Traffic Road Section Investment Risk Modelling and Computer Simulation

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Апстракт – In this work, the model for determination of the coefficient for estimation of investment risk is presented as well as its application when choosing the optimal variant of a traffic road.

Key words – modeling, investments, a confidence interval, traffic, simulation

INTRODUCTION

There are various motives for a construction of a traffic road which are economic, political or military ones. Regardless of which of these is the motive for a construction of a certain traffic road, the variants should depend upon economic evaluation. The choice of a multicriterial evaluation based on economic, investment, environmental and functional evaluation. Setting a unique analytical function and its optimizing is practically impossible. Accordingly, the approach of a choice of an optimal variant is a choice of partial functions for each evaluation and defining of their importance. Moreover, it is known that a great part of the environmental and functional evaluation has an impact on the economic indicators. In order to realize the influence and to decrease the influence of the "untouchable" influences, two hypotheses have been in relation to the environmental and functional evaluation.

1. In each of the variants, supplementary investments will be made so that the negative environmental effects are brought to the same level. Such a hypothesis eliminates the need for an environmental evaluation.
2. The indicators of the functional evaluation, such as the length of the traffic road, the number and the types of accidents, the practical capacity etc., have an impact on the economic indicators and through them they certainly influence the economic evaluation. If these influences are considered to be enough, the functional evaluation may also be eliminated.

The acceptance of these hypotheses means an importance of the economic or the investment evaluation. To determine the economic and the investment evaluation is an interest of two parties: the social community and the investor. The effects of these two evaluations can be seen through the previsibility and visibility studies. Such studies are made by the institutions of the social community as a social Cost-Benefit analysis and by the investor as a financial Cost-Benefit analysis. These two analyses are in opportunity to each other and their opposition can be solved by appropriate legal act.

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DEFINITION OF IRAC (INVESTMENT RISK ASSESSMENT COEFFICIENT)

Investment indicators can be found in the function of the economic indicators expressed through economic costs and benefits. The basic investment indicators are the opportunistic price of capital, the Net Present Value and the Internal Rate for Return. A real analysis of these indicators is complex. The definition of an Internal Rate of return is expressed in the following expression:

$$\sum_{t=1}^{n}\frac{NI_t}{(1+r)^t}-\sum_{j=-m}^{0}\frac{I_j}{(1+r)^j}=0$$

where:

NI_t - net incomes in the t-year,

I_j - investment in the j -year,

n - planned period for a traffic road exploitation,

m - investment period.

By solving this expression according for r , the internal profitability rate of a traffic road is found.

On the other side, the Net Present Value is defined according to the following expression:

$$NPV=\sum_{t=1}^{n}\frac{NI_t}{(1+OCC)^t}-\sum_{j=-m}^{0}\frac{I_j}{(1+OCC)^j}=0$$

In this expression it is obvious that NPV (Net Present Value), which is the aim of the investor, is in the function of NI (Net Income), the investments, OCC (Opportunity Capital Cost) and IRR (Internal Rate of Return). The determining presentation of these dimensions does not correspond with the reality. Also, a presentation of a pessimistic, probably and optimistic scenario, too, does not correspond with the reality because each of them is realized with "0"-probabiliyy. According to that, the real approach could present NPV probability, it could belong to a certain interval or a marginal case of an investment efficacy NPV, not to get a negative value and be indefinite (not positive). The probability for NPV to be negative has been called a coefficient for the evaluation of the investment risk. The definition of this coefficient starts from the probability distribution is IRR and OCC. To determine the probability law of IRR, we should start from the following expression:

$$\sum_{t=1}^{n}\frac{NI_t}{(1+r)^t}-\sum_{j=-m}^{0}\frac{I_j}{(1+r)^j}=0$$

It turns out that NI_1 are in the function of the traffic intensity in the planned period which means that $NI_t = f(AADT_t)$ (AADT – Average Annual Daily Traffic). If this is correct, the traffic intensity depends on a great number of factors, such as: economic potentials of the zones of direct or indirect influence, development strategy of the zones, demographic characteristics etc. As the number of the independent variables is big and, certainly, with unknown distributions for a distribution according to the central marginal theorem, we can accept that the AADT distribution law a gauss one. Determination of the intensity and structure of the traffic is based on prediction. Determination of the confidence intervals of AADT with some certainty coefficient (for economics problems, 0.95 or 0.99) leads determination of confidence interval of NPV and then, through the section of confidence intervals with the axis, confidence intervals of the IRR are

