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OPTIMIZATION OF INNOVATIVE PROJECT REALIZATION CONDITIONS

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A characteristic feature of the innovation process is the uncertainty with the term of efficient use of the new product. The article proposes the use of the "modified internal rate of return" indicator for determining the period of implementation of an innovative project. The application of the present recommendations contributes to an increased objectivity while making important managerial decisions related to setting an optimal duration of innovation use, planning the efficiency value of the employed capital, comparing alternative innovative projects, and also predicting the need for further development of innovations or their complete replacement by more progressive ones.

Keywords: innovative project, economic efficiency, optimization

1. INTRODUCTION

In countries with a high intellectual capacity the tendencies to develop innovative production have become more and more evident in recent times. However, the conditions for initiating innovations can be different. For instance, in Eastern European countries, policies on the implementation of innovative technologies are formed with the issues of regional convergence as the first priority. On a global scale, in regions such as India and China, it is achieved by means of creating a supportive environment for innovative production by offering preferential taxation, simplified registration and operating procedures in special economic areas of these countries.

It is to be noted that the internationalization of economic space and the availability of a large science and technology potential are contributing factors to attract-

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ing global investors, including the Federal Reserve System and the International Monetary Fund, to innovation projects. The activities of these and other organizations increase to a certain degree the opportunities for economic operators of different forms and scales to finance their innovation projects.

On the one hand, new innovative production opportunities simplify the process of attracting investment; on the other hand, they contribute to increasing the requirements of the financed new developments. To a considerable extent the latter refers to the conditions and results of project realization.

2. ANALYSIS OF RECENT PUBLICATIONS

Different theoretical and practical aspects of carrying out innovative activities are represented in the works by such scientists as Drucker (2001), Mintzberg (2013), Stiglitz (2003), Gorynia (2012), Pajak (2015), Blaszczyk (2016), Zwierzchlewski (2016) and Nowak and Kazmierczyk (2013). In Ukraine and post-Soviet countries this line of research has been developed by Dementev (2010, 2011), Lyashenko (Ivanov, Lyashenko, Tolmachova, Kvilinskyi, 2016; Lyashenko, Kvilinskyi, 2016; Pajak, Lyashenko, Kvilinskyi, 2015), Ivanov (2016), Khobta (2003), Bondareva (2015), Meshkov (Bondareva, Kravchenko, Meshkov, 2015), Tolmacheva (Ivanov, Lyashenko, Tolmachova, Kvilinskyi, 2016), Dalevska (Dementev, Dalevska, 2015), Petryna, Tarajewska and Werbowska (2015).

The fundamentals of modern management, including management of innovation projects, have been deeply analyzed by P. Drucker (2001). H. Mintzberg (2013) and B. Alstrand (2013) have dedicated their studies to modern strategic aspects of management. Regarding the issue of direct foreign investment in the countries of Central and Eastern Europe, M. Gorynia (2012) placed emphasis on the modernization of the economies of these regions. Innovation in the context of globalization problems is presented in the work of Stiglitz (2003). The role of small business and its main innovative landmarks have been studied in the works of Pajak (2015), Blaszczyk (2016), Zwierzchlewski (2016), Ivanov (2016), Lyashenko (2016), Tolmachova (2016) and Khobta (2003).

In Lyashenko and Kvilinskyi (2016), the role of external political factors in the development of a national economy has been analyzed; while special attention has been paid to the reflection on economic processes. Further, the relationship between the institutional peculiarities of the economic systems and their innovative component in the context of global development and states of economic crisis, has been demonstrated in the following works: (Dementev, Dalevska, 2015), (Dementev, Vishnevskiy, 2010), (Petryna, Tarajewska, Werbowska, 2015), (Nowak, Kazmierczyk, 2013). Special attention is paid to innovative thinking formation among university students in the work of (Bondareva, Kravchenko, Meshkov, 2015).

