Sensitivity Analysis of Economic Evaluation Parameters of Upgraded Rural Roads Projects

تحليل الحساسية لعناصر التقييم الاقتصادي لمشروعات رفع كفاءة الطرق الريفية

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الملخص

تقدم هذه الورقة تحليل الحساسية لتأثير عناصر مدخلات التقييم الاقتصادي لمشروعات رفع كفاءة الطرق الريفية والتي تشمل تكلفة الإنشاء، معدل نمو الحجم المروري، تكلفة الصيانة على عناصر المخرجات والتي تشمل القيمة الحالية (NPV)، معامل العائد الداخلي (IRR). لم تحدد الخبرة الدولية حدود أو اتجاهات محددة لتأثير عناصر المدخلات على عناصر المخرجات ولكنها أعطت اتجاهات عامة. لذلك فإن الهدف الرئيسي لتحليل الحساسية هو تحديد معدلات واتجاهات تأثير كل من هذه المدخلات على عناصر المخرجات. لتحقيق أهداف الدراسة تم اختيار عينة مكونة من ثلاثة وأربعون قطاع من قطاعات الطرق الريفية في أربعة من محافظات الصعيد وهي المنيا، الفيوم، أسيوط وسوهاج. تم استخدام برنامج RED الخاص بالبنك الدولي في عملية تحليل البيانات وحساب المخرجات. أشارت النتائج إلى أن كل من القيمة الحالية، ومعامل العائد الداخلي تتناقص مع زيادة تكلفة الإنشاء لجميع أنواع الطرق. كما أشارت النتائج أيضا إلى أن كل من القيمة الحالية ومعامل العائد الداخلي يزدادان بزيادة معدل نمو الحجم المروري وذلك بمعدلات ثابتة. أثبتت النتائج أيضا أن تأثير تغير تكلفة الصيانة كان صغير على كل من عناصر المخرجات.

Abstract

This paper presents a sensitivity analysis of the economic evaluation input parameters of the upgraded rural roads projects that includes construction cost, traffic growth rate and maintenance cost on the output parameters that includes Net Present Value (NPV) and Internal Rate of return (IRR). International experience didn't specify specific limits or trends for the effect of them on the output parameters. So, the objective of this sensitivity analysis is defining the general trends and rates of effectiveness of each of them. To achieve the study objectives, forty three road sections were selected in four governorates in Upper Egypt; Menia, Fayoum, Assuit and Sohag to perform the sensitivity analysis. Results indicated that the NPV values decrease with the increase of the construction cost for all roads with approximately the same rate. A 5% unexpected increase in the cost causes the NPV to decline by about 0.6%. Roads that have lower positive NPV values may achieve negative NPV values if the construction cost unexpectedly increased by about 25%. The IRR values decreases with the increase of the construction cost. The rate of decrease of the IRR decreases as the construction cost increases. For roads that have IRR lower than 50%, the IRR percentage decreases as the construction cost increases with approximately constant rates. The NPV increases as the traffic growth rate increases; the increase in NPV is approximately constant for smaller growth rates while it is increasable for higher growth rates. The IRR values increases as the growth rate increases with approximately constant rates for all roads. Both of the NPV and IRR have approximately constant values with the change in maintenance cost escalation. The output parameters of the economic evaluation of roads are less sensitive to maintenance cost escalation.

Keywords:

Sensitivity Analysis, Road Projects, Economic Evaluation, Rural Roads

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Received: 26 April, 2015 – Accepted: 26 July, 2015

1. Introduction

Several times when the project is under execution, certain things go wrong and the desired benefits cannot be achieved within the stipulated time frame. For example, the actual execution of the project is delayed or the cost exceeds the original estimated cost (cost over-run). In such cases, the results get fairly changed. Many times, the Internal Rate of return (IRR) and Net Present Value (NPV) thus get reduced or the Benefit Cost Ratio (BCR) becomes negative from positive. In order to take care of this problem, while the projects are under preparation or under examination, certain assumptions are applied for testing the viability of the project. For example, it is at times assumed that there will be a cost over-run by about 25% or a reduction in revenues by about 10% or a delay in getting the benefits by three years and so on. Keeping one or two or all such assumptions in view, the streams of costs and benefits are re-drawn and the figures of costs and benefits are discounted and the NPV, BCR and IRR are re-worked out. This gives a fairly good picture as to what will be the fate of the projects if such mistakes occur. For the sensitivity analysis, it is very essential to carry out such an exercise in projects where high financial funds are involved [1].

The outputs of the economic analysis are point estimates of the economic return and the gains and losses to the project's different stakeholders. The decision, however, whether to accept a project should not be made only on the basis of this information, because that values for most of the project's variables are subject to change and are difficult to predict. While historical values of a particular variable are known with certainty, predicting future values is a different matter. There is no guarantee that the projected values, irrespective of how they were arrived at, will actually materialize. Naturally, this introduces uncertainty into the results [2].

Uncertainty and its consequences are very significant issues in road appraisal because project costs and returns are spread over time. Estimates of time and vehicle operating cost savings resulting from upgrading a road or maintaining it are tentative due to uncertainty of the traffic forecasts. In turn, this makes the outcome of projects uncertain [2].

There are three types of analysis to deal with uncertainty: sensitivity tests, scenario analysis, and Monte-Carlo risk analysis. For road improvement projects, the minimum requirement in terms of project riskiness assessment are sensitivity tests and scenario analysis for parameters of cost items, assumptions of traffic forecasts, and valuation of benefits [2].

1.1 Sensitivity Analysis

Sensitivity analysis is a mean of testing how sensitive a project's outcomes (whether cash flows, economic NPV, gains and loss to different groups in the economy) are to changes in the value of one parameter at a time. Sensitivity analysis is conducted to identify the impact of input variables on the economic outcomes of a project. Sensitivity analysis is often referred to as "what if" analysis, because it allows the analyst to answer questions, such as "What would happen to the NPV if variable X were to change by a certain amount or percentage?" [2].

