USING COST-EFFECTIVENESS ANALYSIS TO SCREEN AND RANK ROAD PROJECTS IN NAMIBIA

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ABSTRACT

This paper uses Cost-Effectiveness Analysis (CEA) to assist the Namibian Roads Authority cost-effectively allocate a €60.0 million loan from International Development Agencies between 8 trunk road maintenance and upgrade projects in Namibia. The investment objective against which the road projects are assessed is to increase economic growth by supporting a world-class logistics hub. But data limitations, which are common for many developing countries, preclude the use of Cost-Benefit Analysis to reliably evaluate the road projects. Because CEA can be run with only project cost and traffic data, this approach is presented as an alternative to screen and rank the road projects. The screening exercise uses the €60.0 million budget constraint to limit the number of alternative road projects. The available road projects are then ranked in order of their contribution to the stated investment objective, with stress tests conducted using Monte Carlo analysis to account for uncertainty in the traffic forecasts. The cost-effectiveness ratios are analysed to determine: the most efficient road project; the road project with the maximum effect; and the optimal combination of road projects to be funded within the available budget.

1. INTRODUCTION

This paper uses Cost-Effectiveness Analysis (CEA) to help the Namibian Roads Authority (RA) cost-effectively allocate a €60.0 million loan from International Development Agencies (IDA) between the following 8 trunk road maintenance and upgrade projects in Namibia: T0103 from Mariental to Gibeon; T0103 from Tses to Gibeon; T0103 from Tses to Keetmanshoop; T0102 from Keetmanshoop to Grunau; T0204 from Omaruru to Otjiwarongo; T0701 from Usakos to Karibib; T0203 from Karibib to Omaruru; and T0202 from Usakos to Swakopmund.

The RA (2018a) managed a 48 875 km road network in 2017/18. Although the condition of the 7 893 km surfaced road network is acceptable, 38.0% of these roads have either reached or are nearing the end of their design life. This age-related pressure accounts for a high proportion of the N$15.0 billion required for road maintenance and rehabilitation over the next five years. With an approximate annual road sector budget of

N$600.0 million, RA officials must therefore prioritise how the limited funds should be optimally allocated between competing projects.

Section 2 references key policy documents to demonstrate that the RA and IDAs share the same investment objective: to increase economic growth in Namibia through a world-class logistics network. The road projects reviewed in this study, which are outlined in Section 3, must consequently be assessed and prioritised according to their contributions made to this goal.

Despite the RA (2014a) having developed an *Economic Evaluation Manual* to standardise the economic evaluation process, Section 4 presents a review of the available feasibility studies for the projects to demonstrate methodological discrepancies between the evaluations. This makes it impossible to compare and prioritise the road projects based on the provided Net Present Value (NPV) and Internal Rate of Return (IRR) estimates. Section 4 also details the data limitations that preclude the application of Cost-Benefit Analysis (CBA) and thereby the prescribed Highway Development and Management System Version 4 (HDM-4).

This leaves CEA as the most viable alternative to screen and rank the 8 road projects. An overview of the CEA methodology is introduced in Section 5. Given the investment objective to grow the economy through enhanced logistics performance, the effectiveness measure is set as heavy-vehicle-km on each road. Section 6 presents the lifecycle forecasts for the volume of heavy vehicle traffic on each road, with stress tests conducted using Monte Carlo analysis to account for uncertainty in user demand. The resultant effectiveness measures are compared with the respective financial cost of the rehabilitation works required by each road to determine the set of cost-effectiveness (CE) ratios. These CE ratios are analysed to determine which road project maximises the effectiveness measure, which road project is the most cost-effective, and what is the optimal combination of road projects given the available budget.

2. INVESTMENT OBJECTIVE

Namibia's 5th National Development Program (NDP5) runs 2017/18 until 2021/22 and is the fifth in a series of seven five-year national development plans that outline the objectives and aspirations of Namibia's long-term vision expressed in Vision 2030 (Republic of Namibia, 2017). Sustainable transport and logistics infrastructure are a core focus area in NDP5, with the stated objective to develop "a sustainable transport system supporting a world-class logistics hub connecting SADC to international markets" (Republic of Namibia, 2017: 107). In fact, the road indicators are all listed under this focus area. The government reiterates that a functional and efficient transport and logistics sector is the backbone for the realisation of the NDP5 targets in agriculture, mining, manufacturing, and fisheries. An Aid Memoire from the IDAs therefore aims to finance the rehabilitation and upgrade of core sections of the national road network to support the government's objective to raise growth through a world-class network that strengthens the country's logistical hub position.

