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FEATURES OF ENTERPRISE'S OPTIMAL INNOVATION STRATEGY DEVELOPMENT

This paper reveals a need for new models with relevant approaches to economic mechanism functioning in the context of recession. The authors show that making a profit and increasing the market value of a company can be possible if production costs reduce faster than sales. It can be reached by means of a fundamental neoclassical principle of "decreasing marginal cost efficiency". The authors suggest the use of new economic models which are more resistant to growing risks and uncertainties working under the "falling markets" principle.

Keywords: *optimal innovation strategy; capital investment; return on investment.*

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ОСОБЛИВОСТІ РОЗРОБКИ ПІДПРИЄМСТВОМ ОПТИМАЛЬНОЇ ІННОВАЦІЙНОЇ СТРАТЕГІЇ

У статті виявлено, що існує необхідність у нових моделях, які містять актуальні підходи до економічного механізму роботи в умовах рецесії. Обґрунтовано, що отримання прибутку та підвищення ринкової вартості підприємства стає можливим, якщо витрати на виробництво продукції падають швидше, ніж продажі. Цього реально досягнути за умови дії фундаментального неокласичного принципу «спадної граничної результативності витрат». В основі нових економічних моделей, більш стійких до умов зростаючих ризиків та невизначеностей, запропоновано до використання принцип роботи на «спадних ринках».

Ключові слова: *оптимальна інноваційна стратегія; капітальні інвестиції; рентабельність інвестицій.*

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ОСОБЕННОСТИ РАЗРАБОТКИ ПРЕДПРИЯТИЕМ ОПТИМАЛЬНОЙ ИННОВАЦИОННОЙ СТРАТЕГИИ

В статье выявлено, что существует необходимость в новых моделях, содержащих актуальные подходы к экономическому механизму работы в условиях рецессии. Обосновано, что получение прибыли и повышение рыночной стоимости предприятия возможно, если затраты производства продукции падают быстрее, чем продажи. Это достижимо при действии фундаментального неоклассического принципа «убывающей предельной результативности затрат». В основе новых экономических моделей, более устойчивых к условиям умножающихся рисков и неопределенностей, предложено использование принципа работы на «падающих рынках».

Ключевые слова: *оптимальная инновационная стратегия; капитальные инвестиции; возврат на инвестиции.*

Introduction. At present, there are some attempts to provide the "quasi-outrunning growth", to speed up the process of reducing costs relating to sales, boosting it, slowing down the wage growth. Companies and employees are hardly able to manage this situation. To employees it would be difficult to explain why they have to work harder for the same or smaller money. In such circumstances, many of them refuse to

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work. This is the so-called "performance trap", i.e. innovations are always associated with higher productivity that can lead to heavy social losses because "not innovative" jobs are substituted by "innovative" ones. There appear institutional factors in a special form of "neighborhood effects". Implemented innovations provide benefits by means of cost effectiveness in "implementation points", i.e. at enterprises. Society, however, may incur some losses if resources, including labor resources released from "non-innovative" jobs in the absence of economic growth, cannot be applied in other sectors of the economy.

The economic model which is based on the principle of decreasing marginal return, reflects such management mechanism using the "negative feedback" principle which emphasizes the fact that primary costs are always more effective than the following ones. Therefore, new products are assumed to be more efficient than the existing ones.

The principle of decreasing marginal efficiency is not applicable to new products. Innovations implementation corresponds to a converse economic law of "increasing marginal costs return". Each subsequent production costs unit possesses higher efficiency than the previous one. This effect may have an "explosive" nature. A number of costs with no effect can be followed by considerable effect which will provide reasonable efficiency of investments, taking into account even the time factor. Such a model can ensure enterprise's growth almost regardless the external economic factors. Whereas the model of decreasing marginal efficiency using the "negative feedback" principle can represent a certain deterrent in the context of recession.

Literature review. Innovative development based on import substitution and technological leadership are the most promising directions in Russian economic research today (Rodionov et al., 2014; Demidenko and Malevskaya-Malevich, 2014; Kudryavtseva and Babkin, 2015). The leading place in enterprise's investment management is taken by investment plans/programs optimization which ensures the adoption of an effective assets ratio, maximizing investor's returns (Kruschwitz, 2014; Loffler, 2006; Karlik, 2016).

Evaluation of effectiveness and economic feasibility of capital investment and investment projects implemention is an essential stage in introducing innovations into enterprises' production process (Burns and Stalker, 1961; Abel, 1983; Berk et al., 1999).

Drawing up the optimal enterprise's investment plan requires considering not only "continuous" models, but also their modifications with their resource-related and other constraints affecting the assets structure (Drucker, 2014; Lancaster, 2012; Rice, 2013).

