Regional model of simultaneous investment, production and financial planning of programmes for innovative development

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Abstract. The subject of this study is the planning of programmes for innovative development of the region based on the simultaneous investment, production and financial planning. A regional model of planning the programmes for innovative development has been created to reduce on a global scale current domestic costs for research and development (R&D) of the industrial region depending on its investment planning according to the data on investment in stock capital, production planning according to the data on gross regional product (GRP) and financial planning according to the data on corporate accounts payable. In the Nizhny Novgorod Region investments in stock capital and GRP should be increased and the amount of corporate accounts payable reduced in order to minimise all costs for R&D. However, there is a corporate debt limit established for fundamental research. It is not feasible to exceed such limit because this would lead to an outflow of necessary funds for fundamental research, and increase in costs for applied research as well. For developments, there is a lower GRP limit. It is inadvisable to fall below such limit because this would lead to an outflow of necessary funds for developments.
Keywords: innovative development of regions, investment planning, production planning, financial planning, research and development costs

1 Introduction

At present, the external environment of the Russian Federation requires that consideration be given to the effective and well-balanced socio-economic and innovative development of Russian industrial regions at the national level in the light of modeling the processes of such innovative development.

This study aims to develop a flexible science-based management model that, on the one hand, takes into account the cyclical pattern of innovative development of the industrial region, including the level of its socio-economic development, and, on the other hand, helps

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overcome economic determinism of territories and stimulates economic growth of the industrial region. In order to achieve this goal, it is necessary to create a regional model of simultaneous investment, production and financial planning of programmes for innovative development.

Issues in investment, production and financial planning of programmes have been studied with reference to each other by some eminent scientists. Kruschwitz and Lorenz examined the processes of simultaneous investment and financial planning, as well as simultaneous investment and production planning [1]. Limitovsky complemented their outcomes by his research into systemic financial effects of investment programmes [2]. In their monograph Dinges and Pozdeeva proposed methods for improving the investment and financial activities of road enterprises [3].

Despite the utility of these studies on simultaneous investment and financial planning, it should be used to create innovative development programmes for manufacturers and industrial regions. Fabiana et al. concluded that the development of innovation depends on the type of economic activity conducted by a company and interactions between this company and internal and external environments [4]. Vasconcellos et al. argue that the resources invested in studies do not guarantee immediate practical application and risk and return criteria should be used to manage the R&D portfolio when selecting projects [5].

Thus, the problem of cost planning for research and development (R&D) becomes relevant. Feoktistova underscores the need for use of the project approach in R&D planning and financing, choice of the expected results from the research project as a key criterion, choice of the research project results already achieved by its potential implementer as a key criterion [6]. Gaponenko has examined the cases in which actual costs of R&D can potentially be reduced [7].

Thus, it is necessary to address the reduction of R&D costs so that the economy of industrial regions is improved. In the paper of Yashin et al., the evolution foresight of the Federal District innovation system, based on the use of a multi-purpose genetic algorithm, reveals the need for reallocation of investment resources and R&D costs to the regions which lack economic and financial resources in order to increase the synergy effect of the Federal District [8].

In this context, the issue of managing R&D costs in innovative and industrial clusters that contribute to the socio-economic development of the regions where such clusters are located is relevant. For this purpose, it is necessary to address the problems of cluster management. Thus, Polyanin et al. have created a procedure for assessing the economic security of a cluster, which is characterised by a comprehensive approach that caters for all possible risks and threats in the functioning of individual cluster components [9]. Tashenova et al. have developed a method for assessing the digital potential of backbone active innovation industrial clusters [10].

