Edward STAWASZ, Daniel STOS
University of Lodz
e.stawasz@uni.lodz.pl; d.stos@uni.lodz.pl

A METHOD OF SIMPLIFIED ASSESSMENT OF THE ECONOMIC POTENTIAL OF R&D PROJECTS

Key words

Management of R&D projects, assessment methods, commercialisation of research results.

Abstract

The paper presents a method of simplified evaluation based on the concept of the threshold (minimum) value of economic effects, i.e. the value covering capitalised project expenditures constituting the basis for estimating the rate of economic efficiency for different variants of R&D project implementation. The usefulness of the proposed method was assessed using the example of a research unit conducting advanced research and development activity in the area of technical solutions and their deployment in the field of electro-technical equipment and systems. The proposed method of assessing the economic potential can be used for the preliminary assessment of the project in the phase of the preparation of the project concept, when the research unit seeks to select project variants, as well as in the subsequent phases of the project implementation (at the designated checkpoints of the R&D project), when the research unit is focused on effectively managing the research process, making the decision on the continuation or termination of research activity.

Introduction

Research and development (R&D) projects are characterised, in contrast to typical investment projects, by high uncertainty in terms of achieving the intended scientific and technical as well as economic and market results. They

also require incurring significant material expenditure; hence, good management of their implementation is important [10]. In the initial stages of work on R&D projects, capital expenditures may be limited. However, as the work progresses to the subsequent phases, expenditures grow significantly, reaching the highest value at the level of industrial deployment. It is rare that all the phases of R&D project should be carried out in the framework of a single entity with a uniform ownership structure. Even in the early stages of the project, there is sometimes a need for technology transfer between entities. This transfer can be accomplished in different ways, but each requires to a smaller or larger extent an estimate of the value of the project at the stage in which the transfer is made [16].

The literature presents numerous interesting concepts of R&D project management (e.g., concepts of selection of innovative ideas, a staged process of evaluating R&D projects), as well as methods for measuring and assessing the commercial potential of R&D projects. The most popular methods of project evaluation include traditional financial and economic techniques based on the calculation of basic economic and financial parameters of projects, in particular, the ratio of economic outputs to inputs (e.g., the use of discounted cash flow calculation, which is also applied in the more developed analyses conducted by means of the decision tree method) [see: 1, 2, 6–9, 18–22]. These methods are usually complicated and expensive and simultaneously burdened with the high risk of errors in terms of the accuracy of forecasts. They require numerous market, technical, and legal analyses; therefore, they are used primarily in the "in-depth evaluation" of the economic potential of R&D projects or innovative solutions.

The aim of the paper is to present a method of simplified evaluation of the economic potential of R&D projects that can be used for the preliminary assessment of the project, even in the zero phase, when the research unit (primarily research institutes) seeks to select project variants and effectively manage the research process at the designated checkpoints of the R&D project. This method concerns the concept of the threshold value of economic effects, i.e. the value covering capitalised project expenditures constituting the basis for estimating the rate of economic efficiency for different variants of R&D project implementation. The lower the rate of economic effects based on their threshold value, the more effective is a given R&D project.

In the further section of the paper, an attempt is made to verify the proposed method based on the example of a research unit conducting advanced research and development in the area of technical solutions and their deployment in the field of electro-technical equipment and systems. The R&D project evaluation is always based on the assessment of their commercial potential. This potential can be estimated using a variety of analytical and synthetic indicators. The assessment, however, must result in the evaluation of the value of this potential.

1. Methodology of simplified evaluation of the economic potential of R&D projects

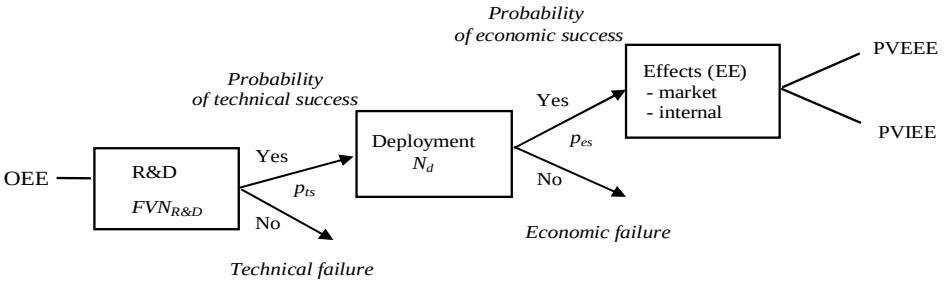
Research institutions and companies focused on the efficient management of R&D projects concentrate on searching for projects with a high technical, market, and economic potential [11, 23]. The principal issue in this area is the generation and assessment of a significant number of ideas/concepts in order to select in the evaluation process only the most attractive projects. One of the main issues is the efficient elimination of unattractive projects that do not suggest desirable results for the institution implementing the project. This process is problematic, because there is an inherent contradiction. On the one hand, the implementation of ineffective ideas takes time and money. On the other hand, a detailed analysis of the project is also expensive and absorbing (expert opinions, market research, etc.) [4].