Despite the in-depth preparation of various aspects of innovation (institutional aspects, financing, estimation of economic efficiency of new developments, their degree of risk, etc.), the issues of planning and correcting the results of innovative project realization in light of globalization and conditions of economic instability require more thorough study and new approaches.

The aim of this article is to establish the economically feasible duration of innovative project realization suitable for planning the productivity of employed capital resources and to predict the moment when the correction of their parameters is required.

3. THE MAIN PART

In terms of a market economy, the duration of the usage period of innovations is normally set by economic operators themselves. Among the main essential factors, the ones which can be emphasized are technical (needs of the production process, maximum possible physical life of assimilated funds), economical (achieving the planned profit level), organizational (time frames for organizational and industrial problem solution), etc. Besides, of no less importance is the pace of technical and technological obsolescence. Still, notwithstanding the fact that the main criteria for most European businesses are the last two factors, for most Ukrainian enterprises, whose financial state can be characterized as unsatisfactory, active innovative activities are now an unaffordable luxury. In view of this, the only main criterion largely determining the usage period of techniques and technologies is the economic feasibility of their further exploitation.

Considering the fact that carrying out an innovation process is related to attracting investments and acquiring a certain effect, it is quite rational for the method of determining the optimal duration of an innovative project realization to be based on the generally known concept of cost-effectiveness. Assuming that the main aim of existence of most economic operators is to make profit on an investment and to increase the productivity of the employed capital, estimations of economic efficiency of further investment in an implemented innovation can act as the main criterion.

Analyzing strengths and weaknesses of different performance indicators, in this work, in order to determine the optimal (from the economic point of view) duration of innovative project realization, it is proposed to use the Modified Internal Rate of Return *MIRR* indicator, or to be more precise, the possible character of its change in value due to a change in the period of innovation use. Considering the fact that the above-noted indicator characterizes the rate of return of an innovative project for the whole fixed period of its realization, the situation is regarded beneficial when a further increase of this period comes with an increase in the relevant indicator's value (which is undoubtedly not below the normative rate of return of the

employed investment capital). With regard to the latter, the objective function for establishing the economically feasible duration of innovation use is as follows:

$$MIRR^{norm} \leq MIRR \rightarrow \max, \quad (1)$$

where

$$MIRR = \sqrt[T]{\frac{FV_T}{PV_0}} - 1 = \sqrt[T]{\frac{\sum_{i=0}^T CIF_i \cdot (1+r)^{T-i}}{\sum_{i=0}^T COF_i \cdot (1+r)^{-i}}} - 1. \quad (2)$$

$MIRR^{norm}$ is a normative (minimum acceptable) Modified Internal Rate of Return value; $MIRR$ is Modified Internal Rate of Return value for the whole period (T).

The character and causes of the change in the relevant indicator value $MIRR$ with the change of an innovative project realization period can be analyzed on the specific example of the innovative project of the subsidiary company Rutex-Ceram of LLC Rutex-Ceram (Tab. 1). For this purpose, let us plot a dependency graph $MIRR = f(T)$ (Fig. 1)

While analyzing the curve $MIRR = f(T)$, three patterns which coordinate with the curve of the innovation life cycle should be outlined. The first pattern – the indicator value $MIRR$ goes up – is characteristic of those innovation life cycle stages when the revenues increase. Here, a relevant decrease in the growth rates of the analyzed indicator value should be noted (interval BC, Fig.1); it is due to the corresponding slowdown of revenue growth rates while achieving full-scale production. Further, at the certain stage of an innovation's life (mature stage), the indicator value $MIRR$, having achieved its maximum (point C), may stay constant or, as in the case considered, begin to decline gradually. The latter is due to the fact that in the course of time (when the mature stage is replaced by the decline stage) the project's operating revenues go down by degrees.

Table 1. Calculation data on the innovative project of the subsidiary company Rutex-Ceram of LLC Rutex-Ceram.*

Indicator	Period, quarters									
	1	2	3	4	5	6	7	8	9	10
Total payment series, thous. US\$	-10,5	124,0	143,1	181,7	185,8	184,3	184,3	184,3	209,2	190,6
Final cost of monetary profit, thous. US\$	-10,5	113,3	258,6	445,5	640,1	837,3	1038,4	1243,5	1477,6	1697,7
MIRR, decimal	-1,011	-0,664	-0,363	-0,183	-0,085	-0,029	0,005	0,028	0,044	0,054

Table 1 cont.

