The Implementation of Engineering Economy in the Transport Development - A Case Study of Road Transport

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Abstract

The engineering economy is a part of skill and knowledge of cost engineering could be applied in many cases of projects in terms of the application of cost and benefit analysis. The purposes of this technical paper is to clearly explain how this particular knowledge is applied into real case transport development project especially land transportation – road transport. The transport development in some cases is related to the regional development which requires for coming up with the particular project that should be adopted either to maximize the benefit or to minimize the cost to the community. The net present value (NPV) and benefit cost ratio (BCR) are two indicators which are commonly used in this evaluation, and this evaluation integrates the engineering economy knowledge with technical transportation analysis. In the end, the result would provide the analysis and what potential solution could be taken into account for the identified issue.

Keywords: *Transport development, Net present value, Benefit cost ratio, Evaluation.*

1. Introduction

The transportation is one of key factors of the economic growth in every country in the world. Powell (2001,p.200) said that the transport highly affects the modern economy, and the movement of resources and goods at different stages of the production process is the prime focus of good transport. This is the most important reason why each country always continually improves their transportation systems and infrastructures to obtain the optimum result for their economy. This is illustrated by building a particular highway which connects the country side to a city that it could provide the trade and the growth of country side. This is because the business person in a particular city or region could transport their commodities to be sold to other city or region and vice versa.

There are three main types of transport systems which are land transport such as roads and railways, waterways transports, and air transports. This technical paper focuses on land transport especially road transport. Generally, there are two parties who directly deal with the road transport issue which are the road agency and the road user. The road agency is the group of transport providers such as government and companies who are being partner of the government, the road users are parties who use the roads such private car owner, buses owner, freight companies, etc.There are many alternative solutions which could be attempted by the transport agency to tackle transport problems that each of them would come up with the benefit and the cost. Maximizing the benefit and/or minimizing the cost are two primary goals of road agencies and road users to deal with transportation issues and their solutions.

The engineering economy which one of particular competencies in the skill and knowledge of cost engineering is the methodology which has been applied for taking decision concerning transport issues. This technique has been a technique of project evaluation that it is be used to show the best project for both the road agency and the road user as well as to analyze the feasibility of a particular solution. Firstly, this paper defines the specific transportation issue and its alternative solutions. Secondly, it explains the implementation of engineering economy in dealing with transport issue, and the last part discusses the result and how the best option is selected.

2. Theory of Project Evaluation and Engineering Economy

2.1. Description of Benefits (B) and Costs (C).

The project evaluation is begun with the difference between benefit and cost. The department of Finance of Australian government (1994,p.7) listed several points which could be identified as benefits:

1. The value of output as reflected in revenues generated directly or indirectly by a particular project.

2. The scrap value of project's capital equipment.

3. Avoided cost – cost which would have been incurred in the 'do nothing' or 'without project' situation.

4. Productivity savings – reductions in existing levels of expenditure which can be shown to result from the project or program.

5. Health, environmental, and other social benefits all of which are either not marketed or are characterized by price which reflect less than the full value of benefits.

6. A reduction in unemployment.

They also listed several examples of cost:

1. Capital Expenditures.
2. Operating and maintenance cost for the entire expected economic life of the project.
3. Labor cost.
4. Cost of other inputs (material, manufactured goods, transport and storage, etc).
5. Research, design and development cost.
6. Opportunity cost associated with using land and /or facilities already in the public domain.
7. Harmful effects on other parties (for example, environmental costs such air pollution and noise nuisance).

2.2. Engineering economy Indicators.

There are four indicators that would be applied in the transport issue in terms of project evaluation.

a. ***Present Value (P).***

   Future value is defined as a single lump sum occurring at time zero, at the first of n time periods (Amos S J, 2007,p.27.1) .

b. Future Value (F).

Future value is defined as a single lump sum value occurring at the end of the last of n time periods(Amos S J, 2007,p.27.1)

c. Number of Period in year (n.)

This indicator informs the duration of benefits and cost would be analyzed.

d. Discount Rate (i)

Furthermore, to decide which the best project as the road user perspective, we should find the NPV in each project option. Using the NPV, we have to understand that the value in the present day would be different with the future day. Eschenbach (2002,p.20) firmly said that there is a different value of money in present, past and in the future.

