# Model for assessing the financing of innovative infrastructure of timber enterprises

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**Abstract.** The article reflects the results of fundamental research aimed at increasing the level of innovative development of timber enterprises. It is proposed to carry out activities to form an innovative infrastructure of the analyzed group of enterprises. The presented model reflects the possibility of attracting financial resources in order to conduct effective innovation activities and maintain the required level of innovation activity. The results obtained were based on the methods of economic and mathematical analysis, comparison of parameters, algorithms for financial calculations. When forming the model, the study reflects all the necessary costs associated with the implementation of the proposed measures in the innovative activities of enterprises engaged in the forest industry. The article also takes into account the influence of various factors (environmental, economic and geopolitical factors) that affect the efficiency of the implementation of an innovative project and the optimality of investment volumes. A function has been formed that determines the possibility of adjusting and redistributing financial resources, adjusted for crisis and sanctions conditions in the economy. Based on the results of the study, the ranking of timber enterprises was carried out and the optimal ratio of attracting financial resources to increase the level of innovative development of forest industry enterprises was determined.

## 1 Introduction

Increasing the level of innovative development of timber enterprises must be carried out in a complex manner using various forecasting methods. The most accessible will be the application of an approach to the formation of an innovative infrastructure of the analyzed enterprises, which will allow enterprises to maintain their positions in the competitive market and develop innovative activities in the long and medium term.

Today, the main conditions for the survival of industrial enterprises, including the timber industry, are the possibility of self-regulation, have intra-industry efficiency, maintain the required level of innovation, and also develop the ability to constantly changing economic conditions, thus having financial and economic flexibility.

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The study proposes a model for estimating the costs of financing activities to form an innovative infrastructure for timber industry enterprises.

The methods of mathematical analysis, algorithmization, and comparative analysis were used in the work.

Let us give the necessary substantiation of the model for the development of the innovative infrastructure of the enterprises of the timber industry complex.

## 2 Material and methods

Before carrying out any activity aimed at increasing the level of innovative development, it is necessary to make calculations on the economic feasibility of a project with justification of the required level of funding. The implementation of measures to form an innovative infrastructure will require a number of expenses.

The costs of implementing measures to improve the innovation infrastructure may be different, but it is necessary to take into account the whole range of possible costs in financing.

To form the function, the initial costs ($R_{ini}$) were determined - they take into account the entire set of costs, taking into account the introduction of the proposed new model of innovation infrastructure (material, labor, financial, natural, information resources).

It is also worth paying attention to the preparatory costs, which in many cases have a large share in the implementation of various activities. $R_{podg.}$ - expenses related to the preparation of the improvement of the necessary innovative infrastructure, including detailing for each type of activity (logging, woodworking, pulp and paper, furniture enterprises) [1-3].

Quite an important role is occupied by the estimated and analytical costs: $R_{oc.}$ – expenses associated with the assessment of the necessary parameters that affect the formation of the innovative infrastructure of timber enterprises.

During the implementation of any project, there may be changes that will require financial costs to change the characteristics of the project being implemented. $R_{opt.}$ - expenses that take into account the necessary measures to optimize the innovation infrastructure for a specific production line of enterprises.

In turn, the value of the total amount of expenses within the proposed direction is calculated by the formula:

$$R_{summ.}=R_{podg.}+R_{oc.}+R_{opt.}, \quad (1)$$

The total amount of expenses for the implementation of the necessary innovative infrastructure at the enterprises of the timber industry complex will be ($R_{total}$), where n is the number of stages for implementing the proposed measures. In turn, it is also necessary to take into account the impact of associated, current and unplanned expenses - Vsp.r.

As a result, we obtain the following equation for calculating the necessary costs associated with improving the innovation infrastructure.

$$R_{tot.}=R_{in}+R_{sum.}\times n\times(f1\times f2\times f3)^{t}, \quad (2)$$

$$V_{sp.r.}=R_{tot.}/\,n^{(t-1)}=P_{ini.}/\,n^{(t-1)}+R_{sum.}, \quad (3)$$

Where $f_1$, $f_2$, $f_3$ - the influence of environmental, economic and geopolitical factors.