3. THE ROAD PROJECTS

High level details for the 8 trunk road projects are presented in Table 1. The length of the road project is a key determinant of the heavy-vehicle-km as well as the relative cost of each project. The project start date influences the period over which the lifecycle analysis must be conducted.

Table 1: Road project details

Road name	Road length (km)	Project completion date	Project cost (N$)
T0103: Mariental – Gibeon	62.0	2023Q1	614 761 216
T0103: Tses – Gibeon	87.0	2022Q1	672 771 309
T0103: Tses – Keetmanshoop	81.3	2023Q1	811 416 018
T0701: Usakos – Karibib	28.0	2022Q1	290 648 527
T0203: Karibib – Omaruru	61.0	2023Q1	580 885 382
T0102: Keetmanshoop – Grunau	158.4	2023Q1	1 420 158 293
T0204: Omaruru – Otjiwarongo	132.4	2023Q1	1 319 727 537
T0202: Usakos – Swakopmund	138.0	2023Q1	1 264 992 080

4. LIMITATIONS OF THE AVAILABLE DATA AND STUDIES

This section covers the challenges faced by the RA and IDA when using the available feasibility studies to prioritise the road projects. Similar data constraints are experienced by many road authorities, especially in developing countries. It is therefore important to identify the key issues and to review how these affect the relevance, accuracy, and comparability of CBA studies.

4.1 Data constraints

Only two pieces of data were available for all 8 road projects: the total project cost and historical traffic data. But to conduct a CBA, which is the generally preferred method to evaluate and prioritise projects, the following additional information is required: detailed lifecycle distribution of the road construction and maintenance costs; road condition data to estimate the vehicle operating costs; road accident data; time preferences of drivers; environmental costs; and, given the high unemployment rate in Namibia, the shadow price of labour. However, there are no reliable estimates for the time preference of drivers or the shadow price of labour in Namibia. Moreover, the environmental costs need to be individually specified for each project and require the application of a currently missing environmental discount rate to be accurate. So, while the RA (2014) prescribes HDM-4's CBA capability for economic evaluation, these data constraints preclude its effective application without incurring costs, for which funding is not available, and time delays that are deemed unacceptable.

4.2 Discrepancies between the estimated project benefits

Feasibility studies were completed for 3 out of the 8 road projects. The studies reviewed include: Feasibility study for the rehabilitation of trunk roads: TR1/2 Grunau - Keetmanshoop (Roads Authority of Namibia, 2013); Pre-investigation study for the rehabilitation and improvement of T0204 between Omaruru and Otjiwarongo (Roads Authority of Namibia, 2018b); and Feasibility study for the rehabilitation of TR2/3: Karibib - Omaruru (Roads Authority of Namibia, 2014b). The feasibility phase was skipped for the remainder of the projects, with the planners moving straight to the detailed design phase.

There are notable differences between how the benefits of the projects were respectively assessed. While this may be addressed through tighter regulation of project feasibility assessments, this does not provide the RA with a short-term solution to ranking the road projects, nor would it provide the RA with a future tool to rank other road projects for which feasibility studies have not been undertaken. The study for T0102 from Keetmanshoop to Grunau reviewed the project benefits qualitatively and hence no NPV or IRR estimates were presented. Following the development of the RA's (2014a) *Economic Evaluation*

Manual, the feasibility studies for T0203 from Karibib to Omaruru and T0204 from Omaruru to Otjiwarongo adopted a quantitative approach, with CBA conducted in HDM-4. Limited details, however, were provided on what was included in the CBA estimates. The opaque nature of these evaluations, which were conducted by different service providers with apparently no external validation, render these findings unreliable for a prioritisation exercise.

For example, there is a significant difference in how the different feasibility studies account for accident costs. The feasibility studies for T0102 from Keetmanshoop to Grunau and T0203 from Karibib to Omaruru assume that the recorded accidents are attributed to driver error rather than road conditions and thereby exclude accident costs from the assessment. On the other hand, the feasibility study for T0204 from Omaruru to Otjiwarongo sourced accident data from the US Department of Transportation Federal Highway Administration to estimate accident cost reductions that might result from the project to widen the carriageway. These methodological and data discrepancies cannot always be readily identified or removed from the NPV and IRR estimates to form a consistent basis for comparing projects.

4.3 Inconsistent traffic forecasts

The RA's (2014a) *Economic Evaluation Manual* requires that growth rates for normal traffic be estimated from historical traffic count data. The Manual notes that certain circumstances, such as upgrade projects, may warrant the assumption that traffic growth could accelerate. But the Manual cautions that exponential traffic growth rates might overestimate actual growth. Given the importance of traffic data to CBA and CEA, it is vital that a sound forecast methodology is consistently applied.