2.3. Decision Making Indicators.

There are four decision indicators which are normally used in engineering economy.

a. Net Present Value (NPV)

Net Present Value of a project is defined as the difference between the present value of benefits and the present value of the costs (Boardman et al, 2006,p.137). The NPV could be calculated by using the formula underneath,:

NPV = PV (B) – PV (C) (Formula.1) (Boardman et al, 2006,p.134)

NPV $= \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+i)^t}$ (Formula.2) (Boardman et al, 2006,p.137)

B_t = Benefit in year t ($)
C_t = Cost in year t ($)
i = Discount rate (%)
n = the number of years for which the project is evaluated

b. Benefit Cost Ratio (BCR)

The BCR is defined as the methodology analysis which is based on the ratio of benefits to costs (Amos S J, 2007,p.28.3). The BCR could be determined by using the formula below,:

BCR = $\frac{PV(B)}{PV(C)}$ (Formula.3)

PV (B) = Present value of Benefit
PV (C) = Present value of Cost
If the BCR is higher than or equal to 1, it means the project is acceptable whereas if the BCR is less than 1, it means the project is unacceptable.

c. Internal Rate of Return (IRR).

The IRR is the rate of return when the benefit is equal to the cost, or in other word, it could occur when the NPV is equal to zero. Powell (2001,p.128) stated that the IRR is defined as that the discount rate (i) at which the NPV of the project is zero. The IRR is mostly used as the parameter of private projects. DeGarmo et al (1989, p.625) obviously mentioned that rate return on capital of private projects is the parameter to measure the project efficiency. Thus, it might be importantly considered in public projects.

d. First Year Rate of Return (FYRR).

The last indicator is First Year Rate of return (FYRR). Powell (2001,p.129) said that:

"The definition of FYRR is as the net benefit in the first full year operation of a scheme divided by the capital cost of the scheme, adjusted to allow opportunity cost of the capital tied up in investment completed in earlier years."

He also explained that this indicator is important to indicate when the project should be commenced (Powell,2001,p.130). The project could be start to be executed if the FYRR is higher than the discount rate; however, if the FYRR is lower than the discount rate, it is recommended to suspend the project until the discount rate is lower than the FYRR. This parameter is inessential for most public projects that in most cases, the project is required to be immediately commenced although the FYRR is lower than the discount rate.

2.4. Rules of Evaluation.

After we calculate the NPV, BCR, IRR, and FYRR, the selection of option must be undertaken. Austroads (2005,p.20) mentioned that in terms of transport project decision, the table underneath is applied to determine which parameter would be used.

Table.2.1. Decision Rule

Decision Context		Criterion		
		Net Present Value (NPV)	**Benefit – Cost Ratio (BCR)**	**Internal Rate of Return (IRR)**
1.Unconstrained Budget				
1.1	Accept – reject decision	Accept if NPV is non- negative	Accept if BCR exceeds / equals unity	Accept if IRR exceeds / equals the hurdle rate
1.2	**Option selection**	**Select project with the highest non-negative NPV**	**No rule exists**	**No rule exists**

2. Constrained Budget				
2.1	Accept – reject decision	Select project set such that NPV of project set in maximized subject to budget constraint	Rank by BCR until budget is exhausted or BCR cut – off reached	No rule exists
2.1	Option selection	Highest NPV subject to budget constraint	No rule exists	No rule exists

Ref : Austroads,2005,p.20

3. Project Case and Data Used

3.1.Preliminary Project Data.

There are a huge number of timbers in to be harvested in the Jeeralang-Victoria-Australia, and it needs to be transported from the harvesting area to the timber mill. The map of location is presented in figure 3.1.

