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Modeling the Management of Patent Activity of Economic Entities

A.V. Gulay^a, A.I. Gourko^b, T.A. Sakhnovich^c, S.V. Yudina^d

^{a,b,c} Belarusian National Technical University, Minsk, Belarus;

^d Kazan National Technical University named after A.N.Tupolev – KAI Kazan, Russia

ABSTRACT

Ratings of the inventive patent activity of researchers in the Republic of Belarus indicate the need to significantly increase the number of filed and registered patents in national and foreign authorities. In this regard, it is necessary to create mechanisms for managing the patent activity of business entities as the foundation for the innovative development of the country's national economy. In this article, the authors identify specific steps to link the management of patent activity with the strategic goals of the entire economic entity. This allows you to experience real economic benefits and make the process of increasing patent activity economically justified. A strategic map for managing the patent activity of an economic entity is proposed as a model. Each goal is associated with indicators that measure the degree of its achievement and determine development prospects. The main stages of creating such a control system are considered.

Keywords: economic object; business entity; patent activity; modeling; management and control system

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INTRODUCTION

The level of innovation in a country is best assessed by the *Global Innovation Index* proposed by the Boston Consulting Group, where patent activity is an important factor.

To measure the quantitative results of research and development with significant technical and technological innovations, patent statistics are used, based on data on the registration of inventions as the results of research and development.

The most important absolute indicators of patenting of inventions include:

- the number of patent applications filed;
- the total number of patents granted, including to domestic and foreign applicants.

For a long period in the Republic of Belarus there was some growth in the inventive activity of national applicants (Fig. 1), but it dropped significantly after a significant increase in the amount of patent fees for inventions in 2014.

The coefficient of inventive activity, calculated as the number of patent applications per 10,000 population, has increased by about 3 times over 20 years and amounted to 1.9 in 2012, falling to 0.6 in 2018, which led to a significant deterioration of Belarus' position in the Global Innovation Index [1].

In the ranking of patent activity of the world's countries issued by the World Intellectual Property Organisation (WIPO), the Republic of Belarus ranked 62nd in 2022 (total applications — 393; resident applications — 298; non-resident applications — 95).¹

Due to the particular specificity of research labour and its results, the potential of inventive activity is a complex object of study and management, so it is advisable to use a different set

¹ Ranking of the world's countries by number of patents. Humanitarian portal. URL: <https://gtmarket.ru/ratings/world-patent-ranking> (accessed on 10.12.2023).

