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EX ANTE AND *EX POST* ECONOMIC EFFICIENCY OF ROAD PROJECTS BASED ON THE EXAMPLE OF OSTRÓDA BYPASS

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Key words: cost-benefit analysis, economic efficiency, road investment projects.

Abstract

The article focuses on the issues of measurement of cost-benefit of road investment projects both at pre-implementation stage and *ex post,* by applying cost-benefit analysis. The studies used cost-benefit analyses for modernization of Ostróda bypass in Warmia and Mazury voivodship. As a result of the conducted studies it was established that the *ex ante* road-bridge costs were underestimated in relation to *ex post* costs. At the same time the savings on user and environmental costs estimated in *ex post* analysis were higher than estimated in *ex ante* analysis by 54,89%. Although the internal rate of return in *ex ante* analysis was 22,95%, and in *ex post* analysis 26,97%, this does not prove credibility of *ex ante* analysis. The studies showed that in pre-implementation analysis there were significant inaccuracies in estimation of both the costs and the benefits related to the investment project.

EFEKTYWNOŚĆ EKONOMICZNA *EX ANTE* I *EX POST* INWESTYCJI DROGOWYCH NA PRZYKŁADZIE OBWODNICY OSTRÓDY

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Słowa kluczowe: analiza kosztów i korzyści, efektywność ekonomiczna, inwestycje drogowe.

Abstrakt

W artykule skoncentrowano się na zagadnieniach pomiaru kosztów i korzyści inwestycji drogowych, zarówno w fazie przedrealizacyjnej, jak i *ex post,* za pomocą analizy kosztów i korzyści. W badaniach wykorzystano analizy kosztów i korzyści modernizacji obwodnicy Ostródy w województwie warmińsko-mazurskim. W efekcie przeprowadzonych badań stwierdzono niedoszacowanie kosztów drogowo-mostowych *ex ante* w stosunku do kosztów *ex post*. Jednocześnie oszczędności kosztów użytkowników i środowiska oszacowane w analizie *ex post* są wyższe od oszacowanych w analizie *ex ante* o 54,89%. Mimo że wewnętrzna stopa zwrotu *ex ante* wynosiła 22,95%, a *ex post* 26,97%, nie dowodzi to wiarygodności analizy *ex ante*. W toku badań wykazano, że w analizie przedwykonawczej wystąpiły istotne niedokładności w szacowaniu zarówno kosztów, jak i korzyści związanych z inwestycją.

Introduction

The condition of transport infrastructure, and in particular roads in Poland is still, by far unsatisfactory. In spite of numerous announcements and programmes of road network development in our country presented by consecutive governments, visible increase in dynamics of investment projects in that area has not occurred. For many years the investment needs in Polish roads have been incompatibly higher than the funds available for the purpose. It should be stressed, however, that poorly developed network of roads as well as low quality of road surfaces represent in increasingly visible barrier to socio-economic development of the country. Those facts gain special importance in the context of preparations of our country for co-organization of the European Football Championship in 2012.

The paper focuses on the issues of measurement of economic costs and benefits of road investment projects during both pre-implementation and the *ex post* evaluation using the cost-benefit analysis. Although there are well-established procedures of conducting such analysis for various types of infrastructure projects, studies on functioning of those procedures and possibilities of further improving them are still necessary. Investments in road infrastructure are among highly capital-intensive projects that at the same time offer multiple benefits for the users and the environment. Measurement of costs and benefits related to road investment projects allows assessment of economic efficiency of such projects. As a consequence, there is a possibility of selecting for implementation of the projects that can offer the highest input in the improvement of social welfare.

The role of cost-benefit analysis (CBA) in the process of road investment projects preparation and evaluation

Classic methods of investment evaluation are not adjusted to assessment of economic infrastructure projects. The basic reason is lack of the possibility of identifying revenues from conducted activity, which results from the character of public services. In case of infrastructural investments two types of efficiency assessment can be used. The first type is called the process efficiency assessment and it involves mainly administrative monitoring of conducting the financial transactions, accounting system, management and data archivation. The second type of assessment that concerns evaluation of efficiency of the results is commonly known as *cost-benefit analysis* (BRZOZOWSKA 2005, p. 34).