Indicator	11	12	13	14	15	16	17	18	19	20
Total payment series, thous. US\$	190,6	190,6	198,9	170,5	170,9	171,4	175,3	175,7	176,1	176,4
Final cost of monetary profit, thous. US\$	1922,2	2151,2	2393,1	2611,4	2834,6	3062,7	3299,3	3540,9	3787,8	4040,0
MIRR, decimal	0,0612	0,0659	0,0694	0,0710	0,0719	0,0725	0,0727	0,0728	0,0726	0,0723
Indicator	21	22	23	24	25	26	27	28	29	30
Total payment series, thous. US\$	176,9	177,3	177,6	178,0	159,5	159,5	161,1	162,0	162,8	163,6
Final cost of monetary profit, thous. US\$	4297,7	4560,9	4829,8	5104,4	5365,9	5632,7	5906,5	6186,6	6473,1	6766,2
MIRR, decimal	0,0719	0,0714	0,0709	0,0703	0,0695	0,0687	0,0680	0,0672	0,0665	0,0658

* project investment costs comprise \$1,000,000 on a nonrecurring basis, reinvestment rate of the released capital is 0.02

Thus, the character of the curve $MIRR = f(T)$ allows an economically feasible duration of innovation use to be considered on a reasonable basis. Nevertheless, one specific feature should be stressed – even though the operating revenues rates of the innovative project are constant, the performance indicator of the employed capital, having reached its maximum level, is bound to decline. This condition is determined by the fact that the revenues generated by the project – even though their reinvestment is considered – from a certain moment of time will not provide further capital development in the time course with the maximum efficiency level achieved.

The above-mentioned feature is of major importance for setting the optimal period of innovative project realization, and as demonstrated in the given analysis, cannot be characterized by means of other performance indicators. It is this factor as well as other benefits of the Modified Internal Rate of Return $MIRR$ indicator that determined the motivation for its use to solve the defined problem.

To consider the causes which provide the specific shape of the curve $MIRR = f(T)$, let us analyze formula (2). Thus, if we take into account that setting the value of (T) lower than the project payback period is economically unfeasible, then it is quite reasonable to state that on further increase of the project realization

period, the denominator of formula (2) (characterizing the development of the invested capital in the course of time) does not influence the indicator *MIRR* value. That is, the change of the value of the above-noted indicator is possible only as a result of the change of the numerator of the analyzed formula. In turn, the increase of the numerator as a result of the change of the innovative project realization period can be brought about by the value of project generated payments (*CIF_t*) in the first place, and by the terms of reinvestment of the released capital (*r*) (Khobta, Kravchenko, 2003) in the second place.

Let us model the situation when the efficiency of the project over the time period from (*t*) to (*t+1*) will be constant and equal to the value of *MIRR**. Along with this, let us set the required character of capital development. Then, after simple mathematical transformations basing on formula (2), we will get the following formula:

$$FV_{t+1} = FV_t \cdot (1 + MIRR^*) \quad (3)$$

Formula (3) will characterize the required conditions of the development of the project generated capital in the course of time that will provide a constant *MIRR* value.

Nevertheless, considering the fact that with the increase of the innovative project's realization period, the change of the indicator *MIRR* value can be determined by both generated payments' value and the terms of reinvestment of the released capital, the character of the capital development in the course of time can be described by the following formula:

$$FV_{t+1} = FV_t \cdot (1 + r) + CIF_{t+1}, \quad (4)$$

where *CIF_{t+1}* is the value of operating revenues in period (*t+1*).

