econometric models and analyze data at national or regional level.

2.1. Definition of infrastructure

There is no agreed single set of infrastructure variables and there is no agreed methodology for their evaluation among researchers. In most of the studies physical indicators of public infrastructure are used rather than monetary indicators to avoid the difficulty of infrastructure evaluation. In order to perform the analysis of potential impact of infrastructure, it is crucial to define the set of common infrastructure indicators (Snieska and Simkunaite, 2009).

According to Agénor and Moreno-Dodson (2006), infrastructure should be broadly defined and it should include transport, water supply and sanitation,

information and technology (ICT) and energy. It is usually understood as basic public infrastructure, which forms the general foundations for society and economics. In our research we will take into account only the main physical infrastructure defined as core physical infrastructure consisting of sub sectors: transportation infrastructure (length of roads, rail tracks, etc.), water supply and disposal infrastructure (resident population connected to wastewater collection and treatment systems), telecommunications and ICT infrastructure (number of telephone lines, cables, broadband, etc.) and energy infrastructure (power plants, transmission and distribution lines). Infrastructure will be considered in terms of quantity, i.e. as a physical stock.

2.2. Impact of infrastructure on macroeconomic performance

We will empirically study the effectiveness of infrastructure investments of African countries in terms of contribution to overall macroeconomic growth, employment creation, access to basic infrastructure and capacity building for the period 1990 - 2010. Availability of infrastructure significantly influences development of regions and countries and has a direct effect on business productivity and growth. Investments into infrastructure may substantially reduce inequality between regions (within countries) as well as between countries. According to the World Bank report infrastructure represents the "wheels" of economic activity (World Bank 1994).

Effective infrastructure supply supports economic growth, enhances quality of life and is important for national security (Baldwin and Dixon, 2008). Moreover, the authors point out that delivery of services, such as water, sanitation, transportation and energy directly benefit households and can dramatically improve welfare and contribute to productivity growth. At the microeconomic level, many of the benefits of infrastructure services lower firm production costs, expand market opportunities, which positively affects competitiveness and production and lead to economic growth. Similarly, the goals related to human development (education and health) rely on services

that require supportive infrastructure. Thus, the relationship of infrastructure to economic development is very heterogeneous and investments to infrastructure stimulate growth and at the same time higher growth often leads to higher demand for infrastructure.

Aschauer (1989) demonstrates the importance of infrastructure investments for growth and productivity in the economy by explaining the productivity slowdown in the United States in the 1970s. He finds that 1% increase in public capital leads to an increase in total factor productivity between 0.35% and 0.49%. Sturm et al. (1999) find that infrastructure investment positively influences output in the Netherlands in the second half of the nineteenth century, causing an increase in demand in short-run. By using data for 29 sectors in the USA during the 1951 - 89, Fernald (1999) finds out that industries, which used road transport had stronger tendencies towards faster TFP growth in the period between 1951 and 1973. Furthermore, the findings of Bristow and Nellthorp (2000) show that infrastructure has not only visible effect on environment but also directly impacts welfare (by time and cost savings, increasing safety, information network development) and economics (employment, economic growth). Egret at al. (2009) find that infrastructure investment impacts growth through connecting both region and countries and improving market access, e.g. through lowering transport costs. Snieska and Bruneckiene (2009) identify infrastructure as one of the indicators of regional competitiveness within the country.

However, not all studies find growth-enhancing effect of infrastructure. In some studies there is evidence of reverse causation found, especially in relation with weak institutions. Esfahani and Ramirez (2002) develop and estimate a structural model of infrastructure and growth for 75 countries. They find benefits from infrastructure investment and performance in infrastructure sectors, but show that achieving better outcomes (in terms of growth) requires institutional and organizational improvements. Thus, the effect of infrastructure is directly related to the institutional advancement.

2.3. Importance of institutional advancement for sustaining impact of infrastructure on macroeconomic performance

Institutional advancement and improved governance in infrastructure emphasize on improving budget, maintenance and project selection and implementation processes with a primary focus on quality. This involves state-owned enterprise reform, improved regulation (including transparency, participation and limited discretionary rights) and increased competition. Institutional advancement emphasizes improved and more transparent processes for budgeting, project selection and oversight, including community-driven approaches.

