

UDC 330.322.5

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ON THE QUESTION OF COST-EFFECTIVENESS ANALYSIS OF INVESTMENT PROGRAMS

Objective. Development of methodological approach to the cost-effectiveness of investment program as a system of interrelated projects taking into account synergistic effect of their program interaction. **Methodology.** Used system approach and complex of general scientific and specialized methods of the research such as scientific obstruction, analyze and synthesis, network planning, quantitative finance, cost-effectiveness analysis of investments, qualitative and numerical scoring of risk level. **Results.** Cost-effectiveness analysis of investment program requires synchronization of investment projects, of which it consists, in this regard it is essential to use method of networking planning. Synergistic effect of investment program can be found in the dissimilarity of cash flow of investment program in general from the sum of cash flow of investment projects, which amounts it, and also from diversification of risks. To assess the last one, it is essential to do numerical risk scoring of each project and the program in general. It is efficient to take into account risk level by means of correcting discount rate, in this regard appropriate methodological approaches were offered in the research work. Major criterion of program effectiveness is value of its NPV, which is more or equal to zero. Additional criterion of effective interaction of investment projects as a part of program is requirement that program NPV will not be lower than integrated NPV of included investment projects, which were evaluated separately. **Scientific novelty.** There was updated methodological approach to cost-effectiveness analysis of investment programs, which unlike the existing, takes into account synergistic effects of investment program, which influence on its cash flow, and such effects, which are consequences of risks diversification within the framework of investment program. It allows to improve accuracy of cost-effectiveness analyses of investment programs as a system of interactive projects taking into account synergistic effect of their program interaction. **Practical implication.** Obtained results can be used to form investment programs, cost-effectiveness analysis, and also to optimize the content of investment program.

Key words: investments; investment program; economic effectiveness; risk; synergistic effect; net present value (NPV); internal revenue rate

Introduction

Under current conditions investment activity of economic entity in the sphere of real investments is realized, as a rule, by means of forming the programs of real investment, which are represented as complexes of interacted and time synchronized investment projects focused on reaching common goals, which are set by chosen investment strategy.

One of the stages for forming investment program is cost-effectiveness analysis. There is a well-developed methodological base of determining the cost-effectiveness of investment projects [see 1, 2, 4, 5, 12, 14]. However it requires further research and development of appropriate methodological approaches for analysis of synergistic economic effect of program interaction, which allow to ana-

lyze economic effectiveness of a program as the systems of interacted programs, i.e. analyze not separate investment projects, but the effectiveness of their complex realization.

Nowadays in Ukraine several statutory documents in the sphere of cost-effectiveness analyses of investments are in force. The main of them are:

- Procedure and criteria of cost-effectiveness analyses of project proposals and investment projects [13].

- Methodological recommendations on investment project development for realization of which can be provided state support [10].

- Methodological recommendations on economic and social effectiveness analyses of state target programs execution [11].

– Methodology on performance of state expert examination of investment projects [7].

– Methodological recommendations on development business plan of enterprises [9].

– Methodology of cost-effectiveness analyses on scientific researches and research results and their manufacturing implication [6].

Procedure and criteria of cost-effectiveness analyses of project proposals and investment projects [13] foresee, that cost-effectiveness analyses of investment project is performed on the base of following criteria: net present value; internal revenue rate; discounting payback period; profit investment ratio. Positive conclusion about effectiveness of investment project is if NPV is positive, internal revenue rate is more than normal standard of discount, profit investment rate is more than 1. Using the criteria of economic effectiveness meets modern principles, theoretical and methodological approaches and global practice in the sphere of investment valuation. However, mentioned document does not contain particular methodological approaches, but foresees, that criteria calculation of economic effectiveness of investment proposal, investment project is done taking into account Methodological recommendations on investment project development for realization of which can be provided state support, authorized by Ministry of Economic Development and Trade.