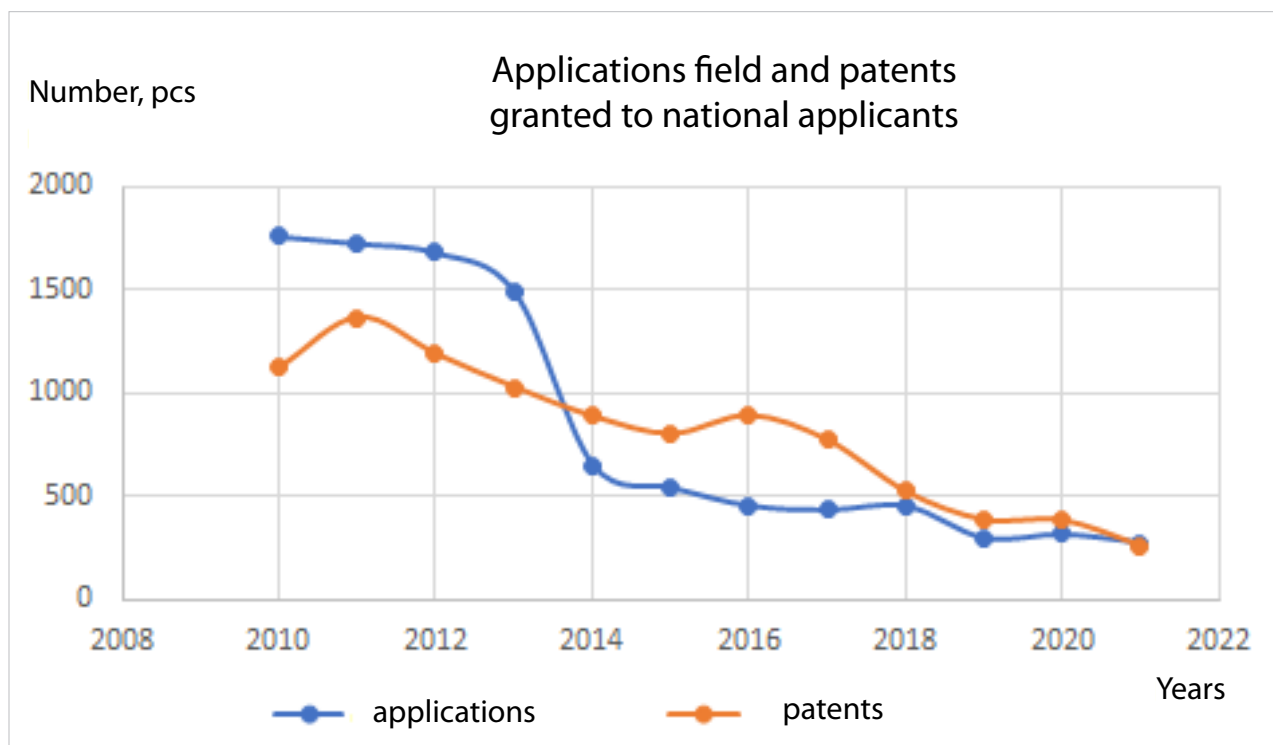


Fig. 1. Time series of patent activity in the Republic of Belarus

Source: URL: https://www.belstat.gov.by/ofitsialnaya-statistika/publications/izdania/public_compilation/index_10865/; https://www.belstat.gov.by/ofitsialnaya-statistika/publications/izdania/public_compilation/index_18023/; https://www.belstat.gov.by/ofitsialnaya-statistika/publications/izdania/public_compilation/index_57394/

(combination) of models, methods and indicators for assessing this activity.

Hypothesis 1: The number of filed patent applications (and granted patents) is determined by a certain number of simultaneously and cumulatively acting factors.

This fact can be represented in the form of a multiple regression equation, which has the following form:

$$y = f(x_1, x_2, \dots, x_n) + \varepsilon,$$

where y — is the number of patent applications filed (dependent variable); x_1, x_2, \dots, x_n — are the factors affecting y (independent variables); ε — is the random error.

The general formulation of the multiple regression problem is as follows:

- according to the available data of n observations of the change in the number of patent applications filed (attribute y), depending on the sets of values of the factors x_1, x_2, \dots, x_n select an econometric model:

$$y = f(x_1, x_2, \dots, x_n) + \varepsilon;$$

- estimate its parameters and statistically justify that the factors x_1, x_2, \dots, x_n are significant, and the constructed function $f(x_1, x_2, \dots, x_n)$ corresponds most accurately to the observational data.

Defining a multiple regression model involves solving two problems:

- selection of independent variables x_1, x_2, \dots, x_n , affecting the number of filed inventions applications;
- selection of the form $f(x_1, x_2, \dots, x_n)$ of y dependence on the variables x_1, x_2, \dots, x_n .
- In this case, it is necessary that the factors x_1, x_2, \dots, x_n , included in the model themselves:
 - were quantifiable;
 - closely related to the effective feature of the outcome;
 - not correlated with each other.

If the latter requirement is violated, it is impossible to determine the individual influence of individual regressors x_1, x_2, \dots, x_n on the result y , which is important for forecasting and making control decisions.

Quantifiable data on R&D in the Republic of Belarus are presented in the *Table 1* below.

The multivariate regression model based on the data in the table is as follows:

$$y = 1864 - 14,743x_1 + 0,06x_2 - 7487x_3 + 9248x_4 + 2,09x_5.$$

It should be noted that there are no other reliable data in open sources characterising patent activity.