One of the more perplexing problems facing developing countries, and particularly African region countries, is sustaining infrastructure investments. It is common to find that positive net benefits of infrastructure investments deteriorate rapidly due to insufficient maintenance and inefficient institutions. The type and level of maintenance required is intimately related to how a facility is designed, financed, constructed, operated and used (Uphoff, 1986). However, no solitary, easy identifiable cause exists for failures. In our research, we argue, that there is one underlying cause of infrastructure maladies: rather than presuming that the individuals involved intend to develop unsustainable infrastructure, we assume that some behave opportunistically. In other words, a substantial fraction of the invested money into infrastructure projects may be lost to high-level corruption and/or mismanagement of the projects due to poor standards or low institutional capacities in developing countries. The task would be then to design the institutional arrangements to prevent such deviations, using a more extensive set of intermediate and overall performance criteria by investors. Poor construction and maintenance can be the result of incompetence and inefficiency as well as corruption, which remains a significant drag on development performance whatever its cause.

Olken (2006) looks at levels of outputs compared to inputs at the local level in infrastructure and uses measures of reported physical inputs and costs. He finds that about 24 percent of expenditures in an Indonesian road-construction project were 'lost.' Canning and Fay (1996) report variations in the cost of construction of a kilometer of similar road that vary by as much as five to ten times. Much of this is due to differences in factors including location, some will also be due to less efficient institutions, more corrupt practices and the misappropriation of funds (Kenny, 2006). More importantly, however, the major damage done by corrupt practices is probably not the narrow financial loss of informal payments given to gain contracts in infrastructure projects, but the economic cost in terms of skewed spending priorities, along with substandard construction, operation and maintenance.

For example, a road project costs $1 million to be built but generates $320,000 in economic returns each year after construction for 10 years. The project's overall economic rate of return is about 30 percent. If the project had suffered from collusive bidding, and this had raised the price of construction by 20 percent, i.e. to $1.2 million, the project's rate of return would drop to 26 percent. This is a significant decline, but it still leaves the project at more than double the 'hurdle rate' of a 10 percent rate of return. This is approximately the economic impact of poor road construction suggested by Olken (2004).

Or, presume instead that the bidder agreed a contract price of $1 million, but used insufficient and substandard materials to build the road, spending only $800,000 on construction and deviating the remaining $200,000. This reduces the road's traffic capacity so that yearly economic returns fall by a quarter. It also shortens the useful life of the road to five years. This would reduce the overall rate of return to 15 percent (Kenny, 2006).

A macroeconomic perspective suggests that the major impact of less advanced institutions and misappropriation of funds in infrastructure projects is usually going to be on what is built where, not how much is paid to build or connect it. The incentives to spend money on building infrastructure rather than operation and maintenance increase the incentives to build poor quality infrastructure in the wrong place and the incentives to poorly operate it. These "wicked incentives" probably account for the bulk of the negative development impact (Tanzi and Davoodi, 1998). Evidence suggests that weak institutions and high misappropriation of infrastructure funds amount up to 20 percent as a mark-up in the costs of investments (Devarajan et. al., 2002).

Nonetheless, our knowledge about levels of particularly harmful misappropriation of infrastructure funds in infrastructure is minimal. On the one hand, there appears to be very strong anecdotal evidence that informal payments for government contracts are the norm in many African countries, yet firm surveys suggest that the frequency or scale of informal payments differ dramatically within the same industry in a country. This is a sign of the fragility of our knowledge regarding institutional advancement and in particular corruption even in an area where it is widely agreed to be a major development problem.

Minimizing the damage done by weak institutions and governance involves countering the incentives to build the wrong thing, to build it at high cost and then to operate it badly. The attention should focus on issues such as overall budgeting and project selection and on physical auditing of the status of physical capital. We have good benchmarks for the cost of maintaining different classes of road, for example. The project evaluation should allow us to determine if project selection in a given sector appears to be following rational procedures or is driven by other concerns. It is a comparatively simple task to determine if a road or pipeline has been constructed and maintained adequately or poorly through a physical audit. For example, in

the Philippines, physical audits combined with a GIS system are being used to determine if roads and bridges actually exist and what state they are in as part of a drive towards improved transport governance (Kenny, 2006).

Besides exploring empirically the relationship between infrastructure projects investment and overall macroeconomic performance for African countries, we will investigate how much overall institutional advancement of individual African countries contributes to the overall effectiveness of infrastructure investments by using existing benchmarks and project evaluations, including data from the African Development Bank Group. We assume that institutional advancement and foreign private or institutional financing of infrastructure projects is associated with more careful project selection, more sound budgeting, better monitoring of construction as well as more efficient operation and maintenance. Hence, we expect that countries with more advanced institutional systems and countries that apply foreign private or institutional financing of infrastructure projects will more likely gain higher direct benefits and higher socio-economic spillovers.