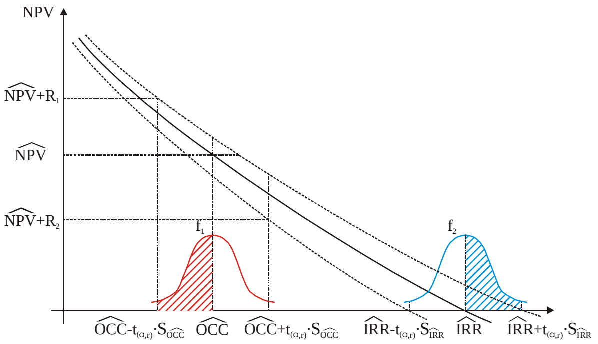


Figure 1. The relation IRR, NPV and OCC as well as their probability distribution and confidence intervals.

defined.

The complex real relation, NPV-IRR-OCC, is shown in the Figure 1:

OCC also depends on a big number of factors. According to their central marginal theorem, its distribution depends on the gauss distribution.

According to this Figure, if we define a partial coefficient for the evaluation of the investment risk is accordance with the expression:

$$P(NPV < 0) = P(OCC \in \Delta r) \cdot P(IRR < r_1)$$

and Figure 2.

The analytical expression of the partial coefficient for evaluation of the investment risk is:

$$P(NPV < 0 / OCC \in [r_1, r_1 + \Delta r]) = f_1(r_1) \cdot \Delta r \cdot \int_{-\infty}^{r_1} f_2(r) \cdot dr$$

If we want this expression to be useful in the whole interval

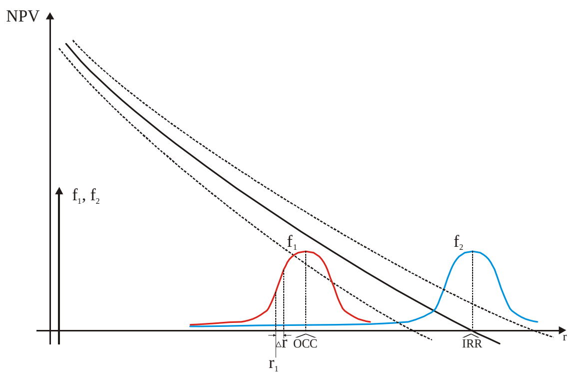


Figure 2. Partial Investment Risk Assessment Coefficient

of possible values of the discount rate, it must be supplemented which means that the sum of all partial coefficients must be determined.

$$IRAC = P(NPV < 0) = \sum_i f_1(r_i) \cdot \Delta r \cdot \int_{-\infty}^{r_i} f_2(r) \cdot dr$$

when $\Delta r \rightarrow 0$ sum turns into an integral and Δr turns into a differential dr. So, the final expression for determination of the coefficient for evaluation of the investment risk gets the following form:

$$IRAC = P(NPV < 0) = \int_{-\infty}^{\infty} f_1(r) \cdot dr \cdot \int_{-\infty}^{r} f_2(l) \cdot dl$$

or

$$IRAC = P(NPV < 0) = \int_{-\infty}^{\infty} f_1(r) \cdot F_2(r) \cdot dr \,.$$

The interval of possible values of IRAC is [0,1], where if the value is closer to “0”, the risk for the project to get a negative net present value is smaller, and vice versa. If the IRAC value is closer to 1, the risk for the net present value not to be positive is bigger.