1.1.1 Construction Costs Overruns

A. Klevchuk and G. P. Jenkins [2] measured the response of the economic NPV due to unexpected escalation of the road construction costs, keeping all other project parameters constant. While the road users are not affected by unexpected cost escalations of the road construction in the range from -5% to +25%, the total economic NPV is moderately sensitive to changes in the initial construction costs. They found that 10% unexpected increase in the costs causes the NPV to decline by 5%.

1.1.2 Traffic Growth Rate

A. Klevchuk and G. P. Jenkins [2] measured the project's performance under various traffic volume levels, resulting from the assumption of the future growth rate. Now, the value of benefits accruing to the owners of light and heavy vehicles varies with the rate of traffic growth. It is implicitly assumed that a higher traffic level does not result in an increased frequency and cost of road maintenance, and that is why the PV of net benefits accruing to the Road Agency remains constant. They found that an unforeseen 10% reduction in the rate of traffic growth makes the NPV lower by about 2%.

1.1.3 Maintenance Costs Savings Factor

A. Klevchuk and G. P. Jenkins [2] stated that this factor adjusts all the maintenance resource savings over a range from -50% to 0% in order to assess the sensitivity of the NPV to the overall value of the maintenance savings. They found that if the overall value of the economic resource maintenance savings becomes lower by 10%, the project's NPV will respond by a 3% decline from the estimated value.

1.1.4 Vehicle Operating Cost (Voc) Savings Factor

A. Klevchuk and G. P. Jenkins [2] tested a range of VOC saving from -50% to 0%; they found that in a situation where the overall VOC savings are 10% lower than the estimated, the NPV will also decline by 10% from its initial level. The response of NPV is directly related to the overall level of VOC savings.

1.1.5 Time Savings Factor

A. Klevchuk and G. P. Jenkins [2] examined the elasticity of the NPV to changes in the total value of time savings in a range of -50% to 0%. A 10% reduction in the overall value of time savings implies only a 2% drop in the value of the project's NPV. The project is not very sensitive to this variable.

1.2 Scenario Analysis

As was indicated above, one-at-a-time testing of variables is not realistic on account of the interrelationships between variables. Scenario analysis recognizes these interrelationships by allowing a number of variables to be altered in a consistent manner at the same time. Scenarios are based on a set of parameters, values of which are pre-defined by the analyst. There could be a number of scenarios, built on the "base" scenario but ranging from the "worst" to the "best" scenario. Even under the worst set of circumstances, the project has a positive NPV, which suggests that the proposed road improvement is indeed a robust project. Obviously, the "worst" and "best" scenarios are two extremes that are very unlikely to happen in practice [2].

The HDM-4 Model of the World Bank was used for testing the sensitivity analysis of the input parameters of economic evaluation. The model computed the project Internal Rate of Return (IRR), the Net Present Value (NPV), and the Benefit/Cost Ratio (BCR) factors that represent the benefits or revenue of the investment cost [3].

2. Objectives

The objective of this paper is performing a sensitivity analysis of the affected input parameters of economic evaluation of rural roads improvements through studying the effects on the economic evaluation output parameters including the Internal Rate of Return (IRR) and Net Present Value (NPV) using the cost-benefit analysis.

3. Methodology

To achieve the objective of this paper, the study was divided into three stages; including engineering studies, economic analysis, and finally the sensitivity analysis. The engineering studies include identifying the highest priority roads in the study area, identification of evaluation criteria and relevant factors, specifying the list of road sections proposed for construction, performing traffic counts, pavement inventory, defining upgrading strategies and cost estimates for each of them.

The economic analysis includes defining vehicle fleet characteristics, defining the investment costs, traffic forecasting, determining the Internal Rate of Return (IRR) and Net Present Value (NPV) for the basic input parameters of construction, maintenance costs and traffic growth rate using the World Bank's HDM-4 RED model and ranking road projects based on their economic evaluation criteria (IRR). The sensitivity analysis includes studying the effect of changing the economic evaluation input parameters on the evaluation output parameters. The input parameters included the construction cost, the traffic growth rate, maintenance cost. Sensitivity analysis of time saving benefits and vehicle operating cost are out of scope of this study.

The study includes investigating the effect of changing one parameter at a time and keeping the other parameters constant, then another parameter was studied. The study concentrated on three parameters only; construction cost, traffic growth rate and maintenance cost. Both of the Internal Rate of Return (IRR) and the Net Present Value (NPV) were calculated for each road project for each change of the three considered input parameters.

4. Data Collection and Traffic Counts

Data collection included identifying the highest priority roads, Traffic Counts, Road Inventory and Pavement Conditions Survey, Upgrading Strategies and Cost Estimates.

4.1 Identifying The Highest Priority Roads

Road sections were selected in four governorates to cover as much as possible rural roads in rural areas; these Governorates are Fayoum, Menia, Assuit and Sohag. The roads were chosen such that they represent variable characteristics of existing roads. The roads were subdivided into smaller road sections to represent links between cities and to be easier in construction and evaluation; the chosen roads are shown on Table 1.

4.2 Traffic Counts Survey

Traffic surveys were carried out for the defined roads to measure the traffic volumes as well as traffic composition on each road. Traffic counts were conducted for Eight (8) hours starting at 07:00 AM to 11:00 AM and from 01:00 PM to 05:00 PM on a two working days to cover the morning and afternoon peak hours. Morning peak hours were from 07:00 to 11:00 AM and the afternoon peak hours were from 13:00 to 17:00 PM. The morning peak hours represent the traveling hours for students and the employees as well as other routine daily trips of other peoples. The afternoon peak hours represent the return hours of them. Traffic survey locations were chosen to cover a reasonable length of roads. For long roads, different locations were chosen for traffic survey while one location was chosen for each of the short roads.

Average Daily Traffic (ADT) was calculated from the counted Eight hours traffic volume during the specified duration through multiplying it by a mathematical combination of the conversion factors including day Factor, seasonal factor, and hourly factor. The conversion factors have been investigated and an approximate combination factor was calculated to be 1.35 times the counted 8 hours traffic volumes. Table 1 also shows the average Daily Traffic (ADT) for all roads.