3. Data and descriptive statistics

This section provides an overview of data this paper uses for examining effects of investment in infrastructure, especially with foreign (co) financing and better institutional quality on selected African countries.

3.1. Data coverage

To study how infrastructure investment, foreign co-financing of infrastructure project investments and overall institutional advancement of individual countries contribute to the overall effectiveness of infrastructure investments of selected African countries we use both the macro-level datasets (such as African Development Bank Group data, World Development Indicators and Africa Competitiveness Report by World Bank, Transparency International) and available specific information on

infrastructure project financing for African countries from the World Bank and European Investment Bank. The period of study covers data for the period from 1990 to 2010.

3.2. Variables investigated

In this paper we take into account five types of main physical infrastructure: transportation infrastructure (length of roads, rail tracks, ports, etc.), water supply and disposal infrastructure (resident population connected to wastewater collection and treatment systems), telecommunications and ICT infrastructure (number of telephone lines, cables, broadband, etc.) and energy infrastructure (power plants, transmission and distribution lines). Infrastructure will be considered in terms of quantity, i.e. as a physical stock.

Moreover, in order to examine institutional advancement we look at effectiveness of governments, their ability to control corruption, improved regulation (including transparency, participation and limited discretionary rights) and increased competition. Institutional advancement also emphasizes improved and more transparent processes for budgeting, project selection and oversight, including community-driven approaches.

3.3. Descriptive statistics

In this section we provide some main descriptive statistics of the countries included in our sample separately for institutional quality, foreign investment in infrastructure and trends in building physical infrastructure in selected countries.

Table 1: Countries used in the paper

African Regions	
Northern	*Southern*
Egypt	Namibia
Morocco	South Africa
Tunisia	

Source: own table structure.

Table 1 presents breakdown of countries we use in this paper. We divide them in two regions, Northern and Southern African region. Egypt, Morocco and Tunisia belong to Northern African region, while Namibia and South Africa to Southern African region.

Table 2: Summary statistics (mean values) for countries by corruption level, government effectiveness, political stability and rule of law

Country Name	Corruption level *mean*	Gov't effectiv. *mean*	Political stability *mean*	Rule of law *mean*
Egypt, Arab Rep.	2.8	-0.4	-0.6	-0.3
Morocco	3.5	-0.1	-0.4	-0.1
Namibia	4.5	0.2	0.6	0.2
South Africa	4.9	0.6	-0.3	0.5
Tunisia	4.4	0.5	0.1	0.1
Total	4	0.1	-0.1	0.1

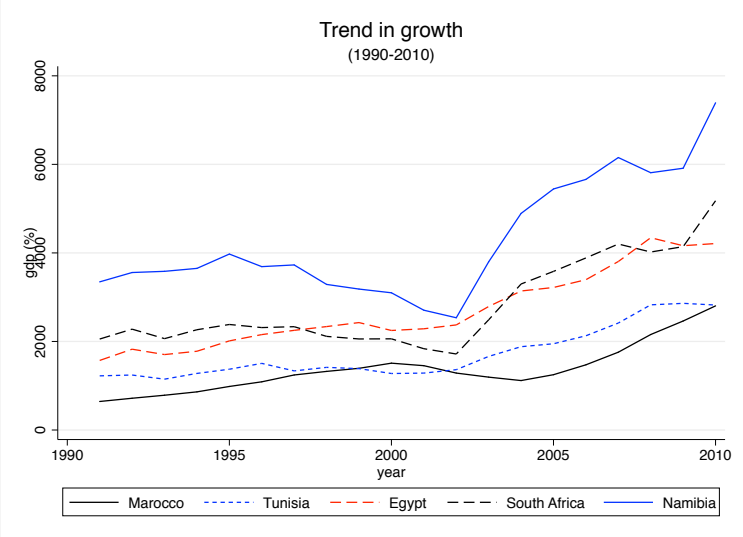
Source: Transparency International, WB World Governance Indicators.
Transparency International corruption perception index (10=highly clean to 0=highly corrupt). The Worldwide Governance Indicators (WGI) scores are based on a model which aggregates the responses from various information sources in the broad 6 clusters. The model constructs a weighted average of the sources for each country. The aggregate indicators range from -2.5 (worst) to 2.5 (best).