The evidence of the multitude of values of this coefficient happens in three cases:

- The first case is shown in a figure,

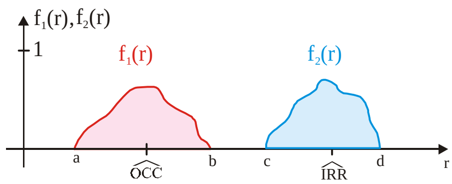
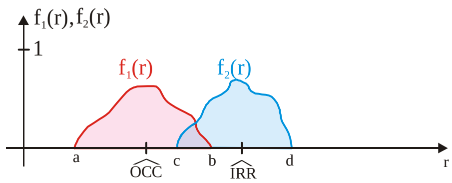


Figure 3. IRR and OCC situations with their distribution.

- The second case is shown in a figure,



Слика 4. IRR and OCC situations with their distributions.

- The third case is shown in a figure.

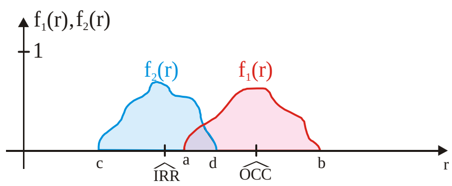


Figure 5. IRR and OCC with their distributions.

Here, we will come to the evidence (proof) of only the second case:

If we develop the expression for IRAC, we get:

$$IRAC = P(NPV < 0) = \int_{-\infty}^{\infty} f_1(r) \cdot \left(\int_{-\infty}^{r} f_2(l) \cdot dl \right) \cdot dr = \int_{-\infty}^{c} 0 \cdot \left(\int_{-\infty}^{r} 0 \cdot dl \right) \cdot dr + \int_{c}^{d} 0 \cdot \left(\int_{-\infty}^{c} 0 \cdot dl + \int_{c}^{r} f_2(l) \cdot dl \right) \cdot dr +$$

$$+ \int_{d}^{a} 0 \cdot \left(\int_{-\infty}^{c} 0 \cdot dl + \int_{c}^{d} f_2(l) \cdot dl + \int_{d}^{r} 0 \cdot dl \right) \cdot dr + \int_{a}^{b} f_1(r) \cdot \left(\int_{-\infty}^{c} 0 \cdot dl + \int_{c}^{d} f_2(l) \cdot dl + \int_{d}^{r} 0 \cdot dl \right) \cdot dr +$$

$$+ \int_{b}^{\infty} 0 \cdot \left(\int_{-\infty}^{c} 0 \cdot dl + \int_{c}^{d} f_2(l) \cdot dl + \int_{d}^{r} 0 \cdot dl \right) \cdot dr =$$

of all the intervals which participate in the sum, only the fourth one is not zero

$$= \int_{a}^{b} f_1(r) \cdot \left(\int_{-\infty}^{c} 0 \cdot dl + \int_{c}^{d} f_2(l) \cdot dl + \int_{d}^{r} 0 \cdot dl \right) \cdot dr = \int_{a}^{b} f_1(r) \cdot \left(\int_{c}^{d} f_2(l) \cdot dl \right) \cdot dr$$

But from the hypothesis in the beginning of the expression, that $\int_{-\infty}^{\infty} f_2(r) \cdot dr = 1$, and it has an important value only in the interval $[c,d]$ т.е. $\int_{-\infty}^{\infty} f_2(r) \cdot dr = \int_{c}^{d} f_2(r) \cdot dr = 1$, follows

$$IRAC = \int_{a}^{b} f_1(r) \cdot dr \,.$$

What has previously been said about $f_2(r)$ is also valid for $f_1(r)$, which means that $\int_{-\infty}^{\infty} f_1(r) \cdot dr = 1$, It has an important value only in the interval $[a,b]$, or

$\int_{-\infty}^{\infty} f_a(r) \cdot dr = \int_{a}^{b} f_1(r) \cdot dr = 1$ It means that

$IRAC = 1$, so that $IRAC = 100\%$.