4.3 Road Inventory And Pavement Conditions Survey

Road Inventory Sheet was used to record all physical properties for each road section including; section length, width, shoulders widths, side slopes, adjacent water Canals, level of water in the adjacent Canals, speed humps and pavement cuttings, ... etc. Inspection of pavement surface conditions for road sections were carried out using the Pavement Condition Index (PCI) Method. Each kilometer of road section was inspected, and then the average rating for the whole road was identified.

5. Rehabilitation (Upgrading) Strategies and Cost Estimates

The suitable rehabilitation (upgrading) strategy for each road section was specified according to its rating as set by the Egyptian Code for Rural and Urban Road Works, Part Ten, Maintenance Works, 2008 [4].

The rehabilitation strategies include three basic types; reconstruction, upgrade and overlay. The reconstruction strategy will be performed for road sections that rated as failed (failed or very poor), this rate is subjected to the destroyed road sections. The upgrade strategy will be performed for road sections that rated as poor to fair; this rate is given to sections with cracks and/or other pavement distresses that were not reached to higher severities. The overlay strategy was suggested to road sections that have good ratings. Road sections that have very good or excellent ratings will not need any type of rehabilitation; its suitable strategy is "Do Nothing". The suggested upgrading strategies were chosen according to the evaluation of pavement quality and corresponding rating as described by reference [4].

Cost analysis and estimation was performed to the proposed rehabilitation (upgrading) strategies for each road section. It includes estimation of the expected quantities as well as different tasks of each strategy. Table 1 also provides the estimated investment cost for each road section rehabilitation strategy.

6. Cost Benefits Analysis

Cost benefits analysis was performed for the above mentioned road sections. It includes defining road sections characteristics, vehicle fleet characteristics, served population, traffic characteristics, economic costs and benefits, and calculation of IRR and NPV parameters discounted at 12% discount rate.

Roads Economic Decision Model (RED) of the World Bank was used to analyze and improve the decision-making process for the development and maintenance of low-volume rural roads. The Model measures the benefits to road users and consumers of reduced transport costs. The model defines the relationship between motorized and non-motorized vehicles operating costs and speeds to road roughness using HDM-4 relationships.

6.1 Road Projects Characteristics

Different roads characteristics had been defined such as altitude, percent of time driven on water and paved roads texture depth. Terrain type's characteristics; rise plus fall, curvature, number of rises and falls and superelevation. The terrain types of the selected road projects are generally flat terrain except two road projects in Assuit Governorate that has a mountainous terrain; they are road sections R33 and R34 of Dronka road. Road types of the selected projects are generally paved roads except two road projects in Assuit Governorate; they are new construction roads; they are road sections R33 and R34 of Dronka road. The associated characteristics of the paved roads: bituminous surface type, 6.00m average carriageway width and 50 km/hr speed limit.

6.2 Vehicle Fleet Characteristics

The characteristics of vehicle types include Vehicle Economic (tire, fuel, lubricants, maintenance and crew costs and interest rate), Vehicle utilization in kilometers & hours driven per year, Vehicle service life, percent of time for private use, and gross vehicle weight. Vehicle fleet characteristics are shown in Table (2).

6.3 Normal Traffic And Served Population

Normal traffic is the traffic passing along the road in the absence of any new investment. For the dry season and for each vehicle type, the normal traffic (AADT) was computed in the model for the first year of the evaluation period and a basic traffic growth rate has been assumed 4%. The generated traffic due to decrease in transport costs and the diverted traffic were not defined in this analysis. Table (1) presents the average daily traffic of road sections. The future 20 years AADT and the traffic composition for each road section were entered as an input to the RED model. The served populations for all road sections are also shown on Table 1.

6.4 Economic Cost-Benefits Analysis

Road agency economic cost factor; the ratio of economic road agency cost to its financial cost, was assumed 0.85% [3]. The investment costs has been computed, it includes all the associate costs related to construction, upgrading, procurement of services, testing & commissioning for the selected road sections. Table (1) shows the investment costs of different road sections. It is assumed that the investment cost was utilized in one year.

Expected annual maintenance cost, fixed and variable for cases of with and without project, has been assumed as per Table (3). The Roughness (IRI) had been assumed 6.0 – 8.0 m/km as an average value for the existing road conditions (without project case) indicating poor conditions and 3.0 - 4.0 m/km for the upgraded pavements [6], [7] and [8]. Table (3) also presents the annual maintenance costs of the suggested road pavements in the both cases without project and with project.

Vehicle Operating Costs (VOC) Module computes the operating cost and speed as a function of road roughness for different types of vehicles listed in Table (2). The relationship between roughness and the speed of a reference vehicle, for different possible combinations of terrain and road types, is defined and the relationship takes the form of cubic polynomials.

Vehicle operating cost presents the unit road user costs ($/veh.km) for each road terrain and type for the upgraded pavement Roughness IRI = 4 considering the following VOC components; fuel costs, lubricants costs, tire costs, maintenance parts cost, maintenance labour costs, crew costs, and depreciation. The VOC as a function of roughness (IRI), for a vehicle, flat terrain and two-lane road is presented as;

$$VOC = a_0 + a_1 * IRI + a_2 * IRI^2 + a_3 * IRI^3$$ [3]

The corresponding coefficients (a_0, a_1, a_2, and a_3) for the cubic polynomials has been obtained as per standards of different types of vehicles and can be easily computed using the RED modules, which includes the HDM-4 vehicle operating costs and speeds equations.

The cost per accident types (Fatality, injury and damage) were assumed as per Table (4), accordingly Average Cost of

Accident is assumed to be 6000 $/accident. Accidents rates are also presented in Table (4). The number of passengers per vehicle type and the value of a passenger time are shown on Table (5)

6.5 Calculating Irr and Npv Parameters

The HDM-4 RED model is used to estimate the Internal Rate of Return (IRR) and the Net Present Value (NPV) discounted at 12 percent for road projects by comparing benefits with the costs. The IRR is the rate of return for which the present value of the net benefit stream becomes zero, or at which the present value of the benefit stream is equal to the present value of the cost stream. Results of economic analysis of road sections are also presented in Table 1. Results show that the IRR percentages range from 7% to 26% for all tested road sections. Road sections that have IRR less than 12% shall not appraised from the economic point of view since the discount rate is 12%. Road sections that have an IRR greater than or equal 12% are economically appraised. It should be noticed that road sections that have an IRR lower than 12% also have negative NPV values and vice versa.