Table 2 presents countries' levels and quality of corruption, government effectiveness, political stability and the rule of law. In order to measure countries on how corrupt their public sectors are seen to be, the data from Transparency International is used. Countries are ranked on scale from 10 (very clean) to 0 (highly corrupt). Furthermore, The Worldwide Governance Indicators (WGI) are used to measure how effective governments are, the level of political stability and the efficiency of the rule of law on scale from -2.5 (worst) to 2.5 (best). The data shows that Egypt experiences the highest levels of corruption, while South Africa the least. Also, the government and the rule of law are most effective in South Africa and least effective in Egypt.

Most politically stable is Namibia, followed by Tunisia. Egypt is least politically stable country.

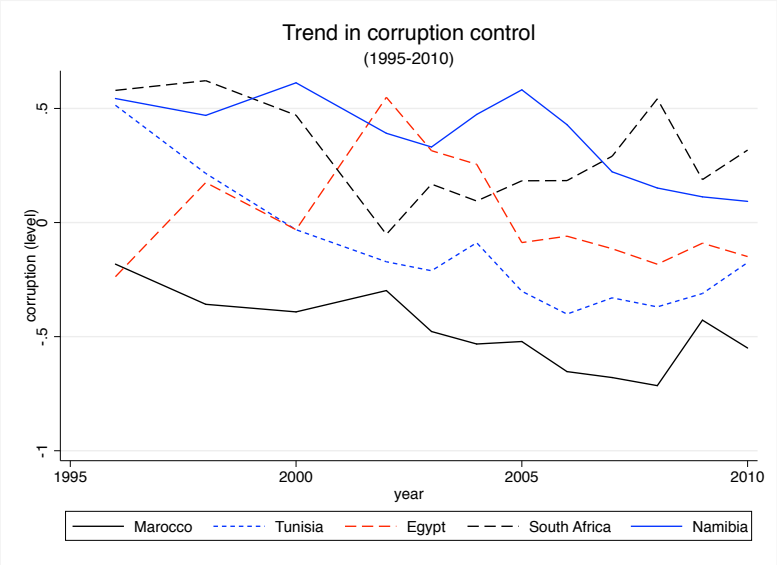
Figure 1 shows trend in growth for all five countries for the period from 1996 to 2010. It seems that countries in Southern region have progressed the most. Namibia has experienced highest levels of growth, while Morocco the lowest levels. In last years it seems that Egypt and Tunisia do not experience growth.

Figure 1: Trend in growth



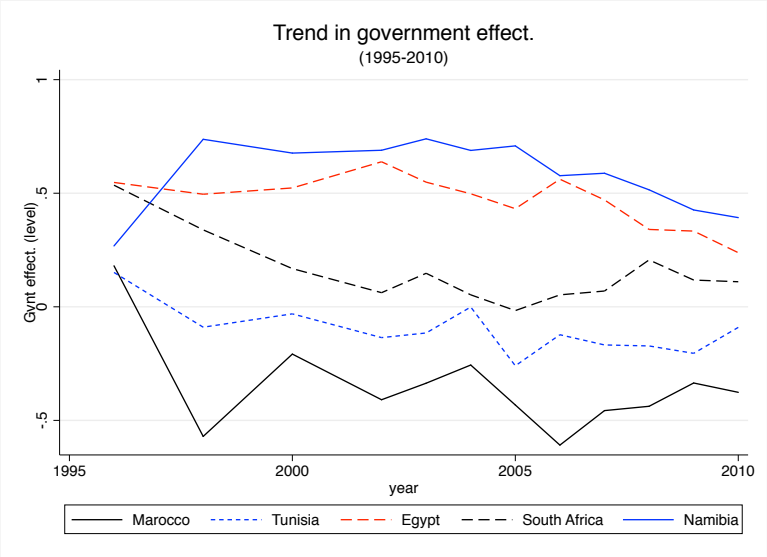
In order to understand the quality of institutions in countries under examination, we also looked at the trends of institutional development by using World Bank Governance Indicators. Figures 2 and 3 show trends in corruption control and government effectiveness. Southern African region progressed the most in controlling corruption and government effectiveness, even though according to data South Africa is still experiencing higher levels of corruption. Figures show that countries ability to control corruption began to decrease in 2003 and 2005 except in South Africa, where downward trend is shown in 2008.

Figure 2: Trend in corruption control



Graph 3 shows slow downward trend in government effectiveness for majority of countries except for Tunisia; however, the figure reveals that government efficiency is comparatively low to other countries. The only country that has less effective government appears to be Morocco.