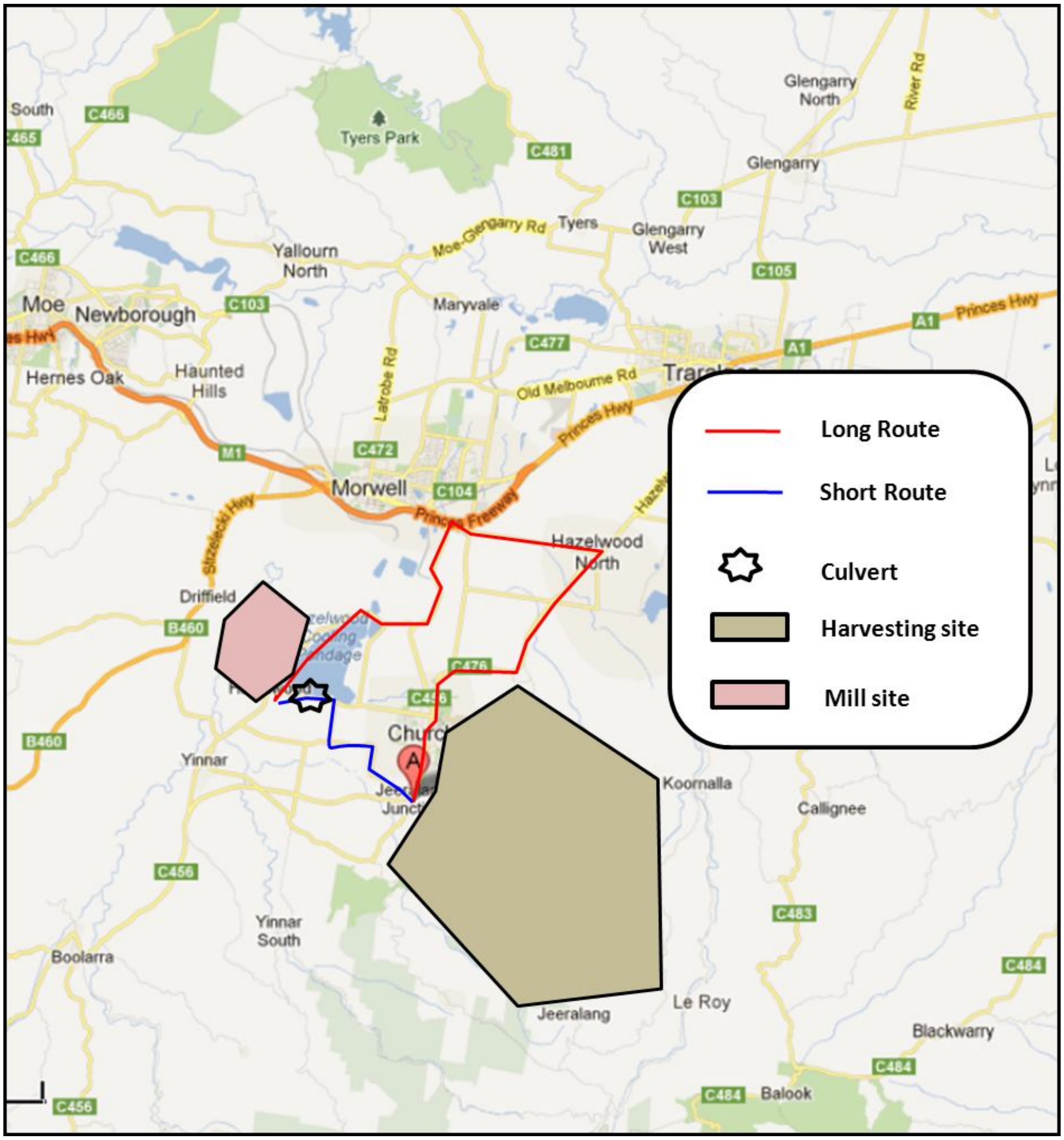

Figure.3.1. the layout of location

There are two alternative routes which are the long route about 49 km and the short route about 18 km. In the middle of short route there is a culvert that it should be upgraded to be a bridge to serve B-Double vehicles. Currently, this culvert can be loaded until 12 tons, and once it is used for B-double vehicles, it must cover the load of 40 tons.

Upgrading this culvert, it costs a capital investment of $ 800,000. The estimation of timbers in this plantation is 2,000,000 tons, and it could be extracted over a four year period, so it is 500,000 tons per year. Timber harvesting within the plantation will occur for 110 days each year. Both of routes are unsealed and the carriage way width is identical at 7.5 meters, and the maximum speed on both routes are 80 km/hr.The table.3.1shows the figure of both roads.

Table.3.1.Basic Data of Roads.

Characteristics		**Long Route**	**Short Route**
Length (km)		49 km	18 km
Road Gradient	**Road Curvature**		
2%	Straight	30%	70%
4%	Straight		5%
	Windy	30%	
6%	Straight	40%	25%

Currently, the traffic volumes in the long route are 600 cars per day and it is no trucks, and in the long route, there are 300 cars per day without trucks. The maintenance cost for both roads is $1,500 per km per year.

Furthermore, the evaluation would come up with two scenarios which are the long route and the short route. The long route scenario is the circumstance that B-Double trucks are required to use the long route, so the road agency would not provide the investment to upgrade the existing culvert. On the other hand, the short route scenario is the condition that B-Double trucks are allowed to use the short route, and the road agency would accommodate the investment to upgrade the existing culvert to be a reliable bridge. In the end, the evaluation would come up with the answer whether or not it is feasible to upgrade the existing culvert to be a bridge to serve heavy trucks (B-Double vehicles).

