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# THE PROBLEM OF CHOOSING AN OPTIMAL STRATEGIC PROFILE OF INNOVATION FOR A DYNAMIC ENTERPRISE

***The article explores the patterns and essential factors of strategic profiles of enterprises' innovation. The formation model and calculation of the criteria of these strategic profiles are elaborated to select the best option from a set of alternative states which a company might enter through management guidelines (strategies).***

***Keywords:*** *strategy; innovative development; optimization; modelling; decision making.*

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# ЗАДАЧА ВИБОРУ ОПТИМАЛЬНОЇ СТРАТЕГІЇ ІННОВАЦІЙНОГО РОЗВИТКУ ДИНАМІЧНОГО ПІДПРИЄМСТВА

***У статті розглянуто закономірності та істотні чинники стратегій інноваційного розвитку підприємств. Побудовано модель формування та розрахунку критеріїв цих стратегій, що дозволяє обрати оптимальний варіант з множини альтернативних станів, у які перейшло б підприємство внаслідок зміни вектора управлінських дій (стратегій).***

***Ключові слова:*** *стратегія; інноваційний розвиток; оптимізація; моделювання; прийняття рішень.*

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# ЗАДАЧА ВЫБОРА ОПТИМАЛЬНОЙ СТРАТЕГИИ ИННОВАЦИОННОГО РАЗВИТИЯ ДИНАМИЧНОГО ПРЕДПРИЯТИЯ

***В статье рассмотрены закономерности и существенные факторы стратегий инновационного развития предприятий. Построена модель формирования и расчета критериев этих стратегий, что позволяет выбрать оптимальный вариант из множества альтернативных состояний, в которые перешло бы предприятие вследствие изменения вектора управленческих действий (стратегий).***

***Ключевые слова:*** *стратегия; инновационное развитие; оптимизация; моделирование; принятие решений.*

**Introduction.** The transition of Ukraine's economy to market framework has increased the role of strategic management of an enterprise, the most important objective of it is the entry into new markets with new products and services.

**The primary means** to solve these problems is the development of innovative strategies that determine the goals and necessary measures. This is one of the major problems that Ukrainian and world economic science face.

**Latest research and publications analysis.** Innovative development has been investigated in the works of G.Y. Goldshtein (2004), S. Davenport and D. Billy (1999), S.M. Illyashenko (2003), J. Clark and K. Guy (1998), N.V. Krasnokutska (2003), M. Porter (1996), A.I. Prigogyne (1989), B. Szanto (2003), R. Solow (1957), C. Freeman (1991), H. Chesbrough and D. Teece (1996), J. Schumpeter (2004), J.V. Yakovets (2004) and others.

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However, despite numerous studies, there is no theoretically proved and generally accepted approach to modelling a choice of strategic profile of innovation for an enterprise. There may be several explanations for that:

- fragmentation and inconsistency are inherent to the theories of strategic management with regard to innovation;
- many methodological and applied problems remain unresolved in the reviewed works due to the complexity and instability of both internal and external environments of an enterprise performance.

These features accentuate the necessity of improving the mathematical tools of choosing an effective strategic profile of innovation for a dynamic business entity under contemporary modern market economy.

**The aim of the research** is to elaborate a relevant model of choosing a strategic profile of innovation for dynamic enterprises.

**The object of the research** is strategic decision-making for innovation.

**The subject of the research** is the complex of economic and mathematical methods and models for optimization of strategic management at an innovative company.

**The methods of the research** are economic and mathematical modelling with designing complex models of strategic management and economic dynamics in order to construct an optimization programme of resources use, theory of methods used to develop a decision-making support system for an innovative enterprise.

**The problems of innovative enterprise development.** Innovations in management at Ukrainian enterprises act as an exotic, though the importance of quality and efficient management and its impact on the performance of any organization haven't been questioned.

In (Antoniv and Kaminska, 2010), 64.66% of the 116 SMEs owners in the Western Ukraine, reported they had difficulties while running their companies, pointing on average at two tasks from this list.

After that all management tasks are divided according to the degree of complexity into 4 groups (Figure 1).

It comes as no surprise that strategic planning takes the lead. That accounts for the fact that the task of strategy development is a novelty for Ukrainian economic practice.

The system of innovation introduction for managers does not represent significant problems. It may be not due to the degree of its complexity but to the fact that such task isn't given. These tasks are probably perceived by the most of the respondents as conventional ones that don't need rethinking.