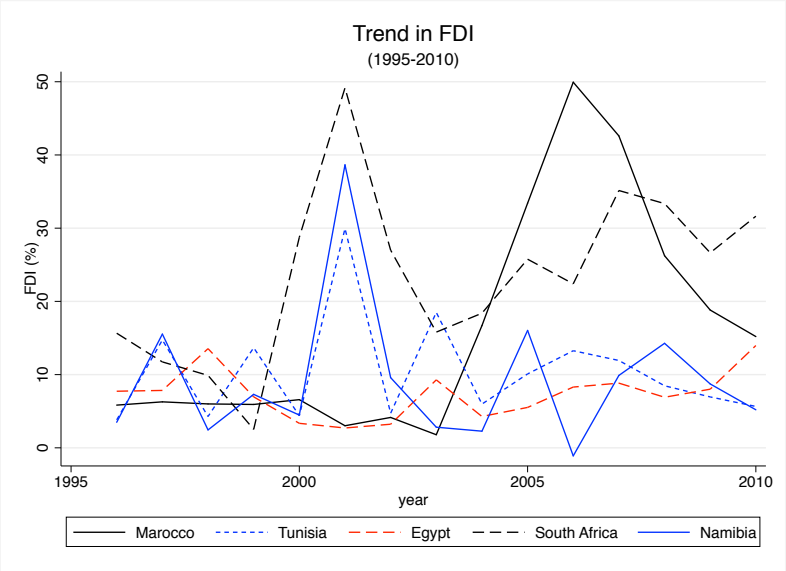
Figure 3: Trend in government effectiveness



When looking at the foreign investment in infrastructure, the Figure 4 reveals that in South Africa and Morocco appear to have most foreign investments, followed by Namibia. Nevertheless, the graph also shows that both countries experienced sharp downward trend in foreign investments, which slowly picked up again in South Africa. Lately, Namibia seems to

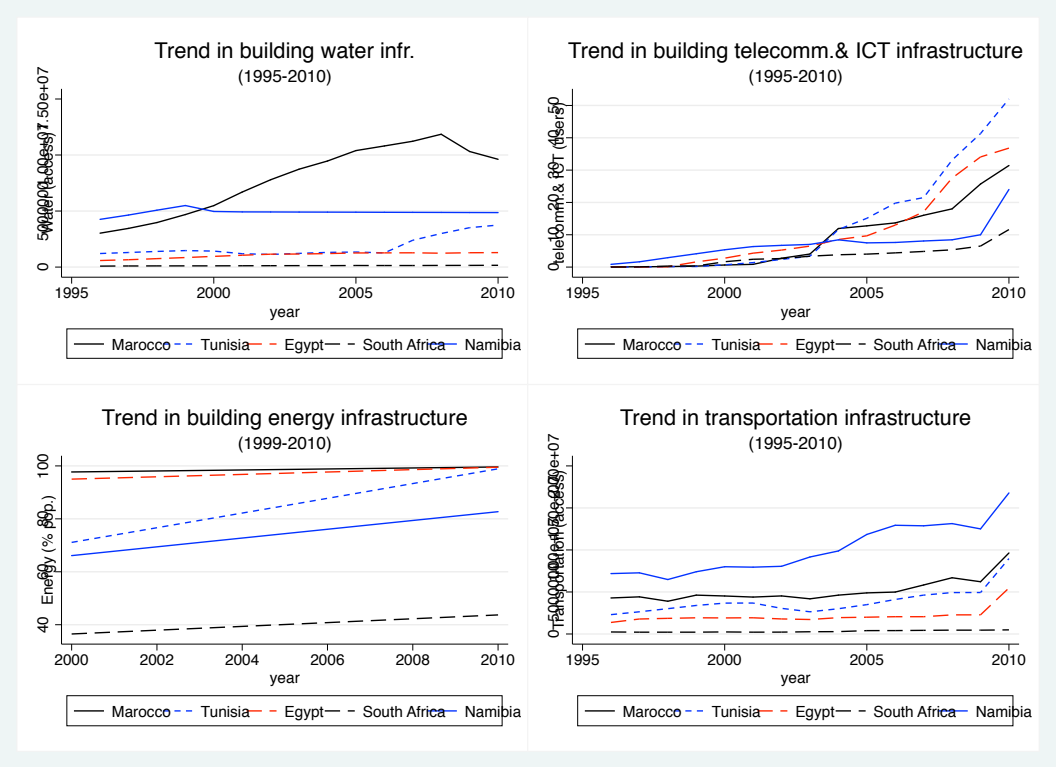
receive the least foreign investments, while South Africa and Egypt have slow upward trend in foreign investments.