The expression for IRAC does not have analytical solution so a numerical solving of this expression is used. Reaching the IRAC value is a long process. We have created an appropriate software solution which contains a great number of models mutually connected with their interactive connection. From the definition of this coefficient, we can see that it has a general use value when the investment risk is estimated. In this research work, models are directed to a determination of this coefficient when the investment risk is estimated and when a choice of an optimal variant for a traffic road is made.

MODULES OF THE SOFTWARE SOLUTION

The software solution of these models will be connected with the existing programming tools which are used in the process of planning and projecting road. AUTO-CAD is one of the widely used software solution which gives an opportunity for the basis of a development of various applications in it. This software contains the PLAEIA application which is used to project roads in almost all Europe, in about 7000 patterns. This software is also used in the projecting companies, in the Republic of Macedonia. This was the reason for us to let this project support for the form of this software. The Software solution consists of the following modules:

1. Module for determination of the speed in a free traffic flow,
2. Module for determination of the direct exploitation costs of a traffic road,
3. Module for determination of costs which depend on the weather,
4. Module for determination of accident costs,
5. Module used to update construction data, maintenance of traffic roads, cost for decreasing the environmental consequences and costs for the protection of the environment.
6. Module for determination of costs for the traveling time of the passengers,
7. Module for estimation of the costs of the lost profit,
8. Module for determination of the incomes gained by payment of special tolls when a traffic road is used,
9. Module for estimation of IRR, IRAC и NPV,
10. Module for a final ranking of variants.

The most important model is the one used to determine the speed in a free traffic flow the diagram of which is presented in the Figure 8.

Prediction for the future AADT has an important influence for determination of IRAC and choosing the optimal variant of the traffic road.

Prediction is made by extrapolation the traffic trend. The trend

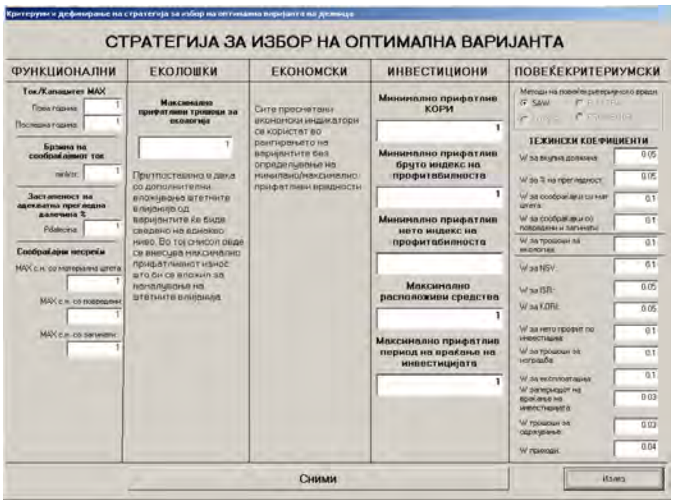


Figure 6. A screen of the module used to define the strategy

prediction is according to a degree or a linear function depending on the correlation coefficient and the average square aberration. A screen of this model is presented in figure 8.