Our research shows that the **coefficients of determination R^2** (the share of the dependent variable explained by the regression model of dependence on the explanatory variables) of the factors available for analysis do not exceed the value of 0.6. This indicates that it is impossible to build an adequate regression model based on the available data, which are not statistically related to the number of filed invention applications.

In order to identify the factors that really influence the number of patent applications filed by national applicants, let us look at the experience of other countries. Let us note a few important points.

The number of patent applications is directly related to *the expenditure on fundamental and applied research and development*. They include commercialisation of the results of scientific and technological activities, which is impossible without proper registration of protection documents. Countries with a high level of investment in scientific research are characterised by a high value of the CIA (coefficient of inventive activity), defined as the number of invention applications filed by domestic applicants with the country's patent office per 10,000 people. [2]. The level of R&D expenditures in some countries of the world is shown in *Table 2*.

The initially low level of R&D expenditure is responsible for the decline in the number of invention patent applications filed in the country by national applicants. Not only *high salaries* but also *incentives for the design of a particular invention* allow to increase inventive activity.

Writing the patent application itself, which is subject to strict rules of formatting, causes certain difficulties for developers. In order to

Table 1

Data on scientific research and innovation in the Republic of Belarus

Year	y	y'	x_1	x_2	x_3	x_4	x_5
2010	1759	1126	468	31 712	0.3	0.67	324
2011	1725	1365	501	31 194	0.25	0.68	443
2012	1681	1186	530	39 437	0.24	0.65	437
2013	1489	1027	482	28 937	0.3	0.65	411
2014	652	887	457	27 208	0.24	0.51	383
2015	543	803	439	26 153	0.24	0.5	342
2016	455	892	431	25 942	0.27	0.5	345
2017	434	772	454	26 483	0.34	0.59	347
2018	454	524	455	27 411	0.39	0.6	380
2019	298	388	460	27 735	0.34	0.59	405
2020	317	386	451	25 622	0.32	0.54	447
2021	276	263	445	25 644	0.29	0.47	448

Note:

 y – number of applications for patenting inventions filed by national applicants (pcs.); y' – number of patents for inventions issued to national applicants (pcs.); x_1 – number of organizations performing research and development (pcs.); x_2 – number of personnel engaged in research and development (persons); x_3 – financing of science from the republican budget (in % of GDP); x_4 – internal expenditures on research and development (in % of GDP); x_5 – number of organizations that carried out technological innovations (pcs.)

Source: URL: https://www.belstat.gov.by/ofitsialnaya-statistika/publications/izdania/public_compilation/index_10865/; https://www.belstat.gov.by/ofitsialnaya-statistika/publications/izdania/public_compilation/index_18023/; https://www.belstat.gov.by/ofitsialnaya-statistika/publications/izdania/public_compilation/index_57394/

Table 2

The level of spending on R&D in some countries of the world

Country	The level of expenditure on R&D (as a % of GDP) by years					
	2013	2014	2015	2016	2017	2018
Belarus	0.65	0.51	0.50	0.50	0.58	0.61
China	2.00	2.03	2.07	2.12	2.15	2.19
Russia	1.03	1.07	1.10	1.10	1.11	0.99
USA	2.71	2.72	2.72	2.76	2.82	2.84

Source: compiled by the authors according to: URL: <https://gtmarket.ru/ratings/research-and-development-expenditure>.

conduct a patent search to identify the patentability of a technical solution, a developer must:

- be able to work with patent databases;
- have skills of formalising the description of the development, writing correct claims;
- know the rules of filing an application, especially for foreign patent offices.

For this purpose, it is necessary to engage professional patent attorneys, whose number is insufficient and their services are expensive.

The financial component of patenting should be noted:

- lack of funds of individual inventors, start-ups and small companies does not allow them to patent their inventions in a timely manner;
- the prospects of obtaining a targeted financial result are rather weak;
- implementation implies certain difficulties;
- revenues from commercialisation of rights to the results of inventive activity will not be received immediately.