Cost-benefit analysis is of particular importance for estimation of economic benefits resulting from implementation of a given project. In principle, the analysis should encompass the project influence at all levels: financial, economic, social, environment protection, etc. The cost-benefit analysis aims at indicating and converting to cash value of all the possible effects of a given project for the purpose of estimating the costs and benefits of the project. Next the results obtained are summed up (the so-called net benefit is calculated) and on that base the decision is taken on whether the project should be implemented or rejected. Costs and benefits should be valued based on the increment principle considering the difference between the option assuming project implementation and alternative options without the project (*Wytyczne*... 2006).

Four stages can be identified in the cost-benefit analysis method:
- identification o all factors (favourable and unfavourable) influencing the society as a result of a specific investment project,
- valuation of benefits and costs in monetary terms,
- computation and selection of the discount rate for computation of the current value,
- choice of the variant indicating net social benefits, i.e. surplus of total benefits over the total costs (BRZOZOWSKA 2005, s.43).

From among numerous variants we choose the one that offers the highest net benefit. Implementation of a given investment project should be determined by the effect of the cost-benefit analysis, i.e. obtaining the highest surface of benefits over the total costs.

Cost-benefit analysis is currently treated as the fundamental tool for assessment of the projects' effects using the criterion of public funds and means allocation efficiency. Generally it is pointed out that public resources allocation efficiency occurs when resources such as land, capital or labour are allocated to achieve the highest value in categories of goods or services that is offered by using them. In this sense CBA is considered the tool allowing comparison of the efficiency of different directions and methods of public resources and funds allocation to projects (FRENKIEL, DROBNIAK 2005, p. 57).

The possibility of expressing all elements of assessment in the same payment units is the main advantage of cost-benefit analysis. Analysing costs and benefits in a longer time perspective is another CBA benefit. Unfortunately, costs of accidents or environmental impact can be difficult to convert into money and imprecise, which is one of the few disadvantages of expressing the assessment elements in cash. To minimize that inconvenience, where necessary, multi-criterion analysis coupled with weighing of individual factors is applied. The result of classic cost-benefit analysis in such a case will be just one of the elements of project assessment (KOWALEWSKI 2005, pp. 55–57).

Cost-benefit analysis of investment projects should be conducted both before and after project implementation. This allows assessment of whether the project really was economically justified, showing mistakes and shortfalls at project planning stage and determining the caused for deviation of costs and benefits *ex post* as compared to *ex ante* values. Which is even more important considering the fact that the given project has been completed, cost-benefit analysis conducted *ex post* can help in taking appropriate decisions based on more complete information concerning implementation of similar projects in the future (KOWALEWSKI, LELUSZ 2004, p. 22).

It should be pointed out that cost-benefit analysis is just a technique of decision taking that applies to numerous decisions of political and social nature related not only to the investment project itself but also the system of determining prices (e.g. in the public sector) and drafts of legal regulations. In case of investment decisions, maximization of discounted value of the surplus of all benefits over the total costs considering the specified limitations is the criterion of choice (KAMIŃSKA 1999, p. 97).

Goal, scope and methodology of studies

Assessment of costs and benefits estimated in *ex ante* analysis as compared to the values obtained during *ex post* analysis was the main goal of the conducted studies. With achievement of the main goal the following objectives are linked:
- comparison of costs and benefits *ex ante* and *ex post* for modernization of Ostróda bypass;
- explanation of the reasons for possible differences between costs and benefits.

Pre-implementation and post-implementation analysis of the road project “Strengthening of the surface of the national road No. 7 Ostróda bypass section” was the basic research material. Those analyses were carried out by Biuro Projektowo-Konsultingowe Transprojekt Gdański on commission by the Directorate of Public Roads (now General Directorate for National Roads and Motorways). The project was implemented during the years 1999–2000. The *ex ante* analysis was prepared in 1996 and the *ex post* analysis was prepared in 2005.