The stage-gate assessment model (including stages and "stage gates") used in management of innovative projects can be seen as a basis of the methodology to evaluate the commercial potential of R&D projects. The essence of this approach is based on conducting only a general selection of ideas at the beginning of the project, then as the work progresses, evaluation criteria become increasingly detailed. Gradually, unattractive projects are "sifted out" and only the ones fit to be put onto the market in one way or another are left. Every subsequent phase of the project costs increasingly more than the previous one, which means that the assessment process assumes the growing commitment of time and resources, depending on the completion of assessment of subsequent phases in terms of the conformity of the idea with the strategy and objectives of the project and in terms of whether the idea meets certain technical, market, and financial criteria, and whether it can be tested or its production can be initiated [5, 15, 16].

The project phases are determined from the point of view of research and technique. Stage-gates are checkpoints for a particular phase of the project designated to assess the end results of a given phase and take the decision on whether to continue work on the project. The end result of each phase of R&D project includes specific outcomes. These are concepts and ideas of varying degrees of detail and documentation – components, prototypes, trials, and final versions. The evaluation of the commercial potential of R&D projects can be carried out before the commencement of the research and after each phase of the R&D process, i.e. the concept phase, the R&D phase, the prototyping and verification phase, as well as the deployment phase.

The use of the stage-gate approach, instead of the traditional approach, is particularly advisable in the early stages of developing new technologies, which – due to their technical and market novelty and a generally low degree of deployment maturity – are identified as high-risk phases [13].

The diagram of the process of in-depth assessment of the economic potential of R&D project is shown in Figure 1. It includes stages of R&D and deployment activities. The resulting economic effects of the application of new solutions can be divided into internal and market ones.



where

OEE	–	estimated economic value of the project at the time of commercialisation
FVNR&D	–	capitalised R&D expenditures at the time of commercialisation
Nd	–	deployment expenditures
EE	–	total sum of economic effects
PVEEZ	–	discounted at the time of commercialisation net value of market economic effects of the project
PVEEW	–	discounted at the time of commercialisation net value of internal economic effects of the project

Fig. 1. The process of in-depth assessment of the economic potential of R&D project

Source: The authors.

The starting point for the evaluation of R&D projects in the subsequent phases of their implementation is the ability to assess the probability of the deployment of the new solution obtained (technical success of R&D activities). If such opportunities exist, it is reasonable to make an in-depth economic assessment involving the identification of quantifiable economic effects of the commercial application of innovative solutions using categories such as revenues and profits, costs and expenditures, efficiency and productivity, quality and reliability, price, etc.

Regardless of the phase in which the assessment is carried out, it always takes into account the level of capitalised expenditures (taking into consideration changes in value over time) needed to carry out the subsequent phases of implementation and the level of deployment expenditures. Deviations from the assumptions in the area of the volume and structure of expenditures for the subsequent phases affect economic effects of the project and the valuation of results of deviations is an important element in the assessment.

The procedure for evaluating R&D projects may include a preliminary assessment (general) and a detailed (in-depth) assessment. The preliminary

assessment may be carried out for the zero phase (i.e. before deciding on the implementation of a given R&D project) and for the subsequent phases (i.e. the concept phase, the R&D phase, the prototyping and verification phases). Although the in-depth evaluation can be performed for each phase, it is advisable to carry it out in the later phases of the project, particularly in the phase of deployment and commercialisation, in order to determine the real possibility of implementing the solution through a detailed analysis of the factors affecting economic success.

Using one of the most popular methods of assessing the effectiveness of projects, it can be assumed that the estimated economic value of the R&D project is equal to the difference between the sum of discounted at the time of commercialisation values of economic effects of the R&D project, (i.e. the discounted net value of external economic effects of the project and/or the discounted net value of internal economic effects of the project) and the sum of the capitalised at the time of commercialisation expenditures incurred on the R&D and deployment phases, as indicated in the following:

$$OEE = (PVEEZ + PVEEW) - (FVN_{R\&D} + N_d).$$

The R&D project is economically viable, if OEE>0.