However, in a broader sense, it is important to manage R&D costs in the industrial region, rather than in its individual cluster. To this end, regional R&D costs should be reduced. Thus, Xu formulated three political recommendations, including the increase in regional investment in R&D, expansion and consolidation of the company as the basis for R&D status, and promotion of regional investment in R&D related human resources [11]. Zh. Chen, Zh. Yang, L. Yang found that increased significance of both internationalisation and externalisation of R&D capabilities improves the technical efficiency of R&D, while spending on government subsidies hampers the technical efficiency of R&D; the effects of R&D extension and Internet penetration are unclear [12]. Dobrzanski and Bobowski determined that increased spending on innovation leads to disproportionate effects in regional public management [13]. Dehmer et al. predict, based on the evolving pattern of past R&D costs for forward-looking projections and considering the absence of any noticeable changes in science policy and spending priorities, a continuing major shift in R&D geography towards Asia, as well as a large and growing (in many contexts) gap between the scientific haves and have-nots in the world [14]. Kiselakova et al. reiterated the importance of placing emphasis on increase in R&D costs, especially in the higher education sector, as this has a significant impact on improving the global competitiveness of Central and Eastern European member states of the European Union [15].

2 Materials and methods

The resolution of these problems leads to the crux of this study: how to reduce R&D costs in an industrial region? The following metaheuristic algorithms of global optimisation will be used to solve this problem:

1) Genetic Algorithm (GA);
2) Simulated Annealing (SA);
3) Pattern Search (PS).

R&D costs will be reduced simultaneously based on the following factors:

1. Investment planning. For this purpose information on the dynamics of investment in stock capital in the region will be used.
2. Production planning. For this purpose information on the dynamics of the gross regional product (GRP) will be used.
3. Financial planning. Since the external financing is considered in such planning, which gives an additional opportunity to industrial companies in the region to develop their innovations, the information on the dynamics of corporate accounts payable will be used for this purpose.

The reduction of R&D costs should also be defined. It is necessary to seek opportunities to reduce R&D costs to such value, which will be achievable with simultaneous regional investment, production and financial planning that allows for determination of the most expedient proportions of the above three planning factors in monetary terms.

Taking into account these assumptions, we will present the stages of implementation of the model in fig. 1. Let us describe these stages in more detail

The stages of the given model implementation are shown in Table. 1 based on the above assumptions.

Table 1. Implementation stages of the regional model of simultaneous investment, production and financial planning of programmes for innovative development. *Source:* prepared by the authors

Collection and preparation of statistical data on the investment dynamics, GRP, and debts of regional companies	**Collection and preparation of statistical data on R&D cost profile of the region by types of activities**	**Construction of non-linear regression models for objective functions of R&D costs by types of activities**	**Regression models optimisation at given intervals by GA, SA and PS methods**
Stage 1	Stage 2	Stage 3	Stage 4

Stage 1 – Collection and preparation of statistical data on the investment dynamics, GRP, and debts of regional companies. In order to construct qualitative future nonlinear regression models for objective functions of R&D costs, it is necessary to receive data on the dynamics of investment in stock capital (x_1), GRP (x_2) and corporate accounts payable (x_3) over a long period covering 10 years. Since the data on domestic current costs of R&D, investment in stock capital and corporate accounts payable for the period up to 2020 are available at the website of the Federal State Statistics Service (*https://www.gks.ru*) without any data on GRP for 2019 and 2020, such data will be predicted separately with the use of *WolframAlpha* (*www.wolframalpha.com*).

In addition, in order to make the data collected comparable, they will need to be adjusted for all annual inflation rates over the period under review.

Stage 2 – Collection and preparation of statistical data on R&D cost profile of the region by types of activities. At this stage statistical information is collected on domestic current costs of R&D in total (y) and by type of work: fundamental research (y_1), applied research (y_2) and developments (y_3). These data should be collected for the same period covering 10 years as at the previous stage. The data are then also adjusted for all annual inflation rates over the period under review

Construction of non-linear regression models for objective functions of R&D costs by types of activities. Nonlinear regression models reflect economic processes more realistically than linear regression models. Furthermore, in this case, such regressions as

$$y = f(x_1, x_2, x_3) \tag{1}$$

will be multiple. To construct them, *Statistica* package is to be used. The quality of the objective regressions will be assessed by the factor of determination (R^2) and adjusted R^2, i.e. by the closeness of their values to 1.

