Helpdesk Report

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Rates of return for railway infrastructure investments in Africa

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Question

Identify the range of internal rates of return for large transport infrastructure projects in Africa and the driving factors (railways primarily but roads for comparison), and whether/how the quantified GDP growth was included as a benefit.

Contents

1. Summary

One of the economic appraisal methods for infrastructure projects which is widely used in Africa is the Internal Rate of Return (IRR), also known as Economic Internal Rate of Return (EIRR) to indicate that the calculation includes externalities and to distinguish it from the financial internal rate of return (FIRR) which considers only costs and returns directly associated with the project. IRR is considered by the European Commission and by the World Bank for justification of capital investments, where values over 12% are normally accepted for developing countries (ECORYS, 2016; The Republic of Liberia, 2012).

This report compares IRR values found for railway projects in Africa. **IRRs ranged from 0 to 40% with a mean of 14.6%**, excluding one set of outlier projects that estimated much higher returns due to the way they included externalities. IRRs estimated for rehabilitation projects averaged 12.2%, and 16.3% for new construction. All of the IRR estimates that we found were pre-construction estimates; we did not find studies reviewing actual rates of return after projects were operational. All projects included various externalities in their calculations (most often air pollution and road accidents), but none of them estimated impacts on GDP. By way of comparison, a wide range of IRR values were also found for highway projects, ranging from -5.5% to over 127% depending on project objectives and methods, with **a mean of 31.5%**.

IRR is well-established as a way of comparing independent projects, but the approach has some weaknesses. IRR may not always be calculated consistently: different projects may take different factors into account when calculating IRR, may assign different values to factors, or may use different approaches to dealing with externalities. Kerali (2003) notes that it is assumed for IRR calculation that all project surpluses are re-invested at the solution rate of interest, which is not accurate for high IRR solutions. Other economic indicators such as Net Present Value (NPV) may also be considered for project appraisal, but there is ongoing debate about which one of them should be preferred, as illustrated for instance by Tang and John Tang (2003).

An unbiased approach was taken to identify a sufficient number of relevant studies. Given sufficient resources, such an approach would ideally seek to identify all relevant literature. However, because of the resource constraints of this review study, consideration was given to locating a sample of studies most pertinent to addressing the research question. This was achieved by carrying out a keyword search of titles and abstracts of studies via Internet search engines and accessing academic journal databases and the websites of specific organisations. Following the initial screening process, the full text of candidate studies were retrieved for further scrutiny.

2. Internal rates of return for railway projects

Table 1 lists the studies identified in this review. IRR values for railway projects in Africa range widely, from a low of zero (Bullock, 2009; Foster & Briceño-Garmendia, 2009) to a maximum of 124.59% (Planet S.A., 2016). The studies are grouped into new construction and rehabilitation projects.

Table 1. Summary of literature on IRR range for railway projects in Africa

	Author	Country	IRR / EIRR (%)	Project evaluation criteria (for various IRR/EIRR only)	Key notes	Use of historical data
New Construction	(PWC, 2016)	Ghana	21.6	Standalone	Construction of new railway line supporting the new Boankra Inland Port.	Distribution road accidents 2000-2012
			17.9	Freight Only		
			18.7	Freight and Passenger		
	(CANARAIL, 2014)	Tanzania, Rwanda and Burundi	11.8	Low Traffic Growth - meter gauge	Construction of a new railway line between the Tanzania, Rwanda and Burundi.	-
			10.9	Low Traffic Growth - cape gauge		
			10.5	Low Traffic Growth - standard gauge		
			17.5	Base Case Traffic Growth - meter gauge		
			16.6	Base Case Traffic Growth - cape gauge		
			16.0	Base Case Traffic Growth - standard gauge		
			25.7	Optimistic Traffic Growth - meter gauge		
			24.7	Optimistic Traffic Growth - cape gauge		
			24.1	Optimistic Traffic Growth - standard gauge		
	(BICO, 2011)	Tanzania	13.7		Construction of a new urban railway line. Despite being presented as IRR it does not include any economic savings	Transit cargo import-export trends and passenger movements (2000-2009)
	(M. A. M. Ali, Osra, & Siegmann, 2016)	Egypt	11.6		Proposal of a new High Speed Railway connecting Cairo and Alexandria -	-