The calculation of costs and benefits of the road project that serves economic efficiency assessment for the implemented project was conducted according to the methodology developed by the Road and Bridge Research

Institute in Warsaw. The schematic representation of that methodology is presented in Figure 1. The methodology is based on the comparison of the difference between costs and benefits for two variants: without investment (W0) and with investment (WI).

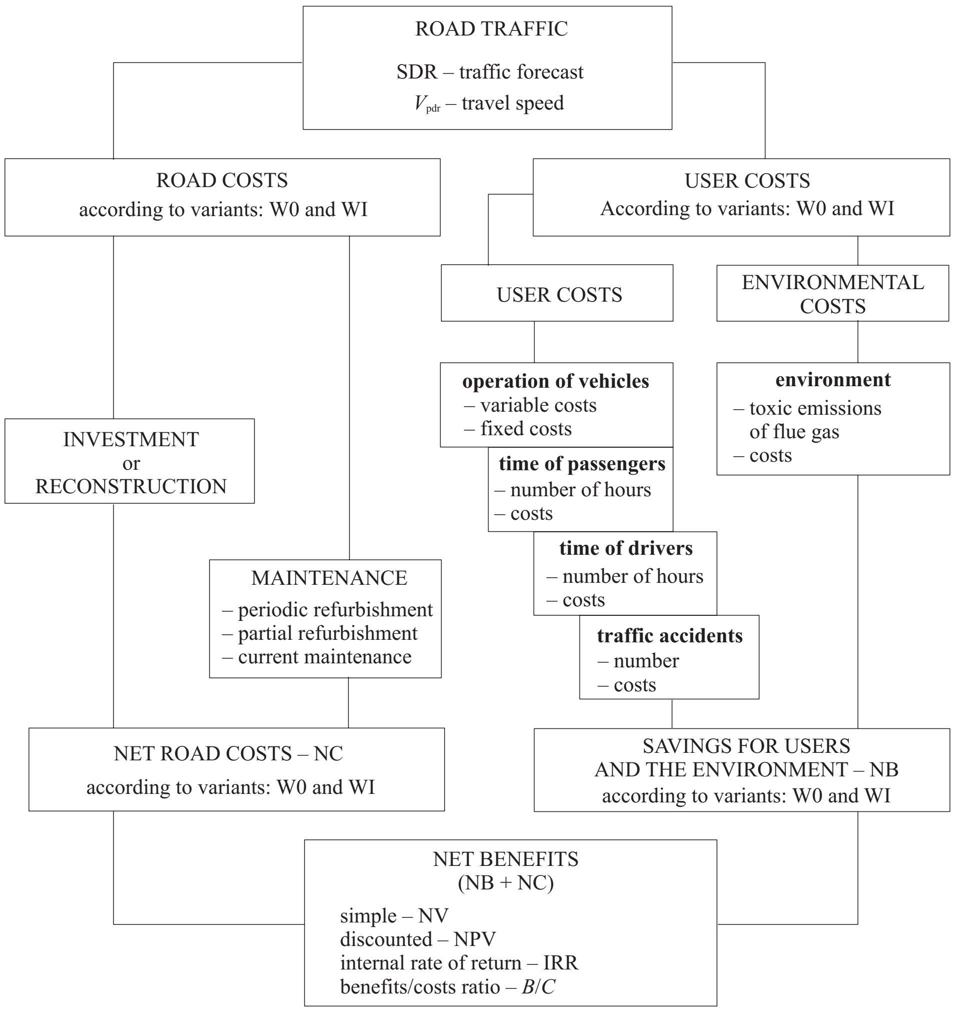

Fig. 1. Economic efficiency computations diagram
Source: *Instrukcja oceny...* (2003).