Figure 4: Trend in FDI



Finally, the Figure 5 shows trends in building physical infrastructure in selected countries. With regards to building water supply and disposal infrastructure, it appears that Tunisia is the only one with upward trend in building it. Nevertheless, Morocco seems to have comparatively higher levels of built water supply and disposal infrastructure than other countries. Upward trend in building telecommunications and ICT infrastructure is seen in all countries, Tunisia having the highest levels. Tunisia, Namibia and South Africa appear to increase their efforts in building energy infrastructure, yet the figure reveals that in South Africa energy infrastructure is comparatively low to other countries. Finally, the figure shows upward trend in building transportation infrastructure in most countries except in South Africa, where it remains at lower levels.

Figure 5: Trends in building physical infrastructure



In what follows, we test empirically whether foreign co-financing of infrastructure project investments and overall institutional advancement of individual countries contribute to the overall effectiveness of infrastructure investments of African countries.

4. Methodology and empirical models

We empirically study the effectiveness of infrastructure investments of African countries in terms of overall macroeconomic growth for the period 1990 - 2010. Our main aim is to investigate how much does foreign co-financing of infrastructure project investments and overall institutional advancement of individual countries contribute to the overall effectiveness of infrastructure investments of African countries. Our prior is that countries with more advanced institutional systems and countries that apply foreign private or institutional financing of infrastructure projects will more likely gain higher direct benefits and higher socio-economic spillovers.

In order to account for the effectiveness of infrastructure projects in African countries we start with the aggregate production technology. In line with Aschauer (1989) and Barro (1991b), we apply the augmented Cobb-Douglas production function:

$$Y_{it} = A_{it} * f\left(L_{it}, K_{it}, G_{ikt}\right) \tag{1}$$

where Y_{it} is a measure of real aggregate output of goods and services in country i in period t, L_{it} t is aggregate employment of labor, K_{it} is aggregate stock of nonresidential capital, and A_{it} is a measure of productivity or Hicks neutral technical change. G_{ikt} denotes a flow of services from public investment in infrastructure type k (whereby $k\{$ transportation, water supply, disposal infrastructure, telecommunications, energy infrastructure).

By log-linearizing and time-differencing (1), we yield the usual growth accounting model:

$$y_{it} = a_{it} + \alpha l_{it} + \beta k_{it} + \gamma_k g_{ikt} \tag{2}$$

where lower-case variables denote growth rates of upper-case variables and α, β, γ_k denote elasticity of output with respect to the variable $j = L, K, G_k$. Assuming competitive product and factor markets, we obtain the total productivity measure from (2):

$$tfp_{it} = y_{it} - s_l l_{it} + s_k k_{it} = a_{it} + \gamma_k g_{ikt} \tag{3}$$

where s_j is a share of factor j in total product, $j = L, K$. Total factor productivity growth is hence positively related to the incremental investments in different types of public infrastructure.

When estimating the impact of public investment in physical infrastructure on overall productivity, however, one should take into account several important complexities. First, we argue above that both institutional advancement and non-government co-financing of infrastructure projects

may play an important role for the effectiveness of public infrastructure projects. In line with this, in models (2) and (3) we should interact the public infrastructure investment of type k with the relevant country-specific institutional advancement indicator as well as with a dummy variable indicating whether the project has been financed in a substantial part by either private of foreign institutional investor. Second, the initial level of infrastructure development (before the start of additional infrastructure investment at the beginning of our time period covered) may as well substantially affect the overall productivity growth rate. One can claim that countries to begin with more developed infrastructure will accumulate the positive infrastructure-related benefits over time, such as better quality business environment affecting the marginal productivity of both traditional factors of production (capital and labor). This implies that models (2) and (3) should include the initial level of infrastructure development. Third, as noticed by Barro (1991) and Barro and Sala-i-Martin (1992, 1995) in growth accounting exercises there is a typical finding of convergence between countries, conditional on initial level of development. On the other side, Barro (1991) demonstrates that the growth rate of real per capita GDP is positively related to initial human capital indicating that countries with higher human capital will also have higher ratios of physical investment to GDP. This implies that models (2) and (3) should include the initial level of GDP per capita and initial level of human capital.