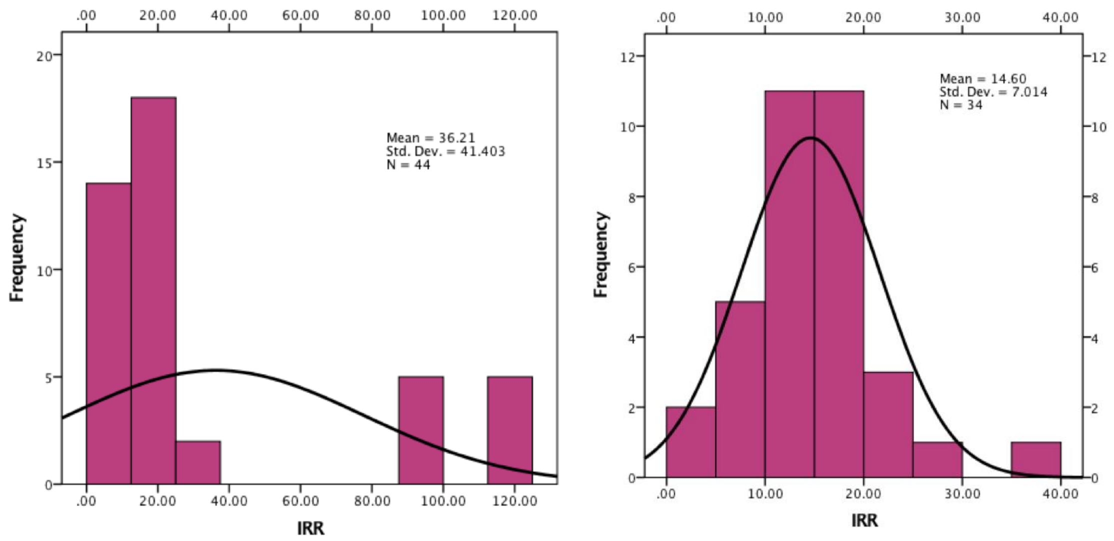
					framework and procedures for evaluation consider passenger operation only (no freight)	
	(Al-Tony & Lashine, 2000)	Egypt	9.2		Proposed electrification scheme for the Cairo–Alexandria railway line. - Framework and procedures for evaluation consider passenger operation only (no freight)	-
	(Mohapatra, 2017)	Djibouti-Ethiopia	18.9	No variation in cost and benefit	Construction of the Ethiopia-Djibouti Rail line. Project economically viable with consideration of only certain benefits such as revenue generated from freight and passenger tariffs and employment generations.	-
			17.12	Cost increase by 15%		
			15.99	Benefit decrease by 15%		
			14.49	Cost increase and benefit decrease by 15%		
	(Abelson, 1995)	Nigeria	8.7		Development of a light rail, Metro, in Lagos for 26 km.	-
Rehabilitation	(Bullock, 2009; Foster & Briceño-Garmendia, 2009)	Africa	0	Volume p.a. (miles net tonnes) 0.25	Examples of EIRR are provided for track rehabilitation in Africa It was concluded that: “a volume of around 1-2 million tonnes needs to be expected before major track rehabilitation is economically worthwhile.”	Traffic growth (1995 – 2005)
			2	Volume p.a. (miles net tonnes) 0.50		
			5	Volume p.a. (miles net tonnes) 0.75		
			8	Volume p.a. (miles net tonnes) 1.00		
			12	Volume p.a. (miles net tonnes) 1.50		
			16	Volume p.a. (miles net tonnes) 2.00		
			37	Volume p.a. (miles net tonnes) 5.00		
	(Planet S.A., 2016)	Uganda	94.95	Tororo-Gulu only - 10% capture rate until 2033	Rehabilitation Feasibility Assessment in which Economic and Financial Rate of Return, ERR (not	Transit cargo import-export trends (2000-2005)
			94.93	Tororo-Gulu only - 10%		

				capture rate until 2031	included) and FIRR, are calculated for 10% and 20% traffic capture rate for three projected years (i.e. 2026, 2031, 2039)	
			94.54	Tororo-Gulu only - 10% capture rate until 2026		
			124.58	Tororo-Gulu only - 20% capture rate until 2033		
			124.57	Tororo-Gulu only - 20% capture rate until 2031		
			124.31	Tororo-Gulu only - 20% capture rate until 2026		
			95.0	Tororo-Gulu-Pakwach - 10% capture rate until 2033		
			94.97	Tororo-Gulu-Pakwach - 10% capture rate until 2031		
			124.59	Tororo-Gulu-Pakwach - 20% capture rate until 2033		
			124.58	Tororo-Gulu-Pakwach - 10% capture rate until 2031		
	(The World Bank, 2014)	Tanzania	15.0	No variations	Rehabilitation of the rail infrastructure and upgrading it to a minimum permissible load of 15t/axle	Data for traffic related to passengers, freight and container (for port) 2005-2010
			9.6	2 services per week decrease		
			10.3	30% reduction in traffic		
			14.1	1-year delay		
			11.0	50% increase in Capex		
	(PADECO Co., 2014)	Tanzania	14.4	Emission reduction effect not included	Rehabilitation of track and bridges and other upgrades and improvements	Data freight tonnage trends 1979-2012
			16.3	Emission reduction effect included		