7. Sensitivity Analysis Results and Discussion

A sensitivity analysis for the input parameters (construction investment cost, traffic growth rate and maintenance cost) of the above economic evaluation of road sections and its effects on the output parameters; IRR and NPV, was performed. The analysis was conducted by changing one parameter at a time and keeping all the other parameters constant in each trial. The World Bank HDM-4 RED Model was used to estimate the effect of changing the input parameters on the output ones as follows:

7.1 Construction Costs Overruns

This analysis measures the response of the economic NPV and IRR due to unexpected escalation of the construction costs, keeping all other project parameters constant. While the road users are not affected by unexpected cost escalations of the road construction in the range from -25% to +25%, the total economic NPV and IRR are moderately sensitive to changes in the initial construction costs.

Figure 1 shows the relationship between the NPV and the construction cost escalation for different road sections. The analysis was performed for the Forty three road sections while only twenty one of them were plotted since some road sections gave similar results so they were excluded from the Figure. The cost escalation ranges from -25% to 25%. The Figure shows that the NPV values decreases with the increase of the construction cost for the tested road sections. The Figure also shows that almost the NPV values for all road sections decrease with approximately the same rate; all relationships seem to be parallel. A 5% unexpected increase in the costs causes the NPV to decline by about 0.6%. The Figure shows also that road sections that having lower positive NPV values may achieve negative NPV values if the construction cost unexpectedly increased by about 25%.

Figure 2 shows the relationship between the IRR and the construction cost escalation. The analysis was performed for the Forty three road sections while only twenty of them were plotted. The cost escalation ranges from -25% to 25%. The Figure shows that the IRR values decreases with the increase of the construction cost. The Figure also shows that the rate of decrease of the IRR decreases as the construction cost increases. The Figure shows also that for road sections that have IRR lower than 50%, the IRR percentages decrease as the construction cost increase with approximately constant rates.

7.2 Traffic Growth Rate

This analysis investigates the road project's performance under various traffic volume levels, resulting from the assumption of the future growth rate. Now, the value of benefits represented by the NPV or IRR varies with the rate of traffic growth. It is implicitly assumed that a higher traffic level does not result in an increased frequency and cost of road maintenance, and that is why the NPV of net benefits accruing to the Road Agency remains constant. Figure 3 shows that the NPV increases as the growth rate increases; the increase in NPV is approximately constant for smaller NPV's while it is increasable for the higher NPV's.
The analysis for the IRR – Growth Rate relationship is quite different in that the IRR values increases as the growth rate increases with approximately constant rates; the relationships for different road sections seem to parallel relationships as shown on Figure 4.

7.3 Maintenance Costs Escalation Factor

This analysis investigates the effects of maintenance cost escalation over a range from -25% to 25% in order to assess the sensitivity of the NPV and IRR to the overall value of the maintenance cost variations. Figures 5 and 6 present the NPV and IRR versus the maintenance cost escalation relationships respectively for different road sections. Both Figures show that both the NPV and IRR have approximately constant values with the change in maintenance cost escalation. The output parameters of the economic evaluation of road projects are less sensitive to maintenance cost escalation.

8. Conclusion

The final conclusions of this paper include the following; a sensitivity analysis should be conducted for the input parameters of the economic evaluation of road projects to define the general trends of the economic evaluation output parameters. The study indicated that the NPV values decreases with the increase of the construction cost for the tested roads. Almost the NPV values for all roads decrease with approximately the same rate; all relationships seem to be parallel. A 5% unexpected increase in the cost causes the NPV to decline by about 0.6%. Roads that have lower positive NPV values may achieve negative NPV values if the construction cost unexpectedly increased by about 25%.

It is concluded also that the IRR values decreases with the increase of the construction cost. The rate of decrease of the IRR decreases as the construction cost increases. For roads that have IRR lower than 50%, the IRR percentage decreases as the construction cost increases with approximately constant rates.

It is concluded also that the NPV increases as the traffic growth rate increases; the increase in NPV is approximately constant for smaller growth rates while it is increasable for the higher growth rates.
The IRR values increases as the growth rate increases with approximately constant rates; the relationships for different roads seem to be parallel relationships.

Both the NPV and IRR had approximately constant values with the change in maintenance cost escalation. The output parameters of the economic evaluation of roads are less sensitive to maintenance cost escalation.

9. Recommendations

The final recommendation that has been reached is that a sensitivity analysis of the economic evaluation input parameters should be performed to investigate its effects on the output parameters in road projects evaluation. A scenario analysis should be performed in addition to the sensitivity analysis to consider the effect of more than one parameter at a time to reach to the optimum alternative.

10. Acknowledgements

This study was prepared to aid decision making managers in the process of road economic evaluation. The Author would like to express his thanks due to the Governorate's Departments of Transportation in Menia, Fayoum, Assuit and Sohag for their cooperation in collecting data and traffic survey and information needed to conduct this research.

