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TRANSPORT ASSESSMENT AND RISK ANALYSIS: THE CASE OF RĂDĂUȚI BY-PASS PROJECT

BY

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Abstract. The objective of this paper is to present a new methodology for evaluation transport infrastructure projects and test it on a road project from the North-Eastern region of România, Rădăuți. In the majority of the cases the transport infrastructure evaluation is made by the use of cost-benefit analysis (CBA) in order to produce aggregated single point estimates. New research has proved that the embedded uncertainties within traditional CBA such as pre-defined investment costs, travel time savings, vehicle operating costs, accident costs and environment pollution, are of high significance. This paper investigates the impacts of these parameters in terms of the optimism bias principle which is used to take account of the underestimation of costs and the overestimation of benefits. By extending this principle into stochastic modelling where a quantitative risk analysis (QRA) is applied, so-called *feasibility risk assessment*, is provided by moving from point-deterministic CBA to interval-stochastic QRA, results. Hereby, decision support as illustrated in this paper will aim to provide assistance to the decision makers in the development and ultimately the choice of action, while accounting for the uncertainties surrounding transport projects. Finally the paper presents the results and conclusions regarding the case study.

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Key words: transport infrastructure; risk analysis; cost benefit analysis.

1. Introduction

There is work going on in many countries with regard to risk analysis and the need to improve the decision making process regarding the management of infrastructural projects. The purpose of this work is to take better decisions and improve the accuracy regarding costs and benefits of the road infrastructure projects.

As an example the statistical data shows that in almost 9 out of 10 projects costs are underestimated. For a randomly selected project, the likelihood of actual costs being larger than estimated costs is 86%. Table 1 shows the differences between actual and estimated costs in these three areas for rail, fixed-link, and road projects. There is no indication of statistical interaction between geographical area and type of project. Therefore in can be considered the effects from these variables on cost underestimation separately. For all projects, the difference between geographical areas in terms of underestimation is highly significant (Bent *et al*., 2003).

Table 1
Inaccuracy of Transport Projects Cost Estimates by Geographical Location (Bent *et al*., 2003)

Project type	Europe		North America		Other regions	
	Number of projects	Average cost escalation %	Number of projects	Average cost escalation %	Number of projects	Average cost escalation %
Rail	23	34.2	19	40.8	16	64.6
Fixed-link	15	43.4	18	25.7	0	–
Road	143	22.4	24	8.4	0	–
All projects	181	25.7	61	23.6	16	64.6

General tendency of underestimation of costs investments and overestimation of benefits (demand forecast/prognosis) reveals that socio-economic analysis become over-optimistic leading to wrongful decision support. To deal with this the risk analysis together with other simulation (*i.e.* Monte Carlo Simulation) based on reference class forecasting is applied for determining the output distribution for benefit cost ratio instead of conventional single point estimate. This is presented by the certainty values and graphs or probability distributions.

2. Trans-Risc-Analist, Model Presentation

Trans-Risc-Analist model, which is based on the Microsoft Excel program and the add on software @Risk, uses the simulation technique, called Monte Carlo, in order to combine all the project uncertinties so that the final result to comprise all the posible variants.

The model follows the classic process structure, which comprise three steps:

a) input data,

b) computational operations,

c) output data.

In the decisional process, even if there are investment, technical or scientific decisions, there are used different hypotheses. Those hypothesis, which, in this case, there are the input data, were selected from recent studies (Eunet/SASI Final Report, 2001). Those studies revealed that the major impacts which have the biggest influence upon infrastructure projects are:

a) investment costs(planning costs, construction costs, land and property costs, disruption costs);

b) system operating and maintenance costs (signaling, enforcement of traffic regulation, carriage delineation-pavement, structural repairs);

c) vehicle operating costs (depreciation, wear and tear of vehicle, consumption of fuel and oil, wear and tear of tyre, repair and maintenance, overhead costs, interest personnel costs of drivers);

d) travel time benefits (car: working, non-working occupant), bus and coach: driver, working passenger);

e) safety(casualty related costs: human costs, lost output, medical and support services), accident-related costs(material damage, police and fire, insurance administration, legal and court costs);

f) local environment (Noise (L_{eq}, L_{10}), local and regional air pollution (SO_2, NO_x, CO), severance, vibrations (indication of high, medium, low), land amenity (indication of severe, moderate, slight).