A basic statistical analysis was conducted on the retrieved data, 44 IRR values, (Figure 1) which showed a mean value of 36.2%. However, after excluding the relatively high values provided by Planet S.A. (2016) the **mean value was 14.6%.** The mean values for rehabilitation and new construction are relatively close without including the Planet S.A. (2016) study, 12.19% and 16.28% respectively.

The high values of IRR in the Planet S.A. (2016) study, around 95% - 125%, are apparently related to the external economic factors as the given financial Internal rate of returns (FIRRs) are in relatively smaller range (around 6% - 60%). The considered external factors are discussed in the following section.

Figure 1: Data distribution for the railway IRR values for all the retrieved studies (a) and excluding Planet S.A. (2016) (b)



(a) (b)

Another factor which was considered in the review was the utilisation of historical data to in making assumptions or for building/validating required projections, e.g. economic and/or traffic growth. Six of the eleven studies used historical data to some extent, especially for traffic growth projection. However, the review did not find any study re-evaluating the projections and associated assumption in a constructed project using historical data. Such a study would be beneficial to evaluate the utilised appraisal method(s) and to review the effectiveness of budget allocations.

3. GDP and other externalities

Benefits estimated from external economic factors (externalities) have a major role in setting the values of IRR. The review suggests that the most common considered factors are:

1. Air pollution (sometimes called greenhouse gas emissions)
2. Reduced road accidents
3. Eliminated highway maintenance
4. Noise reduction
5. Road vehicle operating costs, and
6. Time savings

Air pollution and road accidents are the most frequently considered factors (see Table 2), while noise and eliminated highway maintenance are included less often. There are studies considering other economic, environmental and social factors, for instance Olievschi (2013) suggests taking into consideration climate change, mobility needs, trade and logistic chains, traffic safety, and land utilisation.

Table 2. Summary of literature on included externalities as economic factors for railway projects

Author	Air Pollution	Reduced Road Accidents	Eliminated Highway maintenance	Noise	Road Vehicle Operating Costs	Time Savings
(PWC, 2016)		✓	✓		✓	✓
(Planet S.A., 2016)	✓	✓		✓	✓	✓
(The World Bank, 2014)	✓	✓				
(PADECO Co., 2014)	✓				✓	
(CANARAIL, 2014)	✓	✓	✓	✓	✓	
(M. A. M. Ali et al., 2016) [1,2]	✓	✓				✓
(Al-Tony & Lashine, 2000) [2,3]	✓	✓			✓	✓
(Abelson, 1995)	✓	✓			✓	✓
(Bullock, 2009; Foster & Briceño-Garmendia, 2009)	✓	✓	✓		✓	
(Mohapatra, 2017) [4]	-	-	-	-	-	-
(BICO, 2011)	-	-	-	-	-	-

[1]High Speed Rail line [2]Only for passengers, no freight, [3]Railway electrification, [4]The only considered externality was Employment Generation while other factors were excluded due to data lag and complexity of calculation

The high IRR values in the Planet S.A. (2016) study are related to the externalities considered, which included all of the factors listed above except for highway maintenance, as well as impacts on nature and landscape, up/downstream impacts, and urban effects (Table 3), but the study did not provide details about how these factors were estimated.

Table 3: External factors included the in Planet S.A. (2016) study and their associated values

	Road			Rail	
	LDV	HDV	Total	Diesel	Electric
Accidents	46.7	6.4	10.1	-	-
Noise	43.2	6.5	9.9	4.3	2.4
Air Pollution	115.9	51.1	57.1	11.1	6.1
Climate Change	76.5	17.1	22.5	4.3	-
Nature & Landscape	14.5	2.7	3.9	0.4	0.4
Up-/ Downstream	29.9	9.9	11.7	3.2	3.2
Urban Effects	6.9	1.5	2.0	0.7	0.7
Total	**333.6**	**95.1**	**117.2**	**23.9**	**12.8**

An important external factor in calculating IRR is GDP, as suggested by Ernst & Young (2017) for railways in Europe, which is expected to play a major role in relatively small economies. A main rail line can be expected to enhance national economy through providing new trading routes with higher transportation capacities and also by increasing employment and creating new opportunities. However, the review reveals that none of the included studies quantified this benefit, although they noted its relationship with railway traffic (Table 4).