However, light and heavy vehicles were aggregated and subject to a single growth rate of 1.0% in the feasibility study for T0102 from Keetmanshoop to Grunau. This is problematic as light and heavy vehicles represent distinct road-user classes that make different contributions to the investment objective. For example, it is possible that light vehicle traffic on this road might have declined due to a change in a tourist route while heavy vehicle traffic experienced sufficient growth to counter-balance this effect. While the aggregated growth in traffic would therefore reflect as zero, freight volumes would have increased along with the road's importance as a logistics link. In addition, the stress tests performed on traffic growth were arbitrarily set at 4.0% and 6.0%. The lack of reference to short- and long-term traffic trends diminishes the relevance of these alternative scenarios and their use in reducing the level of uncertainty.

The feasibility study for T0203 from Karibib to Omaruru did distinguish between light and heavy vehicles. This allowed the forecasts to account for changes in the composition of traffic, with the road growing in importance as a logistics route over the project period. But rather than using the recorded average annual growth rate between 2002 and 2013 of 9.0% for light vehicles and 19.0% for heavy vehicles, the study referenced a nearby road between Swakopmund and Arandis to justify a more conservative annual growth rate of 4.0% and 7.0% for light and heavy vehicles, respectively. While this decision was based on the RA's (2014a) procedure to avoid exponential growth rates in traffic, it is problematic that the stress tests, which model a 2.0% upward and downward deviation in traffic growth, also ignored the historical data.

A similar criticism applies to the feasibility study for T0204 from Omaruru to Otjiwarongo. Data from 2005 to 2015 shows average annual growth of 18.6% for heavy vehicles, in line with the higher use of the connected port at Walvis Bay by Angola and Zambia during the commodities super-cycle. Based on the assumption that heavy vehicle growth will not continue at this rate over the design of the road project, the following three traffic growth scenarios were modelled without any justification: a low scenario of 4.0% in the first 10-years and 3.0% in the second 10-years; a medium scenario of 6.0% in the first 10-years and 5.0% in the second 10-years; and a high scenario of 8.0% in the first 10-years and 7.0% in the second 10-years. The sensitivity tests did raise traffic growth by 10.0%, which roughly equates to the historical traffic data.

Inconsistent use of traffic forecast methods can lead to comparability issues between projects. Moreover, traffic forecast methods with a high risk of variability, such as assuming rounded growth rates or growth rates from nearby roads, are associated with a relatively high expected error. This creates the need for a consistent methodology to forecast traffic on the project roads.

5. PRIORITISATION METHODOLOGY

Boardman *et al*. (2005) cite three general conditions that motivate the use of CEA: analysts are either unwilling or unable to monetise the most important impacts of a project; analysts may recognise that a particular effectiveness measure does not capture all of the benefits of each alternative, but the outstanding benefits are difficult to monetise; and analysts may be dealing with intermediate goods whose linkage to preferences is not clear, such as the transportation to a place of interest like a school or church.

As explained in Section 4, insufficient data are available to monetise the impacts of these road projects. Any attempt to do so would thus be highly subjective and speculative. Under these circumstances CEA is a commonly applied alternative to CBA to evaluate and rank projects, as supported by, amongst others, the Asian Development Bank (2017) and the World Bank (2010). Noteable applications of CEA in the roads sector include: The Institute for Transport Studies (2003); The Texas Department of Transportation (2003); The Illinois Center for Transportation (2010); and The European Investment Bank (2013).

Banister and Berechman (2003) explain that, like CBA, the objective behind CEA is to select a project alternative that generates the greatest amount of output. But CEA measures this output in real as opposed to monetised units. CEA is therefore unable to guarantee that a project's benefits will exceed its cost, as in the case of CBA. Rather an index of this output over the cost is produced for different projects and applied to select the most efficient option. To promote expenditure efficiency the effectiveness measure must reflect the investment objective, which for this set of road projects is to increase economic growth by supporting a world-class logistics hub. Effectiveness is thus measured by the number of heavy-vehicle-km on each road as this is a relatively comprehensive proxy for the volume of freight and hence economic activity. It is important to state that this effectiveness measure is distinct from total vehicle-km as this would shift the focus from logistics related traffic to mixed traffic.

Because CEA does not monetise project benefits two metrics are required: the effectiveness measure and monetised costs. Costs are recorded as the financial cost of a project, which is standard practice when CEA is conducted for a government department or agency (Boardman *et al*., 2005). The RA (2014a) requires that import taxes and duties and excise taxes are removed from the financial cost of the project as these expenses are subsequently collected by the government as revenue.

