Modeling the priority directions of innovative development policy of timber processing complex enterprises based on correlation analysis

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Abstract. When developing approaches according to innovative development of the timber industry enterprises, it is necessary to consider the strategy of innovative development of the production direction within its spatial and social and economic features. The system of assessment of indicators criteria has to contain the necessary indicators considering all levels of development of the enterprise before its functioning in world economic relationship. In the applied system of assessment of innovative development of the timber industry enterprises the available financial statistics and their updated data obtained on the basis of the offered new approaches to calculations have to be used. Each innovative process has to be in a condition of continuous development. During change of one process, another and some other change, i.e. the processes to some extent are interconnected among themselves. In certain cases ecologic-economic events seldom develop in an individual order, they have to form complexity of processes where the independent impact of each process on others, on degree of their hierarchy comes to light. During research of influence of a number of factors on one productive process, application of the analysis on the basis of a correlation and regression method with creation of the regression equations is possible. In this method interdependence of factors is considered; therefore, influence of each factor on this or that process is represented in more detail. In a correlation and regression method direct influence of a factor on a productive indicator, indirect influence of group of factors and influence of all set of factors on a productive indicator are considered.

1. Introduction
The need in correlation and regression modeling is defined by the most exact forecast of production of innovative products at timber industry enterprises. On this basis, discharged influencing factors which have the greatest impact on production of innovative products and productive indicators of activity of the enterprises are defined.

We offer an approach to assessment of volumes of innovative products of the timber industry enterprises on the basis of the recursive system of the regression-econometric equations. This approach includes the following consecutive stages:

- selection of the indicators having an impact on production of innovative products [1];
- correlation and regression modeling of production of innovative products and forecasting of productive indicators of activity of the enterprises;
creation of forecasts and plans of production of innovative products with use of models and regression equations [2].

The system of the correlation and regression equations in scientific research is under construction on the basis of the following components.

1. The independent equations – all independent variables (Y) are considered in the form of function of set of contributing factors (X) [3]:

\[
\begin{align*}
Y_1 &= a_{11}X_{11} + a_{12}X_{12} + \cdots + a_{1m}X_{1m} + \epsilon_1; \\
Y_2 &= a_{21}X_{21} + a_{22}X_{22} + \cdots + a_{2m}X_{2m} + \epsilon_2; \\
& \vdots \\
Y_n &= a_{n1}X_{n1} + a_{n2}X_{n2} + \cdots + a_{nm}X_{nm} + \epsilon_n.
\end{align*}
\]

The set of contributing factors (X) in a system of equations can vary. At absence in the system of independent variables of some contributing factor, this factor is characterized as economically inexpedient, discarded and does not join in model. At the same time, the insignificance of extent of its impact on productive indicators of activity of the enterprises is defined (inexpediency of value of criterion (t) and criterion (F) for this insignificant factor). All equations of a system of independent variables are considered independently. When finding their parameters it is necessary to use the least-squares method. At the same time, any of contained in a system of equations, is the regression equation.

As in the course of calculations factors partially or completely can not characterize dependent variables, in this case the absolute term \(a_0\) is entered into the equations. At difference of the actual values of dependent variables from planned, the value of an intermittent error which can be present at each of the system equations should be considered.

2. The system of the correlation and recursive equations is under construction on the basis of the dependent variable (Y) entering one of the equations which is considered as a contributing factor in other equations [4, 5]:

\[
\begin{align*}
Y_1 &= a_{11}X_{11} + a_{12}X_{12} + \cdots + a_{1m}X_{1m} + \epsilon_1; \\
Y_2 &= b_{21}Y_1 + a_{22}X_{22} + \cdots + a_{2m}X_{2m} + \epsilon_2; \\
& \vdots \\
Y_n &= b_{n1}Y_1 + \cdots + b_{nm}Y_{n-1} + a_{n1}X_{n1} + a_{n2}X_{n2} + \cdots + a_{nm}X_{nm} + \epsilon_n.
\end{align*}
\]

In the system of the correlation and recursive equations, each of the available equations can be considered as the independent equation, with determination of its parameters by method of the smallest quadratic deviations.