Table 4: GDP inclusion in the considered studies

Author	Key findings
(PWC, 2016)	There is a close relationship between total traffic volume (in metric tonnes) and the GDP
(Planet S.A., 2016)	The difference of GDP per capita is considered for calculating external saving unit costs
(The World Bank, 2014)	Correlation between GDP and railway traffic
(PADECO Co., 2014)	Correlation between GDP, rail traffic and freight demand
(Foster & Briceño-Garmendia, 2009)	Correlation between GDP and railway traffic
(BICO, 2011)	It was stated that the contribution of transport to GDP accounts for about 6%, while costs are estimated to account for about 10%. Therefore, improvements in transport services in terms of availability, reliability and accessibility improve the contribution of transport to the GDP. However there was no quantification on the stated improvement.
(Mohapatra, 2017)	Contribution of service sector (including transport) accounts for 70% of Djibouti GDP. The transit traffic between Djibouti and Ethiopia is reported to reduce the poverty level by creating more job opportunities in port and transit services, and related transport activities in rail and road, but no quantification was done on impact on GDP.

4. Internal rates of return for highway projects

Table 5 provides an overview of the calculated IRR values for highway projects in Africa from the selected studies identified for this review. A wide range of values are identified for IRRs, ranging from -5.5% to over 127%.

Table 5. Summary of literature on IRR for highway projects in Africa

Author	Country	IRR / EIRR (%)	Key notes
(Roughton International, 2012)	Tanzania	11.15 12.66 14.84 16.52 17.15 20.50 21.25 26.83	IRR for different types of pavement, i.e. Concrete Strips (Unreinforced), Geocells, Concrete Strips (Reinforced), Single Otta Seal with Sand Seal, Double Sand Seal, Slurry Seal, Hand Packed Stone, Double Surface Dressing, Gravel Flat and Hilly) over a design life of 20 years using HDM4-RUC model
(IDA, 2015)	Kenya	24.7 21.0 26.5 24.7 34.6 21.1	For various traffics (i.e. 154 to +10,000 AADT) and lengths (i.e. 80- 363 km)
(Bynens & Taylor, 2012)	DR Congo	17 20	Four different routes with a range of length 72 to 239 km
(The World Bank, 2008)	Ethiopia	14.3 16.3 20.3 25.2	Rehabilitation and upgrade for four different length 196-442 km using HDMIII model
(Southern African Development Community, 2012)	Tanzania	23	Update and road widening
(Japan International Cooperation Agency, 2008)	Tanzania	11.3 39.4 40.3 42.1	4-lane widening with 6 different road widths and to whether include BRT space for two different routes
(Talvitie, 2000)	NA	12.6 16.2 19.7	The study provides EIRR for a motorway construction as an example for World Bank funded projects in developing countries. The study conducted both sensitivity analysis and risk assessment to include any involved uncertainties
(TRRL, 1988)	NA	20.6 23 23.9	Three different scenarios including two different traffic and a third scenario with time savings
(Morosiuk, 2008)	Malawi	-5.5 6 7 11 14 15 25	Maintenance alternations 3 Different material for surface (surface treatment (ST), asphalt mix (AM) and earth (EA) roads), 3 traffic categories for each paved and unpaved roads, 3 categories of surface conditions 4 maintenance options and various lengths 2-4396.6km

		28	
		29	
		30	
		38	
		50	
		54	
		55	
		57	
		62	
		74	
		75	
		82	
		103	
		107.9	
(W. Pienaar, 2008)	Namibia	5.2	Cost comparison of upgrading existing road and designing new project (showing the higher value). A sensitivity analysis showed that 2% change in traffic growth will change the IRR for the new road between 55.4% and 27.4%
		42.3	
(Gael & Supee, 2009)	East Africa	7	Road rehabilitation for different areas of Africa according to 50km and 100km projects, two surface condition categories and two traffic scenarios
		0	
		30	
		15	
		38	
		20	
		127	
		65	
(P. Pienaar, Visser, & Dlamini, 2000)	Swaziland	27.7	Comparison of HDM-III and HDM-4 applied to a case study in Nsoko-Maloma road, Swaziland
		20.6	

The statistical analysis (Figure 2) shows a **mean value of 31.5%** and a standard deviation of 26 compared with 14.6% and 7 respectively for the railway projects excluding the Planet S.A. (2016) (36.2% and 41 respectively including all retrieved studies). The comparison is also presented in Figure 3, in which all the retrieved studies are included, showing that the range are very close together. Having said that, and also by considering the uncertainties involved in IRRs calculation in Planet S.A. (2016), the 14.6% mean value seems to be a more realistic figure and better representative of the gap between the two evaluation.