Problem statement and research objective. As known, evaluation of effectiveness and economic feasibility of implementing (capital) investments and investment projects suggests using the NPV criterion (index), or the net present (discounted) value. Today the NPV formula is supposed to be the most commonly used one in economic science. The use of this criterion, however, is associated with a number of controversial issues:

1. Evaluation of an investment object's market value by means of direct capitalization of returnable cash flows is criticized by the opponents of the monetary approach.

2. Calculating capital investments' effectiveness always requires cash flow forecasting, which can cause additional risks related to inaccurate forecasts.

3. Considering risks through a debt premium reflects only systematic market risks, so the risks of cash flows forecasting errors remain unspecified.

4. The NPV economic model does not reflect significant neoclassical correlations, such as the relationship between investments and returnable cash flows as well as decreasing marginal efficiency of capital investments.

5. There exist some unrealistic assumptions about the changes in the profile of returnable cash flows in the course of time within the economic life of capital objects. In particular, there is an assumption about the form of returnable cash flow when a capital object changes hands being resold to a new owner (assumption of a uniform cash flow annuity with constant growth rate).

Let us analyze the mathematical model of the capital object net present value criterion in case of non-recurring capital expenditures in the initial (zero) time period and subsequent returnable cash flow within the period of an object's economic life:

$$NPV = \frac{\sum_{t=1}^{n} CF_t}{(1+i)^t} - I \to \max, \qquad (1)^3$$

where CF_t is a returnable cash flow from investments (I) for a certain period (t), and i is the interest rate (discount rate), used for a given capital investment object. In case of a risk-free interest rate in NPV assessment, risk or probability of non-receipt/receipt of planned returnable cash flow from investments is to be evaluated separately. In this case the NPV criterion is an expected net present value which cannot be negative, and in case of an alternate choice the maximum value will be preferred. It is obvious, that using the model in a formal way can give absurd results as (NPV) grows with reducing (I) and takes the maximum value at $I = 0$. Here is the (NPV) formula:

$$NPV = NPV(I) \text{ provided that } CF = \begin{bmatrix} CF & if & I \geq I_0 \\ 0 & if & I < I_0 \end{bmatrix}. \qquad (2)$$

So, in the open investment project, the returnable cash flow value is present only when investments exceed the minimum or required size, as a rule – the known I_0 value, otherwise, the investment project cannot be realized. Consequently, (NPV) is an investment size function. The function has no analytical expression (step function) in the given form, but many authors believe that the $NPV(I)$ function can also have an analytical expression and, in particular, can reflect the fundamental principle of decreasing marginal efficiency of capital investments. According to the fundamental rules of financial management, the profit element of the $NPV(I)$ function representing the discounted value of returnable cash flow from investments can always be expressed as an equivalent to an infinite uniform annuity:

- profit element of the $NPV(I)$ function:

$$PV_1 = \frac{\sum_{t=1}^{n} CF_t}{(1+i)^t}; \qquad (3)$$

[3] here and further are given commonly accepted formulas adapted to solving tasks, set by the authors.

- discounted returnable cash flow in the form of infinite uniform annuity:

$$PV_2 = \frac{\sum_{t=1}^{\infty} CF}{(1+i)^t} = CF / i. \tag{4}$$

The condition of $PV_1 = PV_2$ equivalence allows defining the unknown CF value. In view of the above, it is possible to express the NPV criterion as follows:

$$NPV(I) = -I + \frac{CF(I)}{i}. \tag{5}$$

Key results. As an example, we can take the following functional dependence of investment returnable cash flow which is based on the assumption of decreasing marginal returns, and of the net present value criterion using this dependence:

$$CF(I) = a\sqrt{I},\ NPV(I) = -I + \frac{a\sqrt{I}}{i}, \tag{6}$$

where a is a parametric variable.

The continuous and twice differentiable $CF(I)$ function rises to its maximum $I = (a/2i)^2$ at the interval from 0 to I $(CF(I)_i'' < 0)$. For example, if $a = 0.3$, $i = 0.1$ is a risk-free rate, then $I = 2.25$ MU is the maximum NPV value under the given conditions.

When the algebraic form of the $CF(I)$ function is not specified, the $NPV(X)$ mathematical expectation maximization is determined by the following condition:

$$NPV(X) = (-(I - X) + \frac{CF(I - X)}{i} \times P(X))'_X = 0. \tag{7}$$

This example provides that in an open investment project the X part of the project investment resources I can be committed to some conventional "risk reduction fund" which is to be spent for reducing the likelihood of not receiving the planned returnable cash flow of income from investments $P(X)$.

