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A study on techno-economic aspects for highway projects

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ABSTRACT

The paper outlines several methods of carrying out economic analysis of highway projects. The emphasis is on the factors to be considered and their effect on the results of economic analysis. Viewpoints of various authors about inflation and discount rate are given. Various cost and benefit factors related to the highway transportation projects are given in the paper. The different concepts available to use in various economic analysis methods are highlighted. This paper outlines the important information which should be considered while selecting particular type of economic analysis methods for a specific project. This paper also covers the various applications of economic analysis methods in different projects. Primarily, the different problems, which are met usually in carrying out economic analysis, are also incorporated.

***Key words** : Project evaluation, Economic analysis, Highway pavement*

1.0 INTRODUCTION

Economic studies intended to demonstrate economic justification for a particular project, to permit comparison of alternative schemes or locations, to determine priority of improvement, and so on may be carried out by one or several methods. The application of principles of economic study to transport projects, including pavements, occurs at two levels. Firstly, it is the management decision required to determine the feasibility and timing of a project; secondly, it is the requirement to achieve the maximum economy for the project once it is selected. Project feasibility is determined at the network level, by comparison of alternatives capable of satisfying the overall project requirements.

There are several economic analysis methods that can be used for comparing alternatives but present worth, annualized cost, rate of return, and benefit cost ratio methods are most often used. Factors that will influence the analysis results include inflation, discount rate and analysis period. Cost elements most often used are construction, rehabilitation, maintenance, and salvage value of pavements. The selection requirements can be understood by the problems and design parameters for specific pavement being considered. The principle of engineering value can be used to generate alternatives.

2.0 PURPOSE OF ECONOMIC ANALYSIS

It is seldom readily apparent which is the economic alternative for a particular project. Many pavement types will be available for a particular project having different merits and demerits. Every pavement type has different pavement alternatives with similar factors. Each rehabilitation strategy has unique initial construction costs, performance expectations, and future maintenance needs. What is most economical for one pavement may not be for another. Local costs may differ from one location to another, and material performance expectations may be different from region to region. The only rational way to compare one alternative and another is to perform an economic analysis. The following are some of the reasons for carrying out economic analysis.

* to produce information for making investment decisions
* to determine feasibility of a transport project
* to compare alternative alignments
* to compare various highway pavement types
* to select the most cost effective rehabilitation technique
* to determine priority of improvement
* to compare mutually exclusive schemes

3.0 ECONOMIC EVALUATION CONCEPTS

In economic analysis, it is important to recognize the time value of money. Because the existence of interest, Rs 100 today will be worth Rs. 672.75 at end of 20 years if invested at 10 percent compound rate of interest. Similarly, a sum of Rs. 672.75 which might become due to an individual after 20 years from today is worth only Rs. 100 at present, assuming the same rate of interest. Therefore, in order to compare costs and benefit of highway improvements on a sound basis, they must be converted to equivalent values at some common date. This procedure, which is known as discounting, is accomplished by using a suitable interest rate in accordance with established principles of compound interest and present value concepts. The following formulae are very useful in economic analysis.

* The amount S to which Re. 1 will increase in 'n' years with a compound interest rate of r is :
  $S = (1+r)^n$
* The present value A of Re. 1, 'n' years hence, when discounted at interest rate r is:
  $A = 1(1+r)^n = (1+r)^{-n}$
* The present value A of an annuity of Re. 1. per year for n years when discounted at interest rate r is :
  $A = 1-(1+r)^{-n}/r$
* The amount P per annum for 'n' years at interest rate r needed to accumulate Re.1 at the end of 'n' years (sinking fund factor) is :
  $P = r / (1+r)^n-1$

* The amount P per annum for n years at interest rate r needed for recovery of a capital Re.1 including interest (Capital recovery factor) is :

  $P = r / (1+r)n /(1+r)^n-1$

* Present Worth A for uniform payments of Re. 1 per year for n years at interest rate r (present worth factor) is :

  $A = (1+r)n -1/r (1+r)^n$

4.0 COST AND BENEFIT CATEGORIES OF HIGHWAY PAVEMENT

The cost of a road project consists of the sum of the highway investment cost, the maintenance and operating costs, and the highway user cost. The highway initial cost is the cost of preparing a service including the cost of rights-of-way, engineering design, construction, traffic control devices, and landscaping. Maintenance cost is the cost of preserving a highway and its appurtenances and keeping the road in serviceable condition. Operating costs include the costs of traffic control, lighting, and the like. Salvage value represents the remaining market value at the end of selected life span. A major component of the cost of highway transportation, highway users' costs include vehicle operating costs, the value of travel time, and traffic accident costs.