The specificity of the origin of intellectual property objects is that they are the results of intense intellectual labour mainly of individual researchers, and they are inseparable from their creators [3]. Creativity is an environment of purely individual activity. It is necessary to make a clear distinction between the labour of generating a creative result and contributing to such a result. The basis for the emergence of the right is only a personal contribution – the new thing that is made by the creator [4].

Keeping the invention secret should not be favourable to the inventor. In a market economy, the use of intellectual property objects gives the researcher an opportunity to obtain additional income from monopoly on new technologies, sale of patents and licences. The sale of the right to use the invention should cover the direct costs of its creation and the transaction costs of specification of property rights. The creator must be able to recoup the costs incurred and have incentives (including rents) to continue his intensive and complex activities [5].

The costs of the inventor and other interested agents can be attributed to specific, often unrecoverable (for example, due to imperfect legislative protection) investments. The underdevelopment of the market of intellectual products, the lack or incompleteness of information on transactions with such complex products create the problem of adequate assessment of their market value, and, therefore, the receipt of income and the existence of incentives for their creation.

Hypothesis 2. In order to increase the number of patents applied for and registered in the country, it is necessary to develop adaptive mechanisms for managing the patent activity of economic entities and implement them in the system of regular management.

In order to do this, the following *tasks* must be done sequentially:

1. Identify the *management object* from the environment, as which we will consider the patent activity of the business entity.
2. Determine the *objectives of the management system*.

The management system of patenting activity of a business entity is created in order to achieve an economically justified number of declared and registered patents.

3. To outline the *objectives of the research*. This is the development of internal mechanisms for increasing the patent activity of economic entities and the application of management tools embedded in regular management on their basis.

4. Identify the *functions of patenting activities* of business entities. These include:

- determination of needs;
- motivation;
- goal setting;
- selection of technologies to achieve the maximum possible number of patents applied for and registered.

5. *To set objectives* to achieve the goals of patenting activities, including:

- selection of forms, methods and means;
- obtaining the planned results in the form of filed applications and granted patents;

- diagnostics of the obtained results of patent activity;
- reflexion depending on the obtained results.

In order to realise the *management of patenting activity*, a special structural unit of the economic object (e.g., patent office) is required, which is responsible for the consistent performance of the following functions:

- information gathering;
- planning;
- implementation (including organisation and monitoring of implementation);
- diagnostics (accounting, control, analysis of the results obtained);
- regulation (including adaptation processes) within the business entity.