## 3 Results and Discussion

For an optimal assessment of the level of costs in the innovation infrastructure, the solution of the problem is proposed by means of a function that has the form: ($f_x$ ($R_{init.}$, n, $R_{summ.}$, f(1…n), $DO_0$). DO0 - discounted payback period of the project for the planned period. The impact of associated, current and unplanned expenses on the development of innovative infrastructure is taken into account in the first period in the calculations, in the future in accordance with the forecast coefficients: (Vsp.r./DO0).

$$V_{sp.r.0}^{\ t-1} = \frac{V_{sp.r.}}{DO_0} = \frac{1}{DO_0}\left[\frac{R_{init.}}{n} \times f_{1...n} + R_{summ.}\right], \tag{4}$$

Another important component in the implementation of the project to create an innovative infrastructure is the level of reliability of the project executors. When forming an innovative infrastructure, it is worth considering the specific features of each type of production of timber enterprises. A number of points need to be taken into account:

In conditions of instability of economic relations, it is necessary to take into account and assess the risks of implementing a project to form an innovative infrastructure. Among them, it is worth paying attention to the level of reliability of potential project executors; accordingly, when selecting executors, a system of criteria should be formed that will allow assessing each potential executor with a high level of financial reliability and minimizing the risks of non-fulfillment of tasks by the executor. The feasibility of a project to form an innovative infrastructure should strive for the maximum level of optimality and reliability. To fulfill the tasks set, the required number (from three to five) of potential executors with the highest indicators of financial stability and economically stable over the past 3 years is being selected [4,5,6].

Let's assume that there is a required number of potential project executors - $k_i$. The level of reliability ($S_i$) of the performers is determined according to the approved methodology used in the financial analysis of enterprises. The amount of allocated financial resources will be – $V_i$. Based on this, the function will look like:

$$S(V_i) = \frac{(1-\alpha_i)}{R_{tot.}} V_i, \tag{5}$$

Where is the $\alpha_i$ - value of the constant function, which must be positive, reflecting the number of measures being implemented for the purpose of innovative development of enterprises.

If one or another project executor does not have the necessary resources, including financial ones, then the degree of project completion should strive for 1.0%, instead of 100.0% required. Consequently, if the necessary resources are sufficient for the contractor, the risk of project failure is minimal, the level of feasibility tends to the upper limit.

The functional dependence will have the following form, the total amount of expenses of the contractor for the implementation of the project is covered by the appropriate funding, 1/1, at which $V_i = R_{total}$, under these conditions, the risk of a negative result in the implementation of the project will be $-\alpha_i$. Provided that all involved organizations fulfill their list of works on the formation of an innovative infrastructure, then the level of reliability ($S_i$) is calculated according to the presented formula:

$$S(s_{1.1}, s_{2.1}, ....s_n) \times (f_{1...n}) = S(v_{1.1}, v_{2.1}, ....v_n) = \sum_{i=1}^{k} \frac{(1-\alpha_i)}{R_{tot.}} \times V_i \times (f_{1...n}), \tag{6}$$

The level of financing directly proportionally affects the degree of reliability of the project being implemented in the future, therefore, with a certain dependence

$S(s_{1.1}, s_{2.1}, ....s_n)$, taking into account the influence of various factors $(f_{1...n})$ and the financial dependence of the type $S(v_{1.1}, v_{2.1}, ....v_n)$. If the project is not completed or financial resources are insufficient, the function will look like this:

$$\sum_{i=1}^{k} V_i \leq R_{tot.}, \tag{7}$$

To carry out work on the formation of an innovative infrastructure, the level of reliability ($S_i$) of the performers should be at the maximum level, which is achieved through the optimal level of project financing. In order to successfully implement the project, the following ratio will be optimal:

$$V_i = \frac{R_{tot.}}{\sum_{i=1}^{k} \frac{(1-\alpha_i)}{1-\alpha_j}} \times (f_{1...n}), \tag{8}$$

I,j=1,2,3……n.

Formula 7 reflects the optimal implementation of the project by the contractor.

With the optimal ratio of financial resources allocated for the implementation of the project to form an innovative infrastructure, the degree of accuracy in achieving the planned indicators increases [7].

The main elements of the strategy for the formation of the innovative infrastructure of timber enterprises are the innovative activity of enterprises and investment activities, i.e. opportunity to attract investment in innovation.