The non-commensurate metrics mean that it is impossible to obtain a single measure of net benefits. However, the ratio of the metrics provides the basis to screen and rank alternative projects. This ratio can be expressed as a cost-effectiveness ratio (CE ratio), which is the cost of an alternative divided by the measure of its effectiveness, or as an effectiveness-cost ratio (EC ratio), which is the effectiveness measure of an alternative divided by its cost. Costs and effectiveness must be measured incrementally to indicate expenditure efficiency. Boardman *et* al. (2005) demonstrate this by considering the example of two projects, *i* and *j*. The cost-effectiveness ratio of project *i* relative to project *j*, CE_{ij}, is given by the formula:

$$CE_{ij} = \frac{C_i - C_j}{E_i - E_j} \quad (1)$$

where C_i is the cost of alternative *i*, C_j is the cost of alternative *j*, E_i is the effectiveness units produced by alternative *i*, and E_j is the effectiveness units produced by alternative *j*. The comparison alternative, *j*, is a scenario where no project is undertaken and the road finally becomes impassable. While this alternative is an unrealistic outcome, at least over the short term, this benchmark is necessary to estimate the average CE ratio. Once a preferred project is selected it can be used as the comparison alternative to calculate the incremental CE ratio.

But CE ratios ignore scale effects. An important implication of this oversight is that projects that produce small impacts at a relatively low unit cost will be ranked above projects that produce larger impacts but at a somewhat higher unit cost. Boardman *et al*. (2005) reiterate that CE ratios measure technical efficiency and must therefore be interpreted as such. While scale differences among alternative projects may distort choice, a common practice to mitigate this concern is to impose a constraint. This constraint could either be a minimum acceptable level of effectiveness, denoted as $\overline{E}$, or a maximum acceptable cost, denoted as $\overline{C}$. The latter constraint is suited to the RA's situation where a budget constraint is present. If a maximum cost is specified then the project that supports the highest number of heavy-vehicle-km might be selected, subject to the cost constraint:

$$\begin{gathered}\text{Maximise } E_i \\ \text{Subject to } C_i \leq \overline{C}\end{gathered} \quad (2)$$

Boardman *et al*. (2005) point out that this rule ignores incremental cost savings, meaning that cost savings beyond $\overline{C}$ are not valued. Alternatively, it is possible to select the project that most cost-effectively meets the imposed cost constraint, as shown in Equation 3. This rule places some weight on the incremental cost savings and is more likely to result in the selection of a project with less than the maximum cost.

$$\begin{gathered}\text{Minimise } CE_i \\ \text{Subject to } C_i \leq \overline{C}\end{gathered} \quad (3)$$

6. COST-EFFECTIVENESS ANALYSIS

6.1 Project screening based on the cost constraint

Figure 1 illustrates the project costs in relation to the IDA's loan of €60.0 million, which converts to N$1.01 billion at an exchange rate of N$16.77 per Euro. The project costs were provided by the RA who extracted them from the detailed design reports. The following projects exceed the budget constraint: T0102 from Keetmanshoop to Grunau; T0204 from Omaruru to Otjiwarongo; and T0202 from Usakos to Swakopmund. Because these projects exceed the limit of the loan they are removed from further consideration. While the excluded road projects could be divided into smaller sub-sections to be assessed as separate projects, this option was not provided by the RA and not considered in the analysis as it would create service inconsistencies along a single trade route. The 5 remaining projects can all be viably funded, with the cheapest project (T0701 from Usakos to Karibib) at only 28.9% of the available loan.