Having as a starting point the impacts mentioned above the next step was to make the model and to structure it so that it will be functional and easy to use. To every impact a probability distribution it is assigned which is taking into account by using Monte Carlo simulation.

After running the simulation the model generates graphs and data which will help de decision makers in taking informed and calitative decisions.

3. Case Study – Rădăuți By-Pass Project

The Rădăuți road network has a radial concentric shape with all the roads that penetrate the city intersected in the centre, as can be observed in the Fig. 1. In the North, near the railway, there are some streets which can lower the congestion in the centre of town, but they do not compose a functional by-pass. For this reason almost all the traffic flows transit the centre of the city.

Considering those aspects the need of constructing a ring-belt around the city has become vital for the municipality.

The main data for Rădăuţi ring belt project is collected from the local and national data (Search Corporation, 1998). These are the construction costs, data regarding the traffic, accident statistics, economic data, road maintenance information, etc. The data related to external effects such as noise, pollution, etc. on the other hand, is not directly accessible. Hence, correspondence with local and regional authorities together with relevant companies is made in order to access reliable data and parameters.

Following the Trans-Risc-Analist main structure, as shown in Fig. 1, the first step is to fill in the input data.

INPUT DATA

Project title	Rădăuţi - By Pass
Date	25.12.2012

1A GENERAL INFO

Project description	The Rădăuţi road network has a radial concentric shape with all the roads that penetrate the city intersected in the centre. In the north, near the railway, there are some streets which can lower the congestion in the centre of town, but they do not compose a functional by-pass.
City	Rădăuţi
Population (no. inhabitants)	29744
Opening year	2015
Investment period (no. of years)	3
Tax (euro)	0
Investment costs with VAT (mii euro)	35844
Investment costs without VAT (mii euro)	44447

NOTE:
There will be completed only the fields:

1B ROAD TYPE

Project type	By Pass
Lanes	2
Total length of the road (km)	16.5
Average speed - whitout project(km/h)	50
Average speed - with project(km/h)	90
No. of sectors	7

1D FINANCIAL PARAMETERS

Reference period(years)	28
Discount rate for financial analysis	5%
Discount rate for economic analysis	5,5%

1C TRAFFIC DATA

2013

			Vehicles (MZA)				Veh. Etalon
Nr. Crt.	Sector	L(km)	Auto+autobus	2 axles	3+4 axles	5 axles+	(MZA)
1	DN 2H - DJ 178	3.0	2654	165	79	67	3499
2	DJ 178 - DN 17A	2.4	3518	234	87	89	4632
3	DN 17A - DC 46	1.1	2156	173	117	184	3525
4	DN 46 - DN 2H	1.5	1721	140	88	175	2904
5	DN 2H - DJ 178C	2.3	739	104	97	244	2096
6	DJ 178C - DN 17A	3.0	1200	115	107	262	2672
7	DN 17A - DN 2H	3.2	2036	130	92	302	3648

2025

			Vehicles (MZA)				Veh. Etalon
Nr. Crt.	Sector	L(km)	Auto+autobus	2 axles	3+4 axles	5 axles+	(MZA)
1	DN 2H - DJ 178	3.0	4550	405	123	208	6598
2	DJ 178 - DN 17A	2.4	6398	521	140	237	8880
3	DN 17A - DC 46	1.1	4003	321	172	365	6513
4	DN 46 - DN 2H	1.5	3238	273	134	355	5498
5	DN 2H - DJ 178C	2.3	1889	227	165	468	4507
6	DJ 178C - DN 17A	3.0	2141	247	172	495	4921
7	DN 17A - DN 2H	3.2	3259	291	147	620	6574

Fig. 1 – Trans-Risc-Analist form with input data.