A difficult situation with innovations at small and medium-sized businesses in the Western Ukraine is demonstrated by the fact that only 52% out of the surveyed executives believe that changes are necessary at their enterprises while searching and introducing innovations. 20.86% are focused on significant changes and 31.14% — on minor changes. 21% of the respondents hold opposite views; they don't see the need for a change. Approximately 27% of the respondents don't have a clear position about this issue.

**An economic and mathematical model of generating and choosing a strategic profile of innovation for an enterprise.** There is a need to build a mathematical model of developing and choosing a strategic profile of innovation for an enterprise in terms of time and scarcity of resources.

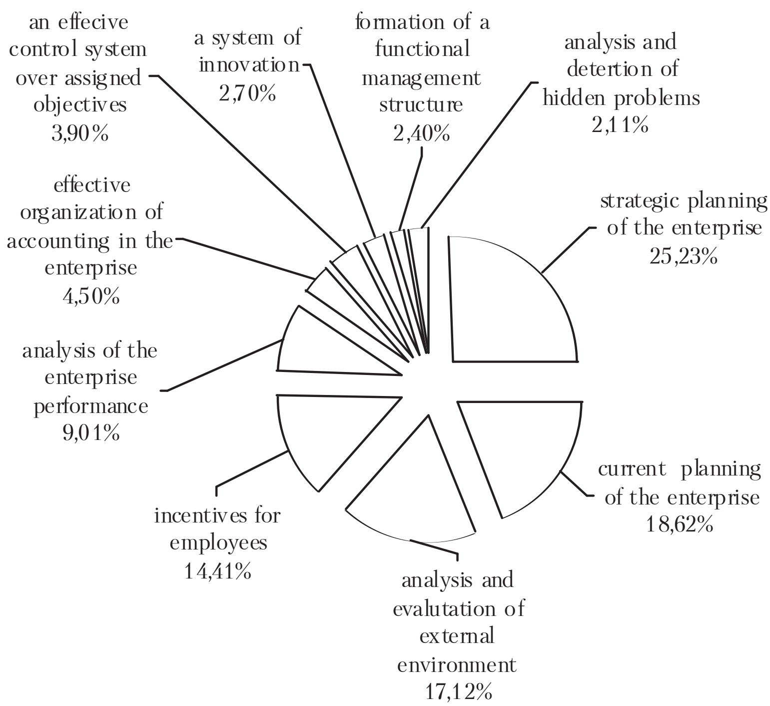


*Figure 1.* **Assignment of managerial tasks according to the degree of their complexity,** *developed by the authors*

Since a dynamic system is being examined, it is necessary to define the starting points of making and implementing managerial decisions. The consideration of time factor in economic calculations is determined by the fact that during the assessment of economic efficiency the effect components are distributed over time.

To take into account the time factor, the life cycle of any innovation project is divided into the phases, whose junctions hold the moments of decision-making process (MDMP). This will move towards achieving long-term strategic goals of enterprise's innovation development through optimal implementation of its short-term goals.

In the proposed model it is assumed that each innovation project is assigned a unique "ID" number (*i*), which is constant throughout its operations.

Thus, near MDMP is searched:

$$t_{j+1} = \min\left\{\left(\tau_i + \sum_{r=1}^{G_i(t_j)} \tau_{ri}\right) \quad i \in I(t_j)\right\}, \tag{1}$$

that $t_j$ – $j$-th MDMP; $\tau_i$ – MDMP as to the launch of the $i$-th innovation project; $\tau_{ri}$ – expectancy of a $r$-th stage of the life cycle $i$-th innovation project; $G_i(t_j)$ – a set of numbers of the life cycle stages of the $i$-th innovation project, being implemented at the time $t_j$; $I(t_j)$ – a set of projects being implemented at time $t_j$.

Knowing the current and following MDMP, you can determine the length of the innovation as follows:

$$\Delta t_j = t_{j+1} - t_j. \qquad (2)$$

Under the present conditions of economy's development, a rational allocation of available resources, acts as a determinant factor of successful business activity. Since innovation in terms of resource allocation is non-standard, therefore the role of subjectivity expands at all stages of decision-making.

May a set $H(t_j)$ of resources is given needed to implement innovative projects at time $t_j$. In this case, it is necessary to specify for each project $i \in I(t_j)$ the amount of the resources $h \in H(t_j)$ spent on its implementation – $a_{hri}(t_j) \in M(t_j)$. In this case $M(t_j)$ is a set of projects' evaluations $a_{hri}(t_i)$ in MDMP $t_j$ that are metric data for each project that is being implemented at the moment $t_j$.