Methodological recommendations on investment project development for realization of which can be provided state support [10] contain (article 2.8) methodology of determining indexes of investments return. Methodological recommendations do not have information concerning risk assessment in the process of cost-effectiveness analyses of the project. It is foreseen to add information about project risks, preventive measures and risks hedging in cases contemplated by the laws (law point 2.10) as a separate paragraph. Moreover, only qualitative characteristic of risks is required. In other words, mentioned Methodological recommendations do not contain quantitative methods of risks assessment of investments and they are not taking into account in cost-effectiveness analyses of investment project.

Methodological recommendations on economic and social effectiveness analyses of state target programs execution [11] contain the algorithm of calculation for four main cost-and-saving factors of economic effectiveness, which are the same as methods of Methodological recommendations on investment project development. There was also offered to use several specific indexes for innovation projects: additional value, investment ratio

(private and public), index of commercialization, index of new product sale. Methodological recommendations, which are considered, contain evaluation method of synergistic economic effect of programs interaction, which gives an opportunity to estimate cost-effectiveness of the program as a system of interconnected projects, i.e. analyze not separate investment projects, but the effectiveness of their complex realization.

Synergistic effect of program interaction includes effects of programmed interlocking, concentration, specialization, cooperation and replication of intermediate and eventual results. Mentioned Methodological recommendations contain methodological approaches for determining of each effect. However, Methodological recommendations do not have methodological approaches related to risk level evaluation and risk assessment in the process of cost-effectiveness analyses of investment projects and programs.

Methodological recommendations on development business plan of enterprises [9] contain methodological approaches related to forecasting of cash flow from enterprise performance and determining the indexes of economic effectiveness of investments, they are similar to Methodological recommendations on investment projects development, but more detailed. Methodological recommendations do not contain approaches for scoring of risk level of investments. But on the base of analyses of point 2.1.10.3, can be drawn certain conclusion, that the major way of risks assessment in the process of cost-effectiveness analyses of investments, they determine as rise of discount rate on premium for risk, considering that “Discount rate (r) – profit ratio, which investors usually get from investments of analogic content and risk level”.

Methodology of cost-effectiveness analyses on scientific researches and research results and their manufacturing implication [6] contains approaches for determining the major indexes of project economic effectiveness. There are some differences from standard regulations discussed above in determining profitability ratio. In the Methodology it is determined as ratio of NPV to present value (PV) of investments, in the other standard regulations – ratio of PV of results (net incoming cash flow) to PV of investment costs. Giving the fact that Procedure and criteria of cost-effectiveness analyses of project proposals and investment projects [13] as effectiveness criterion determined that profitability index was more than 1. The index can be determined more correctly using Methodological recommendations on investment project devel-

opment for realization of which can be provided state support [10]. But Methodology [6] contains defined elements of methodological approaches on risk assessment in the process of cost-effectiveness analyses. To assess the uncertainty factor can be used the following methods: test of project resistance, correcting of project parameters, formalized description of uncertainty. Project resistance is determined with the help of break even point. Correcting of project parameters is performed on the base of updating initial technical and economic task, among them terms of project implementation resulting from delay of its financing, irregularities in the procedure of innovation, delay in delivery of materials and the other complications. In such duties breach are added project expenses. Point 3.22 (formula 3.16) Methodology [6] is foreseen using of capital assess pricing model to determine discount rate taking into account risk.

Therefore, national standard regulations in the sphere of cost-effectiveness analyses of investment projects shows certain methodological tools related to the structure of forecasted cash flow, determination of their components, calculation of the major economic effectiveness indexes of investments taking into account time factor. But there was paid less attention to quantitative risks assessment of investment projects and also when economic effectiveness is determined. It is essential to develop methodological approaches for assessment of investment programs as a single system taking into account synergistic effect of their interaction.