For the purpose of conducting the analysis the following was computed:
– net benefits and costs of the project as the sum of net outlays and savings that were discounted using the discount factors appropriate for the given discount rate (NV),

– updated net benefits (NPV – Net Present Value) for the discount rate "r" e.g. 8%, 10%, 12% and other up to achieving the NPV = 0, as the sum of net benefits during the consecutive years of the analysed period,
– benefits to costs ratio (B/C), as the ratio of discounted benefits to discounted net outlays during the analysed period for each discount rate separately,
– Internal Rate of Return (IRR), that is the discount rate at which NPV = 0 or $B/C = 1$.

Costs and benefits calculated in *ex ante* and *ex post* analysis as well as economic efficiency measures (IRR, B/C) were compared to develop the comparative cost-benefit analysis for the analysed investment project. Assessment of efficiency conducted in *ex post* analysis was done in 1999 prices while for the *ex ante* analysis in those of 1995. To assure compatibility of costs and benefits measured in the subject analyses individual values were converted to the monetary measures applied in *ex ante* analyses by means of the index of prices increase for consumption goods and services.

Results of studies

Net road-bridge costs

The costs of investment project in the *ex ante* analysis were assumed on the basis of the initial investor's bill of costs while the costs of investment project *ex post* are the actual outlays incurred. Comparison of the volume of outlays divided into settlement elements included in the pre-implementation and post-implementation analyses is presented in Table 1 and Figure 2. The data presented in table 1 indicate that in pre-implementation analysis 8 out of 10 elements of road works were priced. This, however, is not an error but only a contents difference between the two analyses. It was established that the value of elements not priced in the pre-implementation bill of costs (e.g. earthworks, elements of streets, etc.) were included in items "Base course" and "Surfaces". As a consequence, it had no influence on the scope of planned and implemented road works. The revealed discrepancy in contents makes partial comparative analysis of both research materials useless. In totalled values the actual outlays on road works were higher by 8,56% than the road works outlays estimated in pre-implementation analysis.

It was established that the higher *ex post* costs of the project as compared to the pre-implementation bill of costs resulted from performance of necessary supplementary works (mainly concerning bridges). Underestimation of the scope of necessary works (relatively frequent in construction sector) seems to be the main reason for the difference in costs found.

Table 1

Specification of Ostróda bypass modernization costs accounting elements in *ex ante* analysis and *ex post* actual values (in PLN)

No.	Specification of accounting elements	Investment costs		*Ex post/ex ante* [%]
		ex ante	*ex post*	
A.	Road works	4 824 220	5 237 024	108.56
1.	Preparatory works	0	913 899	–
2.	Earth works	0	117 062	–
3.	Body drainage	0	66 354	–
4.	Base course	938 120	350 406	37.35
5.	Surfaces	3 886 100	2 967 904	76.37
6.	Finishing elements	0	131 086	–
7.	Traffic safety devices	0	655 448	–
8.	Elements of streets	0	11 784	–
9.	Road greenery	0	0	–
10.	Other works	0	23 081	–
B.	Bridge works	2 333 170	395 114	16.93
	Total	7 157 390	5 632 138	78.69

Source: Own computations based on the data included in *ex ante* and *ex post* analyses.

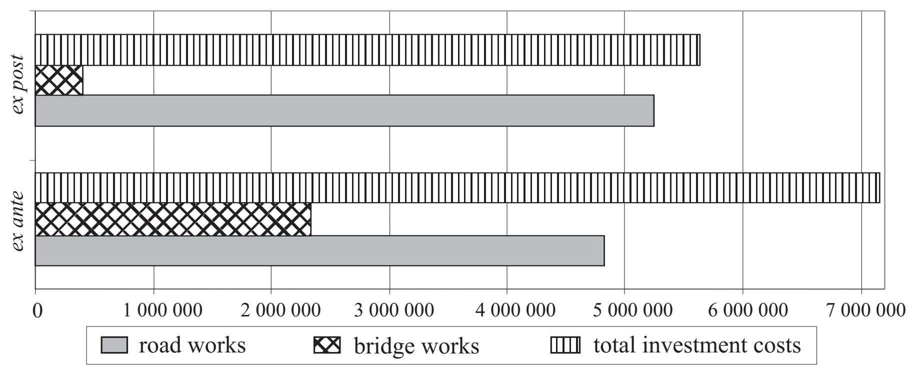

Fig. 2. Comparison of the elements of accounting for Ostróda bypass modernization project in *ex ante* and *ex post* analysis in actual values (in PLN)

Source: Own work based on the data included in *ex ante* and *ex post* analyses.