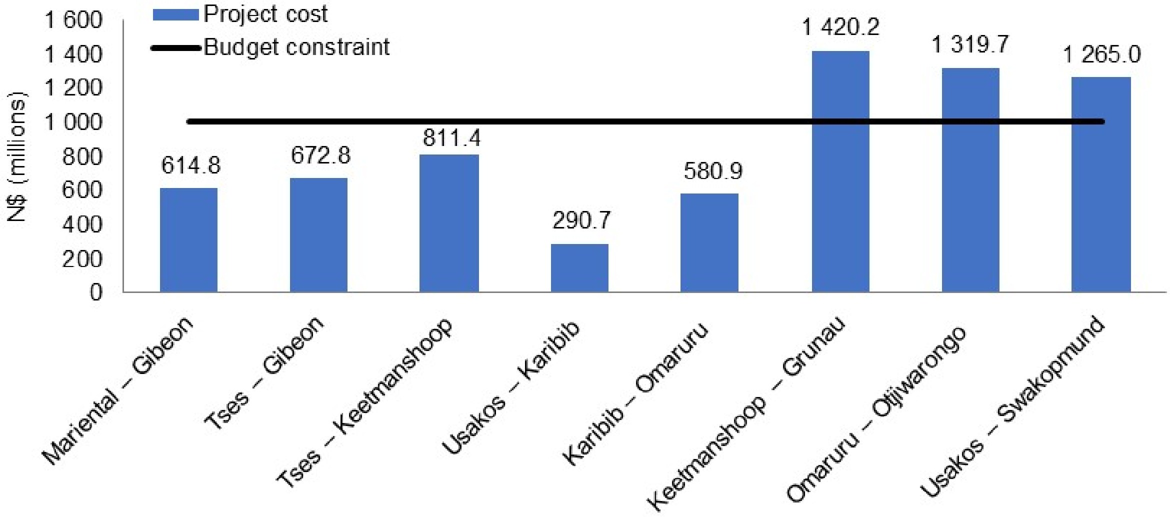

Figure 1: Project costs compared against the budget constraint

6.2 Effectiveness measure

Table 2 presents the historical heavy vehicle traffic data collected through automatic counting stations by the RA for the 5 viable roads. Reliable traffic data are unavailable prior to 2013. The largest percentage increase in heavy vehicle traffic was recorded at 30.4% for T0203 from Karibib to Omaruru. While growth in heavy vehicle traffic was initially high on T0701 from Usakos to Karibib between 2013 and 2015, the AADT stagnated in 2016 and fell in 2017. The 5-year growth in heavy vehicle traffic was more moderate on T0103 from Mariental to Gibeon, T0103 from Tses to Gibeon, and T0103 from Tses to Keetmanshoop at 2.6%, 2.9%, and 1.3%, respectively.

Table 2: Heavy vehicle annual average daily traffic, 2013-2017

Project road	2013	2014	2015	2016	2017
T0103: Mariental – Gibeon	380	390	390	390	390
T0103: Tses – Gibeon	340	355	355	365	350
T0103: Tses – Keetmanshoop	380	390	390	385	385
T0701: Usakos – Karibib	580	680	724	725	694
T0203: Karibib – Omaruru	253	271	290	311	330

Equation 4 was used to forecast AADT, where: E_{t+n} is the AADT value of year t, forecast n years in the future; E_t is the base year AADT value, observed during year t; and g is annual AADT growth rate.

$$E_{t+n} = E_t(1+g)^n \quad 4$$

The average annual AADT growth rate is calculated using Equation 5, where k is the number of years between the first and last AADT value. The 5-year traffic data from

Table 2 was used to generate the growth factor. The design life of the roads was set at 20-years post completion of the respective road works.