After entering the input data the model guide the user to the next sheet which is the one where the construction and road maintenance costs are analysed, the other sheets are the travel time savings, evaluating the benefits obtained from vehicle operating costs, accident costs, environmental costs and the cost benefit analysis. All those sheets are composed from two parts: a computational part and a risk analysis part. The computational part computes the cost and benefits and the risk analysis part evaluate the uncertainties regarding the results obtained in the first part.

For example, in order to analyse the benefits obtained from travel time savings the model needs as the input data the costs of business or work trips and non-work or leisure trips, because the unit values of time are different for each other. Since there is no local or national information regarding the values of time, the data was taken from the European study called HEATCO. The Fig. 2 shows the results obtained after the data are entered.

Travel time savings

3A	Travel purpose	
	work-trip	80%
	non-work	20%
	Average no. of passengers	2,5

3B	Time value(euro)	
	work-trip	8
	non-work	4

3C	Route info	
	Average speed (km/h)	50
	Average speed + project	90
	Road length(km)	16,5

3D	Travel time savings														
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Work-trips	0	0	0	1926	2032	2143	2261	2385	2517	2655	2801	2955	3118	3289	3470
	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
	3645	3718	3792	3868	3945	4024	4159	4242	4327	4413	4501	4591	4683	0	0
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Non-work	0	0	0	111	116,812	123,237	130,01	137,2	144,71	152,67	161,07	169,924	179,27	189,13	199,53
	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
	210	214	218	222	227	231	239	244	249	254	259	264	269	0	0
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
TOTAL(mii euro)	0	0	0	2036	2148	2266	2391	2523	2661	2808	2962	3125	3297	3478	3670
	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24	Year 25	Year 26	Year 27	Year 28	Year 29	Year 30
	3855	3932	4010	4090	4172	4256	4398	4486	4575	4667	4760	4855	4952	0	0

Fig. 2 –Trans-Risc-Analist form with input data for travel time savings.

The next step is to commute to risk analysis part. Recent research has proved, that even though a vast amount of funds are being omitted to the development and determination of accurate demand forecasts, transport infrastructure projects have a tendency to be overestimated when it comes to the future demands. Whether this is intentional, strategic or modeling deficiencies are left un-said, however, this modeling bias clearly affects the overall appraisal in terms of over-stating the travel time savings resulting in inadequate decision support (Eunet/SASI Final Report, 2001; Flyvbjerg & COWI, 2004).

After completing the above information the user has to introduce in the risk register section the estimated variability value in term of percentage above or under travel time saving hours. The probability distribution and the variability is chosen by the user and this data should be based on studies and statistics (Salling, 2008).

In the Fig. 3 there can be observed the probability distribution for the total time saving costs generated by @Risk.

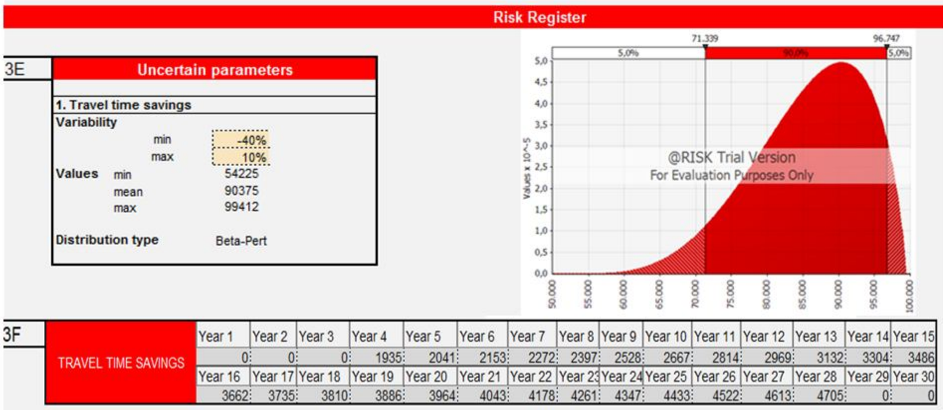

Fig. 3 – Trans-Risc-Analist screen with the generated data, from risk register section, for travel time savings.