Net roads and bridges maintenance costs are also a component of the costs of roads and bridges in addition to the investment outlays. The roads maintenance costs include costs of periodic surface renovation, current refurbishment and current maintenance (snow removal, painting of horizontal signs, etc.). Net roads maintenance costs represent the difference between the costs estimated in the "zero" variant and costs in the investment variant.

The actual net roads maintenance costs (348 133 PLN) are definitely lower than the costs estimated in pre-implementation analysis (2 600 000 PLN) and represent only 13,4% of *ex ante* costs. The reason for the indicated underestimation is the significant differences in unit costs of road maintenance estimated in pre-implementation and post-implementation analyses. The relations between the outlays and net roads and bridges maintenance costs included in *ex ante* and *ex post* analyses influence the net value of roads and bridges costs directly (Tab. 2).

Table 2
Road and bridge costs net and their major components in *ex ante* and *ex post* analyses for Ostróda bypass modernization

Item	*Ex ante* (PLN)	*Ex post* (PLN)	*Ex post/ex ante* (%)
Investment project costs	7 157 390	5 632 138	78.69
Net roads maintenance costs	2 600 000	348 133	13.39
Net road and bridge costs (investment project costs minus maintenance costs)	4 557 390	5 284 005	115.94

Source: Own work based on the data included in *ex ante* and *ex post* analyses.

High savings on roads maintenance costs assumed in *ex ante* analysis would result in decreasing the investment outlays by 36,33%, while actually they were compensated in 6,18% only. Investment outlays in *ex post* analysis were lower by 21,31% than estimated in *ex ante* analysis.

Compensation of both described phenomena resulted in the situation that the net road and bridge costs as a result of project implementation were higher than estimated in the pre-implementation analysis by 15,94%.

Savings of users and environment costs

The next stage of road investment project efficiency assessment involves totalling all savings on user and environmental costs, i.e.:
– vehicles operational costs,
– costs of time of passengers and drivers,
– costs of road accidents,
– costs of emissions of flue gases arduous to the environment.

Net savings (benefits) are the difference between costs estimated in the "zero" variant and in the investment variant.

In case of the analysed investment project, in both *ex ante* and *ex post* analysis it was estimated that there would be no savings on the costs of passengers and drivers time. Modernization investment projects (and the project used as example qualifies as such) do not result in a change in the cross section of the road, or the purpose of W0 and WI variants the traffic density did not change and, as a consequence, the speed of vehicles remains at roughly the same level. This results in the same driving times in both variants and, as a result, the costs of time of road infrastructure users are identical. This causes zeroing of the balance of economic benefits of the variants for each year. For the same reasons it was estimated that there would be no savings on costs of toxic components of flue gases that are dependent mainly on the driving speed of automotive vehicles.

Figure 3 indicates that savings on automotive vehicles operation costs estimated in the post-implementation analysis are higher than in the pre-implementation analysis and represent 174,03% of *ex ante* estimated savings. Because as a result of implemented investment project the length of the road section did not change and technical parameters of the road were also the same, it should be concluded that significantly higher savings of costs in *ex post* analysis resulted from errors in projecting the traffic density occurring in *ex ante* analysis. This, in turn, could influence the level of unit costs used in computations. The studies conducted showed that savings on costs of traffic accidents were lower in *ex post* analysis and represent 74,7% of such costs determined in *ex ante* analysis.