3.2. Project Specific Data.

There are six parameters of project should be determined (Rockliffe, Tsolakis, Boyd,2006, excel file). The value of each parameter is shown on the table.3.2.

a. Discount rate.

AACE defines the discount rate is the investor's time value of money which is represented by the rate of interest, and it is used for determining discount factors for converting benefits and costs occurring at different times to a base time (AACE International, 2007, pA-5). It is considered because the value of dollar in particular time would be different as it is mentioned above.

b. Operational life.

Operational life is the period of project would be run and be analyzed.

c. Growth rate.

The growth rate is defined as the rate in percentage which indicates the increasing of the number of traffic certain operational life.

d. Type of growth.

The type of growth could be either exponential or linier.

e. Average Annual Daily Traffic (AADT).

The AADT is the number of vehicles per day.

f. Demand elasticity.

Demand elasticity might be fully considered in urban roads which have highly elastic and highly interconnected network because the project option would generate the additional traffic. In the rural area, however, the project option mostly tends to be inelastic, so the demand elasticity could be zero.

3.3. Option Specific Data.

Other than the project specific data above, there are nine data of option specific data which are required in this project evaluation.

a. Proportion affected

Proportion affected is the percentage of project influence to the traffic condition, and it is affected by a particular nature and circumstance.

b. Average speed

The average speed is the speed of each type vehicle in certain length of road of each option.

c. Average trip time

The average trip time is the trip time can be performed by using the average speed in a particular length of road.

d. Composition

The composition is in the percentages of different types of vehicle.

e. Unit cost of travel time of passenger

Because of the remuneration of drivers of commercial vehicles whereas there is no remuneration of private car driver, there is a difference of hourly cost of travel time as suit as types of vehicle.

f.Unit cost of travel time of freight

The unit cost of travel time of height is the cost per vehicle per km of logistics transportation. This would be different depend on type of vehicles which carry the different of quantities of freight.

g. Crash risk probability

The crash risk probability is the probability of crash in certain road physical characteristic.

h. Unit cost of crash.

The unit cost of crash covers human cost arising from crashes, vehicle damage cost, insurance cost, police, property and fire.

i. Vehicle Operating cost

The vehicle operating cost covers several components which are fuel cost, lubricant oil cost, vehicle depreciation cost, and repair and maintenance cost.

The value of each parameter above is presented on the table.3.4.

Table.3.2. Project Specific Data

No	Items	Unit	Range Name	Value
1	Discount rate	% p.a	Disrate	5%
2	Operational life	Years	Begin	1
			End	4
3	Growth rate	% pa	Growth	2%
4	Type of growth	Logical	Trend	Linier
5	Demand elasticity		Elasticity	0

From the data above, the average speed and trip time are required to be early determined as the data for the number of trucks and unit cost of travel time in further explanation. These data are calculated such underneath.

Average speed and Trip time analysis B-Double Trucks in the road :

Long Route 49 km

Gradient	Curvature		Length (km)	Speed (km/hr)	Trip time (hr)
2	Straight	70%	34.30	80	0.43
4	Straight	5%	2.45	40	0.06
6	Straight	25%	12.25	28	0.44
			Average =	**49.33**	**0.93**

Short Route 18 km

Gradient	Curvature		Length (km)	Speed (km/hr)	Trip time (hr)
2	Straight	30%	5.40	80	0.07
4	Windy	30%	5.40	36	0.15
6	Straight	40%	7.20	28	0.26
			Average =	**48.00**	**0.47**

Hence, the result of value of average speed and trip time is shown on table.3.3

Table.3.3 Average Speed and Trip time

Type of Vehicle	Long Route		Short Route	
	Average speed (km/hr)	Trip time (hr)	Average speed (km/hr)	Trip time (hr)
B-Double	49.33	0.93	48	0.47

After we know the average speed and trip time of each vehicle in each route, the number of B-Double trucks per day could be determined by using the calculation below.