Here, the most optimal will be the use of discontinuous and non-discontinuous functions (without instantaneous jumps), where the continuity condition of the function is taken into account [8].

There is a different set of functions, but the linear regression function, the linear search function and the traditional function based on standard solutions of applied programs - the exponential development function, which is based on the exponent, will be optimal for our study.

If the linear regression function is used, the basis is the possibility of sustainable growth of the function without unexpected and abrupt changes, which is under the index - $C_{(t)}$, defined as the volume of all costs for the formation of innovative infrastructure in a particular type of activity in the i-th period, for period is a calendar year [9].

$$C_{(t^i)} = G_{a/b} + (\beta(const) \times t) + (f_{1,2,3....n}).., \tag{9}$$

Where, g - The amount of expenses for the first year of the investment project to increase the innovative activity of enterprises.

The function determines the amount of expenses for the first period of the study.

$G_{a.}$ - the value of the planned costs for the implementation of the project.

$G_{b.}$ - the value of the actual costs incurred for the implementation of the project.

$\beta$ - the possible value of the increase in the cost of related work.

In subsequent periods, this function can be used, but with a constant increase in financial resources.

In the most obvious way, the share of implementation of the necessary measures can be represented by a linear search function. It builds on the previous one, but has a number of advanced options:

$$C_{(t^i)} = \begin{cases} G_a + \beta(const) \times t + (f_{a1,2,3...n}) \\ G_b + \beta(const) \times t + (f_{b1,2,3...n}) \\ G_{a/b} + \beta(const) \times t" + (f_{a1,2,3...n})" \\ \dfrac{G_{a/b} + \beta(const) \times t"}{(T-1)"}(T-1) \end{cases}, \quad (10)$$

The optimal parameter limits for the presented system are presented in the function [10]:

$$C_{(t^i)} = \begin{cases} \beta(const)_{a,b} \geq 0; t \geq 0; t" \geq t \\ t" \leq T; (f_{b1,2,3...n}) \geq 0 \\ t \geq t"; G_{a/b} \geq 1 \end{cases}, \quad (11)$$

The use of this function is allowed only in case of positive changes associated with an absolute increase in the used financial resources. With negative changes, it is necessary to change the project financing strategy.

The next type of system for this direction is the function of exponential development, based on the use of application programs.

$$C_{(t^i)} = R_{tot.} \times \left( \left( \frac{1}{t"} \times e(const)^{1-t"} \right)^{\beta^t} \right), \quad (12)$$

Provided that the financial resources are in the required quantity and the set goals are achieved, then the function tends to the maximum, the dynamics of expenses corresponds to the tasks being solved. The function takes into account the process of using financial resources over the entire time period, from 1 year to 3 or 5 years, respectively (t"=1,2,3…$t_n$) [11,12]. The maximum value of the function is reached at the point t", which shows the most efficient use of the resources involved and the achievement of the required level of innovative activity.

In the functions proposed earlier, all calculations are given for 1 year, therefore, we will consider the function of distributing funds by years:

$$C_{(t^i)} = \begin{cases} R_{tot.}(t) - R_{tot.}(t-1) \\ C(0)_{(t^i)} = 0; C(1)_{(t^i)} = 1 \\ t_{\min} \leq 0; t_{\max} \geq 0; \\ t^i \leq t^{\max} \leq 1; t^i \geq t^{\max} \geq 1; \end{cases}, \quad (13)$$

This function is determined by the condition of continuity from the initial period, i.e. the first year of the project, at a value of t", the function tends to a maximum. At $t_{max}$, the greatest use of financial resources is achieved in the conditions of the formation of an innovative infrastructure of enterprises. In turn, with the values of the function, in the reverse order, a decrease in the extreme of the function closer to 0 can be observed.

The value of the indicator $\beta(const)$ characterizes the degree of fulfilment of the key indicators of the innovative activity of the enterprise for both long-term and medium-term forecast periods. In conditions of crisis, the assigned tasks can be changed, within a certain interval of the developed function. If the project work is transferred to other performers, then the indicator values $\beta(const)$ are adjusted and a new functional dependence is built, but the time intervals must be unchanged and not be cyclical for given amounts of funding.