It is obvious that many benefits result from improved highway transportation. Some of these benefits are direct and readily apparent; others are indirect and more difficult of discernment. The most significant highway benefits are those that result from a reduction in user costs. Such benefits results from decreased operating costs, higher operating speeds, fewer delays, and decreased accident losses. Those benefits that accute to the owner of property located adjacent to or in the vicinity of improved highways are fairly simple to observe and delineate but are somewhat more difficult to evolve. In the vast majority of cases highway improvements result in an increase in the value of land located, adjacent to or served by the highway involved. The various categories of costs and benefits involved in highway transportation are shown in Tables 1 & 2.

5.0 BASIC FACTORS NEEDED FOR ECONOMIC ANALYSIS

Basic factors required for the economic analyses are:

* the initial costs of the pavement structure, including shoulder.
* the costs of future overlays, major maintenance, reconstruction, or other activities,
* time, in years, from initial construction until each major activity,
* salvage value of the last major activity,
* an interest rate,
* an inflation rate,
* present worth factors, and
* an analysis period.

Table 1 : Various Costs Related to Transportation Highway Project

Initial costs		Annual recurring costs		Non-recurring costs
Item costs	Conducting value study Testing	**Operating costs**	Utilities Fuel Custodial care	**Repair and Replacement costs** Predicted failure and and replacement of major system components Predicted alteration costs To bring systems upto current standards
Development costs	Building a prototype Designing Constructing models		Insurance Faxes Fees and labour	
Implementation costs	Redesign Tooling Inspection Testing Control administration Training Documentation	**Maintenance costs** **Other recurring costs**	Scheduled upkeep Preventive maintenance Use of equipment Support costs for management overhead	**Salvage**
Miscellaneous costs	Owner furnished equipment Financing Licences Fees.			

Table 2 : Various Benefits Related to Transportation Highway Project

Indirect benefit	Cost reduction Gains in business Land use and values Aesthetics Community activities				
Direct benefits					
Vehicle Operating costs	*Road maintenance cost savings*	*Time savings by travellers*	*Reduction in road accidents*	*Higher operating speeds*	*Fewerdelays*
Fuel consumption Lubricating oil consumption Spare parts consumption Vehicle maintenance labour Tyre consumption Vehicle depreciation Crew costs (trucks, buses etc.)	Paving a gravel road where traffic exceeded levels strengthening a road which has deteriorated	Shorter road alignments Higher average speeds	**Engineering** **Education** **Enforcement**	Geometric design Road surface Road markings and delineation Traffic management	

5.1 Discount rate

Costs and benefits incurred at different levels of the service cannot be directlycompared and should therefore be discounted to a base year- normally year 0 of the analysis period. In short, it is more attractive to earn a given benefit today than next year. Since discount rate used in the analysis plays such an important role in decision making for design strategies, it provides means to compare alternative uses of funds. Since, pavement alternatives with large initial cost and low maintenance or users costs are favoured by low interest rates. Conversely, high interest rates result in selection of alternatives that combine low initial costs with high maintenance and users' costs.

Viewpoints about the extent of discount rate, however, differ. According to one view, the interest should be charged at the current rate at which the highway authority could borrow money. The second view is that discount should be charged at a rate representing the minimum attractive return. The other view is that when public works are to be financed from current taxation, no interest should be charged.