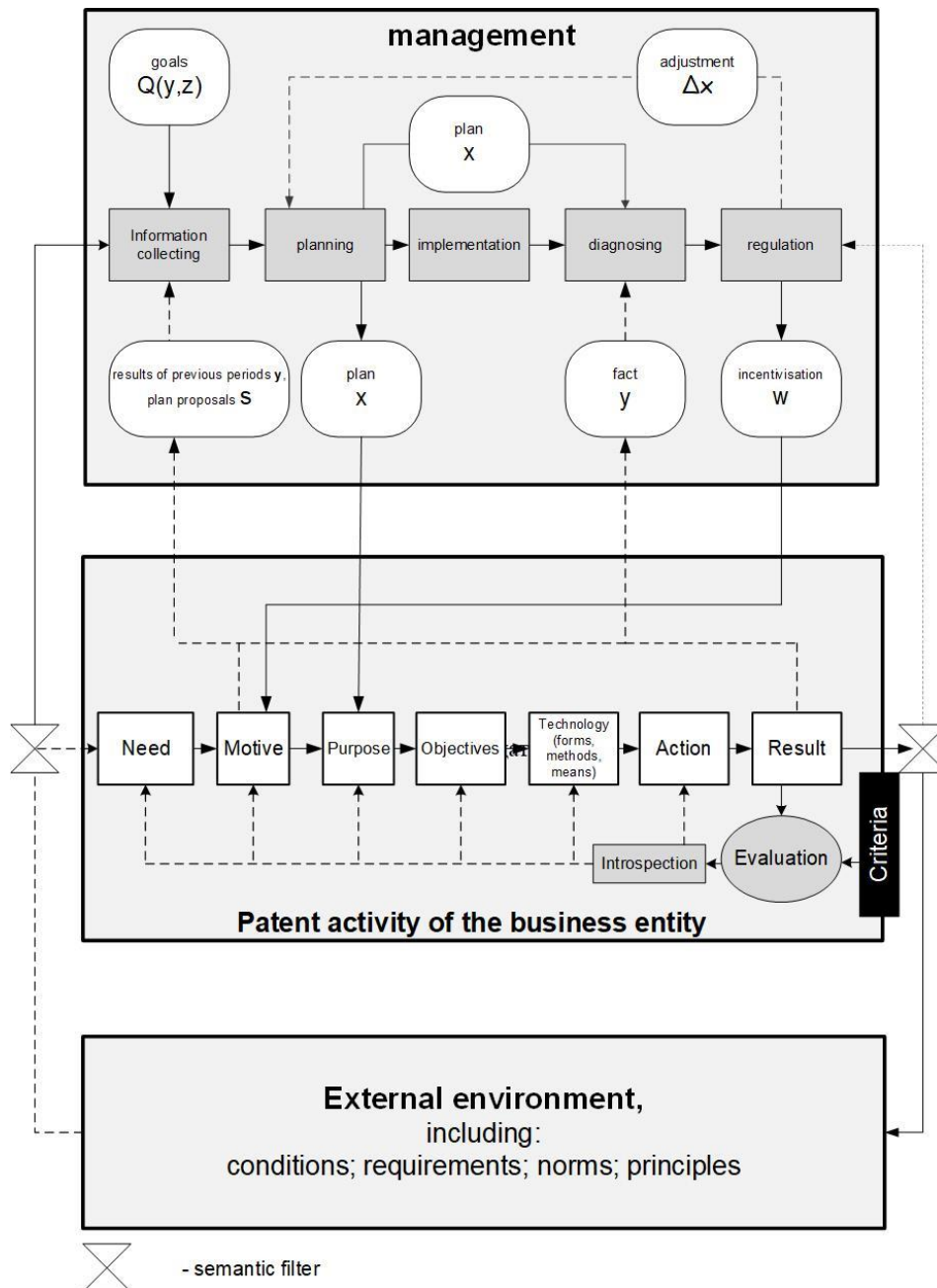


Fig. 2. Mental model of the control system patent activity of an economic object

Source: compiled by the authors.

To determine the *interrelationships and interdependencies* between the elements of the patent activity management system and the external environment.

The structure of the patent activity management system can be presented as a private mental model of the third level management (*Fig. 2*).

As the external environment of the patent activity management system, it is advisable to consider the supersystem representing the general, regular management of the business entity, as well as the state management system, which creates conditions for commercialisation of rights to the results of intellectual activity (RIA).

Let us analyse the economic aspect of increasing the patent activity of economic entities.

Innovations as a result of implementation of patents of own development are realised in the economic entity itself. In addition, patents are sold in order to become innovations in the sphere of consumption. Therefore, patents can be developed both for own needs (implementation in own production or accumulation) and for sale.

A patent can become:

- accumulation in an economic object;
- innovation in an economic object;
- object of sale as a commodity.

The efficiency of patent activity of an economic entity is expressed through economic and financial indicators. In the conditions of market relations there cannot be a unified system of indicators. Each investor determines it independently, based on the peculiarities of the innovation project, professionalism of specialists, managers and other factors.

In fact, if we take into account only the final results of implementation or sale of patents, this activity can be estimated in value terms.

The increase of patent activity should be linked to the strategic goals of the economic object. This will allow to feel real economic benefits and make this process economically justified [6].

Comprehensive consideration of patent activity of an economic entity allows to:

- formulate strategic goals of an economic object;

- to select indicators assessing the impact of patent activity on the achievement of strategic goals;

- to develop strategic measures in several directions that really influence patent activity and ensure it.