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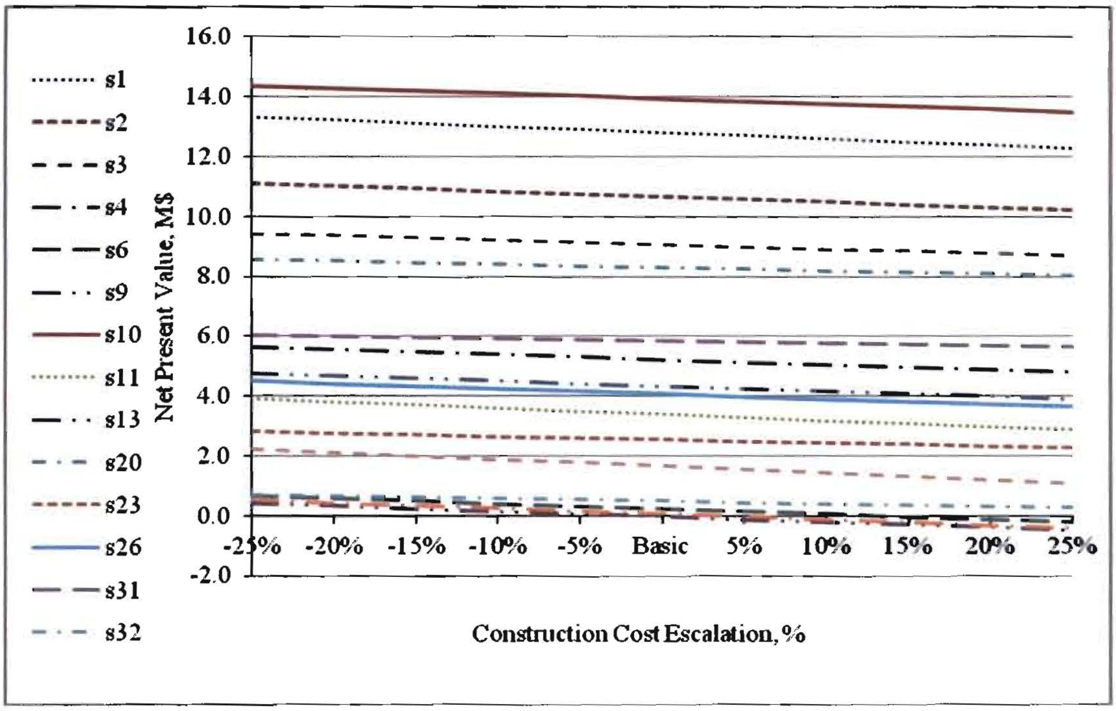