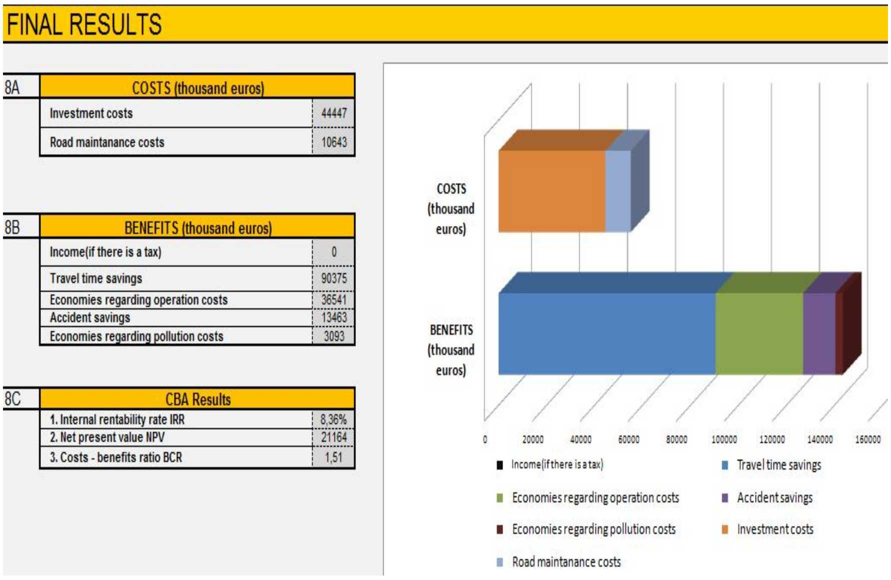

Fig. 4 – Final results from Trans-Risc-Analist model.

In the same way the model analyses the rest of the parameters. The final results, including cost benefit parameters, are summarized in an Excel form, as shown in the Fig. 4.

On the same screen are presented the results from risk analysis, which can be observed in the Fig. 5.