Stage 4 – Regression models optimisation at given intervals by GA, SA and PS methods. This global optimisation will be performed in *Matlab* using genetic algorithm (GA), simulated annealing (SA) and pattern search (PS). To clarify the results of GA and SA, the results of objective function optimisation will be supplemented by hybrid functions of template search and interior point method. That is, GA or SA algorithms are used first and then their results as a starting point for further optimisation of the objective function with the hybrid function. This will provide a better solution in each case for optimising all the costs of R&D, fundamental research, applied research and developments.

3 Results

The results of the given model are illustrated in the example of the Nizhny Novgorod Region, which is a large industrial area.

The following conclusions have been made by comparing the optimal (minimum) value of the relevant R&D costs with their actual minimum value for the period under review.

For all domestic current costs of R&D:

1. With the global optimisation algorithms, minimum costs of all R&D can be planned (RUB 30,666.8 M), which is less than the minimum value observed in the period under review (RUB 49,755.1 M).

2. Minimum costs of all R&D can be achieved with maximum investments in stock capital (RUB 383,102.1 M), maximum GRP (RUB 1,478,448.5 M) and minimum corporate accounts payable (RUB 578,234.4 M). This means that investment and GRP should be increased, and corporate debts reduced.

For fundamental research:

1. The amount of costs for fundamental research depends only on the corporate accounts payable.

2. Reduction of such debts down to the amount less than RUB 25,140.5 M requires costs for fundamental research.

3. Increase in debts up to the amount higher than RUB 25,140.5 M is inexpedient because it leads to an outflow of necessary funds for fundamental research.

For applied research:

1. Costs for applied research depend only on the corporate accounts payable.

2. Such costs can be reduced to the minimum amount (RUB 5,310.3 M) in the absence of the above-mentioned debts.

3. Increase in such debts requires more costs for applied research.

For developments:

1. The amount of costs depends on GRP only.

2. Increase in GRP up to the amount higher than RUB 814,037 M requires development costs.

3. Reduction in GRP down to the amount less than RUB 814,037 M is inexpedient, as it leads to an outflow of necessary funds for developments.

4 Discussion

Comparing the obtained results with the experience of other scientists, it can be noted that Feoktistova [6] highlights in planning and financing of R&D the project approach, choice of expected results of the research project as one of the key criteria, choice of already achieved results of the research project by its potential implementer as the key criterion.

Gaponenko [7] also considered cases when it is possible to reduce the actual costs of R&D: performance of R&D similar to those performed earlier by the same implementer – scientific institution or researcher; performance of R&D similar to those performed earlier by other implementers – scientific institutions; performance (possibly simultaneous) of similar R&D for different customers; using previously obtained research results, previously assembled units in new research, with topics of old and new researches being different; inclusion in the TA (technical assignment) of tasks that are not relevant to the purpose of R&D, the results of which could be used, for example, in another R&D or publication, patent.

Reasonable quantitative benchmarks are offered for planning regional R&D costs; such benchmarks have been obtained after routine and global reduction of the costs outlined.

5 Conclusion

The most important conclusions on the study:

1. The regional model of planning innovative development covers the reduction of domestic current costs for R&D in the industrial region depending on its investment planning according to the data on dynamics of investments in stock capital of the region, production planning according to the data on dynamics of GRP and financial planning according to the data on dynamics of corporate accounts payable.

2. In order to minimise all domestic current costs for R&D in the Nizhny Novgorod Region, investments in stock capital and GRP should be increased and corporate accounts payable reduced. However, there is a corporate debt limit established for fundamental research. It is not feasible to exceed such limit because this would lead to an outflow of necessary funds for fundamental research, and increase in costs for applied research as well. For developments, there is a lower GRP limit. It is inadvisable to fall below such limit because this would lead to an outflow of necessary funds for developments. Since a large part of all costs for R&D is used to fund developments, the management of GRP, i.e.

production, accounts for the bulk of successful financing of all R&D costs in the industrial region under review.

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