Data				
The number of timber	tonnes	a	2,000,000.00	
Project duration	Days	b	440	
Ratio loaded & unloaded truck speed		c	0.6	
Working hours	hours/day	d	8.00	
Truck Capacity	tonnes	e	40	
The number of timbers can be loaded	tonnes / truck	f	40	
			Long Route	**Short Route**
Trucks calculation				
Hauling distance	Km	g	49	18
The number of trip	trips	h = a ÷ f	50,000	50,000
Loading time at harvesting site	hour	i	0.5	0.5
Speed transport to the mill site	km/hour	j	49	48
Time Transporting to the mill site	hour	k = g ÷ j	0.99	0.38
Time Unloading at site	hour	l	0.5	0.5
Speed go back to the harvesting site	km/hour	m = (1 + (1-c))*j	69	67
Time go back to harvesting site	hour	n = g ÷ m	0.71	0.27
Cycle time per truck	hour	o = i+k+l+n	2.7	1.6
The number of trip per truck per day	trips	p = d ÷ o	3	5
The number of trips per day	trips	q = h ÷ b	114	114
The number of truck	**Trucks/day**	R = q ÷ p	**38**	**23**

Thus, by using the result of calculation above, the number B-Double trucks per day in the long route would be 38, and in the short route, it would be 23 trucks per day. These numbers would be inputted into table.3.4 as a part of AADT.

Table.3.4.Route Option Specific Data.

No	Component	Unit	Long Route	Short Route	Remaks / Notes
6	Traffic				
	6.1. AADT in year 0	veh/d	38	23	
	6.2. Proportion affected		1.00	1.00	(Austroads,2000,p.6)
	6.3. Trip length	km	49	18	
	6.4. Average speed	km/hr	49.33	48.00	
	6.5. Average trip time	hr	0.93	0.47	
	6.6. Composition		1.00	1.00	
7	Travel time				
	7.1 Unit cost (Pax)	$/pax-h	25.76	25.76	(Austroads,2012, Part - 4 table 3.4) x price factor
	7.2 Average occupancy	pax/veh	1.00	1.00	(Austroads,2012, Part - 4 table 3.4)
	7.3 Unit cost (Freight)	$/veh-h	28.58	28.58	Austroads,2012, Part - 4 table 3.4) x price factor
8	Crashes				
	8.1 Risk	ax / m veh-km	0.2138	0.2138	(Austroads,2012, Part - 4 table 4.1)
	8.2 Unit cost	$000/ax	399.21	399.21	(Austroads,2012, Part - 4 table 4.2) x price factor
9	Vehicle operate Cost (VOC)				
	9.1 Unit cost:	$/veh-km	2.786	2.827	
10	Capital expenditure	$000	0	800	
11	Maintenance	$000 / km /year	1.5	1.5	
	11.1 Maintenance	$000 / year	73.5	27	

The road user cost (RUC) in each route, furthermore, would be analyzed by using the data of table 3.2 and 3.4. The analysis of road user cost (RUC) is calculated such below, and all the formulae of it refer to the Part – 8 of Guide to project evaluation (2006, Austroads, [excel files]).

1.Average trip time for each type of vehicle.

The average trip time could refer to the table.3.4 as it is shown underneath in the table.3.5.

Table.3.5. Average trip time

Type of vehicle	Average trip time (in hour)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	0.93	0.47

2.*Traffic in year – 0 for each type of vehicle*.

The traffic in year – 0 is influenced by composition proportion affected and AADT. It could be determined by using the formula underneath, and the result is presented in table.3.6.

Traffic in Year – 0 (units of vehicle) = Composition (in %) x Proportion affected (in %) x AADT in year 0 (in vehicle/day) x 365……(Formula.4)

Table.3.6. Traffic in Year – 0

Type of vehicle	Traffic in Year – 0 (units of 000 vehicle)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	14.01	8.52

3.Travel time unit cost.

The travel time unit cost is affected by the average number of passenger per vehicle, the unit cost of passenger, the unit cost freight and trip time. The formula to determine it is revealed below, and the result is shown on table.3.7.

Travel time Unit cost (in $/vehicle) = [Average occupancy (in pax/vehicle) x Unit cost (Pax) (in $/pax-hour) x Unit cost (Freight) (in $/vehicle-h)] x Average trip time (in hour)……(Formula.5)

Table.3.7. Travel time Unit cost

Type of vehicle	Travel time Unit cost (in $/vehicle)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	50.40	25.79

4.Travel time total cost.

The travel time total cost is calculated using the formula underneath, and the result is in the table.3.8.

Travel time total cost (in $) = Traffic in Year – 0 (units of vehicle) x Travel time Unit cost (in $/vehicle)……(Formula.6)

Table.3.8. Travel time total cost

Type of vehicle	Travel time total cost (in $ 000)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	706.24	219.69

The table.3.8 obviously indicates that the short route option would provide a reduction of travel time cost due to short distance compare to the long route in each type of vehicle.

5.Crashes unit cost.

The crash unit cost is prevailed by the risk probability, unit cost of crash, and the length of road (trip length). The formula to count this unit cost is present below and the result of its calculation is shown on the table.3.9.