R&D expenditures include expenditures on subsequent phases and activities of project implementation and should be assessed using an interest rate as a basis for estimating the price of purchase of innovative solutions by the commercial user. For social projects, a minimum interest rate (e.g., 4%) can be assumed; however, for business projects, this rate should additionally include a risk premium. R&D expenditures have phase-specific standards in the course of the project (defined in the zero phase), and the adherence to these standards should be evaluated in terms of economic effects.

Deployment expenditures include overall expenditures for the commercial application of the solution; hence, they encompass not only the expenditures on commercialising the products of the project (internal expenditures), but also on their economic application (external expenditures). In the analysis, they are set at the minimum level necessary for the technical implementation of production under normal industrial conditions or under the guidance of industry innovators/ inventors, in the case of innovative solutions – the estimate is conducted by experts. Showing deployment expenditures in terms of economic effects serves to point research activities towards solutions that lower their necessary level and consequently increase the probability of commercialisation of research results.

R&D expenditures and deployment expenditures comprise initial expenditures on an innovative solution and can provide a basis for estimating the threshold effects ensuring the return on investment.

In the assessment of the commercial potential of R&D projects, when there is the possibility to reliably estimate economic effects, the project is economically viable, if the total sum of discounted economic effects is not lower than the sum of capitalised initial expenditures, as indicated in the following:

$$(PVEEZ + PVEEW) \geq (FVN_{R\&D} + N_d).$$

Only above this value ($FVN_{R\&D} + N_d$) is economic value added for the use of R&D results by an investor.

The earlier the time of the assessment of economic effects, the more difficult it is to reliably assess the market and financial parameters required to make this evaluation. Nowadays, however, there is a growing need for conducting such evaluations even in the zero phase, when a research unit seeks to select variants of research projects to implement and effectively manage the research process implementing many projects simultaneously, with limited resources and without the possibility of reliable estimation of economic effects.

The proposed methodology presented below of the "simplified evaluation" of the commercial potential is based on the concept of threshold effects understood as the quotient of the capitalised value of R&D expenditures (through their capitalisation at the time of commercialisation of research products) increased by estimated internal deployment expenditures by the product of the probability of technical and economic success. This leads to the determination of minimum economic effects that will cover not only expenditures, but also offset the risks of continuing research at a given level of risk. The estimated threshold effects are not the estimated value in the market sense, although their amount may be compared to the scale of achievable effects. However, they may serve as a "point of reference" in the subsequent phases of the research process by setting the upper threshold. In the course of the subsequent phases, the level of threshold effects should decrease. Therefore, it is a measure that allows one to "estimate" technical and economic risk associated with the project in terms of economic effects.

The technical success of R&D projects means achieving the set technical and organisational parameters (i.e. deployment maturity), while the economic success means achieving its set market and economic parameters (e.g., in terms of market share, profit growth rate or reduction in the cost of income growth, etc.). The probability of technical and economic success of R&D projects can be assessed by an expert method using, for example, scoring techniques of risk measurement, which includes the method for assessing the deployment (implementation) maturity of innovative technical projects (AID) [see: 12, 14]. The estimation of the probability of economic success of R&D projects is carried out with the use of the scoring method, taking into account

the following parameters [17]: (i) the area of economic benefits (the so-called "benefit tree"), (ii) the scale of the potential market, (iii) the scale of potential buyers, (iv) the scale of actual orders (the "built-to-order" research project).

An expert method should be used to assess the weights of individual parameters (generally uniform throughout the duration of the project, differentiated for variants and projects) and the number of points "awarded" in the given phase of the project. The probability of economic success is the weighted average of the share of the points awarded for a given parameter in a particular phase in the number of points arising from the weights of the parameters and the weights adopted for the different parameters.

The proposed method provides a simplified assessment of economic effects that consists in replacing forecasts of future economic benefits (revenue increase, cost reduction) and external expenditures on deployment with subjective, experts' assessments of the probability of technical and economic success of the project implementation in the specific, identified areas of risk. Deployment expenditures are limited to internal expenditures incurred by the research unit in the phase of commercialisation of products of R&D project.

By applying the concept of future value in estimating R&D expenditures, the threshold value of economic effects, covering thus capitalised initial costs of the research project, decreases along with shortening the time period between the moment of incurring expenditures and the time of commercialisation of research results, which allows the inclusion of the duration of the research process into the criteria of project evaluation using the efficiency ratio of research activities calculated as the quotient of the sum of capitalised expenditures and the sum of nominal expenditures.