At that, the development of the patent activity management system is carried out within the framework of reengineering of business processes of the economic object and includes the following steps:

- specification of strategic goals of the economic object;
- linking strategic objectives by cause-and-effect chains (building a strategic map);
- selection of indicators and determination of their target values;
- determining the connection of indicators with business processes;
- development of strategic measures to increase patent activity;
- cascading, spreading the strategy to all management levels;
- integration of the patent activity management system into the management system of the economic object, for example, with the help of *Business Studio*.²

DISCUSSION OF THE RESULTS

An example of a strategic map of patent management of a business entity is shown in *Fig. 3*.

Fig. 3 presents strategic objectives describing planned results and cause-and-effect relationships between individual objectives. For each objective one or more development directions are specified and the indicators — measures of the degree of its achievement — are given, providing management with timely signals based on deviations of the real state of affairs from the planned one, i.e. the actual quantitative results obtained are compared with the planned ones.

² Documentation of Business Studio. URL: www.businessstudio.ru/wiki/docs/v5.1/doku.php/ru/start (accessed on 10.12.2023).

Strategic map of patent activity management

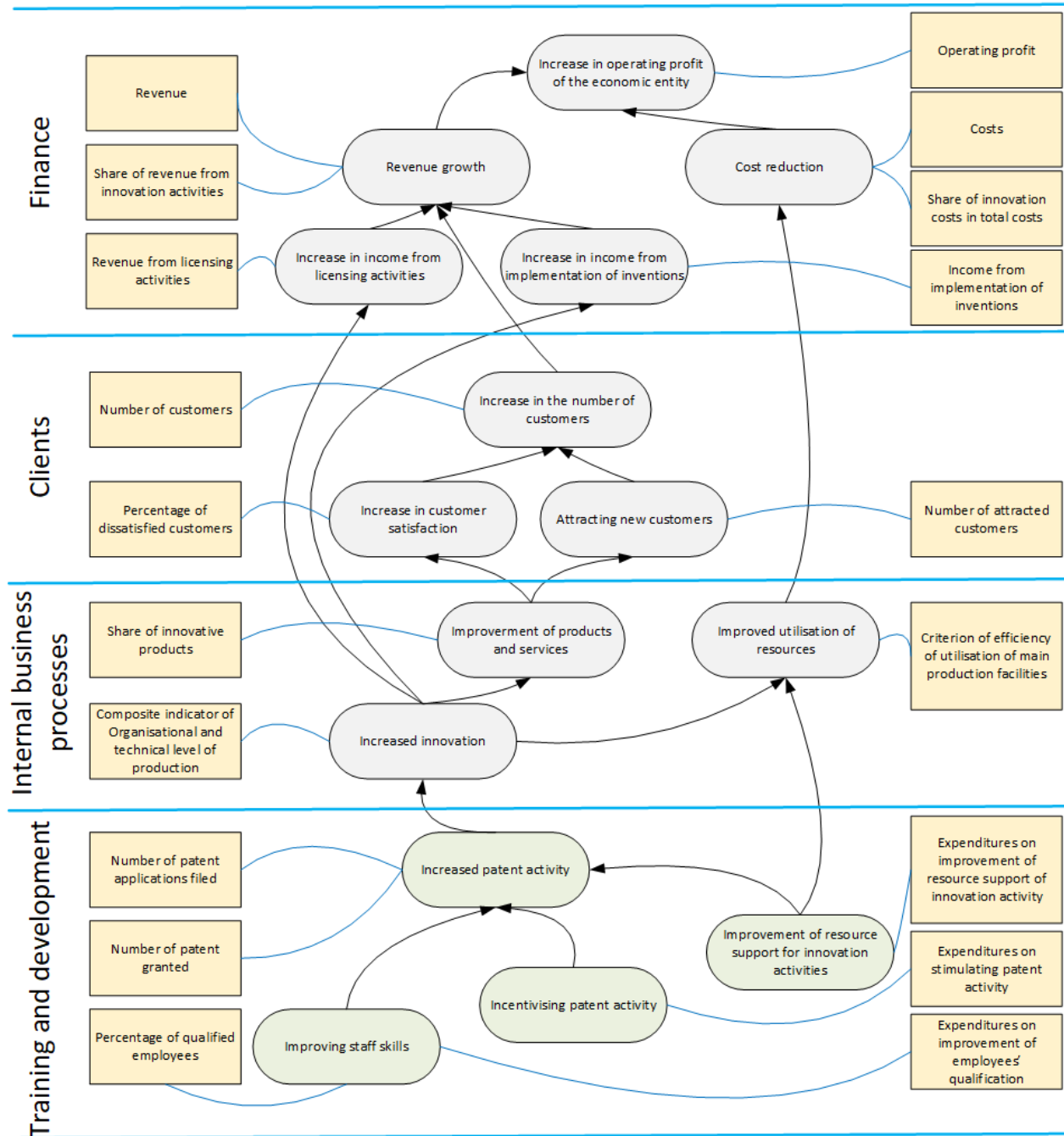


Fig. 3. Strategic map of managing the patent activity of an economic objects

Source: compiled by the authors.

The indicators in the patent activity management system simultaneously serve to assess both the efficiency of business processes and the degree of goal achievement.

The sequence of designing the patent activity management system of an economic entity is as follows:

- formulation of the highest goal of the economic entity;
- development of a strategy for its achievement;
- formation of the upper level of the system of objectives and indicators;

- definition of management objects (economic entities);
- development of a model of business processes, formation of the lower level of the system of goals and indicators;
- designing the organisational structure;
- formation of regulatory and methodological documentation;
- automation of the management system (if necessary).

The process approach is used to describe management activities.