Having equated the right-hand parts of the expressions (3) and (4) and having solved the expression for the value of *CIF_{t+1}* we will obtain:

$$CIF_{t+1} = FV_t \cdot (MIRR^* - r) \quad (5)$$

It should be noted that if the real value of future revenues generated by the project in period (*t+1*) is more than the value of *CIF_{t+1}* calculated by formula (5), then with extension of the term of project realization, an increase in its efficiency level will be observed; and conversely, a decrease will lead to a decrease in efficiency.

Thus, in view of the above matter, the most informative and most determining condition while setting the optimal period of innovative project realization is the moment when the indicator *MIRR* value, having reached its maximum, begins to go down. It is this moment that signals project managers that further extension of the term of project realization is inappropriate under the analyzed conditions as it leads to a decrease in the employed capital's efficiency.

Thus, in case of the project under consideration, with the extension of the project realization period (fig.1), the indicator *MIRR* value goes up and at point (C)

reaches its maximum – $MIRR_{18} = 0.0728$. Further on, beginning with the 18th quarter, the value of the above-noted indicator goes down and, for instance, in the 30th quarter it equals – $MIRR_{30} = 0.0658$. That is, the decrease in the project’s rate of return when its realization is extended to 30 quarters will be $0.0728 - 0.0658$, or 0.7% quarterly. Thus, the company’s managers, when setting the duration of the innovation’s use, should target the period equal to 18 quarters as thereafter a decrease in the employed capital’s efficiency will be observed. In view of this, if the company after 18 quarters of project realization has another alternative for capital investment with an efficiency no less than the achieved level (7.28% per quarter), it will be necessary to abandon the further realization of the innovative project under analysis.

Practically, each enterprise generally sets its own normative (minimum acceptable) efficiency level ($MIRR^{norm}$), whose value is often lower than the maximum possible efficiency level of realized innovative projects. That is why, in relation with this normative level, it is possible to set a maximum duration of innovative project realization which is equal to the period when the ($MIRR$) value will go down to the determined level. Thus, in the case under consideration, the company has a $MIRR^{norm} = 6,8\%$, consequently, it is appropriate to set the optimal period of realization equal to 27 quarters (period T_4 , fig.1), otherwise the project will be inefficient after that time.

Thus, the ground for setting the optimal economically feasible period of an innovative project realization can be either the moment of the beginning of capital efficiency decrease (inflection point C) or the moment when the level of efficiency will go down to normative (point D, fig.1) Table 2 represents the main alternatives of solutions related to setting an economically feasible period of innovation use (with respect to period t).

Table 2. Alternative solution choices while selecting an economically feasible duration of innovation use

Expected conditions ¹	Subject matter
$MIRR^{max} < WACC$	Project realization should be abandoned.
$MIRR^{max} = WACC$	It is reasonable to abandon further project realization as it is bound to become inefficient in the next period ($t+1$).
$WACC \leq MIRR^{max}$	It is appropriate to set the duration of project realization equal to the period when indicator $MIRR$ value gets down to the value of $WACC$.
$WACC \leq MIRR^{max} < MIRR^{norm}$	Project realization should be abandoned.
$WACC \leq MIRR^{max} = MIRR^{norm}$	It is reasonable to abandon further project realization as it is bound to become inefficient in the next period ($t+1$).
$MIRR^{max} > MIRR^{norm}$	It is appropriate to set the duration of project realization equal to the period when indicator $MIRR$ value gets down to the value of $MIRR^{norm}$.

It should be noted that the indicator *MIRR* value can be largely dependent on the sum generated from the project closeout. In this case the criterion for increasing an innovation's use period can be stated as the following:

$$CIF_{t+1}^n > CIF_{t+1}^{\min} = FV_t \cdot (MIRR_t - r) + 2 \cdot L_{t+1} - L_t \cdot (1 + r) \quad (6)$$

where

CIF_{t+1}^n is the value of payment planned in the following period;

CIF_{t+1}^{\min} is the minimum acceptable value of payment in the following period providing a constant efficiency level;

L_t и L_{t+1} are project liquidation costs in period (t) and ($t+1$) correspondingly.