$$g = \sqrt[k]{\frac{E_t}{E_{t-k}}} - 1 \qquad 5$$

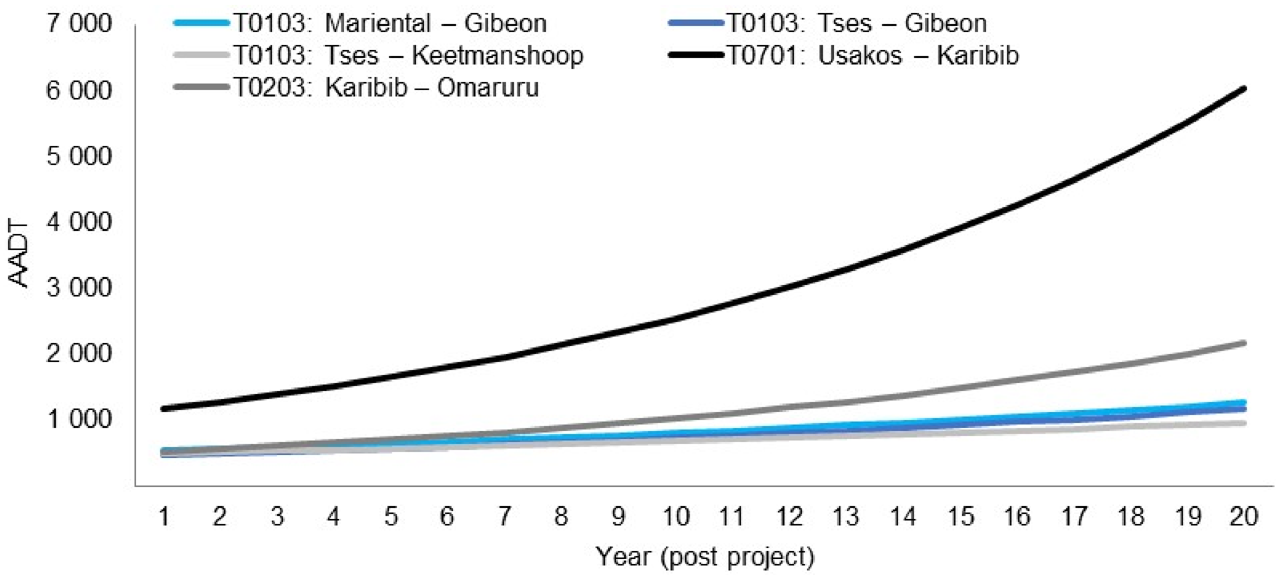

Figure 2: 20-year heavy vehicle traffic forecasts

Monte Carlo analysis was applied to improve the reliability of the traffic forecasts. This approach analyses the distribution of the annual growth in heavy vehicles that results from treating the numerical values of historical growth rates as draws from probability distributions. Boardman *et al*. (2005) explain the steps to perform a Monte Carlo analysis, which were fitted to this study. The first step is to specify the probability distributions for annual growth in heavy vehicles on each road. A uniform distribution was specified for the 10-year sample, which assumes that any growth rate between the upper and lower bound of recorded values is equally likely. In the second step a trial is done for each road by taking a random draw from the distribution of annual growth in heavy vehicles to generate a value for calculating the number of heavy vehicles on a road over its 20-year design life. The third step repeats this trial 1 000 times to produce a large number of realisations of the number of heavy vehicles on each road. The average of the 1 000 trials provides an estimate of the number of heavy vehicles that are expected to travel on each road over its design life.

Sensitivity analysis then accounts for the uncertainty in demand for a road and conveys how sensitive the predicted number of heavy vehicles is to changes in the annual growth rate. The historical traffic data provides a lower and upper bound for annual growth rates in traffic. These worst- and best-case scenarios, however, were not chosen for the sensitivity tests because of two key limitations: this approach focuses on growth rates near the extreme of their plausible ranges, which we know are the least likely to occur, and ignores a lot of the available information about traffic volumes; and this approach does not provide information about the variance of the statistical distribution of realised growth in heavy vehicle traffic. The scenarios in Table 3 were therefore based on the 95.0% confidence interval from the Monte Carlo simulations.

Table 3: Sensitivity tests of the heavy vehicle traffic forecasts

Project road	Compounded annual growth rate		
	Low-case	Base-case	High-case
T0103: Mariental – Gibeon	4.5%	4.6%	4.7%
T0103: Tses – Gibeon	4.7%	4.9%	5.0%
T0103: Tses – Keetmanshoop	3.4%	3.5%	3.6%
T0701: Usakos – Karibib	8.9%	9.1%	9.3%
T0203: Karibib – Omaruru	7.8%	7.8%	7.9%

7. COST-EFFECTIVENESS RATIOS

Table 4 compares the project costs and heavy-vehicle-km over the 20-year design life of the roads for the low-, base-, and high-case traffic scenarios. The heavy-vehicle-km estimates were generated by converting the forecast AADT into annual traffic volumes that were multiplied by the road length and summed to reach a total. The low- and high-cases are not symmetrically different from the base-case because of the Monte Carlo simulations. The highest and lowest forecast heavy-vehicle-km are on T0103 from Mariental to Gibeon and T0701 from Usakos to Karibib, respectively. Over its 20-year design life T0701 from Usakos to Karibib is expected to facilitate between 581.2 million and 619.0 million heavy-vehicle-km, which is expected as this road is an important logistics link to both the central and northern parts of Namibia.

Table 4: Project costs and effectiveness

Project road	Cost (N$)	Effectiveness (total 20-year heavy-vehicle-km)		
		Low-case	Base-case	High-case
T0103: Mariental – Gibeon	614 761 216	381 066 539	388 776 877	396 134 595
T0103: Tses – Gibeon	672 771 309	473 815 403	481 055 292	496 783 316
T0103: Tses – Keetmanshoop	811 416 018	403 207 598	411 823 253	421 855 456
T0701: Usakos – Karibib	290 648 527	581 206 277	612 371 553	619 038 634
T0203: Karibib – Omaruru	580 885 382	512 632 653	516 689 402	519 855 060

Any distortions introduced into the effectiveness measure by road distance are controlled for in the CE ratio by the project costs. The CE ratios are presented in Table 5 along with the relative efficiency ranking of the alternative road projects. For the low-, base-, and high-case scenarios T0701 from Usakos to Karibib is the most efficient project. The base-case CE ratio of 0.47 for T0701 indicates that 1.0 heavy-vehicle-km is supported for every N$0.47 spent on the project. There is a 419.2% difference in the CE ratios between T0701 from Usakos to Karibib and the lowest ranked project, T0103 from Tses to Keetmanshoop. This signals a notable discrepancy in the relative efficiency of the alternative projects.