Since in most cases the inputs of resources are not evenly distributed over time, it is necessary to determine their use in the period from MDMP till the following decision $t_{j+1}$:

$$t_j^l = t_j^{l-1} + \alpha_{rih}(t_j),\ h \in H(t_j),\ \ i \in I(t_j),\ r \in G_i(t_j), \qquad (3)$$

that $\alpha_{rih}(t_j)$ – the moments of change of resources inputs $h$ to perform a $r$-th stage of the life cycle of the $i$-th innovative project MDMP.

Graphically, this can be shown in Figure 2.

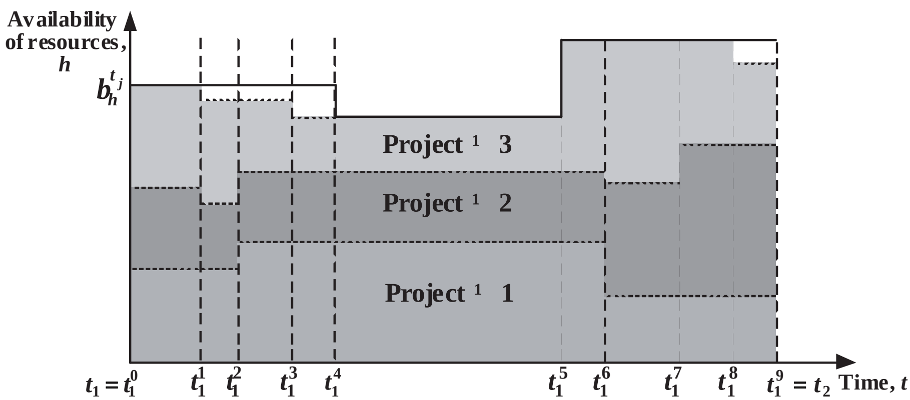


*Figure 2.* **Time allocation for the change of available resources use h,** *developed by the authors*

May a variable that indicates the share of the fulfillment of a $r$-th stage of the life cycle of the $i$-th innovative project in the period of MDMP $t_j$, be indicated through $x_{ri}(t_j)$.

This variable can take the following values:

- $x_{ri}(t_j) = 1$ – enterprise performs a $r$-th stage of the life cycle of the $i$-th innovation project independently;
- $x_{ri}(t_j) = 0$ – enterprise does not carry any actions related to a $r$-th stage of the life cycle of the $i$-th innovation project or another entity fulfills it entirely;
- $0 < x_{ri}(t_j) < 1$ – enterprise fulfills a $r$-th stage of the life cycle of the $i$-th innovation project partly and outsources the other part from other subjects of innovation in the amount $(1 - x_{ri}(t_j))$.

Then the limitation of the resources takes the form:

$$\sum_{i\in I(t_j)} a_{hri}(t_j^l)\times x_{ri}(t_j)\le b_h(t_j^l),\ h\in H(t_j),\ r\in G_i(t_j),\ \ t_j\le t_j^l\le t_{j+1}, \tag{4}$$

that $a_{hri}(t_j^l)$ – the amount of resource $h$, spent on the implementation of a $r$-th stage of the life cycle of the $i$-th innovation project between the moments of the change in the intensity of its use $t_j^l$; $b_h(t_j^l)$ – the predicted amount of available resource $h$ in the moments $t_j^l$.

Using the limitation (4) while making a decision on the implementation of any stage, we can come to a situation when this stage is unlikely to implement. Thus, it is desirable to ask minimum and as well as maximum values $x_{ri}(t_j)$:

$$\underline{x_{ri}}(t_j)\le x_{ri}(t_j)\le \overline{x_{ri}}(t_j),\ i\in I(t_j),\ r\in G_i(t_j). \tag{5}$$

The above discussed limitation of resources and budgetary constraints are suggested to consider separately, although they refer to resource limitations in general. The reason for this is that projects do not have the ability to endogenously produce resources, except financial ones. In addition, many resources cannot be accumulated from one period to another.

The formation of optimum structure of the portfolio of innovation projects is extremely a difficult and cumbersome process. It encompasses a comprehensive analysis of a large number of dynamic both exogenous and endogenous variables and determines the need for a dynamic approach to the optimality criteria selection. The criteria are suggested to be presented by 3 parameters that characterize the main components of innovation feasibility: the maximization of net present value, the minimization of innovation risk and the maximization of public needs satisfaction.