For the assessment of R&D projects, two measures related to the concept of threshold effects may be used: an absolute measure (the future threshold value of economic effects – FTEE) and a relative measure (the estimated rate of economic efficiency – EER). The use of absolute measure in the zero phase allows the comparison of the economic efficiency of individual variants of the implementation of the given R&D project as well as the monitoring of changes in the assessment of effectiveness in the subsequent phases of the project, since the reduction in the value of these indicators in the subsequent phases of implementation of the project justifies its positive evaluation. This measure also allows one to select the projects to be implemented by the research unit at a given level of total expenditures that the unit can finance. The use of relative measure allows one to select the project with the highest economic potential out of a group of projects with different levels of R&D expenditures and internal deployment expenditures. Out of two or more projects, the project for which the estimated rate of economic effects is lower is more effective.

The method of calculating both measures for the total project expenditures (research and deployment) is presented below:

$$FPEE = (FVN_{R\&D} + FVP_k + N_d)/(p_{st} * p_{se})$$

where

FPEE – future threshold value of economic effects (at the time of commercialisation of the project),
$FPEE_{R\&D}$ – future value (at the time of commercialisation of the project) of R&D expenditures,
FVP_k – future (at the time of commercialisation) value of revenues from commercialisation of research products created in the phases of the R&D project implementation
N_d – nominal value of internal deployment expenditures,
p_{ts} – probability of technical success of the project,
p_{es} – probability of economic success of the project.

Whereas, the rate of economic efficiency (SPEE) is as follows:

$$SPEE = (FPEE – N_{R\&D} – N_d)/(N_{R\&D} + N_d)$$

where

FPEE – future threshold value of economic effects (at the time of commercialisation of the project),
$N_{R\&D}$ – nominal value of R&D expenditures.

Both discussed measures of evaluating the commercial potential of R&D projects allow the effective management of an innovative project at the designated project checkpoints.

2. Simplified evaluation of the economic potential of selected R&D projects

The simplified evaluation of the commercial potential of R&D projects can be carried out by various entities, such as research institutes, institutions distributing public funds, universities, or businesses with innovative capital, which can independently implement the research process or any part thereof in cooperation with other units. The assessment may be useful in the zero phase for the selection of projects for implementation with a limited research (human, technical or financial) potential or in the various phases of the project to determine the progress of the work and select (screen) projects that are not promising in terms of their effective commercialisation.

The application of the simplified assessment of the commercial potential of two R&D projects for the zero phase is shown below, based on the example of an R&D unit in order to decide on the inclusion of one of these projects in the project portfolio when applying for public funds for their implementation.

Project A is related to the development of an innovative product for civil aviation, based on 3-D components, the total project expenditures were estimated for the period of 4 years at 15 million PLN (including one year of deployment activities). The share of the R&D unit's private funds in the financing of the project should be 15%. Although the distribution of expenditures in time differs, the financing structure (public funds vs. private funds) is constant throughout the project. The phase of research concept preparation (6 months) and the commercialisation phase (6 months) are financed entirely by the research unit's funds. The period of the preparation of the concept of research activities was six months.

Project B is related to R&D activities associated with the development of a technology and initiating the production of individual medical implants. The involvement of a manufacturing company is planned during the implementation of the project. Its participation is to be connected with designing and constructing a production line for the manufacture of implants used in surgery on the skull and with conducting experimental studies on selected implants. The total expenditures for the project are estimated at 10 million PLN, and the deployment expenditures are estimated at approx. 2.5 million PLN. The duration of the project is planned for 2 years, and the period of deployment is estimated at 12 months. The share of the R&D unit's and the manufacturing company's private funds in the financing of the project should be 25% of the total expenditures, and the remaining funds would be raised in the form of public assistance in the framework of competition organised by the National Centre for Research and Development. Although the distribution of expenditures in time differs, the financing structure (public funds vs. private funds) is constant throughout the project. The period of the preparation of the concept of research activities was six months.

The human, technical, and financial potential of the R&D unit allows it to participate in only one project, which is associated with the need for the project selection. Therefore, the analysis had to be conducted in the zero phase of both projects.

The preliminary calculation of expenditures on the implementation of the prepared projects is as follows:

1) Both projects will be implemented in four R&D phases:
   a) The concept preparation phase,
   b) The basic research phase,
   c) The research and development phase, and
   d) The prototype and deployment testing phase.
2) The next part of the project implementation is the phase of deployment (commercialisation) of the research results obtained, including deployment activities related to the testing and the demonstration of the way the products work, as well as to the search for market applications of technologies developed.