Table 5: Project CE ratios and ranks

Project	Low-case		Base-case		High-case	
	CE ratio	Rank	CE ratio	Rank	CE ratio	Rank
T0103: Mariental – Gibeon	1.61	4	1.58	4	1.55	4
T0103: Tses – Gibeon	1.42	3	1.40	3	1.35	3
T0103: Tses – Keetmanshoop	2.01	5	1.97	5	1.92	5
T0701: Usakos – Karibib	0.50	1	0.47	1	0.47	1
T0203: Karibib – Omaruru	1.13	2	1.12	2	1.12	2

8. INVESTMENT DECISIONS

8.1 The project with the maximum effect

Figure 3 shows the effectiveness measure for each of the alternative road projects. The project with the highest effect, under all three scenarios, is T0701 from Usakos to Karibib. The relatively high volume of heavy vehicles that use T0701 from Usakos to Karibib offsets the fact that this road is the shortest of the alternative projects. The RA should therefore allocate the available funds to T0701 from Usakos to Karibib, and failing that T0203 from Karibib to Omaruru, if the desired outcome is to maximise effectiveness from a single project.

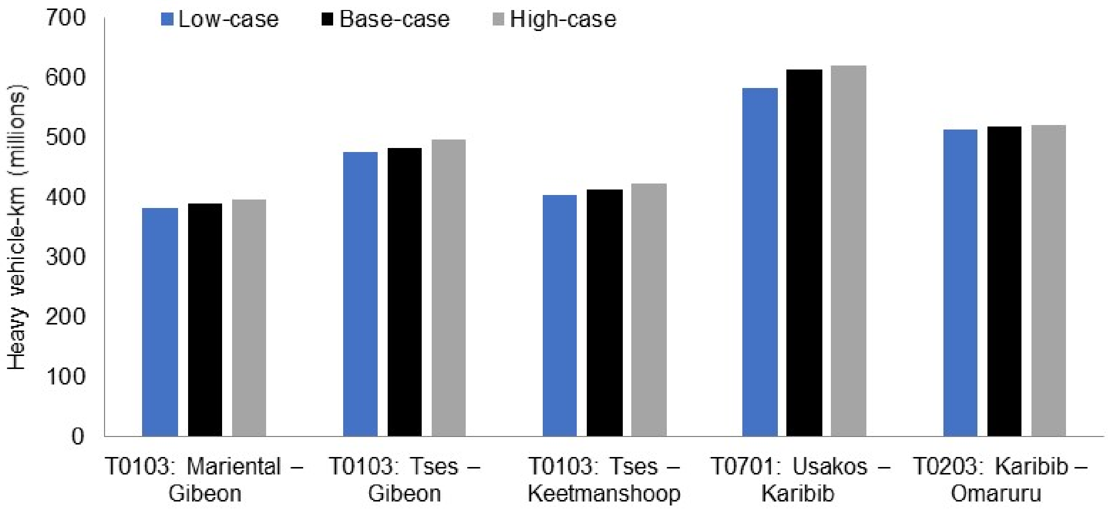

Figure 3: Project effectiveness

8.2 The most efficient project

Figure 4 visualises the CE ratios for the alternative road projects. The most cost-effective road project under all three of the scenarios, which is identified by the lowest CE ratio, is T0701 from Usakos to Karibib. The CE ratios for the other 4 road projects are separated by a 75.0% margin, which signals a relatively large difference in efficiency between the alternative road projects. The RA should again allocate the available funds to T0701 from Usakos to Karibib, and failing that T0203 from Karibib to Omaruru, if their objective is to cost-effectively support logistics activity and economic growth in Namibia through only one of the available projects.