Taking into account the above considerations, the empirical model (2) can be rewritten as:

$$y_{it} = a_{it} + \alpha l_{it} + \beta k_{it} + \gamma_k g_{ikt} + \eta_k I_{it} * g_{ikt} + \kappa_k F_{it} * g_{ikt} + \nu_k I_{it} + \lambda_k F_{it} + \phi G_{ik0} + \delta Y_{i0} + \phi H_{i0} + u_i + \tau_t + \varepsilon_{it} \quad (4)$$

where I_{it} and F_{it} measure country's institutional advancement and foreign private or institutional co-financing of infrastructure, respectively. Variables G_{ik0}, Y_{i0}, H_{i0} denote the initial levels of k-type infrastructure development,

GDP per capita and human capital, respectively. In line with Barro (1991) and Barro and Sala-i-Martin (1992), human capital will be measured by country's primary and secondary school enrollment. The model also includes country fixed effects u_i, year dummies τ_t that control for unobserved exogenous aggregate shocks, and the usual white noise error term ε_{it}.

Note that I_{it} and F_{it} are introduced in the model separately and in interaction with our main variable of interest g_{ikt}, i.e. public investment in the k-type of infrastructure. The coefficients ν_k and λ_k therefore measure the overall impact of institutional advancement and non-government investment on economic growth, respectively, while coefficients η_k and κ_k measure the differential impact that the institutional advancement and foreign (co-) investment, respectively, exert on the contribution of public investment to economic growth. One should bear in mind that coefficients γ_k, η_k and κ_k measure the impact of public investment on economic growth conditional on country's initial levels of k-type infrastructure development, GDP per capita and human capital, respectively.

We estimate the model (4) for a set of five African countries by using the macro-level datasets and some available micro-level data with specific information on financing type of infrastructure projects for African countries. Macro-level data for GDP per capita, GDP growth, employment, capital investment and human capital stocks are obtained from the World Development Indicators by World Bank. Data on infrastructure development and investments are obtained from the (African Development Bank Group data. Data on institutional advancement and different measures of corruption perception are obtained from Africa Competitiveness Report by World Bank and Transparency International. Additional information on financing type of infrastructure projects will be obtained from the World Bank and the European Investment Bank.

In spite of worldwide interest in the problem of infrastructure impact on development there are no extensive studies carried out in this field in African countries. There is a tendency that studies either lump infrastructure's sub sectors together in one category or one type of infrastructure is studied, e.g. transportation, and ignore any relationship among different types of infrastructure.

The proposed research is a novel as it addresses output effects of infrastructure project investments in selected African countries in a very comprehensive way and in the extent that has not been studied so far. Lack of methodological concepts that can be used in the analysis of the African region is becoming an obstacle for evaluation of the return of European Union investments and other foreign co-financing in infrastructure, as well as their impact on social and economic development. This work can substantially contribute to the assessment of overall macroeconomic impact of infrastructure projects for selected African countries.

In the next section we discuss this issues in more detail when presenting the results.

5. Results and discussion

In this Section we present results of estimating the impact of infrastructure investment on GDP per capita growth conditional on institutional advancement and foreign co-financing. The model (4) was estimated for a set of five African countries (Egypt, Morocco, Tunisia, Namibia and South Africa) for which data on infrastructure investment was available.

We first present correlation among variables in the model (4) and then proceed with presentation of results.

Table 3: Correlation matrix of variables in the model (4)

	rGDP (%)	rGFCF (%)	rLab (%)	Inv_Road	Inv_Rail	Inv_Tel	Inv_El_Cap	CPI	Rule_law	FDI
rGDP (%)	1									
rGFCF (%)	0.1770*	1								
rLab (%)	0.1109*	0.1041	1							
Inv_Road	0.2646*	0.0032	0.3847*	1						
Inv_Rail	0.2337*	0.0341	0.0414	0.8808*	1					
Inv_Tel	0.0155	-0.0754	-0.1318	0.4431*	0.6407*	1				
Inv_El_Cap	-0.0284	-0.073	-0.176	0.4511*	0.8349*	0.9708*	1			
CPI	-0.1872*	0.0341	0.1288	0.1016	0.4173*	-0.4032*	-0.2371*	1		
Rule_law	0.1197*	0.1398	0.2156*	-0.1027	0.0904	-0.8498*	-0.7766*	0.7854*	1	
FDI	0.0725*	0.3143*	0.1545	0.0487	0.0288	-0.2391*	-0.3173*	-0.0503	0.2302*	1

Note: * indicates coefficient significant at 95 per cent.

Correlation matrix shows that GDP per capita growth is positively correlated to two types of infrastructure investment – to investment into roads and railways, but not correlated to investment into fixed telephone lines and electric generation capacity. On the other side, GDP per capita growth is negatively correlated to CPI index and positively correlated to the variable of rule of law. This indicates that less corrupt countries and countries with higher institutional quality are more likely to increase faster the welfare of their citizens.