5.2 Inflation rate

The long -term general increase in prices, i.e., inflation has no effect on the economic cost of a project. The real resources in terms of plant, labour, and materials generally remain much the same although time usually involves changes in productivity for reasons other than inflation (e.g., improvements in technology). Yoder points out that the economic analysis is based on current prices. These same prices are applied to estimates of future costs. Further, national economy also expands and inflation effects are balanced out. Yoder concludes that it is common practice to omit inflation as a factor when comparing alternatives. Ralph Hass suggests that an exception exists when the price of one item in the analysis inflates at a rate that does not follow the general trend of inflation in the rapidly than general inflation rate. The author concludes the following for not using an in-economic evaluation of pavement projects :

* Inflation is difficult to forecast and merely introduces another uncertainty into the evaluation. In fact, if inflation was used in highway economic studies, it would tend to justify higher capital investment today. This could in turn contribute to more inflation, and for a public agency the morality of such actions could be questioned, (i.e., governments are usually committed to fighting inflation).
* If inflation was considered, benefits as well as costs would be increased so that their relative magnitude would still be the same.
* The purpose of economic evaluation is to provide management with a basis for decision making.
* Inserting a factor for inflation is no guarantee that the results will a be more reliable and lead to a different or better selection of alternatives.
* The uninflated value of the alternatives in "real constant dollars" is a better total for economic analysis than inflated values.

Ole Moller believes that the effect of future inflation will be ignored since in most cases it can be assumed to affect costs and benefits equally. It is understood that the newly constructed road needs major repair only after certain period.

6.0 BASIC CONSIDERATIONS IN SELECTING AN EVALUATION METHOD

The purpose of the economic analysis is to produce information, based on which investment decisions can be made. The economic evaluation of pavement alternatives can be done by various methods. The following factors can be considered to select the most appropriate method.

* The importance of initial construction cost,
* Prior knowledge of economic analysis method,
* Proposed type of pavement strategies, i.e., network level or project level,
* Agency involved in the investment,
* decisions related to the design standard, and alignment of a road,
* optimum timing of an investment,
* ranking of a group of mutually independent road projects,
* type of project like new construction, rehabilitation, stage construction and maintenance projects,
* type of road like urban or rural and
* the availability of economic skills and data.

7.0 PROCEDURES FOR ECONOMIC ANALYSIS

7.1 Benefit cost ratio method

The benefit-cost ratio is nothing more than the ratio of benefits (or road user savings) to the extra annual cost of initial investment and maintenance. The ratio is unit less and, when greater then unity, simply means that for the alternative being examine the benefits are greater than the extra annual costs at the amortization rate selected. This method is perhaps the best known in the engineering field. The benefit/cost ration method, currently favoured by many economists, planners and others in the public works field, expressed by the equation.

benefit-cost ratio=annual benefit from improvements/annual cost of improvements

7.2 The annual cost method

As the name implies, this is simply the total of all costs associated with a certain alternative. Capital costs are amortized over the service life and to these are added the annual maintenance costs and users' costs (and any other costs properly assignable and capable of identification). The alternative with the lowest annual cost is the most favourable investment and the proper alternative to select.

7.3. The present-worth method

Present-worth economic study determines, for each alternative, the sum of money required at the present to cover all costs of the proposed improvement for the duration of the study period. Thus, for alternatives of equal life, the plan with the lowest present worth, or stated differently, that requiring the smallest commitment of money, is the most attractive.

7.4. The rate of return method

As the name would imply, this is simply the computation of the return on investment. The return is the benefit that will be realized through adopting a particular alternative. The investment is the incremental cost of that alternative over the base condition.

8.0 THE APPLICATION OF ECONOMIC ANALYSIS TECHNIQUES

The designer and administrator can make required decisions subjectively, or by judgement. The judgement decisions should be based on the experience to use as the benchmark. The best way is to go for objective approach. This is available using economic technique. While economic techniques can be applied in principle to all forms of investments, they are more applicable where economic criteria are predominant. This means that where the motive is profitability and costs are measured in market terms, there is considerable scope for their application.

However, in fields of public investment, economic techniques are often difficult to apply because economic considerations are less dominant. The problems associated with public investment apply generally to investment on roads, but for most projects, it is possible to make a partial analysis. The important thing is to remember that the analysis is and always will be partial. There is no point in using highly sophisticated techniques if data is inaccurate and only part of the total problem can be analyzed. On the other hand, one should not fall into the trap if the results of a partial analysis are of little value. In many cases, partial analysis can be a valuable aid to engineering judgement and lead to a deeper understanding of the real problems.