Crashes unit cost (in $ / vehicle) = Risk (in ax/m vehicle-km) x Unit cost (in $/ax) x Trip length (in km)……(Formula.7)

Table.3.9. Crashes unit cost

Type of vehicle	Crashes unit cost (in $ / vehicle)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	4.18	1.54

6.Crashes total cost.

The crashes total cost is calculated by using the data of table.3.6 and table.3.9. The formula is presented underneath, and the result of its calculation is displayed on the table.3.10.
Crashes total cost (in $) = Traffic in Year 0 (units of vehicle) x Unit cost (in $ / vehicle)……(Formula.8)

Table.3.10. Crashes total cost

Type of vehicle	Crashes total cost (in $ 000)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	58.60	13.09

The table.3.10 reveals that the total of crash cost of both car and B-Double truck are different in each route. This is because the cost is influenced by the traffic volume that this traffic is affected by the proportion and number of vehicles.

7.VOC unit cost.

The VOC unit cost per vehicle is counted by using its cost per vehicle-km and the data of length of road. The formula of it is shown underneath, and its result is presented in the table.3.11.

VOC unit cost (in $ / vehicle) = Unit cost (in $/vehicle-km) x Trip length (in km)……(Formula.9)

Table.3.11. VOC unit cost

Type of vehicle	VOC unit cost (in $ / vehicle)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	136.51	50.89

8. VOC total cost.

The total cost VOC in determined by the data of the number of traffic in year-0 and the data of table.3.11. The formula is presented underneath, and its result is shown on table.3.12.

VOC total cost (in $) = Traffic in Year 0 (units of vehicle) x Unit cost (in $ / vehicle)……(Formula.10)

Table.3.12. VOC total cost

Type of vehicle	VOC total cost (in $ 000)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	1,912.83	433.47

9. Total road user cost (RUC).

The components of road user cost are travel time cost, crashes cost, and VOC cost. The formula of it can be read below, and its result is shown on table.3.13.

Total road user cost = Travel time total cost + Crashes total cost + VOC total cost……(Formula.11)

Table.3.13. Total road user cost

Type of vehicle	Total road user cost (in $ 000)	
	Long route	Short route
Heavy Vehicle (HV) (B-Double)	2,677.67	666.24

4. Evaluation and Decision

4.1. Index during Operational Life.

The index during operational life is calculated to estimate the increasing of cost. The formula to calculate the index is shown underneath,:

Trend linier Index = 1 + (Growth x Year)……(Formula.12)
Trend exponential Index = 1 + ($Growth^{Year}$)……(Formula.13)

Because in this case it is assumed the trend is linier; hence, the formula would be applied is the first formula. This assumption is because the location is rural area that would not significantly generate the growth of traffic. The growth is decided to be 2%.

The sample of index calculation is shown underneath, and table.4.1 shows all indexes during operational life.

e.g. Trend exponential index year-1 = 1 +(2% x 1) = 1.020

Table.4.1. Index

Year	Index
0	1.000
1	1.020
2	1.040
3	1.060
4	1.080

4.2. The Road Agency Cost (RAC) and Road User Cost (RUC) during Operational Life.

It is mentioned in the chapter – 3 that the road maintenance cost for each route is $1,500 per km per year, and there is an investment about $ 800,000 to upgrade the bridge in the short route.The calculation of maintenance cost for both roads is shown underneath:

Long route maintenance cost ($ 000 per year) = 49 km x $1.5 per km = $ 73.5
Short route maintenance cost ($ 000 per year) = 18 km x $1.5 per km = $ 27.0

Determining RUC, it should refer to table.3.13 and it sample calculation is presented such:

Year -1,Base case, Long Route, RUC ($000) = Index x Total RUC = 1.020 x 2,677.6 = 2,731.22

Year -1,Option, Long Route, RUC ($000) = Index x Total RUC = 1.020 x 666.24= 679.57

The RAC and RUC are displayed in the table.4.2.

Table.4.2. Road Agency Cost (RAC) and Road User Cost (RUC).

Year	Base Case – Long Route ($000)		Option – Short Route (Including the upgrading of existing culvert) ($000)	
	Road Agency Cost	Road User Cost	Road Agency Cost	Road User Cost
0	-	-	800.00	-
1	73.50	2,731.22	27.00	679.57
2	73.50	2,784.78	27.00	692.89
3	73.50	2,838.33	27.00	706.22
4	73.50	2,891.88	27.00	719.54

4.3. Short Route Evaluation.

The next stage is to figure out the cost and benefits as well as to evaluate them by using the net present value (NPV) method. As a part of determination of NPV, the discount factor should be established that it indicates the value of money in both present and future is diverse. The discount rate (i) is shown on Table.3.2 which is 5%. The formula of discount factor determination is such below and the discount factor in each year operational life is displayed on table.4.3.