The basic assumptions of project A are as follows:

1) Total expenditures on the project implementation 15,000 thousand PLN, of which:
   a) on R&D activities 12,000 thousand PLN,
   b) on deployment activities related to commercialisation 3,000 thousand PLN.
2) The expenditures will be financed from both public and private funds (the R&D unit's funds):
   a) The conceptual work is 100% financed by the R&D unit's own funds,
   b) R&D activities are 85% financed by public funds and 25% by the R&D unit's own funds, and
   c) Commercialisation of the research is 100% financed by the R&D unit's own funds.
3) The probability of technical success of the project was evaluated by the expert research method at the level of 0.8 and of the economic success at the level of 0.9.
4) On the basis of the preliminary assessment of the commercial potential of the project, the main risk factors of the project implementation were estimated, divided into technical factors (related to R&D and deployment) and economic factors (related to economic, production and market parameters), which allowed estimating the cost of capital in terms of different sources of financing for the project in its different phases.
5) The risk factors related to the implementation of the project and its commercialisation were included in the cost of private capital and the social cost of public capital was assumed at the lowest level – the rate of return on the lowest risk investment, i.e. without the project risk premium – currently, for example, bonds at 4%. For the earliest periods, the risk rates typical of the highest risk projects, from 15% to 7%, were assumed. The value of deployment expenditures was estimated for the time of the planned commercialisation of the project (the end of zero period).
6) In order to estimate the future value of the indicators, it was assumed that the expenditures on the various phases of the research will be incurred “in advance”, and expenditures on its deployment incurred “in arrears”. Thus, the time for incurring the first expenditures and the time for incurring the expenditures on commercialisation of the project divides the implementation of the project into five periods.
7) The value of internal deployment expenditures was estimated at 3,000 thousand PLN for the time of the planned commercialisation of the project (the end of zero period).

In the light of the above-presented assumptions, the economic potential of project A can be evaluated (see: Table 1). The capitalised value of expenditures on research project A excluding deployment expenditures is 13,477 thousand PLN, at the nominal value of expenditures at the level of 12,000 thousand PLN,

and the total capitalised value of expenditures including deployment expenditures is 16,477 thousand PLN, at the nominal value of expenditures at the level of 15,000 thousand PLN. Assuming that the probability of technical success amounts to 0.8 and of the economic success to 0.9, the threshold value of economic effects of the project ensuring the return on investment is as follows:

- For the return on private expenditures 8,587 thousand PLN,
- For the return on total expenditures 22,885 thousand PLN.

The estimated rate of economic efficiency is respectively:

- For the return on private expenditures 0.5793,
- For the return on total expenditures 0.5256.

The basic assumptions of project B are as follows:

1) Total expenditures on the project implementation 10,000 thousand PLN, of which:
   a) on R&D activities 7,500 thousand PLN
   b) on deployment activities related to commercialisation 2,500 thousand PLN
2) The expenditures will be financed by both public and private funds (the R&D unit's funds and the funds of the deploying company):
   a) The conceptual work is 100% financed by the R&D unit's own funds.
   b) R&D activities are 85% financed by public funds and 25% by the R&D unit's own funds.
   c) Commercialisation of the research is 100% financed by the deploying company's own funds.
3) The probability of the technical success of the project was evaluated by the expert research method at the level of 0.8 and of the economic success at the level of 0.9 – similarly to project A.
4) On the basis of preliminary assessment of the commercial potential of the project, the main risk factors of the project were estimated, divided into technical and economic ones, which allowed estimating the cost of capital for the different sources of funding for the project in its various phases.
5) The risk factors associated with the deployment of the project and its commercialisation are included in the cost of private capital and the social cost of public capital assumed as in project A.
6) The assumptions for estimating future values were adopted as in project A.
7) The value of deployment expenditures was estimated at 2,500 thousand PLN for the time of the planned commercialisation of the project (the end of zero period).

In the light of the above-presented assumptions, the commercial potential of project B can be evaluated (see: Table 2). The capitalised value of expenditures on research project B is 8,122 thousand PLN, at the nominal value of expenditures at the level of 7,500 thousand PLN, and the total capitalised value

of expenditures including deployment expenditures is 10,622 thousand PLN, at the nominal value of expenditures at the level of 10,000 thousand PLN. Assuming that the probability of technical success amounts to 0.8 and of the economic success to 0.9, the threshold value of economic effects of the project ensuring the return on investment is as follows:

- For the return on private expenditures 6,823 thousand PLN,
- For the return on total expenditures 14,753 thousand PLN.

The estimated rate of economic efficiency is respectively:

- For the return on private expenditures 0.4833,
- For the return on total expenditures 0.4753.

Given the above-presented results of the analysis of the projects, it can be concluded that project B is economically more effective, taking into consideration only private expenditures, where SPEE(A) = 0.5793 > SPEE(B) = 0.4833, as well as taking into account the total expenditures, including the expenditures financed by public funds, where SPEE(A) = 0.5256 > SPEE(B) = 0.4753.