9.0 PROBLEMS WITH ECONOMIC ANALYSIS

* The assumption in some methods is that, the benefit derived from alternative rehabilitation methods is essentially the same. However, it is readily recognized that a rigid pavement repair work would not provide the same benefit as rehabilitation options. In this example, improvement in riding quality or distress or reduction in user cost could yield benefit. Thus, the problem is that it considers only the cost; in fact, there are two things, cost and benefits.
* In some economic analysis methods, it requires to use the same analysis period for all alternatives. The problem with this is that it requires prediction of future actions. Some methods are usually directed at the question, which alternative is most eco-

nomical. The answer provided depends not only on which alternative but the timing of future rehabilitation maintenance actions.

* Some economic analysis methods are usually defined in terms of discounted money. Discount on the capital can have a substantial influence on results of the economy study. Higher discount rate will disfavour costlier constructions like cement concrete pavements. View points about the extent of the interest rate, however differ. The problem is that the selection of interest rate is highly controversial.

* Some economic methods are most suitable for making the project level decision, which alternative is best assuming all alternatives provide equal benefit? However, for pavement preservation programs, the important economic issues are which program provide the most cost effective increase in ride quality, distress condition, structural capacity, etc.,

* A major disadvantage of the benefit cost ratio method is the abstract nature of the ratio, which is difficult to comprehend alone. Another disadvantage is the possible confusion over whether maintenance cost reductions should be in the numerator or the denominator, whether cost reductions are benefits or negative costs and so no.

* Benefit cost ratio method does not consider analysis period, rather analysis is based on average benefit derived over the useful life of the rehabilitation alternative. Therefore, problem is that it is necessary to have a means of selecting rehabilitation alternatives that best fit the existing condition status of the network and will provide long term stability to the network's condition.

10.0 CONCLUSIONS

The inflation rate is not a critical parameter in selecting pavement alternatives. So, inflation can be omitted as a factor when comparing alternatives. Viewpoints about the extent of discount rate differ. However, it should be never less than the rate of borrowing or lending by the government, or the market rate of interest. The highway initial cost is the cost of preparing a service including the cost of rights-of-way, engineering design, construction, traffic control devices, and landscaping. Maintenance cost is the cost of preserving a highway and its appurtenances and keeping the road in serviceable condition. Operating costs include the costs of traffic control, lighting, and the like. The most significant highway benefits are those that result from a reduction in user costs. The economic analysis technique should be selected by considering various factors like initial costs, type of project, optimum timing of an investment, availability of economic skills and data etc.

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12.0 BIBLIOGRAPHY

1. Kadiyali, L.R., "Traffic Engineering and Transport Planning", Khanna Publishers, Delhi, 1987.
2. Ralph Hass, Ronald Hudson, W., and Jojn Zaniewskui "Modren Pavement Management ", Krieger Publishing Company, Florida, 1994.
3. AASHTO, "Guide for Design of Pavement Strucres", American Association of State Highway and Transportation Officials, Washington, 1993.
4. Roger L. Brockenbrough, Jr. P. E., "Highway Engineering Hand Book Building and Rehabili tating the Infrastructure", Mc Graw - Hill, New York.
5. Leo J. Ritter, JR.Radnor J. Paqnetts, "Highway Engineering ", The Ronald Press C o m - pany, New York.
6. NCHRP 122, "Life-cycle Cost Analysis of Pavements". Transportation Research Board, National Research Council, Washington, 1985.
7. Ggenereux, R.J., "The Use of Economic Tools in Highway Decision Making", Transport Economic Selected Readings, Hardwood Academic Publishers, The Korean Research Foundation For the 21st century, 1997.
8. Yoder, E.J., and Wit. C Zak, "Principles of Pavement Design", A Wiley-Interscience Publication, John Wiley & Sons, Inc. New York.
9. Finlay, M.J., and Campbell, K.D., "Discount Rates for Pavement Alternatives", 13th arrb/5th reaaa, 1986.
10. Beatly, D. W. and Noel, S. L. "Economic Appraisals of Highway Projects", N.Z, Roading Symposium, 1971.