Figure 1: Net Present Value versus Construction Cost Escalation Relationship

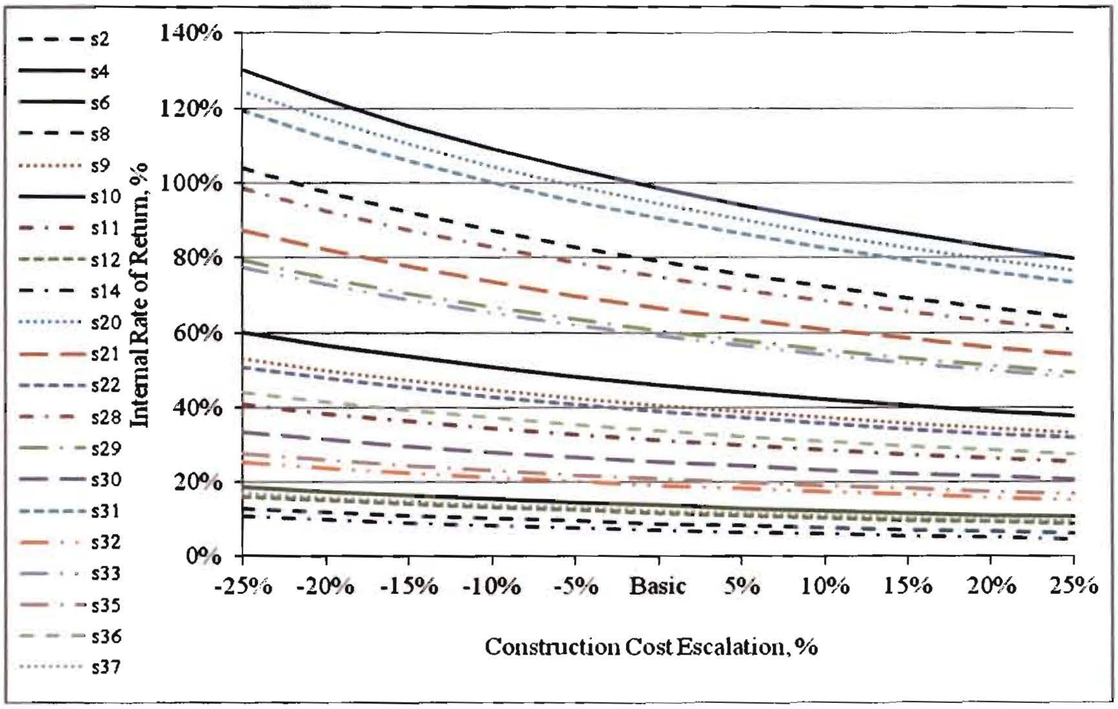

Figure 2: IRR versus Construction Cost Escalation Relationship

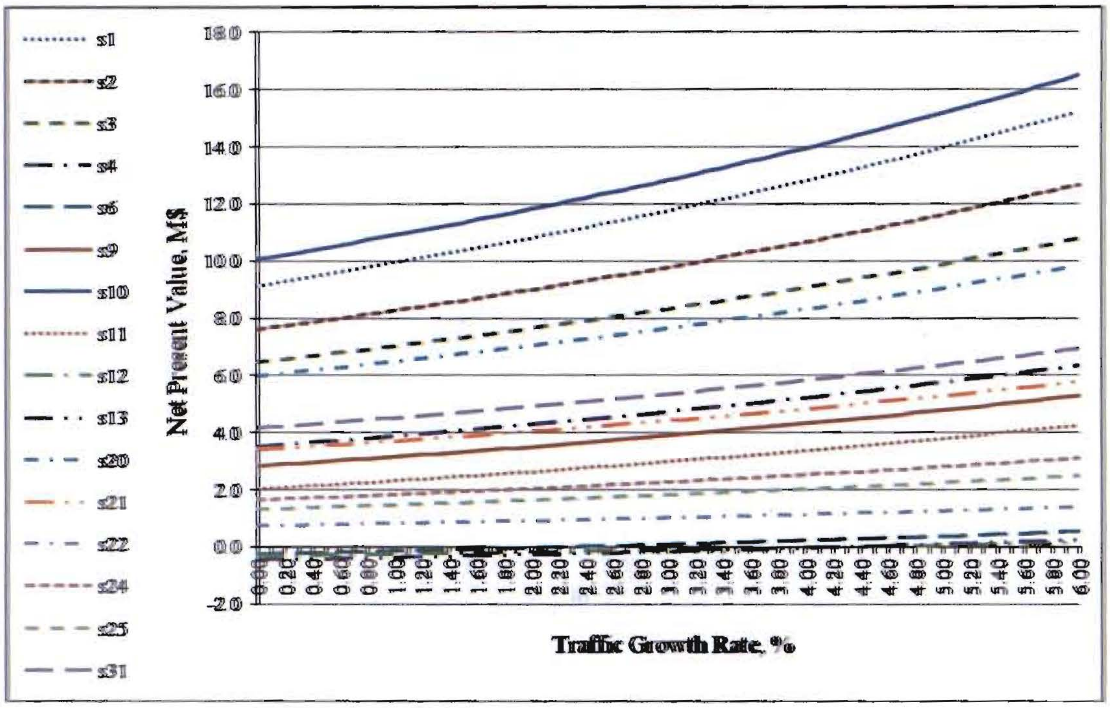

Figure 3: NPV versus Traffic Growth Rate Relationship

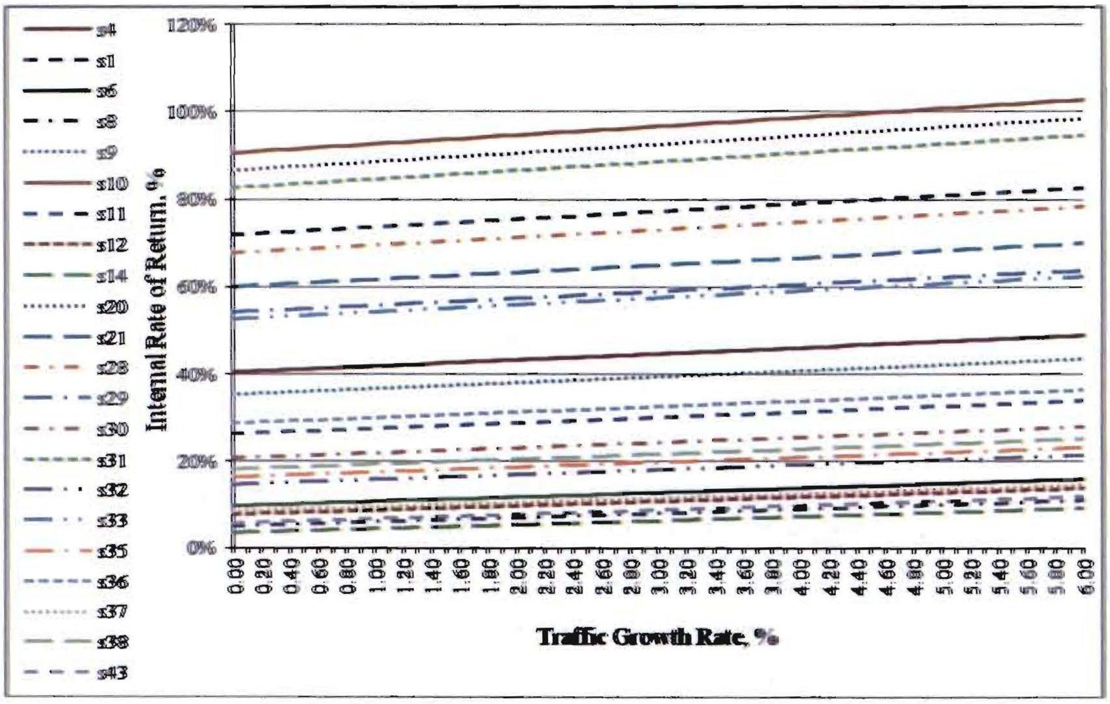