Therefore, presented method of the assessment of the threshold value of the project (FPEE) can be used for the evaluation of variants of the implementation of the particular project or various projects that differ in terms of the following:

- The length of the period in which work is conducted in the different phases of the project (e.g.: its increase or decrease),
- The distribution of expenditures in time,
- The cost of capital used to finance the project,
- The structure of the sources of funding of the expenditures, and
- The assessment of the probability of technical and economic success.

The presented calculations show that B variant is more effective, because the estimated threshold value of economic effects to cover the expenditure is 14,753 thousand PLN (for project A respectively 22,885 thousand PLN), even though this option requires a relatively larger financial contribution on the part of the research unit in financing the expenditure (25% for project B, and 15% for project A).

The FPEE as an absolute value is not useful, however, for the comparison of variants of the given project differing in terms of initial expenditures. The rate of economic efficiency may be used for this purpose. When the possibility of implementing projects is limited, the portfolio of R&D projects implemented by a given research unit should consist of projects with the lowest value of EER and the "k" number of projects for which the following holds true:

$$\sum_{i=1}^{k} N_{R\&D}(P_i) < N$$

where

$N_{R\&D}(P_i)$ – nominal expenditures for i-th research project,

N – total value of expenditures that a research unit can incur (including subcontracts to other research units).

Table 1. The assessment of the economic potential of project A

	Item	Total	Total	Duration of project implementation					Total	Total
	The period of expenditures until the completion of R&D activities			–4	–3	–2	–1	0		
	Phases	$N_{R\&D}$	$N_{R\&D}+N_d$	Phase I*	Phase II	Phase III	Phase IV	N_d	$FVN_{R\&D}$	$FVN_{R\&D}+N_d$
I	Estimated value of expenditures	12000	15000							
1	percentage distribution in time	80%	100%	5%	20%	25%	30%	20%		
2	distribution of financial resources in time	12000	15000	750	3000	3750	4500	3000		
II	Structure of financing the expenditures									
1	percentage structure									
a	public funds			0,%	85%	85%	85%	0%		
b	private funds			100%	15%	15%	15%	100%		
	including:									
	R&D unit			100%	100%	100%	100%	100%		
	other private entities									
2	structure of financial resources	15000								
a	public funds	9562.5		0	2550	3187.5	3825	0		
b	private funds	5437.5		750	450	562.5	675	3000		
	including:									
	R&D unit	5437.5		750	450	562.5	675	3000		
	other private entities	0		0	0	0	0	0		
III	Cost of capital									
1	public funds			4%	4%	4%	4%			
2	private funds			15%	12%	9%	7%			
IV	Future value indicators									
1	public funds			1.147141	1.124864	1.0816	1.04	1.000000		
2	private funds			1.630957	1.327532	1.137993	1.07	1.000000		
V	Capitalised expenditures									
1	public funds			0	2868	3448	3978	0	10294	10294
2	private funds			1223	597	640	722	3000	3183	6183
VII	The sum of capitalised expenditures at the time of completion of R&D activities								13477	16477
VIII	The efficiency ratio of R&D activities								0.8904	0.9104
IX	Probability of technical success	0.8								
X	Probability of economic success	0.9								
XI	FPEE to cover private expenditure									8587
XII	SPEE for private expenditures									0.5793
XIII	FPEE for total expenditures									22885
XIV	SPEE for total expenditures									0.5256

Source: The authors' calculations; FPEE – future threshold value of economic effects; SPEE – the estimated rate of economic efficiency of the project; * – the conceptual phase of the project lasting 6 months.

Table 2. The assessment of the economic potential of project B

	Item	Total	Total	Duration of project implementation					Total	Total
	The period of expenditures until the completion of R&D activities			-4	-3	-2	-1		0?	
	Phases	$N_{R\&D}$	$N_{R\&D}+N_d$	Phase I*	Phase II	Phase III	Phase IV	N_d	$FVN_{R\&D}$	$FVN_{R\&D}+N_d$
I	Estimated value of expenditures	7500	10000							
1	percentage distribution in time	33%	25%		3%	30%	42%	25%		
2	distribution of financial resources in time	7500	10000	0	300	3000	4200	2500		
II	Structure of financing the expenditures									
1	percentage structure									
a	public funds				0%	75%	75%	0%		
b	private funds				100%	25%	25%	100%		
	including:									
	R&D unit				100%	100%	100%	0%		
	other private entities							100%		
2	structure of financial resources	10000								
a	public funds	5400		0	0	2250	3150	0		
b	private funds	4600		0	300	750	1050	2500		
	including:									
	R&D unit	2100		0	300	750	1050	0		
	other private entities	2500		0	0	0	0	2500		
III	Cost of capital									
1	public funds	4%		4%	4%	4%	4%			
2	private funds	7%		15%	12%	9%	7%			
IV	Future value indicators									
1	public funds			1.147141	1.10302	1.0816	1.04	1.000000		
2	private funds			1.630957	1.327532	1.1881	1.07	1.000000		
V	Capitalised expenditures									
1	public funds			0	0	2434	3276	0	5710	5710
2	private funds			0	398	891	1124	2500	2413	4913
VII	The sum of capitalised expenditures on the day of completion of R&D activities								8122	10622
VIII	The efficiency ratio of R&D activities								0.9234	0.9414
IX	Probability of technical success	0.8								
X	Probability of economic success	0.9								
XI	FPEE to cover private expenditure									6823
XII	SPEE for private expenditures									0.4833
XIII	FPEE for total expenditures									14753
XIV	SPEE for total expenditures									0.4753