The formula for calculating the net actual value of the portfolio of innovation projects at MDMP tj takes the form:

$$\begin{aligned} NPV^{p}(t_j) &= \sum_{i\in I(t_j)} x_{ri}^{\circ}(t_j)\times\left(\sum_{t_j^m=t_j}^{t_{j+1}} \frac{CF_i(t_j^m)}{\left(1+d^{wacc}(t_j^m)\right)^{t_j^m-t_j}}\right)\pm \\ &\pm \sum_{i\in Ik(t_j)} x_{ri}^{\circ}(t_j)\times\left(\frac{L_i(t_j)}{\left(1+d(t_j)\right)^{\Delta t_j}}\right),\ \ r\in G_i(t_j), \end{aligned} \tag{6}$$

where $x_{ri}^{\circ}(t_j)$ – a binary ratio that refers to the $i$-th innovative project whose $r$-th stage of the life cycle is planned to be implemented ($x_{ri}$ = 1), or vice versa – an appropriate project won't be implemented ($x_{ri}$ = 0); $CF_i(t_j^m)$ – cash flows regarding the $i$-th innovative project at the moments $t_j^m$; $d^{wacc}(t_j)$ – discount rate in MDMP $t_j$, using the WACC methods; $NPV^p(t_j)$ – net present value of the innovation portfolio at MDMP $t_j$.

Thus, the maximization of net present value of the portfolio of innovation projects is assumed as a basis of an objective function of the specified optimization model.

$$NPV^{opt}(t_j)=\max\{NPV^{p}(t_j)\}. \tag{7}$$

The innovation activity refers to the category of the most risky one for investment. That is determined by a complex process of risk management associated with a high degree of uncertainty and time gap between the launch of new products and acquisition of benefits.

The formula is suggested to determine an average integrated risk of a certain strategic profile of innovation:

$$IR(t_j)=\frac{1}{n(t_j)}\sum_{i\in I(t_j)}\left\{x_{ri}(t_j)\times\sum_{s=1}^{S}\alpha_s\sum_{m=1}^{M}p(DV_{ism}(t_j))+(1-x_{ri}(t_j))\times\sum_{q=1}^{Q}\beta_q\sum_{n=1}^{N}p(DZ_{iqn}(t_j))\right\}, \quad (8)$$

where $n(t_j)$ – the number of projects planned for implementation at MDMP $t_j$; $DV_{ism}(t_j)$ – a probable impact of $m$-th causes of $s$-th events on the risk of the $i$-th project at MDMP $t_j$, associated with a plurality of internal factors; $DZ_{iqn}(t_j)$ – $l$-th cause of $q$-th risky events of the $i$-th project at MDMP $t_j$, associated with a plurality of external factors; $\alpha_s$, $\beta_q$ – the factors of significance of $s$-th and $q$-th type of risk under the general vector of risk decisions ($0\le\alpha_s\le1$, $\sum_{s=1}^{S}\alpha_s=1$ and $0\le\beta_q\le1$, $\sum_{s=1}^{S}\beta_q=1$).

The integral indicator of risk (8) is assumed as a basis of an objective function of the optimization model that chooses a strategic profile of innovation for an enterprise.

$$IR^{opt}(t_j)=\min\{IR(t_j)\}. \quad (9)$$

Since the efficiency of the innovation project is evaluated by its potential attractiveness both for businesses and society, it is necessary to determine the significance and usefulness of some projects and innovation portfolio in particular. The social significance of the innovation project can be measured by the share of population that receives benefits from a project, and public utility, as a rule, should be assessed in quantitative terms.

To quantify a social utility of an innovation project with an expert approach a matrix $\|\Lambda(t_j)\|$ with elements $\lambda_{im}(t_j)$ should be built, that reflects the impact of the $i$ – the innovative project on other MDMP $t_j$ development.

Then the coefficient of social utility portfolio of innovative projects takes the form:

$$KSK(t_j)=\frac{\sum_{i\in I(t_j)}\sum_{\substack{m\in I(t_j)\\ i\ne m}}\lambda_{im}(t_j)\times SK_i(t_j)\times x^{\circ}_{ri}(t_j)}{\sum_{i\in I(t_j)}SK_i(t_j)},\quad x^{\circ}_{ri}(t_j)\in\{0;1\}, \quad (10)$$

where $\lambda_{im}(t_j)$ – the impact of the $m$-th innovative project on the value of public utility of the $i$-th project at MDMP $t_j$.