Figure 4: IRR versus Traffic Growth Rate Relationship

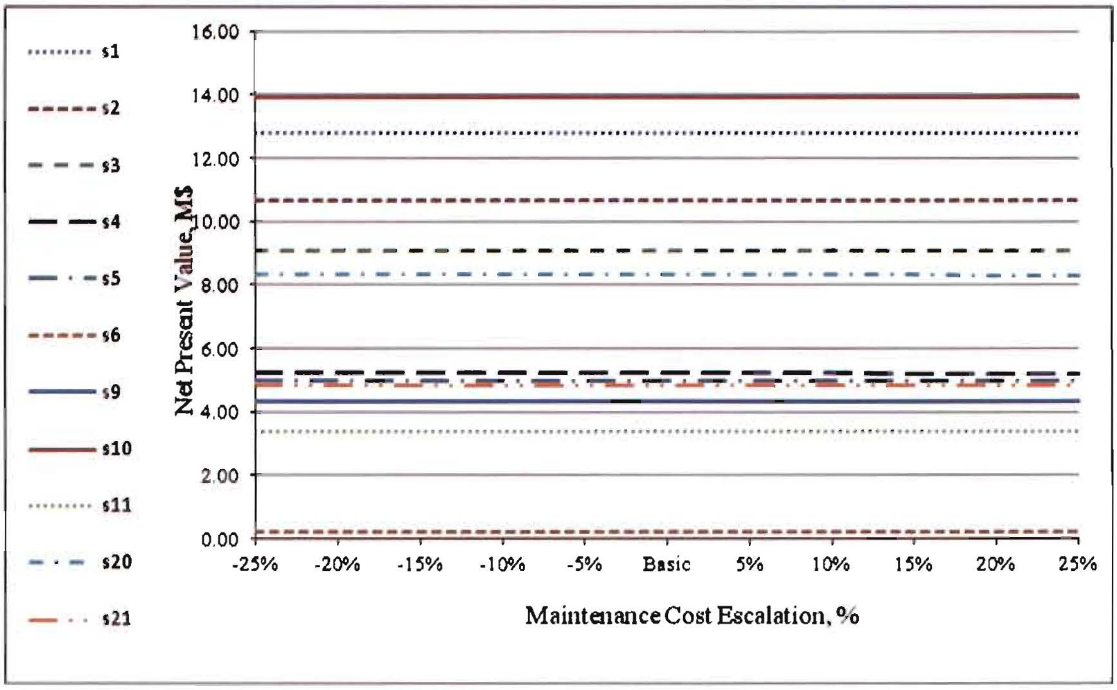

Figure 5: Net Present Value versus Maintenance Cost Escalation Relationship

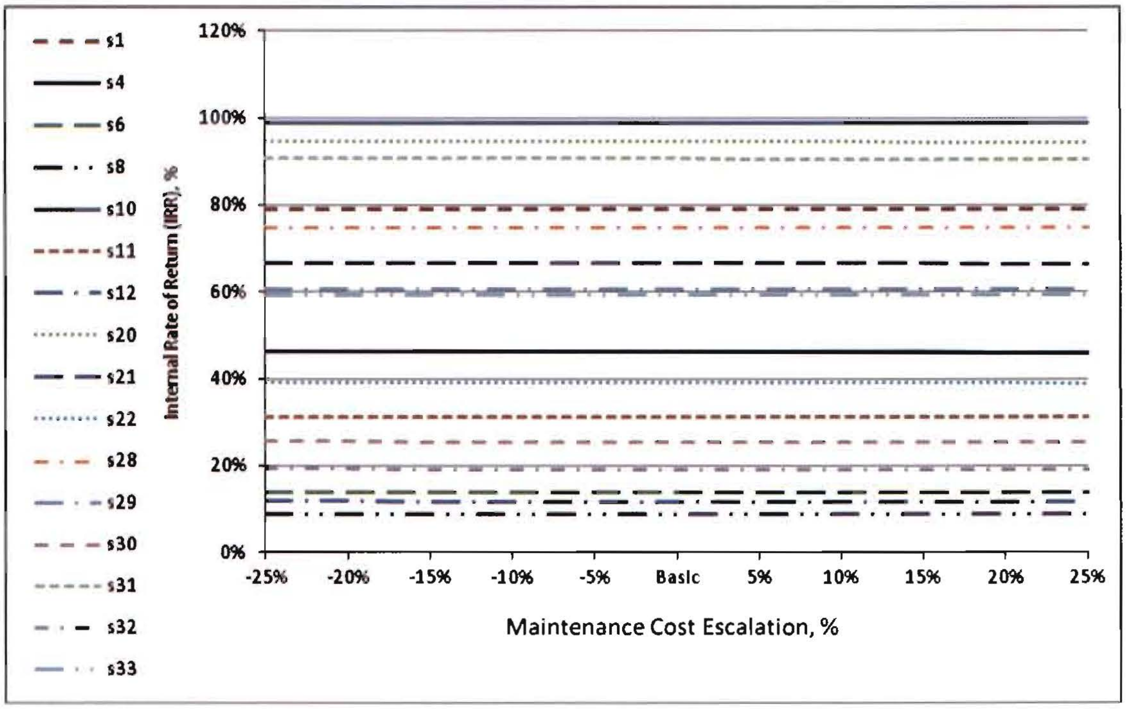

Figure 6: Internal Rate of Return versus Maintenance Cost Escalation Relationship