Source: The authors' calculations; FPEE – future threshold value of economic effects; SPEE – the estimated rate of economic efficiency of the project; * – the conceptual phase of the project lasting 6 months.

Conclusions

In general, it can be assumed that one of the methods to assess the economic potential of R&D projects can be a simplified evaluation based on the concept of the threshold value of economic effects. The nature of the method consists in replacing forecasts of future economic benefits (revenue increase, cost reduction) and external expenditures on deployment with subjective experts' assessments of the probability of technical and economic success of implementation of the project in specific identified areas of risk. This method can be used widely, e.g., in the initial assessment phase of the project, even in the zero phase, when a research unit seeks to select variants of projects and effectively manage its project portfolio and the research process at the designated checkpoints in the R&D project as well as compare economic efficiency of different projects. The research unit, by "sifting" through projects with the use of this method, selects the most effective projects and pathways to their implementation with limited funding opportunities of financing the total expenditure for the projects.

It is worth noting that the threshold value of economic effects of R&D projects estimated based on the proposed method does not specify the expected benefits derived from commercialisation of products of the given project, it is only a reference point for subsequent stages of evaluation. The advantage of the proposed method is that it requires no estimation of market and economic parameters associated with high risk, which are particularly difficult to assess in the early stages of R&D projects. This simplified evaluation, however, is no substitute for the in-depth assessment of the economic efficiency of R&D projects carried out in the phase when the decision concerning their implementation is made.

The assessment based on the concept of threshold economic effects can be used to evaluate different project variants that differ in terms of the following:

- The length of the period in which work is conducted in the different phases of the project;
- The amount of R&D expenditures and internal deployment expenditures, as well as their distribution in time;
- The type of sources of funding of the expenditures;
- The scale of revenues from commercialisation of selected research products in various stages of R&D; and,
- The probability of technical and economic success.

The analysed cases using the concept of the threshold value of economic effects indicate that it can be used to evaluate different project variants that differ in terms of the following:

- The length of the period in which work is conducted in the different phases of the project (e.g., its increase or decrease);
- The distribution of expenditures in time;

– The distribution of sources of funding of the expenditures; and,
– The assessment of the probability of technical and economic success.

References

1. Achleitner A.-K., Lutz E., First Chicago Method: Alternative Approach to Valuing Innovative Start-Ups in the Context of Venture Capital Financing Rounds, "Betriebswirtschaftliche Forschung und Praxis (BFuP)", 2005, Vol. 57, No. 4, pp. 333–347.
2. Bandarian, R. Evaluation of Commercial Potential of a New Technology at the Early Stage of Development with Fuzzy Logic, "Journal of Technology Management & Innovation", 2007, Vol. 2, Issue 4, pp. 72–85.
3. Berg S., Water utility benchmarking: measurement, methodologies, and performance incentives, IWA Publishing, London 2010.
4. Christensen C.M., Kaufman S.P., Shih W.C., Zabójcy innowacji, "Harvard Business Review Polska", 2008, nr 65/66, p. 145.
5. Cooper R.G., Product Leadership. Pathways to Profitable Innovation, Basic Books, New York 2005, p. 200.
6. Ćwiąkała-Małys A., Nowak W., Sposoby klasyfikacji modeli DEA, „Badania Operacyjne i Decyzje", 2009, nr 3, pp. 5–18.
7. Domagała A., Metoda data envelopment analysis jako narzędzie badania względnej efektywności technicznej, "Badania Operacyjne i Decyzje", 2007, Nr 3–4, pp. 21–34.
8. Gwarda-Gruszczyńska E., Modele procesu komercjalizacji nowych technologii w przedsiębiorstwach. Uwarunkowania wyboru – kluczowe obszary decyzyjne, Wyd. Uniwersytetu Łódzkiego, Łódź 2013, pp. 86–105.
9. Heidenberger K., Stummer CH., Research development project selection and resources allocation: a review of quantitative modeling approaches, "International Journal of Management Reviews", 1999, No. 1(2), pp. 197–224.
10. Kisielnicki J., Zarządzanie projektami badawczo-rozwojowymi, Wolters Kluwer – Oficyna, Warszawa 2013, p. 14.
11. Krawiec F., Zarządzanie projektem innowacyjnym produktu i usługi, Difin, 2000, pp. 28–29.
12. Mazurkiewicz A., Belina B., Giesko T., Karsznia W., Operational system for the assessment of the implementation maturity level of technical innovations, „Problemy eksploatacji. Maintenance Problems", 2013, nr 4, pp. 79–92.
13. Mazzarol T., Entrepreneurship and Innovation, Tilde University Press, Prahran 2011, p. 417.
14. Rutkowski I.P., Zmodyfikowane metody analizy portfelowej i ich zastosowanie do oceny projektów innowacji produktowych, „Nauki o zarządzaniu. Management sciences", 2013, Nr 4(17), pp. 109–122.