While analyzing international experience, it is necessary to claim attention at Russian Methodological recommendations on assessment of investment projects effectiveness [8]. There is given detailed account of basic principles, methods of efficiency assessment and financial realization of investment projects, which meet modern approaches and requirements. As effectiveness index was offered net profit, net present value, internal rate of return, demand for additional financing, profit investment ratio of investments, payback period, indicator set, which give characteristic to financial standing of the enterprise – participant of investment project. In comparison with Ukrainian methodologies there is foreseen wider variety of indexes, but the major is net discounting income, which is identical to NPV, internal rate of return, payback period taking into account discounting. Russian Methodological recommendations [8] contain the characteristic of incoming information, which is essential for effectiveness assessment, methodological approaches for assessment of social, budget and commercial effectiveness of the

project in general, effectiveness assessment of participating in the project, and also methods of accounting inflationary developments, uncertainty and risk (extend assessment of project sustainability, calculation of break-even point, method of parameters variation, assessment of project effectiveness taking into account qualitative characteristic of uncertainty, and also expert approaches for risks assessment in discount rate.

Objective

Objective of research work is development of methodological approach to the cost-effectiveness of investment program as a system of interrelated projects taking into account synergistic effect of their program interaction.

Methodology

End of purpose using system approaches and complex of general scientific and specialized methods of the research such as scientific obstruction, analyze and synthesis, network planning, quantitative finance, cost-effectiveness analysis of investments, qualitative and numerical scoring of risk level.

Results

Cost-effectiveness analyses of investment program, which consists of real investment projects can be performed in the following way:

1. Determine life cycle of each investment project, which is the part of the program and the program in general.
2. Forecast cash flow using base projects scenarios.
3. Form many scenarios of each investment project realization, which take into account influence of uncertainty and risks factors.
4. Determine internal revenue rate on invested capital of each scenario for each investment project of the program.
5. Qualitative assessment of risk level of each investment project.
6. Determine discount rate for each investment project on the base of connection return rate with risk level.
7. Determine NPV of each investment project using standard scenario and discount rates, which take into account risks.
8. Form standard scenario of investment program realization in general on the base of time referenced standard scenario of investment projects realization and forecasting of its cash flow.

9. Form many scenarios of programs realization, which take into account uncertainty and risks factors.

10. Determine internal revenue rate on invested capital of each scenario of the program.

11. Qualitative assessment of risk level of investment program in general.

12. Determine discount rate for the program in general on the base of connection return rate with risk level.

13. Determine NPV of each investment project using standard scenario and discount rates, which take into account risks.

14. Conditional check to guarantee program effectiveness in general.

Life cycle of each investment project is determined as sum duration of pre-investment, investment and operation stages. To determine full duration of program life style, it is necessary to synchronize in time all its investment projects on stages. It is recommended to use methods of network planning.

To determine forecasted cash flow of standard scenarios of investment projects it is necessary to do forecasting of net profit, amortization, investments, interest on long-term obligations and values changes of long-term obligations for each year of projects life cycle.

Net cash flow for invested capital is defined by the following formula:

$$NCF_{ic} = NP + A + I_{lto} \cdot (1 - \gamma) - I, \quad (1)$$

NCF_{ic} – net cash flow for invested capital;

NP – net profit;

A – amortization of payments, which is taken into account while determining net income;

I_{lto} – interest on long-term obligations;

γ – tax rate on income;

I – investments of nominal and circulate capital (sum of capital contributions, investments in fictitious assets and growth of working capital).

Financing of investments of nominal and circulate capital can be done at the expense of owned or borrowed capital. That is why net cash flow for investment capital shows project results for investors and creditors, participants of investment project.

Net cash flow for owned capital is defined by the formula:

$$NCF = NP + A - I + \Delta LTO, \quad (2)$$

NCF – net cash flow for owned capital;

ΔLTO – increment of long-term obligations.

Index of net cash flow for owned capital takes into account investments of owned capital and funds flow for procurement of borrowed capital. It reflects the results of investment project from the view point of investors.

Financing of owned capital investments can be done at the expense of enterprise internal sources, which is done the investment project (accumulated net profit and amortization assignments), and outward investments.

In the process of forming scenarios of project realization, forecasted cash flows for invested capital of each scenario, initial information, probability of each scenario realization are determined.

Internal revenue rate on invested capital of each scenario is determined by solution of equitation:

$$\sum_{t=0}^T \frac{NCF_{ic,t}}{(1 + IRR_{ic})^t} = 0, \quad (3)$$

IRR_{ic} – internal revenue rate on invested capital;

T – life cycle of investment project.