3. A system interdependent (integrated, simultaneous) the correlation equations – in this system interdependent variables are identical by sign contain ed in the left part of a system of equations, and in other equations in the right part [6, 7]:

\[
\begin{align*}
Y_1 &= b_{12}Y_2 + \cdots + b_{1m}Y_n + a_{11}X_{11} + a_{12}X_{12} + \cdots + a_{1m}X_{1m} + \epsilon_1; \\
Y_2 &= b_{21}Y_1 + b_{22}Y_2 + a_{22}X_{22} + \cdots + a_{2m}X_{2m} + \epsilon_2; \\
& \vdots \\
Y_n &= b_{n1}Y_1 + \cdots + b_{nm}Y_{n-1} + a_{n1}X_{n1} + a_{n2}X_{n2} + \cdots + a_{nm}X_{nm} + \epsilon_n.
\end{align*}
\]

In comparison with other systems, each of the equations in systems with the simultaneous equations cannot be considered as the independent equation. When finding its parameters the classical method of the smallest quadratic deviations is unacceptable. In this regard, ad hoc methods of assessment are applied.
2. Results and Discussion

Correlation analytic function belongs to analytical valuation methods of the innovative development where as parameters the nonrandom components determined by a time series on the basis of creation of forecast curves by means of which the regression model is implemented are defined. In correlation analytic function as dependent variable the Yt variable, and quality trend, a variable on t time is taken [8]. Parametrical components of the majority of forecast curves can be evaluated by the method of the smallest quadratic deviations, i.e. selection of variables is carried out, thus, at which the function graph of a forecast curve is located at minimum remote level from values of basic data. The results of creation of correlation analytic function of volumes of the innovation products of the timber industry enterprises executed are presented in the computer application "Microsoft Office of Excel" in figure 1.

![Figure 1. Dynamics of volumes of innovative products of the timber industry enterprises](image)

In calculation results it is visible that in application of the approaches aimed at innovative development of timber processing complex, trends of growth of indicators of production of innovative products will remain. But, in comparison with other industries, these expected values are at the insufficient level. In this regard, identification of the major factors having an impact on success of innovative activity of the timber industry enterprise and functional interrelations between these factors can represent special value for managers-managers and the highest top management of the timber industry enterprises.

According to the Ministry of Economic Development of the Russian Federation the value of balanced financial result on the directions "Processing of Wood and Production of Products from a Tree and a Stopper, except Furniture, Production of Products from Straws and Materials for Weaving" for the period decreased in January-August, 2017 by 34.4 billion rubles in comparison with a similar interval of the previous period. And the value of financial result was 2.3 billion rubles (at 180 enterprises of timber processing complex profit in the general size of 20.5 billion rubles is observed, and at 107 enterprises the loss of 18.1 billion rubles is observed).

The value of balanced financial result on the Production of Paper and Paper Products direction for the period decreased January-August, 2017 by 26.41 billion rubles in comparison with a similar interval of the previous period and the value of financial result was 2.3 billion rubles (at 180 enterprises of timber processing complex profit in the general size of 20.5 billion rubles is observed, and at 107 enterprises the loss of 18.1 billion rubles is observed).

For carrying out modeling the recursive system of the regression-econometric equations as endogenous (internal) variables used the following indicators [9]:

\[ y = 3448.1\ln(x) + 28236 \]
Y1 – the volume of the made innovation products at the enterprises of timber processing complex, million rubles;
Y2 – cumulative financial result at the enterprises of timber processing complex of the country, million rubles.
Y3 - costs of the innovation activity, one million rubles.
Y4 – profitability of the innovation products, one million rubles.

Various factors have an impact on all set of the studied indicators. So, the level of innovative development of the enterprises of timber processing complex of the country is influenced by a condition of fixed assets of the enterprises, namely the used equipment and the used machines, investments into science and innovations in the form of capital investments and also financing in development of the human resources and highly skilled employees capable to introduce and create innovative products. In this regard they act as factorial indicators:

X1 is an exponent of wear of the fixed business assets of the enterprises, %;
X2 are investments into science and innovations in the form of capital investments, thousand rubles;
X3 is an indicator of the made products, goods of LPK, one billion rubles;
X4 – number of the human resources and highly skilled employees capable to introduce and create innovative products, persons.