Discount factor = $1 \div (1+ i)^{Year}$ ….. (Formula.14)

Table.4.3. Discount factor list

Year	Discount Factor
1	0.952
2	0.907
3	0.864
4	0.823

After the discount factor is found out, the next step is the evaluation of feasibility by using NPV method that it is explained in the table.4.4 and table 4.5.

The evaluation of feasibility of road agency perspective is presented on the table.4.4 underneath:

Table.4.4. Short Route evaluation-Road agency perspective.

Year (n)	Evaluation of Short Route (upgrade existing culvert)				
	Road Agency				
	Cost ($ 000)	Benefit ($ 000)	Discount $1 \div (1+i)^n$	PV (C) ($ 000)	PV (B) ($ 000)
a	b	c	d	e = b * d	f = c * d
0	800.00		1.000	800.00	
1	27.00	46.50	0.952	25.71	44.29
2	27.00	46.50	0.907	24.49	42.18
3	27.00	46.50	0.864	23.32	40.17
4	27.00	46.50	0.823	22.21	38.26
Total (∑)				895.74	164.89
NPV ($ 000)	∑ PV (B) – ∑PV (C)				**(730.85)**
BCR	∑ PV (B) ÷ ∑ PV (C)				**0.18**

After the short route option is analyzed by using the road agency point of view, the evaluation based on road user vantage point is shown on the table.4.5 below.

Table.4.5. Short Route evaluation-Road user perspective.

Year (n)	Evaluation of Short Route (upgrade existing culvert)				
	Road User				
	Cost ($ 000)	Benefit ($ 000)	Discount $1 \div (1+i)^n$	PV (C) ($ 000)	PV (B) ($ 000)
a	b	c	d	e = b * d	f = c * d
0	-	-	1.000	-	-
1	679.57	2,051.66	0.952	647.21	1,953.96
2	692.89	2,091.88	0.907	628.47	1,897.40
3	706.22	2,132.11	0.864	610.06	1,841.80
4	719.54	2,172.34	0.823	591.97	1,787.19
Total (∑)				2,477.71	7,480.35
NPV ($ 000)	∑ PV (B) – ∑PV (C)				**5,002.64**
BCR	∑ PV (B) ÷ ∑ PV (C)				**3.02**

The process of NPV calculation is explained such underneath.

It assumed that the benefit would be indicated by on the top of horizontal line whereas the cost is denoted on the bottom of horizontal line. The sketch of it is shown on figure4.1 and 4.2

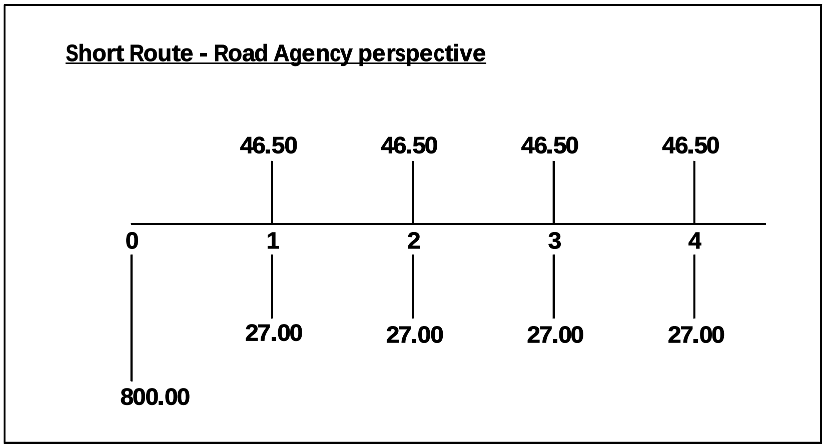

Figure.4.1. Diagram of benefit and cost ; Road agency perspective

The NPV is calculated such the calculation below:

NPV ($ 000) = ∑PV (B) – ∑ PV (C)