As qualitative index of risk level of investment project can be used standard deviation of internal revenue rate on invested capital. If there are known probabilities of scenarios realization, standard deviation is defined by the formula:

$$\delta_{IRR} = \sqrt{\sum_{i=1}^n (IRR_{ic,i} - M_{IRR})^2 \cdot p_i}, \quad (4)$$

δ_{IRR} – standard deviation of internal revenue rate and invested capital;

$IRR_{ic,i}$ – internal revenue rate on invested capital i-scenario;

M_{IRR} – mathematic correlation of internal revenue rate on investment capital;

p_i – probability of i-scenario realization.

Mathematical correlation is defined by formula:

$$M_{IRR} = \sum_{i=1}^n IRR_{ic,i} \cdot p_i. \quad (5)$$

If there is no information about probability of scenario realization, their set is considered as statistical sampling. In this case standard deviation is defined as sample estimation using the following formula:

$$\delta_{IRR} = \sqrt{\frac{\sum_{i=1}^n (IRR_{ic,i} - M_{IRR})^2}{n - 1}}. \quad (6)$$

Sample estimation of mathematical expectation of internal revenue rate on invested capital is defined by formula:

$$M_{IRR} = \frac{\sum_{i=1}^n IRR_{ic,i}}{n}. \quad (7)$$

To define discount rate, it is necessary to find formal connection between rate of return and risk level, evaluated as standard deviation of rate of return. One of the possible ways to reach it is analyses of bank deposits revenue position and obligation of domestic government loan (ODGL) according to data of National Bank of Ukraine. Statistic series of average profitability of appropriate tools are considered as statistical sampling, defined their estimation of expectations and standard deviation. Using these data, linear function of connection rate of return to risk level is built. It is reasonable to estimate revenue of bank deposit using average rate of interest of fixed deposits of economic entities in native currency. These rates should be corrected for coefficient of "tax shield" $(1-\gamma)$ and change to rate of return after tax assessment. The result of the procedure, which was examined, will be connection of specified rate of return after tax assessment to risk level, which is defined by standard deviation. This rate of return can be used as discount rate to define NPV, in case if it is used to predict cash flow of anticipated prices. Thereby it corresponds to weighted capital cost and can be used to discount net cash flow for invested capital.

More precise methodological approach, which defines correspondence of rate of return to risk level, is based on model probability of investment market.

To define the discount rate for owned capital, which is essential for adduction of net cash flow for owned capital, is used the formula:

$$R_{oc} = \frac{R_w - R_{bc} \cdot (1-\gamma) \cdot (1-\alpha)}{\alpha}, \quad (8)$$

R_{oc} – discount rate for owned capital;
 R_w – weighted capital cost;
 R_{bc} – interest on borrowed capital;
 α – part of owned capital in invested capital.

If are used base prices in the process of forecasting cash flow, inflationary component excludes from discount rate using the following formula:

$$R_r = \frac{R_n - i}{1 + i}, \quad (9)$$

R_r – real discount rate;

R_n – nominal discount rate;

i – inflation rate, which is forecasted.

Any other solid approach can be used to define the discount rate in accordance to level risk.

NPV of investment project is defined by formula:

$$NPV = \sum_{t=0}^T \frac{NCF_t}{(1 + R_{ow})^t}, \quad (10)$$

NPV – net present value.

Forming the base scenario of program realization in connection with time synchronized base scenarios of project realization and forecasting of their cash flows is done by means of dividing the data of base scenarios of investment projects taking into account their interaction. Thereby program cash flows can differ from sum of projects cash flows because of emergence (e.g. expenses exclusion, which duplicate; rise of assets productiveness by means of using intensification; using intellectual property assets formed in one project or another one and etc.).

Set of scenarios realization is built analogically to investment projects. Qualitative assessment of risk level of the program is defined by formula (4, 6). Furthermore, risk diversification in the framework of the program is taken into account, which is also is a display of its system effect. If investment program consists of separate projects and synergistic effect isn't defined in cash flows, it can arise as a result of influence of risk diversification upon the project and appear in common level of investment program risks.