The exponential development function (12) makes it possible to estimate the real level of costs for the formation of an innovative infrastructure, and to determine the maximum and minimum values under acceptable conditions.

The entire amount of expenses for the implementation of the innovative development program is calculated subject to the known time periods (t and t") and the parameters $\beta(const)$ presented in formula (14):

$$R_{tot.} = \frac{C_{(t^i)}}{\left(\left(\frac{1}{t"} \times e(const)^{1-t"}\right)\right)^{\beta^t}}, \tag{14}$$

This function is used to calculate the total cost of implementing a program to increase the innovative activity of an enterprise. Another condition for the formation of the innovation infrastructure is the period of turnover of the proposed activities, taking into account the timing of the implementation of the activities, the function will look like this:

$$\beta^t = \frac{\left[C_{(t_0{}^i)} / P\right]}{\left[(t_0 / t^{"}) + 1 - (t_0 / t")\right]} \times (f_{1,2,3...n}), \tag{15}$$

Based on function 12 and the indicator $\beta(const)$, it is possible to adjust and redistribute financial resources, adjusted for crisis and sanctions conditions in the economy. The implementation period of the proposed measures t" is adjusted in the required range.

$$C(t^i) = R_{tot.}\left(\frac{1}{t^{"}} \times e(const)^{1-t^{"}}\right)^{\beta^t} \times (f_{1,2,3...n}), \tag{16}$$

In this case $\beta^t$, it is a constant variable, and $C(t_0)$ is a parameter that takes into account the amount of financial security at the required time t.

**Table 1.** The optimal ratio of attracting financial resources to increase the level of innovative development of timber enterprises.

| **Levels / $C(t^i)$** | **Logging enterprises** | | | **Woodworking enterprises** | | | **Pulp and paper enterprises** | | | **Furniture enterprises** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Periods ($t_0$)** | | | | | | | | | | | |
| | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** | **1** | **2** | **3** |
| 1 | 3,9-4,1 | 4,2-4,4 | 3,7-3,9 | 4,2-4,4 | 4,5-4,7 | 4,7-4,9 | 4,3-4,5 | 4,6-4,7 | 4,8-5,0 | 3,3-3,6 | 3,7-3,9 | 4,0-4,3 |
| 2 | 3,6-3,9 | 4,0-4,3 | 4,4-4,6 | 3,9-4,1 | 4,2-4,4 | 3,9-4,3 | 3,7-3,9 | 4,0-4,3 | 4,5-4,7 | 4,1-4,3 | 4,4-4,6 | 4,4-4,9 |
| 3 | 3,1-3,3 | 3,4-3,7 | 3,3-3,9 | 3,3-3,5 | 3,7-3,9 | 4,1-4,2 | 4,0-4,2 | 4,3-4,5 | 4,7-4,9 | 4,4-4,6 | 4,7-4,8 | 4,9-5,0 |
| 4 | - | - | - | - | - | - | 4,5-4,7 | 4,7-4,8 | 4,9-5,0 | - | - | - |
| 5 | - | - | - | - | - | - | 4,1-4,3 | 4,4-4,6 | 4,7-5,0 | - | - | - |

Table 1 presents the calculated values of the optimal ratio of attracting financial resources to increase the level of innovative development of timber enterprises, the calculations were made for a 3-year period, i.e. 3 years of implementation of measures, 5 possible options for the development of the situation are proposed, taking into account the

crisis phenomena and the influence of various factors. If, for a specific type, the innovative development program does not fall into any field, then it is necessary to review the amount of funding and the periods of their implementation.

Figure 1 shows the ratio of the proposed functions for the first development option according to the maximum values.