Thus, the coefficient of social utility is based on the criterion of the proposed optimization model in the form of its maximization:

$$KSK^{opt}(t_j)=\max\{KSK(t_j)\}. \quad (11)$$

Having solved the proposed optimization model, the optimal values can be obtained: net present value, integral indicator of risk and coefficient of social utility of the innovation portfolio.

Solving of model optimization model with changing the limit (5) is suggested to choose an optimal strategic profile of innovation. Each solved problem is assigned a serial number $q$, $q\in Q(t_j)$.

The main criterion for choosing a strategy is the distance from its attributes to certain artificially-constructed point, to so-called benchmark of development or an "ideal state". In this case, we assume a benchmark of development is the state in which:

- the value of the integral indicator of risk of the innovation portfolio is equal to zero;
- the coefficient of social utility is equal to 1;
- the value of net present value is equal to the "ideal" the value of $NPV^{*}(t_j)$ at MDMP $t_j$.

A three-dimensional model (Figure 3) is used for the graphical interpretation of model's solution. This model is the analogue of the three-dimensional model in (Porter, 1996). But it is adapted to modern dynamic economic environment and innovative companies. A on Figure 3 will show the so-called "ideal-state" point.

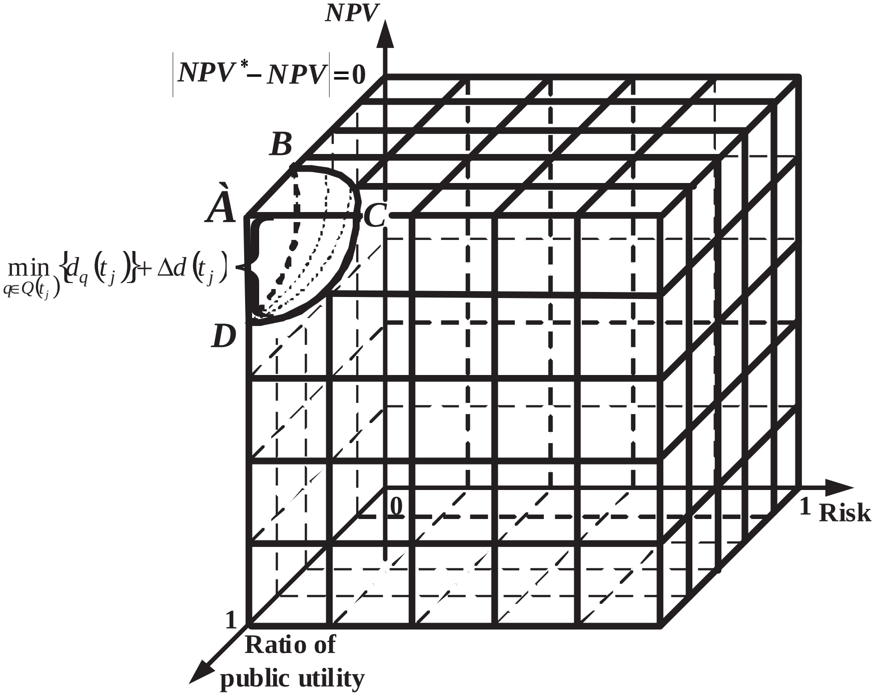


*Figure 3.* **The matrix of choosing strategic profiles of innovation for a dynamic economic and production system,** *developed by the authors*

Thus, having the 3 elements of a particular innovation strategy (*NPV, IR, KSK*), we can construct a point in three-dimensional space that corresponds to the number of the solved problem $q$. Having the multiple of innovative strategies' elements, we can construct a set of such points.

The next step is to determine the deviation, calculated by the distance from the found points to the point of "ideal state", using the formula:

$$d_q(t_j) = \sqrt{(NPV^{*}(t_j) - NPV_q^{opt}(t_j))^2 + (0 - IR_q^{opt}(t_j))^2 + (1 - KSK_q^{opt}(t_j))^2}, \; q \in Q(t_j), \quad (12)$$

where $d_q(t_j)$ – the distance from the point, that corresponds to the $q$-th problem to the point of "ideal state" in MDMP $t_j$.