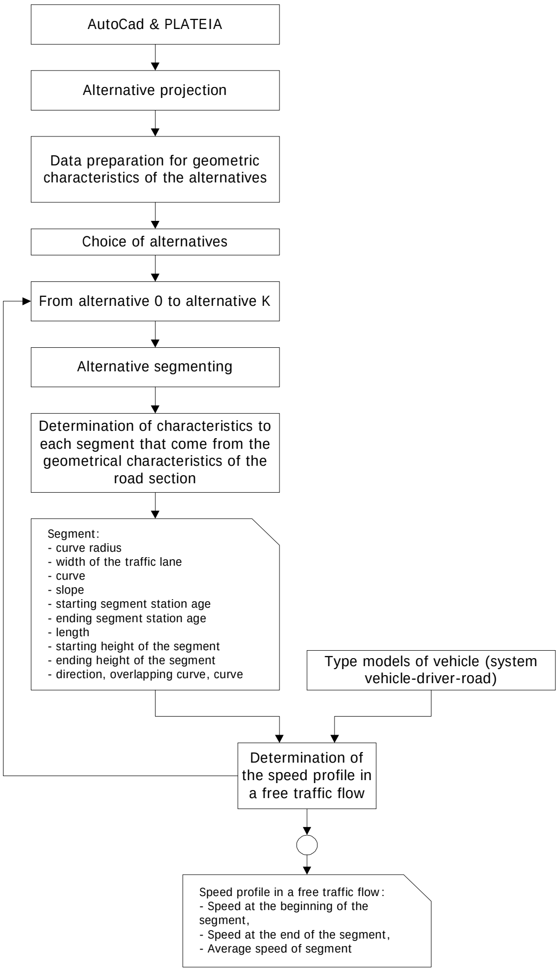


Figure 7. A block diagram of the module used to determine the speed in a free traffic flow.

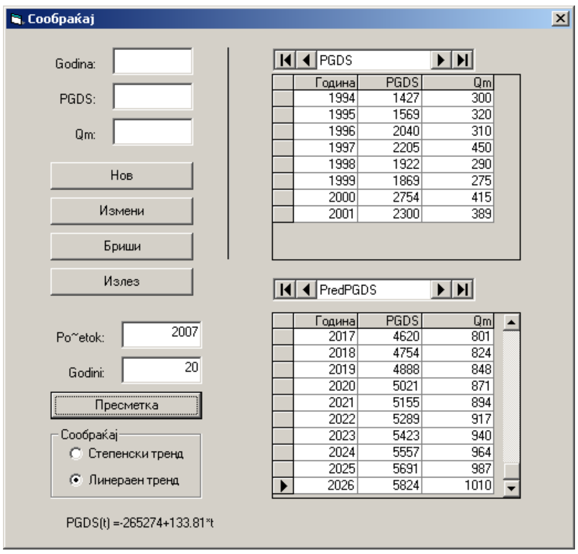
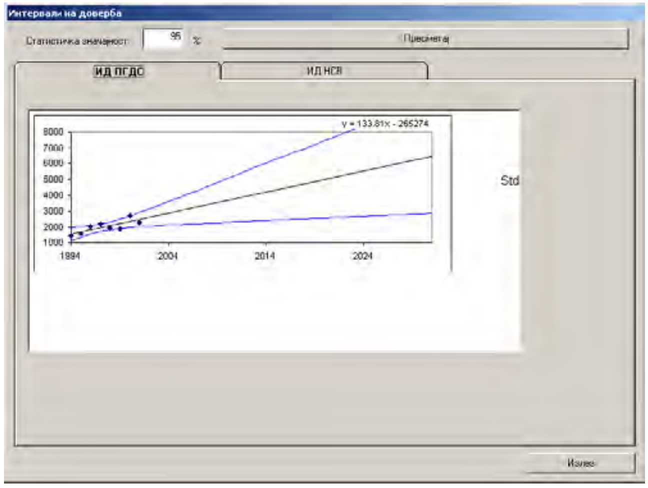


Figure 8.A screen of the model used to predict the future/next AADT

4. 

5. Figure 9. A screen of the module used to estimate the confidence interval

CONCLUSION

The Investment Risk Assessment Coefficient has been included as quantitative indicator to estimate the risk investing in general. This coefficient has also been specially analyzed for the filed of investments in roads and the choice of the optimal variant of a traffic road considering, construction, maintenance and exploitation. The interval of values [0, 1] and one part of its proof has been presented here. A software solution has been made for the purpose of this coefficient and the models necessary for the choice of the optimal variant of a traffic road. Data adaptation is quite possible in the software which makes it be widely used for certain regions. This software and this coefficient might be used in previsibility and visibility studies as a quantitatively qualitative indicator of the investment risk. This coefficient is also suitable when variants are ranked.

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