Further procedures of program assessment are the same as assessment procedures of its separate parts (projects).

NPV of the program is defined by the formula (10).

Internal revenue rate on owned capital of the program is defined by solution of equation:

$$\sum_{t=0}^T \frac{NCF_{oc,t}}{(1 + IRR_{oc})^t} = 0, \quad (11)$$

де IRR_{oc} – internal revenue rate of owned capital.

The criterion of program effectiveness is a value of internal revenue rate on owned capital of the program, which is more or equal to program discount rate for owned capital.

Payback period of investment program is defined as time period from the beginning of program life cycle to the moment after which accumulated NPV of the program stops and remains positive.

Effectiveness criterion is value of dynamic pay-back period, which is less or equal to the level of program life cycle.

Profitability index is defined by formula:

$$ID = \frac{\sum_{t=0}^T \frac{NP_t + A_t}{(1 + R_{oc})^t}}{\sum_{t=0}^T \frac{I_t - \Delta LTO_t}{(1 + R_{oc})^t}}. \quad (12)$$

Criterion of program effectiveness is value of profitability index, which is more or equal to zero. The major criterion of program effectiveness is its NPV, which is more or equal to zero.

Additional criterion of effective interaction of investment projects as a part of a program is a condition – NPV of the program is not less than sum of net present worth of included project investments, which are evaluated separately. This criterion demands to provide positive synergistic program effect.

Scientific novelty.

There was updated methodological approach to cost-effectiveness analysis of investment programs, which unlike the existing, takes into account synergistic effects of investment program, which influence on its cash flow, and such effects, which are consequences of risks diversification within the framework of investment program. It allows to improve accuracy of cost-effectiveness analyses of investment programs as a system of interactive projects taking into account synergistic effect of their program interaction. Practical implication. Obtained results can be used to form investment programs, cost-effectiveness analysis, and also to optimize the content of investment program.

Conclusions

As a result of research can be done the following conclusions:

1. National standard regulations in the sphere of cost-effectiveness analyses of investment projects shows certain methodological tools related to the structure of forecasted cash flow, determination of their components, calculation of the major economic effectiveness indexes of investments taking into account time factor. But there was paid less attention to quantitative risks assessment of investment projects and also, when economic effectiveness is determined. It is essential to develop methodological approaches for assessment of in-

vestment programs as a single system taking into account synergistic effect of their interaction.

2. Cost-effectiveness analysis of investment program requires synchronization of investment projects, of which it consists, in this regard it is essential to use method of networking planning.

3. Synergistic effect of investment program can be found in the dissimilarity of cash flow of investment program in general from the sum of cash flow of investment projects, which amounts it, and also from diversification of risks. To assess the last one, it is essential to do numerical risk scoring of each project and the program in general.

4. It is efficient to take into account risk level by means of correcting discount rate, in this regard appropriate methodological approaches were offered in the research work.

5. Major criterion of program effectiveness is value of its NPV, which is more or equal to zero. Additional criterion of effective interaction of investment projects as a part of program is requirement that program NPV will not be lower than integrated NPV of included investment projects, which were evaluated separately.

6. Offered methodological approach can be used to optimize the structure of investment program. In this case the criterion of optimization is maximization of NPV of the program.