CONCLUSIONS

According to the data of the State Statistics Committee of the Republic of Belarus, for a long period of time there has been some growth in the inventive activity of national applicants, but patent activity in the country has recently declined markedly.

The authors' research shows that it is impossible to build an adequate regression model based on the available data, which are not statistically related to the number of filed invention applications.

The considered factors affecting patent activity indicate an initially low level of R&D expenditures, which causes a decrease in the number of patent applications filed in the country by national applicants.

The mental model of the third level of management of economic entities provides a sequence of tasks in the design of the patent activity management system.

Its enhancement should be linked to the strategic goals of the whole economic entity.

The general approach outlined in the paper can be used in the creation of the patent activity management system of any economic entity.

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ABOUT THE AUTHORS



Anatoli V. Gulay — Cand. Sci. (Techn.), Associate Professor, Head of the Department of Intelligent and mechatronic systems, Belarusian National Technical University, Minsk, Republic of Belarus
<https://orcid.org/0009-0006-1368-2196>
avgulay@bntu.by



Alexandre I. Gourko — Cand. Sci. (Techn.), Associate Professor of the Department of Engineering Economics, Department of Mechanical Engineering, Belarusian National Technical University, Minsk, Republic of Belarus
<http://orcid.org/0000-0002-1042-3328>
alexgourko@bntu.by



Tatyana A. Sakhnovich — Cand. Sci. (Econ.), Head of the Department of Engineering Economics, Department of Mechanical Engineering, Belarusian National Technical University, Minsk, Republic of Belarus
<http://orcid.org/0000-0001-7774-9843>
Sahnovich@bntu.by



Svetlana V. Yudina — Dr. Sci. (Econ.), Prof. of the Department of E&UR, Kazan National Technical University named after. A.N. Tupolev, Kazan, Russia
<http://orcid.org/0000-0001-7774-9843>
Corresponding author:
SVYudina@kai.ru

Author's declared contribution:

A. V. Gulay — development of the major concept of the article.

A. I. Gourko — collection and analysis of data, processing of research results.

T. A. Sakhnovich — processing and interpretation of research results.

S. V. Yudina — development of the research methodology.

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