4. PROSPECTS AND CONCLUSION

In summary, the consequence of determining the economically feasible period of an innovative project realization can be ultimately formulated as follows:

- on the basis of expected economic properties of an innovative project and re-investment conditions of the released capital it is essential to calculate the indicator *MIRR* value at equidistant intervals for the long term (for instance, for a period equal to the maximum possible period of technical operation of the utilized equipment).
- according to acquired data one should construct a graph $MIRR = f(T)$.
- on this graph the following characteristic properties should be marked:
 - a) maximum modified internal rate of return value *MIRR*_{max} – the point of inflection $MIRR = f(T)$ (which characterizes maximum possible efficiency level of employment of the capital invested in the project, and period of time required for its achievement);
 - b) the value of normative (minimum accepted) return of the capital employed in the investment of the innovative project *MIRR*_{norm}, set for current conditions – the line parallel to the time axis (which characterizes the period of time required for achieving a normative level of efficiency, and sets limits to the maximum economically feasible realization period of innovation);
 - c) reinvestment rate value (r) of the capital released with the project realization – the line parallel to the time axis (the point of intersection of the curve $MIRR = f(T)$ with this line defines the project payback period);
- having analyzed the shape of the curve $MIRR = f(T)$ as well as its position as for the line characterizing the normative value of return, one can make a preliminary conclusion about the economically feasible period of innovation use;
- using Formula (6) one can ultimately define the optimal period of innovation use.

Apart from the alternatives given in Table 2 there is one more. Having predetermined the potential directions for the increase of the project's operating revenues, it is possible to intentionally provide for (plan) further increases in efficiency level or at least its constancy (dashed lines 1 and 2 in Fig.1). Special mention should be made of the mathematical reasoning of the method of defining values of minimum accepted operating revenues from innovation use in further (future) periods (Khobta, Kravchenko, 2003).

On practical grounds, the required growth of future revenues can be achieved, for example, by an increase in the volume of sales, a rise in prices or a reduction of production costs. It should be noted though, that over time further enhancement of existing techniques and technologies becomes economically unfeasible as the eventual outcome will not compensate for the spent effort (S-shaped curve of technology development) (Mensch, 1975; Modelski, Tompson, Volnyi, Kondrateva, 1992; Solovev, 1994). In other words, the moment when further investment in enhancing production processes and products will not pay back is inevitable. The main reason of this matter is defined, for instance, by R. Foster as reaching the limits of objective development of the corresponding scientific, engineering or organizational idea. And in this case he suggests diverting the funds to develop and launch fundamentally new ideas and also to prepare, master and produce new-generation products (Foster, 1987).

Thus, considering the fact that creation and development of an innovation requires a certain amount of time, it is reasonable to provide a continuous innovation process. Hence, knowing the specific properties of proposed innovative projects (economically feasible period of realization, possibility to provide the target level of investment efficiency, etc.) will help company managers avoid unwanted costs (e.g., realization of innovative projects of little promise) and be duly prepared for a new technological solution having worked out their own innovation strategy.

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OPTYMIZACJA WARUNKÓW REALIZACJI PROJEKTÓW INNOWACYJNYCH

Streszczenie

Charakterystyczną właściwością procesu innowacyjnego jest nieokreśloność dotycząca terminu efektywnego wykorzystania wprowadzanych know-how. W artykule dla określenia terminu realizacji projektu innowacyjnego zaproponowano wykorzystanie charakter zależ-

ności wskaźnika „modyfikowana wewnętrzna norma dochodowości” od zmiany długotrwałości wskazanego okresu. Wykorzystanie zaproponowanych rekomendacji pozwala zaprowadzić optymalną długotrwałość wykorzystania innowacji, zapewnić możliwość planowania efektywności wykorzystania kapitału, a także prognozowania momentu powstania potrzeby w modernizacji innowacji albo pełnej ich zamianie innymi, bardziej progresywnymi.

Słowa kluczowe: projekt innowacyjny, efektywność ekonomiczna, optymalizacja