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ДО ПИТАННЯ ОЦІНКИ ЕКОНОМІЧНОЇ ЕФЕКТИВНОСТІ ІНВЕСТИЦІЙНИХ ПРОГРАМ

Мета. Розробка методичного підходу до оцінки економічної ефективності інвестиційної програми як системи взаємопов'язаних проєктів з урахуванням синергетичного ефекту їх програмної взаємодії. **Методика.** Застосовуються системний підхід та комплекс загальнонаукових та спеціальних методів дослідження: наукової абстракції, аналізу та синтезу, сітьового планування, фінансової математики, оцінки економічної ефективності інвестицій, якісного та кількісного оцінювання рівня ризику. **Результати.** Оцінка економічної ефективності інвестиційної програми вимагає синхронізації інвестиційних проєктів, з яких вона складається, для чого доцільно використовувати методи сітьового планування. Синергетичний ефект інвестиційної програми може виявитись у відмінності грошових потоків інвестиційної програми в цілому від суми грошовий потоків інвестиційних проєктів, що її складають, а також у диверсифікації ризиків. Для врахування останнього необхідно кількісне оцінювання ризикованості кожного з проєктів та програми в цілому. Доцільним є врахування рівня ризику шляхом коригування ставки дисконту, для чого в роботі запропоновані відповідні методичні підходи. Основним критерієм ефективності програми є величина її чистої приведенної вартості, що більша або дорівнює нулю. Додатковим критерієм ефективної взаємодії інвестиційних проєктів у складі програми є вимога, щоб чиста приведена вартість програми була не нижчою, ніж сумарна чиста поточна вартість включених до неї інвестиційних проєктів, оцінених окремо. **Наукова новизна.** Удосконалено методичний підхід до оцінки економічної ефективності інвестиційних програм, який, на відміну від існуючих, враховує синергетичні ефекти інвестиційної програми, що впливають на її грошові потоки, та такі, що є наслідком диверсифікації ризиків в межах інвестиційної програми, що дозволяє підвищити точність оцінки економічної ефективності інвестиційних програм як системи взаємопов'язаних проєктів з урахуванням синергетичного ефекту їх програмної взаємодії. **Практична значущість.** Отримані результати можуть використовуватись для формування інвестиційних програм, оцінки їх економічної ефективності, а також для оптимізації складу інвестиційної програми.

Ключові слова: інвестиції; програма інвестицій; економічна ефективність; ризик; синергетичний ефект; чиста приведена вартість; внутрішня норма доходу

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К ВОПРОСУ ОЦЕНКИ ЭКОНОМИЧЕСКОЙ ЭФФЕКТИВНОСТИ ИНВЕСТИЦИОННЫХ ПРОГРАММ

Цель. Разработка методического подхода к оценке экономической эффективности инвестиционной программы как системы взаимосвязанных проектов с учетом синергетического эффекта их программного взаимодействия. **Методика.** Применяются системный подход и комплекс общенаучных и специальных методов исследования: научной абстракции, анализа и синтеза, сетевого планирования, финансовой математики, оценки экономической эффективности инвестиций, качественного и количественного оценивания уровня риска. **Результаты.** Оценка экономической эффективности инвестиционной программы требует синхронизации составляющих инвестиционных проектов, для чего целесообразно использовать методы сетевого планирования. Синергетический эффект инвестиционной программы может выражаться в отличии денежных потоков инвестиционной программы в целом от суммы денежных потоков составляющих ее инвестиционных проектов, а также в диверсификации рисков. Для учета последнего необходимо количественное оценивание рискованности каждого из проектов и программы в целом. Целесообразным является учет уровня риска путем корректировки ставки дисконта, для чего в работе предложены соответствующие методические подходы. Основным критерием эффективности программы является величина ее чистой приведенной стоимости, превышающая или равная нулю. Дополнительным критерием эффективного взаимодействия инвестиционных проектов в составе программы является требование, чтобы чистая приведенная стоимость программы была не ниже, чем суммарная чистая текущая стоимость включенных в нее инвестиционных проектов, оцененных отдельно. **Научная новизна.** Усовершенствован методический подход к оценке экономической эффективности инвестиционных программ, который, в отличие от существующих, учитывает синергетические эффекты инвестиционной программы, влияющие на ее денежные потоки, и являющиеся следствием диверсификации рисков в рамках инвестиционной программы, что позволяет повысить точность оценки экономической эффективности инвестиционных программ как системы взаимосвязанных проектов. **Практическая значимость.** Полученные результаты могут использоваться для формирования инвестиционных программ, оценки их экономической эффективности, а также для оптимизации состава инвестиционных программ.

Ключевые слова: инвестиции; программа инвестиций; экономическая эффективность; риск; синергетический эффект; чистая приведенная стоимость; внутренняя норма дохода