15. Stabryła A., Metodyka podejmowania decyzji w systemie dwustopniowej oceny projektów, „Zeszyty Naukowe AE w Krakowie", 2006, nr 700.
16. Stawasz E., Stos D., Selected aspects of the valuation of innovative undertakings, "Operations Research and Decisions," 2011, nr 3–4, pp. 57–68.
17. Stawasz E., Głodek P, Stos D., Stos-Roman A., Metody analizy potencjału wdrożeniowego i komercyjnego innowacyjnego produktu technicznego lub procesu technologicznego, Uniwersytet Łódzki, Łódź 2013, p. 46.
18. Thomke S., Enlightened Experimentation: The New Imperative for Innovation, "Harvard Business Review", 2001, Vol. 79, No 2, pp. 69–75.
19. Thore S.A. (ed.), Technology Commercialization: DEA and Related Analytical Methods for Evaluating the Use and Implementation of Technical Innovation, Kluwer Academic Publishers, Boston/ Dordrecht/London 2002, pp. 23–44.
20. Tritle G.L., Scriven E.F.V., Fusfeld A.R., Resolving Uncertainty in R&D Portfolios, "Research-Technology Management", 2000, Vol. 43, No 6, pp. 47–55.
21. Trzmielak D., Komercjalizacja wiedzy i technologii – determinanty i strategie, Wyd. Uniwersytetu Łódzkiego, Łódź 2013, pp. 162–175.
22. Valderrama T.G., Groot T.L.C.M., Controlling the Efficiency of University Research in the Netherlands, [in:] THORE S. (ed.), Technology Commercialization: DEA and Related Analytical Methods for Evaluating the Use and Implementation of Technical Innovation, Kluwer Academic Publishers, Boston/Dordrecht/London 2002, pp. 147–182.
23. Wang J., Lin W., Huang Y-H., A performance-oriented risk management framework for innovative R&D projects, "Technovation," 2010, Vol. 30, No 11–12, pp. 601–611.

Metoda uproszczonej oceny potencjału ekonomicznego projektów B+R

Słowa kluczowe

Zarządzanie projektami B+R, metody oceny, komercjalizacja produktów badawczych.

Streszczenie

W artykule przedstawiono metodę uproszczonej oceny opartej na koncepcji wartości granicznej (minimalnej) efektów ekonomicznych, czyli wartości pokrywającej zaktualizowane nakłady na projekt, stanowiącej podstawę

szacowania stopy efektywności ekonomicznej dla wariantów realizacji projektów B+R[5].

Oceny przydatności proponowanej metody dokonano na przykładzie jednostki badawczej prowadzącej zaawansowane prace badawczo-rozwojowe i wdrożeniowe nad rozwiązaniami technicznymi w dziedzinie urządzeń i systemów elektrotechnicznych. Proponowana metoda oceny potencjału komercyjnego może być stosowana zarówno w ramach oceny wstępnej projektu, jak i w fazie przygotowania koncepcji projektu, gdy podmiot badawczy stara się wybrać warianty realizacji oraz po poszczególnych etapach realizacji projektu (w punktach kontrolnych projektu B+R), gdy podmiot badawczy stara się skutecznie zarządzać procesem badawczym rozstrzygając o kontynuowaniu lub wstrzymaniu prac badawczych.

[5] Metodyka jest podana jest za E. Stawasz, D. Stos, *Metoda oceny potencjału ekonomicznego projektów B+R*, „Przegląd Organizacji", 5/2015, s. 4–9.