It should be noted that using the index deviation $d_q(t_j)$ arranges the points on the basis of Euclidean distance from each point to the artificially-constructed standard point. This means that the same assessment of deviation degree can be given to the points located at a considerable distance from each other, in other words, that differ greatly.

Thus, having forming a set of distances $D(t_j)$ whose elements are the values of $d_q(t_j)$, it is necessary to find the values of $d_q(t_j)$ that fall within a certain neighborhood of the smallest value:

$$d_q(t_j) \in \min_{q \in Qt(t_j)} \{d_q(t_j)\} + \Delta d(t_j),\ q \in Q(t_j), \tag{13}$$

that $\Delta d(t_j)$ – the dispersion value of solution at MDMP $t_j$, which is mainly given by an expert committee.

The elements $d_q(t_j)$, for which the condition (13) is fulfilled, create a set of solutions $D^*(t_j)$. In Euclidean space, these elements will be in the segment ABCD with a sphere radius $r(t_j) = \min_{q \in Q(t_j)} \{d_q(t_j)\} + \Delta d(t_j)$, as shown in Figure 3.

The set $D^*(t_j)$ shows the solved problems $q$, which correspond to the strategies of innovative development, it is difficult to choose among them due to the same proximity to the "ideal point", the totality of which forms a set of $Q^*(t_j)$.

In this regard, the coefficients of importance of 3 indicators in the innovation models for the company's management are introduced:

- $\alpha(t_j)$ – the coefficient of importance in net present value at MDMP $t_j$;
- $\beta(t_j)$ – the coefficient of importance of the integral risk at MDMP $t_j$;
- $\gamma(t_j)$ – the coefficient of importance of public utility at MDMP $t_j$.

Moreover, $\alpha(t_j) + \beta(t_j) + \gamma(t_j) = 1$.

Then the elements of the solution set $D^*(t_j)$ should be calculated using the coefficients of importance as follows:

$$dp_q^*(t_j) = \sqrt{\begin{array}{l}\alpha(t_j)\times(NPV^*(t_j) - NPV_q^{opt}(t_j))^2 + \beta(t_j)\times \\ \times(0 - IR_q^{opt}(t_j))^2 + \gamma(t_j)\times(1 - KSK_q^{opt}(t_j))^2\end{array}}. \tag{14}$$

Having listed the value of the distances, we can find a $q$-th point, which corresponds to the best strategy of innovative development:

$$d_{q^{opt}}(t_j) = \min_{q \in Q^*(t_j)} \{dp_q^*(t_j)\}, \tag{15}$$

where $d_{q^{opt}}(t_j)$ – the distance from the $q$-th optimal point to the point of "ideal" state at the time $t_j$ of management decision.

$q^{opt}$ indicates the strategy number that will be optimal to the enterprise under relevant economic conditions at MDMP $t_j$. Having identified the best strategy, it is possible to learn about the set of optimal solutions $x_{ri}(t_j)$, $NPV_{q^{opt}}(t_j)$, $IR_{q^{opt}}(t_j)$, $KSK_{q^{opt}}(t_j)$. Afterwards the forecast of innovation activity $x_{ri}^p(t_j)$, which will form the basis for designing and choosing a strategic profile of innovation for the dynamic enterprise, is made.

The realities of the modern theory of strategic development is that almost all existing models provide only one set of alternative strategies, which are often opposite to each other. Thus, the movement in one direction can lead the development of innovative enterprises in a wrong way (Goldshtein, 2004; Illyashenko, 2003; Porter, 1996).

Taking into account the above mentioned information, company management is advised not to disregard alternative strategies that can have hidden efficiency. They should be considered in the light of the subjective experts' opinions and after comparing the responses with a proposed model, the optimal decision regarding dynamic innovative development companies is to be made.

**Conclusions.** The article offers new substantiated results obtained that enable creating the tools for efficient strategic management of innovative enterprise. Along with it organizational and economic mechanisms of innovation management (based on the complex of mathematical economic models of strategic goal formation), distribution of available resources among various innovative projects, determination of decision-making moments regarding innovation are elaborated. These mechanisms improve qualitative and quantitative indicators of business activity, reduce innovation costs and ensure its competitiveness.

The practical significance of the obtained findings is to provide businesses with methodological tools of strategic management of innovation at a market, regardless ownership and industries.

The main results of the study have been tested in practice at the following companies: JSC "Galenergobudprom" and JSC "Metalist".

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