Table 1: Roads Characteristics, Investment Costs and Economic Analysis Results

Gov.	Road Sec.	District	Length, Km	Width, m	Type	ADT, vpd	IRI[1]	Rating	Cost, M$/km	C/B[2] Ratio	NPV[3], M$	IRR, %	MIRR[4], %	NPV/ FI[5], Ratio
Menia *Muhit Road*	R 01	Edwah	12.0	6.00	Existing	3770	6.0	Fair	0.207	0.311	12.806	79%	24%	6.07
	R 02	Magha	10.0	6.00	Existing	3770	6.0	Fair	0.207	0.259	10.671	79%	24%	6.07
	R 03	Mazar	08.5	6.00	Existing	3770	6.0	Fair	0.207	0.220	9.071	79%	24%	6.07
	R 04	Samal	10.0	6.00	Existing	3770	4.0	Good	0.207	0.259	5.230	46%	20%	2.97
	R 05	Samal	09.5	6.00	Existing	3770	4.0	Good	0.207	0.246	4.968	46%	20%	2.97
	R 06	Minia	10.0	6.00	Existing	1050	4.0	Good	0.207	0.259	0.232	14%	13%	0.13
	R 07	Minia	10.0	6.00	Existing	1050	4.0	Good	0.207	0.259	0.232	14%	13%	0.13
	R 08	Qorqas	17.0	6.00	Existing	1050	4.0	Good	0.293	0.623	-0.848	9%	11%	-0.20
	R 09	Malawi	10.0	6.00	Existing	3285	4.0	Good	0.207	0.259	4.339	41%	19%	2.47
	R 10	Malawi	10.0	6.00	Existing	3285	8.0	Poor	0.207	0.259	13.939	99%	26%	7.92
	R 11	Mowas	12.0	6.00	Existing	950	8.0	Poor	0.207	0.311	3.390	31%	18%	1.61
Serry Basha Road	R 12	Magha	07.0	6.00	Existing	265	8.0	Poor	0.201	0.176	-0.018	12%	12%	-0.01
	R 13	Mazar	10.5	6.00	Existing	265	8.0	Poor	0.201	0.264	-0.026	12%	12%	-0.01
	R 14	Matai	04.0	6.00	Existing	265	6.0	Fair	0.201	0.101	-0.209	7%	10%	-0.31
	R 15	Samal	12.0	6.00	Existing	265	6.0	Fair	0.201	0.302	-0.626	7%	10%	-0.31
	R 16	Samal	13.0	6.00	Existing	265	4.0	Good	0.201	0.327	-1.331	1%	7%	-0.60
	R 17	Minia	17.0	6.00	Existing	265	4.0	Good	0.201	0.427	-1.741	1%	7%	-0.60
	R 18	Qorqas	15.0	6.00	Existing	265	6.0	Fair	0.201	0.377	-0.783	7%	10%	-0.31
	R 19	Malawi	04.0	6.00	Existing	265	8.0	Poor	0.201	0.101	-0.010	12%	12%	-0.01
Kherg-een Road	R 20	Edwah	10.0	6.00	Existing	1816	8.0	Poor	0.130	0.163	8.307	95%	25%	7.52
	R 21	Edwah	09.0	6.00	Existing	1816	6.0	Fair	0.130	0.146	4.864	67%	23%	4.89
	R 22	Magha	04.5	6.00	Existing	1816	4.0	Good	0.130	0.073	1.145	39%	19%	2.30
	R 23	Mazar	10.0	6.00	Existing	1816	4.0	Good	0.130	0.163	2.545	39%	19%	2.30
	R 24	Mazar	10.0	6.00	Existing	1816	4.0	Good	0.130	0.163	2.545	39%	19%	2.30
	R 25	Matai	08.0	6.00	Existing	1816	4.0	Good	0.130	0.130	2.036	39%	19%	2.30
	R 26	Samal	16.0	6.00	Existing	1816	4.0	Good	0.130	0.260	4.072	39%	19%	2.30
	R 27	Minia	10.0	6.00	Existing	1816	4.0	Good	0.130	0.163	2.545	39%	19%	2.30
Fayoum	R 28	G. Saad	16.0	8.00	Existing	2940	8.0	Poor	0.174	0.348	13.434	75%	24%	5.68
	R 29	Tobhar	13.0	8.00	Existing	2492	8.0	Poor	0.185	0.301	8.848	61%	22%	4.33
	R 30	Sonors	18.0	8.00	Existing	1813	8.0	Poor	0.208	0.468	3.485	26%	16%	1.09
	R 31	Defino	06.0	6.00	Existing	786	20	V. Poor	0.160	0.120	5.839	91%	25%	7.16
	R 32	Shawsh	06.5	6.00	Existing	62	20	V. Poor	0.163	0.132	0.496	19%	15%	0.55
Assuit	R 33	Dronka	10.0	8.00	New	No	20	-	1.091	1.364	39.032	59%	22%	4.21
	R 34	Dronka	11.0	8.00	New	No	20	-	1.091	1.500	42.935	59%	22%	4.21
	R 35	Manflot	14.0	6.00	Existing	2565	4.0	Good	0.198	0.347	1.659	21%	15%	0.70
	R 36	Manflot	14.0	6.00	Existing	2565	6.0	Fair	0.198	0.347	4.324	34%	18%	1.84
	R 37	B Korra	12.0	6.00	Existing	574	4.0	Good	0.188	0.282	0.066	12%	12%	0.03
	R 38	B Korra	12.0	6.00	Existing	574	6.0	Fair	0.188	0.282	1.640	23%	16%	0.86
	R 39	Dierot	10.0	6.00	Existing	590	4.0	Good	0.186	0.233	-0.177	10%	11%	-0.11
	R 40	Dierot	10.0	6.00	Existing	590	6.0	Fair	0.186	0.233	0.901	19%	15%	0.57
Sohag	R 41	Jehina	10.0	6.00	Existing	1674	4.0	Good	0.200	0.250	0.060	13%	12%	0.04
	R 42	Jehina	10.0	6.00	Existing	1674	4.0	Good	0.200	0.250	0.060	13%	12%	0.04
	R 43	Jehina	12.0	6.00	Existing	530	8.0	Poor	0.200	0.300	-0.302	10%	11%	-0.15

[1]: International Roughness Index, [2]: Cost/Budget Ratio [3]: Net Present Value, [4]: Modified Internal Rate of Return, [5]: Financial Investment

Table (2): Vehicle Fleet Characteristics [5]								
Item	Car Medium	Goods Vehicle	Bus Mini	Bus Medium	Horse Cart	Truck Light	Truck Medium	Truck Heavy
Economic Unit Costs								
New Vehicle Cost ($/vehicle)	15000	21000	28500	50000	1500	50000	65000	110000
Fuel Cost ($/litre)	0.26	0.20	0.11	0.11	0.00	0.11	0.11	0.11
Lubricant Cost ($/litre)	2.00	2.00	1.00	1.00	0.00	1.00	1.00	1.00
New Tire Cost ($/tire)	50	65	85	170	15	200	230	260
Maintenance Labor Cost ($/hour)	1.50	1.50	1.50	1.50	0.50	1.50	1.50	1.50
Crew Cost ($/hour)	2.00	2.00	2.00	2.00	0.5	2.00	2.00	2.00
Interest Rate (%)	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
Utilization and Loading								
Kilometers Driven per Year, km	20000	40000	50000	70000	10000	25000	50000	70000
Hours Driven per Year (hr)	500	1100	2000	2000	1000	1300	1800	2000
Service Life (years)	10	8	8	8	8	8	8	8
Percent of Time for Private Use, %	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross Vehicle Weight (tons)	1.50	3.26	5.40	10.40	1.00	16.00	32.00	52.00

Table (3): Annual Maintenance Costs [6, 7, 8]		
Annual Maintenance Costs	Without Project (Existing)	With Project (Upgraded)
Roughness (IRI)	6.0 - 8.0	3.0 - 4.0
Fixed Financial Maintenance Costs, ('000$ /km/year)	10.00	2.00
Variable Financial Maintenance Costs, ('000$/km/year/ADT)	0.0007	0.000

Table (4): Accidents Cost and Rates [9, 10, 11, 12]			
Accident Type	Costs, $	Accidents Rates	
		Without Project	With Project
Accidents Rate (Accidents per 100 million vehicle.km)		200	100
With Fatality	15000	15%	10%
With Injury	2000	40%	20%
Damage Only	2000	55%	70%
Average Cost per Accident, LE	6000		

Table (5): No. of Passengers per Vehicle Type/Passenger Time costs									
Vehicle	Car Medium	Goods	Bus Mini	Bus medium	Bus Heavy	Truck Light	Truck Medium	Truck Heavy	Animal Cart
No. Of Passengers	2	2	14	28	56	2	2	2	2
Passenger Time Cost, (LE/pas-hr)	15.00	10.00	5.00	5.00	5.00	10.00	10.00	10.00	5.00