Figure 2: Data distribution for the highway IRR values for all the retrieved studies

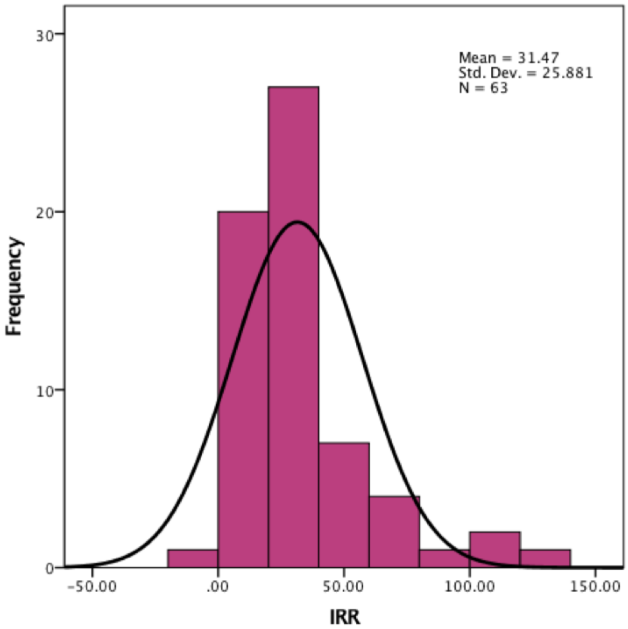
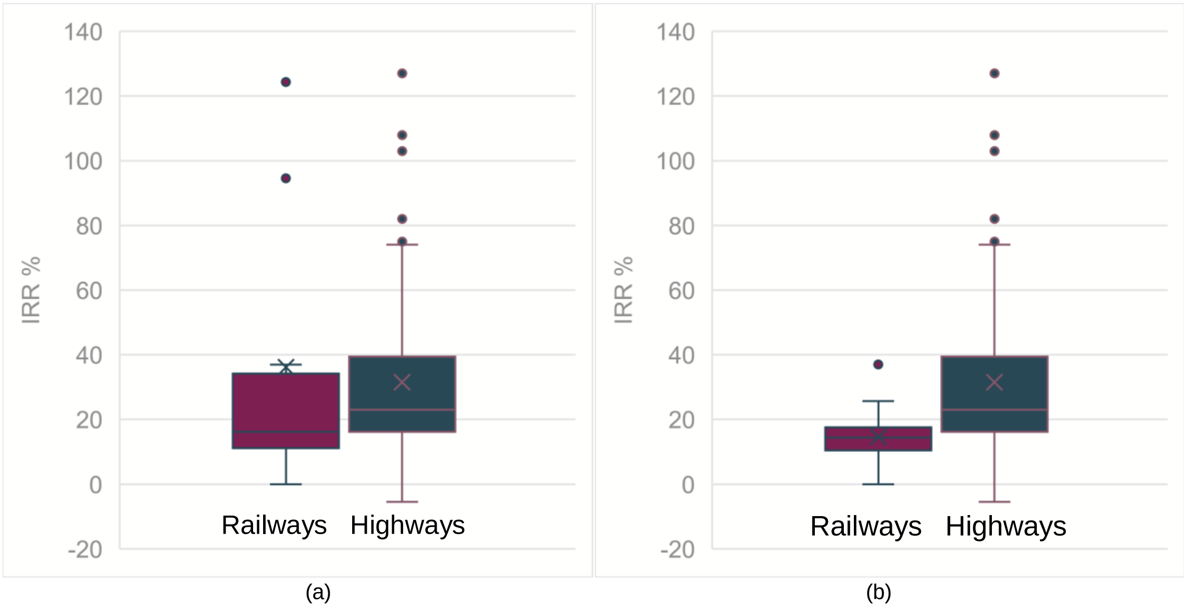


Figure 3: Comparison between railway and highway IRRs, (a) including Planet S.A. (2016) and (b) excluding the study



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