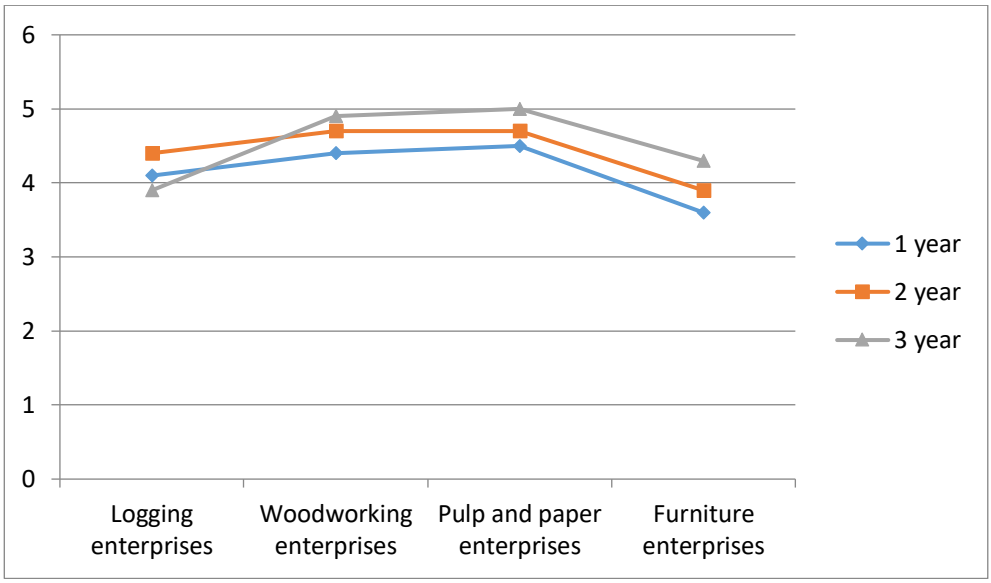


**Fig. 1.** The ratio of the proposed functions for the first development option for the maximum values

## 4 Conclusion

According to the presented approach and the developed model, it is for the enterprises of the timber industry complex that it becomes possible to assess the costs of implementing measures to form the innovative infrastructure of enterprises. For each type of activity, the model can be adjusted, but only in terms of the timing of the project or the amount of financial resources brought to the contractor. The assessment of the required amount of expenses for the implementation of activities in the areas should be carried out based on up-to-date analytical data both for the industry and for a particular enterprise.

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## References

1. S. A. Smolyak, Evaluation of the effectiveness of investment projects under risk and uncertainty The theory of the expected effect, Moscow, Nauka, 182 (2002)
2. L. H. R. Alvarez, E. Koskela, Progressive Taxation, Tax Exemption, and Irreversible Investment under Uncertainty Journal of Public Economic Theory, **1**, 149–169 (2008)

3. F. Crocce, E. Mordecki, Explicit solutions in one-sided optimal topping problems for one-dimensional diffusions Stochastics, **3**, 491–509 (2014)
4. M. V. Drapalyuk, T. L. Bezrukova, I. I. Shanin, B. A. Bezrukov, Methodology of probabilistic modelling of the current activity of industrial enterprises Journal of Physics: Conference Series, 1333, 072022 (2019)
5. L. Trigeorgis, J. J. Reuer, Real options theory in strategic management Strategic Management Journal, **38**, 42-63 (2017)
6. T. L. Bezrukova, I. S. Igolkin, Yu. A. Salikov, I. V. Smolyaninova, A. E. Akhmedov, Innovational approach to diversification of activities of a modern university on the basis of remote education The International Journal of Educational Management, **33(3)**, 486-493 (2019)
7. T. Gries, U. Prior, C. A. Sureth, Tax Paradox for Investment Decisions under Uncertainty Journal of Public Economic Theory, **3**, 521–545 (2012)
8. L. Trigeorgis, A. E. Tsekrekos, Real options in operations research: A review and synthesis European Journal of Operational Research, **270**, 1–24 (2018)
9. I. I. Shanin, Modeling the priority directions of innovative development policy of timber processing complex enterprises based on correlation analysis Journal of Physics: Conference Series, 1333, 072024 (2019)
10. Tian Yu, Optimal policy for attracting FDI: Investment cost subsidy versus tax rate reduction International Review of Economics and Finance, **53**, 151–159 (2018)
11. I. I. Shanin, O. A. Boris, Economic-mathematical simulation modeling of management and innovative activities of the industrial enterprises Journal of Physics: Conference Series, 1333, 072023 (2019)
12. V. M. Vasiltsova, S. A. Dyatlov, V. S. Vasiltsov, T. L. Bezrukova, B. A. Bezrukov, Methodology of management innovation hypercompetition Asian Social Science, **20**, 165-169 (2015)