Table 1. **The expected NPV(X) net present values,** *authors'*

Risk reduction fund contribution (X), MU	Infinite equivalent to returnable cash flow of income from investments F(I-X), MU	Probability of returnable cash flow of income from investments P(X)	NPV(X) expected value, MU
0	5	0.5	15
1	4.5	0.6	18
2	4	0.7	20
3	3.5	0.8	21
4	3	0.9	21
5	2.5	1.0	20

As the example shows (Table 1), the maximum of the expected $NPV(X)$ net present value, being equal to 21 MU, is obtained if "risk reduction fund" contribution equals to 3–4 MU.

When drawing up investment programs one can use the possible approach to risks treatment reflected in the optimization model below, which is applicable to both enterprises and the economic system. Suppose there are n alternative investment patterns, provided that $\bar{X}_1 \ldots \bar{X}_n$ are the minimal requirements for the value of investment in alternative patterns of the economic system, which meet the current needs or demand, $X_1 \ldots X_n$ is the actual value of investment in alternative patterns of the economic system (variables in the optimization problem considered). The funds limit available in the economic system equals to $\bar{X}$, it cannot be exceeded in total in all investment patterns, and it is represented in the form of balance constraint: $X_1 + \ldots X_n \le \bar{X}$.

The target function of the problem reflects the requirement to minimize the risk of low or negative return from all investments in the economic system assuming that risks are independent/uncorrelated in terms of investment patterns (such an assumption allows considering the optimization model as a linear one).

The task statement:

$$\begin{gathered} \Delta_1 \times X_1 + \ldots \Delta_n \times X_n \to \min \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ X_1 \quad \ge \bar{X}_1(z_1) \qquad \ldots, \quad X_n \ge \bar{X}_n(z_n) \\ -X_1 - \ldots X_n \ge -\bar{X}(z_{n+1}), \\ \Delta_1 \ldots \Delta_n \end{gathered} \tag{8}$$

is a coefficient of relative error/risk $(0 \le \Delta \le 1)$ of investments. It characterizes the risk of receiving low or negative return from each investment pattern through underutilization of some investments to achieve the required return. In fact, risk minimization is determined by minimization of the released investments underutilization. Variables of the dual problem are given in brackets.

It is necessary to define the amount of investments for each pattern, which provides the minimal risk in the context of given requirements for minimum investments in patterns, and for resource limits. The optimal solution must ensure the investments amount in each pattern to exceed the required level and to lay within available limits. The solution can be characterized as an optimal investment plan. The given linear model is a primal optimization problem.

Let us define a dual problem:

$$\begin{gathered} z_1 \times \bar{X}_1 + \ldots z_n \times \bar{X}_n - z_{n+1} \times \bar{X} \to \max \\ z_1 - z_{n+1} \le \Delta_1 \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ z_n - z_{n+1} \le \Delta_n. \end{gathered} \tag{9}$$

The target function of the dual problem expresses the amount of economic profit or economic added value created in the system. Solving the dual problem allows determining the prices/costs of the optimal investment plan, which is obtained by solving the primal problem. The required return/profitability on investments for the patterns $z_1 \ldots z_n$, as well as the "price of money", i.e. market % risk-free rate z_{n+1}, are variables. As follows from the solution, we can determine what level of required return on investment in patterns, as well as the market % rate, with resource limitations specified by the optimal investment plan of the primal problem, gives the maximum added value from the investment plan implementation.

For a comprehensive dual problem constraints analysis let us represent the dual problem constraints in the following equivalent form:

$$\begin{gathered} z_1 \le \Delta_1 + z_{n+1} \\ \dots\dots\dots\dots\dots\dots \\ z_n \le \Delta_n + z_{n+1}. \end{gathered} \tag{10}$$

The right side of the expression represents the market % rate as the sum of the risk-free % rate and risk premium, which is individual for each investment pattern. The left side of each inequality is the required return on pattern investments, it also represents the most favorable price of attracting investment resources into the system. Obviously, the price of attracting investment resources should not exceed the requirement for their hurdle rate of return. This means that the variables "required return / profitability on pattern investments" have dual meanings. On the one hand, they represent the minimum investment return based on investment activity patterns (target function), on the other hand – the maximum favorable, in terms of the optimal investment plan, price of attracting investment resources into the economic system. If the requirement for constraints is not carried out, added value will not be created.

When explaining the economic sense of a dual problem one can use the "fundamental economic rule", which is expressed by the following formula:

$$\begin{pmatrix} \text{minimum requirement} \\ \text{for return on investment /} \\ \text{capital investment with} \\ \text{allowance for risk} \end{pmatrix} = \begin{pmatrix} \text{maximum price} \\ \text{of attracting} \\ \text{investment} \\ \text{resources} \end{pmatrix}. \tag{11}$$

Further analysis of the above pair is a dual task "determining the optimal investment plan" – "maximizing the added value as a result of the optimal plan implementation", which leads to a number of additional conclusions. Let us change the statements of the primal and dual problem, supposing that the risk ratio Δ out of the specified range of possible values $(0 \le \Delta \le 1)$ takes only the value $\Delta = 1$. As a result, we obtain a new statement of the problem.