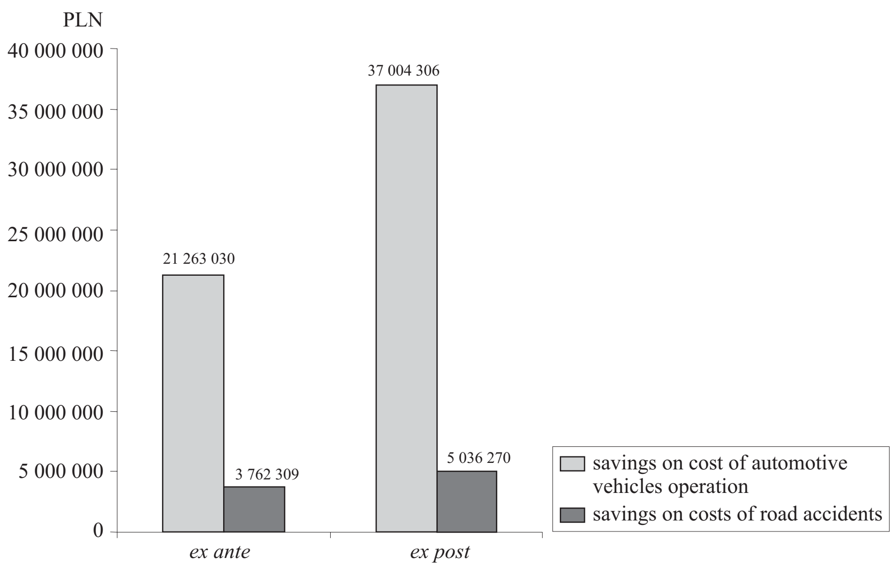

Fig. 3. Savings on automotive vehicles operation costs and costs of road accidents in *ex ante* and *ex post* analysis of Ostróda bypass modernization (PLN)
Source: Own work based on the data included in *ex ante* and *ex post* analyses.

During further diagnose of the observed phenomenon it was established that the accident rate indicators assumed for the post-implementation analysis were lower by ca. 50% than those assumed in pre-implementation analysis (i.e. the actual number of accidents was lower than planned). Additionally the situation was also influenced by lower costs per accident, because analyses of the other determining factors of accidents showed an increase of the same level in their values.

The total savings of user and environment costs resulting from bypass modernization amounted:

– *ex ante*: 26 299 280 PLN,
– *ex post*: 40 734 409 PLN.

The data presented indicate that the savings on user and environment costs estimated in *ex post* analysis were in case of the studied project higher than those estimated in *ex ante* analysis by 54,89%.

Measures of investment project economic efficiency *ex post* and *ex ante*

The cost-benefit analysis is conducted using aggregated data originating from partial analyses of individual components of costs and benefits conducted at the earlier stages. They allow assessment of efficiency of the analysed investment project. The investment efficiency assessment is done by means of the following indicators: net present value (NPV), benefits/costs indicator (B/C) and internal rate of return (IRR).

The values of those indicators are determined using the following formulas (PERKINS 1994, pp. 67 and 85):

$$\mathrm{NPV} = \sum_{i=0}^{n} \frac{(B_t - C_t)}{(1 + r)^t},$$

where:

NPV_r – net present value (discounted net profit – discounted net benefit at the discount rate r) from the investment project; positive NPV is the condition for accepting the project for implementation,
n – number of project use periods,
B_t – project benefits in the consecutive year t,
C_t – project costs in the consecutive year t,
r – financial or economic discount rate

$$B/C = \frac{\sum_{t=0}^{n} \frac{B_t}{(1 + r)^t}}{\sum_{i=0}^{n} \frac{C_t}{(1 + r)^t}}$$

IRR represents the economic discount rate at which the NPV = 0, i.e. investment outlays are covered by the future benefits resulting from it while the profit equals zero or $B/C = 1$. The higher the IRR than the social cost of capital in a given country, the higher is the contribution of a given project in increasing the social welfare. If the IRR is lower than the social costs of capital then the social welfare deteriorates as a consequence of implementation of the specific project.