∑PV (B) ($ 000) = 46.50 (0.952) + 46.50 (0.907) + 46.50 (0.864) + 46.50 (0.823) = 164.89

∑PV (C) ($ 000) = 800 + 27.00 (0.952) + 27.00 (0.907) + 27.00 (0.864) + 27.00 (0.823) = 895.74

NPV ($ 000) = 164.89 – 895.74= **- 730.85**

Thus, in road agency perspective, the NPV of short route is (-) **730.85**

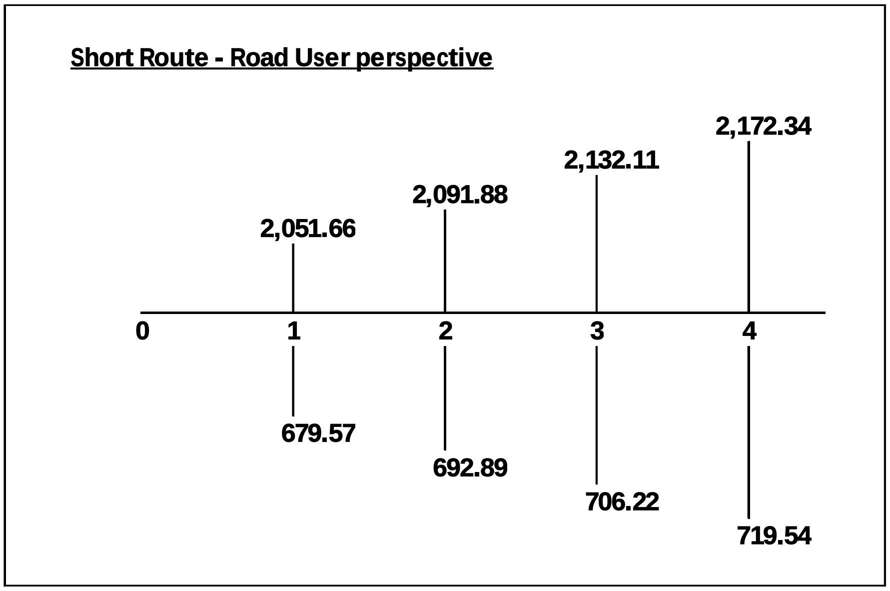

Figure.4.2. Diagram of benefit and cost ; Road user perspective

The NPV is calculated such the calculation below:

NPV ($ 000) = ∑PV (B) – ∑ PV (C)

∑PV (B) ($ 000) = 2,051.66 (0.952) + 2,091.88 (0.907) + 2,132.11 (0.864) + 2,172.34 (0.823) = 7,480.35

∑PV (C) ($ 000) = 679.57 (0.952) + 692.89 (0.907) + 706.22 (0.864) + 719.54 (0.823) = 2,477.71

NPV ($ 000) = 7,480.35 – 2,477.71= **5,002.64**

Thus, in road user perspective, the NPV of short route is (+) **5,002.64**

4.4. The Decision.

As it is can be seen in the table.4.4 and table.4.5, the decision of short route including upgrading the existing culvert is unacceptable in terms of road agency point of view whereas in road user perspective, the short route is feasible decision. DeGarmo et al (1997, p.245) clearly stated that in most cases, the public project is usually planned to be non-profit. This is the trade-off issue among two parties in transport development case. Because the location in the rural area needs to be developed such new regional development, and it requires for having a growth in there; therefore, the short route decision must be attempted. Creating employment for local people in maximum way is a case in point regarding the other advantages of this decision. The road user who mostly influences the upgrading of existing culvert structure is the B-Double trucks user, so it is required to have a fair dealing with a logging company as the owner of these trucks to contribute in this decision.

Participating in the maintenance cost of bridge structure and road are two alternatives to reduce the road agency cost during operational life as well as expected future cost after four years. The other alternative is to maximize the value for money which is spent by road agency. This area should be developed such urban development, so it would lead to many transportation to this rural area using this route. Building a new living area including a shopping area to be such a small town as well as the tourism or other attraction and the industrial location that it could make people from urban area visit this town, are some concrete examples for this solution. Hence, in terms of transport development and a new regional development, the infeasible project would be executed in some particular cases.

5. Conclusion

The engineering economy could be applied as a part of the decision techniques for the feasibility of the transport development project in planning phase. It covers the cost and benefits both the road agency which is mostly represented by the government and the road users. This analysis would be ended by the value of NPV and BCR of selected option which is integrated by the decision rule that it comes up with whether the project is unconstrained or constrained budget, and then whether it is for accepting and rejecting the options. These indicators and concepts are helpful to support the both evaluation and final decision. Thus, by using the engineering economy technique in the evaluation of transport projects, the benefit mostly can be maximized and the cost can be minimized by selecting and deciding the appropriate project even though in some circumstances the unacceptable project must be accepted due to other advantages which are closely related to its projects.

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