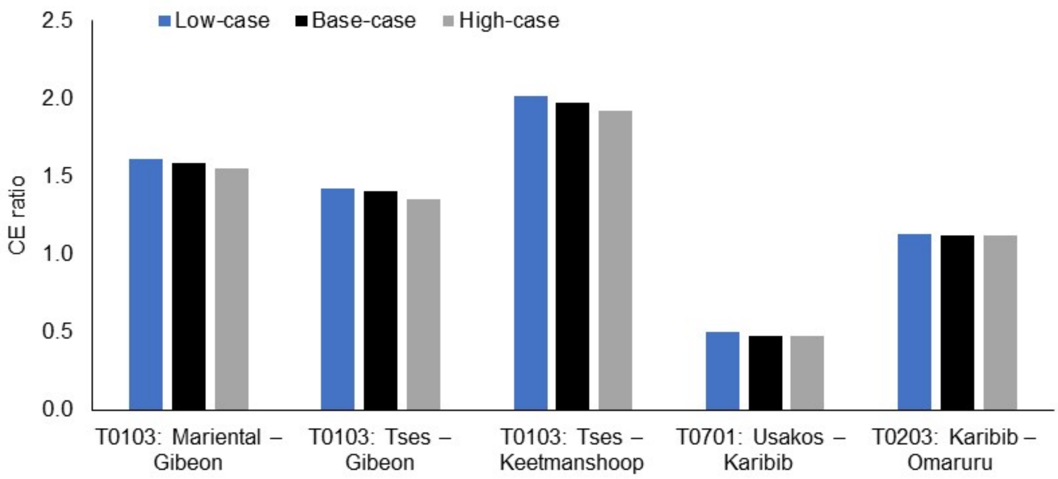

Figure 4: Project efficiency

8.3 The optimal combination of projects

Combinations of the road projects provide other investment alternatives if the RA and IDA are willing and able to allocate the entire €60.0 million budget. Figure 5 indicates that there are 4 potential project combinations within the budget constraint. The set of projects that maximise overall effectiveness are T0701 from Usakos to Karibib and T0203 from Karibib to Omaruru. As discussed, these two road projects are the most effective and cost-effective alternatives. It is therefore an attractive option for the RA and IDA to jointly fund these rehabilitation projects.

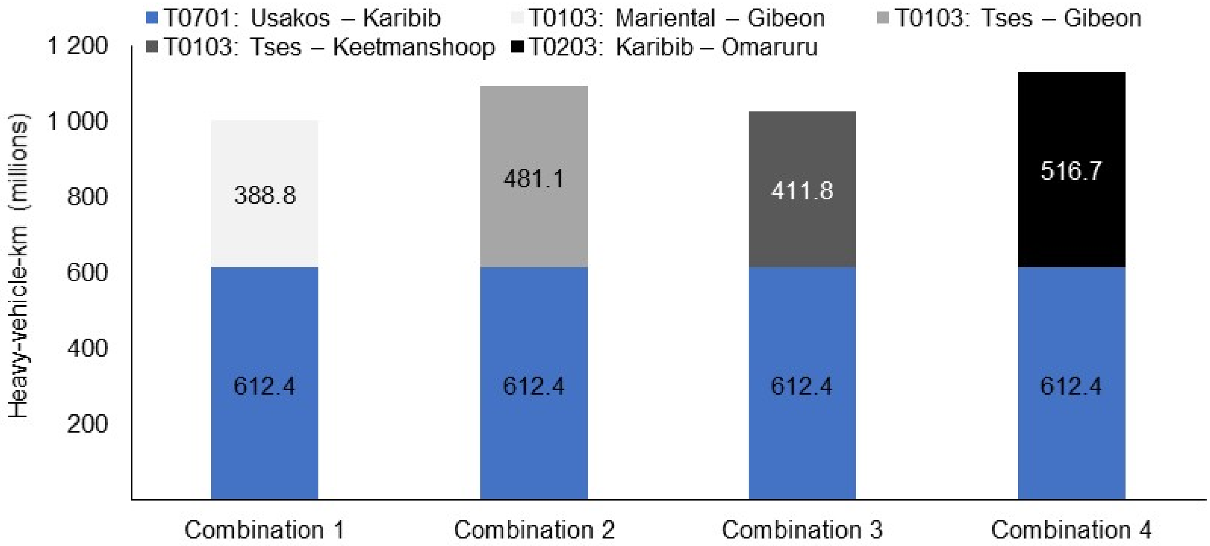

Figure 5: Possible project combinations and their effects

9. CONCLUSION

This paper used the 8 alternative trunk road projects in Namibia to demonstrate how financially constrained road authorities can apply CEA to screen and rank road projects. This approach is proposed as the best alternative when insufficient data is available to undertake comprehensive and comparable CBA studies across road projects. Although the CEA methodology is relatively simple for officials to apply, it still generates enough information to enable authorities to allocate their available budget to the most effective or efficient road projects according to their specific investment objective. If sufficient funding is available for multiple road projects, then CEA can be used to prioritise the combination of possible road projects that provide the maximum effect on the investment objective.

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