Aiming at comparing the efficiency of the studied project at pre-implementation stage and *ex* post we focused on the comparative analysis of B/C and IRR indicators. In case the discount rate was assumed at 12% the benefits/costs indicator in *ex ante* analysis was lower (1,93) than in case of *ex post* analysis (2,55). There was also no large difference in the IRR, which in case of *ex ante* analysis was 22,95%, and in case of *ex post* analysis 26,97%. In other words, at that discount rate the project showed the NPV = 0 and $B/C = 1$.

The studies project was a public investment and its social use balanced the motif of profit and eliminated the alternative investment options from the decision path. In such a case, disregarding the imperfections in contents already indicated in this paper, at the stage of *ex ante* studies one should make absolutely sure as concerns the optimal organization of the project – starting from time-organization schedule of works across the entire project through the technical-technological choice of works performance (materials, techniques) while not decreasing the quality and companies-contractors and suppliers (project implementation costs) up to organization of traffic for the duration of road works. Only due diligence at the stage of public investment project planning and programming allows assuring economically optimal use of funds, which is reflected in the IRR.

Summary and conclusions

The comparative analysis of *ex ante* and *ex post* analyses for the project of Ostróda bypass modernization including assessment of efficiency of that investment project from the perspective of achieved benefits and incurred costs was the subject of interest here. Conducted studies allowed formulating the following conclusions:

1. Road and bridge costs were found underestimated by 15,94% in *ex ante* analysis as compared to *ex post* costs. That difference resulting mainly from prognostic, planning and estimation errors could determine the long-term success if implementation of the subject investment project.

2. User and environment costs savings estimated in *ex post* analysis are for the studied project higher than those estimated during *ex ante* analysis by 54,89%, which allows the project achieving higher than assumed parameters of economic efficiency. The difference detected, however, does not allow expressing a positive opinion on *ex ante* analysis as concerns its contents.

3. The internal rate of return showed a relatively low difference – IRR *ex ante* was 22,95%, and *ex post* 26,97%. This does not prove credibility of *ex ante* analysis. During the studies it was shown that during pre-implementation analysis significant inaccuracies in estimation of both the costs and the benefits related to the project occurred. It seems obvious that similarity of the IRR values is the resultant of the prognostic errors made and imperfection of methodological facilities in estimating efficiency of road projects.

In view of the above observations it should be concluded that it is necessary to further improve the methodological bases of *ex ante* analysis also in the direction of eliminating the human factor errors. That issue is of particular importance considering limited public funds allocated for funding of roar investment projects.

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References

BRZOZOWSKA K. 2005. *Finansowanie inwestycji infrastrukturalnych*. CsDeWn, Warszawa.

FRENKIEL W., DROBNIAK A. 2005. *Zorientowane na cele planowanie projektów rozwoju lokalnego*. Wydawnictwo Akademii Ekonomicznej w Katowicach, Katowice.

Instrukcja oceny efektywności ekonomicznej przedsięwzięć drogowych i mostowych. 2003. IBDiM, Warszawa,

Wytyczne dotyczące metodologii przeprowadzania analizy kosztów i korzyści. Metodologiczne dokumenty robocze. 2006. Komisja Europejska, Dyrekcja Generalna ds. Polityki Regionalnej, http://ec.europa.eu/regional_policy/sources/docoffic/2007/working/wd4_cost_pl.pdf

KAMIŃSKA T. 1999. *Makroekonomiczna ocena efektywności inwestycji infrastrukturalnych na przykładzie transportu*. Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk.

KOWALEWSKI M. 2005. *Koszty i korzyści inwestycji drogowych*. Wydawnictwo Uniwersytetu Warmińsko-Mazurskiego, Olsztyn.

KOWALEWSKI M., LELUSZ H. 2004. *Analiza efektywności ekonomicznej inwestycji drogowych*. Biuletyn Naukowy UWM, 24: 19-28.

PERKINS F. 1994. *Practical Cost Benefit Analysis*. Macmillan Education Australia, Sydney.