Primal problem:

$$\begin{gathered} X_1 + \dots X_n \to \min \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ X_1 \ \ge \bar{X}_1(z_1) \quad \dots, \quad X_n \ge \bar{X}_n(z_n) \\ -X_1 - \dots X_n \ge -\bar{X}(z_{n+1}), \end{gathered} \tag{12}$$

In order to retain the task of risk minimization for this problem, like in the previous statement, we suggest using full-size investments in alternative patterns $X_1 \dots X_n$ as a risk indicator. This means that risk value is quantitatively characterized by production costs (current or capital), and simultaneously they characterize both the quantity of resources consumed, and the value of production/operating risk. Such a statement reflects the actual production activity in a "risk environment": higher production costs, higher risk of decline in efficiency/returns when the desired results from an investment project are not obtained. So, it turns out that any amount of money is at the same time a characteristic of the risk to possess this amount, as the losses from losing it are the risk itself, and therefore, the larger is the amount, the greater is the risk (and vice versa). At the same time, the minimum costs value must be limited, otherwise, the optimal solution of the risk minimizing problem would have a zero costs value (he who takes no risks makes nothing). The optimal solution of the problem is the amount of investments in each pattern, which guarantees minimum risk in the context of the existing requirements for a minimum investment amount and other resource constraints. The target function reflects the whole value of the risk to receive low or negative return assuming that risks are uncorrelated. The solution can be considered as an optimal investment plan.

Dual problem:

$$\begin{gathered} z_1 \times \overline{X}_1 + \ldots z_n \times \overline{X}_n - z_{n+1} \times \overline{X} \to \max \\ z_1 - z_{n+1} \le 1 \\ \ldots\ldots\ldots\ldots\ldots\ldots \\ z_n - z_{n+1} \le 1. \end{gathered} \qquad (13)$$

Target function is, like in the original statement, the economic value added, while the revenue side expresses the requirement for the return on minimum investments in alternative patterns of the economic system which meet the current needs and demands.

It is necessary to add an economic explanation of constraints. Let us reformulate any of the constraints (same could be done for the rest of constraints): $z_n \le 1 + z_{n+1}$. At the same time the required investment return should reflect the price of attracting investment resources. Thus, the price of attracting 1 monetary unit should not exceed the most employed amount, i.e. unit. According to economic theory, this requirement agrees with the "second law of marginal utility" which ensures the equality of exchanged products' price ratios and the ratios of their (products') marginal utilities, identical products have identical marginal utility. When we handle a static problem (for one time period), like in our situation, we have exactly the same case. If we take into account that z_{n+1} is a risk-free % rate, the factor $(1 + z_{n+1})$ reflects a time value of money and fulfills the function of bringing to a single time point. According to the abovementioned "fundamental economic rule", z_n is treated as the cost of attracting resources in the dual problem. It is necessary to reduce the time factor because cash investments are made at the beginning of the period, and income from investments is gained at the end of the period.

Conclusion. The above approaches to investment projects evaluation can be applied to prove the effectiveness of various investment programs at industrial enterprises. One of such application can be drawing up investment programs of import substitution at Russian enterprises, and optimization plans of import substitution. With regard to implementing import substitution programs by Russian companies, reindustrialization or production potential recovery are of critical importance today. These processes are a chain of successive events, or process elements. These events are distributed in time, or in their relation to the final or intermediate objective of a process, or refer to certain process elements. These elements, however, are interconnected within a certain interaction mechanism which we call "technology", "production stage", "costs chain."

Directions for further research. From this perspective, import substitution includes a variety of relatively independent elements or stages. These elements are an integral part of the process which is aimed at achieving the desired result by means of an appropriate mechanism, but not all of them can simultaneously be involved in the process of import substitution, even though at the end all process elements have to "get through" import substitution.

The number of elements for "achieving the desired result", which in a certain period of time can be involved in the import substitution process, are defined by the costs necessary for import substitution of the element and the enterprise‘s total capital expenditures limit in a certain period of time. A common task type of optimal import substitution is distributing a limited resource of capital investments between the elements involved in import substitution process. Drawing up the enterprise’s optimal import substitution investment program includes selecting investment projects which will provide larger increase in enterprise’s sales within the available capital investments limit. The article provides one of possible solutions for the enterprise’s optimization problem using a dynamic programming method, and provides a relevant numerical illustration.

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