Major limitation of our study is low number of observations as the data spans over two decades but with some missing data. Given the five countries in our dataset, this leaves us with some 80 observations only. This limits the use of any sophisticated econometric techniques and robustness checks and renders the fixed effects approach as the only feasible econometric method.

Table 4: Main results of estimating model (4)

	(1) Base	(2) Law	(3) FDI
rGFCF (%)	0.013	0.017	0.016
	[0.11]	[0.08]	[0.05]
rLab (%)	0.892	.656	-0.715
	[0.55]	[0.34]	[0.51]
Log Inv_Road	1.618	1.308	1.160
	[0.97]	[0.87]	[0.94]
Log Inv_Road * law		2.070	2.365
		[1.89]*	[1.69]*
Log Inv_Road * fdi			0.869
			[1.78]*
Log Inv_Rail	0.188	0.915	0.442
	[0.88]	[0.94]	[0.78]
Log Inv_Rail * law		1.802	1.556
		[1.72]*	[1.77]*
Log Inv_Rail * fdi			0.915
			[1.91]
Log Inv_Tel	0.650	0.632	-1.221
	[0.38]	[0.47]	[-0.93]
Log Inv_Tel * law		-0.254	1.275
		[-0.40]	[0.99]
Log Inv_Tel * fdi			0.500
			[0.74]
Log Inv_ElCap	0.071	0.313	1.891
	[0.73]	[0.99]	[0.84]
Log Inv_ ElCap * law		0.888	0.809
		[0.82]	[0.76]
Log Inv_ ElCap * fdi			1.083
			[1.31]
Constant	9.139	-6.327	-9.295
	[1.11]	[-0.79]	[-0.87]
Observations	81	81	81
R-squared	0.140	0.176	0.222

Notes: Fixed effects estimates of model (4). Dependent variable: GDP per capita growth rate. Standard errors in brackets obtained by bootstrapping (200 replications); *** p<0.01, ** p<0.05, * p<0.1.

Results of estimating model (4) are presented in Table 4. First column shows our base results of the impact of four different types of infrastructure investment on GDP per capita growth. It indicates that in absence of controlling for institutional advancement and foreign co-financing none of the four different types of infrastructure investment has a significant impact ng GDP per capita growth in the five African countries. However, when controlling for institutional advancement in column 2 investment into roads and railroads seem to have a positive and significant impact on GDP per capita growth. Investments into fixed telephone lines and electric generation capacity do not seem to affect welfare growth significantly.

These results are further strengthened when, in addition to institutional advancement, controlling also for foreign co-financing of infrastructure investment projects. The coefficients for both investments into roads and railroads are further increased when these projects are, at least partly, internationally co-financed.

Empirical results can hence be summarized as follows. First, results suggest that African countries with sustainable infrastructure projects are more likely to grow faster and achieve higher quality of living standards.

Second, in a less corrupt environment infrastructure projects are long-term sustainable. In other words, with more advanced institutions infrastructure projects in the same sector can be expected to have longer sustainability than similar infrastructure projects in a more corrupt African country. This would imply that institutional environment in individual countries matters and serves as a structural determinant of infrastructure projects sustainability and overall quality.

Finally, our results show that African countries that apply, at least partly, foreign private or institutional financing of infrastructure projects would more likely gain higher direct benefits and higher socio-economic spillovers.

6. Conclusions

In this paper we study the impact of infrastructure investment on GDP per capita growth conditional on institutional advancement and foreign co-financing in five African countries (Egypt, Morocco, Tunisia, Namibia and South Africa).

Our results show that African countries with sustainable infrastructure projects are more likely to grow faster and achieve higher quality of living standards. Second, in a less corrupt environment infrastructure projects are long-term sustainable. In other words, with more advanced institutions infrastructure projects in the same sector can be expected to have longer sustainability than similar infrastructure projects in a more corrupt African country. This implies that institutional environment in individual countries matters and serves as a structural determinant of infrastructure projects sustainability and overall quality. These results, however, are significant only for investment into roads and railroads, but not for investments into fixed telephone lines and electric generation capacity.

Finally, our results show that African countries that apply, at least partly, foreign private or institutional financing of infrastructure projects would more likely gain higher direct benefits and higher socio-economic spillovers.

This work is important both for policy makers in African and other emergent economies, as well as financial institutions. Results of the analysis will contribute to a better understanding of the impact of infrastructure project investments in selected African countries on economic growth in the presence of different measures of institutional advancement and institutional financing.

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