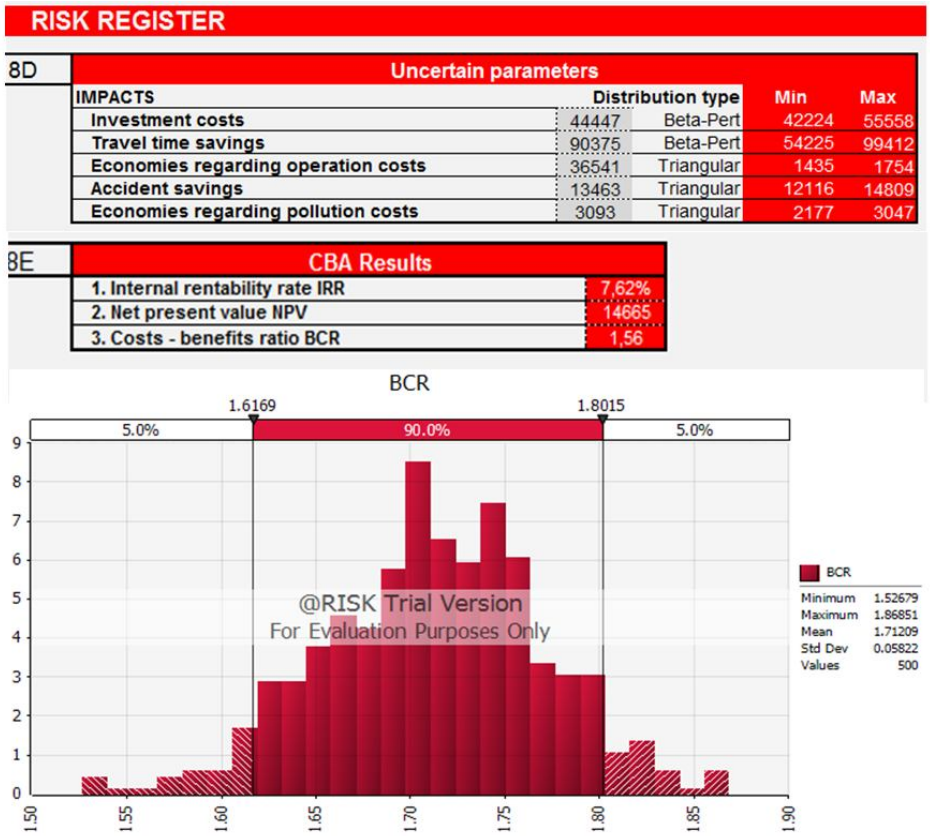

Fig. 5 –Trans-Risc-Analist scree with input data.

In order to evaluate the risk of this project, with the aim of obtaining a BCR of 1.71, and establishing the possible boundaries for the defined BCR, the user may consider the BCR variability illustrated by the histogram generated in the model. Thus, for a confidence level of 90%, as shown in the Fig. 5, the resulted boundaries are 1.61 and 1.80 which might be considered by decision-makers to be sufficient for an implementation decision. However, the user may change the boundaries and, in this way, increase or decrease the risk level.

Those results are of particular importance in the case where a choice among several alternatives has to be made.

4. Conclusions

This model has been conceived as a combined approach between CBA and a stochastic approach based on @RISK software.

With Trans-Risc-Analist model it is possible to conduct a project appraisal according to the described methodology from cost benefit analysis to risk analysis.

This practical study shows that there is an advantage that conventional cost–benefit analysis can be supplemented with a risk analysis examination. However, even though Monte Carlo simulation is a well-established technique in the field of risk analysis, it still lacks a generally approved way of implementation in the transport infrastructure area. A particular interest is the variety of various probability distributions and their strengths and weaknesses.

Helping decision-makers to address exact risks by identifying uncertain parameters and variables is also a big advantage.

The decision support model will be further developed in the current doctoral thesis. The next stage within the investigation involves the application of multi-criteria analysis elaborating upon non-monetary impacts and testing the Trans-Risc-Analist model on other projects.

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EVALUAREA PROIECTELOR DE INFRASTRUCTURĂ PRIN PRISMA ANALIZEI DE RISC. STUDIU DE CAZ: CENTURA RĂDĂUȚI

(Rezumat)

Obiectivul principal al acestei lucrări este de a prezenta o nouă metodologie pentru evaluarea proiectelor de infrastructură de transport rutieră şi aplicarea acesteia pe un proiect din regiunea de nord-est a României, Rădăuți. În cele mai multe cazuri proiectele sunt judecate doar prin prisma unor indicatori punctuali rezultați din analiza cost–beneficiu. Studii recente au demonstrat că incertitudinile încorporate în cadrul analizei cost–beneficiu tradiționale, cum ar fi costul investiției, economiile de timp, costurile de operare a vehiculelor, costurile cu accidentele şi poluarea mediului sunt de mare importanță. Modelul nou creat înlesneşte investigarea riscurilor aferente acestor efecte, în ce priveşte subestimarea costurilor şi supraestimarea beneficiilor. Prin extinderea acestei investigații la modelarea stocastică în care se aplică o analiză de risc cantitativă, aşa-numita evaluare a riscurilor de fezabilitate este asigurată prin trecerea de la analiza deterministă, cu valori unice, la analiza stocastică, care generează valori multiple. Urmare a simulării vor rezulta diferite grafice care vor înlesni factorilor decidenți luarea unor decizii informate şi bine fundamentate funcție de percepția față de risc (i. prin prezentarea probabilității atingerii unor costuri nefezabile). În final sunt prezentate rezultatele obținute în urma rulării modelului, concluziile şi perspectivele cercetării ulterioare.