Creation of the regression equations taking into account factorial and productive indicators requires use of a steam room and multiple correlation. The interdependence between the studied indicators is measured by a correlation ratio which in the form of function of rectilinear dependence is called correlation coefficient. The used coefficient was calculated by a formula [10, 11]:

\[ r = \frac{\sum_{i=1}^{n} x_i y_i - n \bar{x} \bar{y}}{\sqrt{\left(\sum_{i=1}^{n} x_i^2 - n \bar{x}^2\right) \left(\sum_{i=1}^{n} y_i^2 - n \bar{y}^2\right)}} \]

(4)

where xi, yi – indicators variables;
x, y – mean values of variables;
n – selection volume.

The value of coefficient of correlation can change within [-1;1]. Here r = 1 is characterized as value of ideally positive regression correlation, r = -1 characterized as value of ideally negative regression correlation. The value of coefficient of correlation of r = 0 is not considered, at r > 0 value of linear regression positive correlation, at r < 0 value of linear regression negative correlation. Interdependence degree between factorial and productive indicators is brought in a correlation matrix (table 1).

| Variable | X1     | X2    | X3    | X4    |
|----------|--------|-------|-------|-------|
| X1       | 1,12   | 0,49  | -0,84 | -0,71 |
| X2       | 0,47   | 1,24  | 0,02  | 0,34  |
| X3       | -0,73  | 0,09  | 1,07  | 0,41  |
| X4       | -0,61  | 0,31  | 0,42  | 1,31  |

Interdependence among factorial and productive indicators are estimated on Cheddok's scale:
0.1 < r < 0.3 – the weak level of interdependence;
0.3 < r < 0.5 – the moderate level of interdependence;
0.5 < r < 0.7 – the noticeable level of interdependence;
0.7 < r < 0.9 – the high level of interdependence;
0.9 < r < 1 – very high level of interdependence.
On the basis of calculations, it is possible to draw the following conclusions. The greatest interdependence is observed between an exponent of wear of the fixed business assets of the enterprises and an indicator of the made products (interdependence the return, high level); between an exponent of wear of the fixed business assets of the enterprises and investments into science and innovations in the form of capital investments (the straight line at the noticeable level interdependence is observed). It is also observed between an exponent of wear of the fixed business assets of the enterprises and number of the human resources and highly skilled employees capable to introduce and create innovative products (the return interdependence at the noticeable level) [12].

In the course of calculation of correlation coefficient and determination of interdependence between these or those influencing factors and the used indicators, the major problem of confirmation of the importance of the received values of the calculated coefficient is solved [13, 14]. After calculations it is necessary to carry out an inspection and to make justification of a possibility of use of the received value (r), within a sample and correctness of a conclusion about admissibility or inadmissibility of rectilinear dependence to all data array [15]. Conducting check of the importance was carried out on the basis of criterion (t) of a method of statistical check of hypotheses. On calculation results it is possible to check the null hypothesis defining the provision of correlation coefficient in the chosen data array at value equal 0. The calculated value of criterion (trasch) needs to be compared to its value in the table chosen from the calculation table for numerical values of degrees (n-2) and the available confidential probability (α). In the course of the research the value α was 7% (0.07). Provided that trasch> ttabl, it is possible to claim the fact that the correlation coefficient matters more than 0 and between the analyzed indicators there is a factorial dependence. When calculating in the research, it is revealed that among the selected influencing factors on indicators with the greatest interdependence, trasch at all positions above ttabl that can be characterized by existence of a reliable communication between them, at the same time value of correlation coefficient is at the noticeable level.

With application of this method calculation of correlation coefficients between the influencing factors and the available productive indicators of activity of the enterprises (table 2) was carried out.

**Table 2. Values of correlation coefficients between the factorial and determined productive signs**

| Variable value | x1     | x2     | x3     | x4     |
|----------------|--------|--------|--------|--------|
| y1             | -0.704 | 0.261  | 0.682  | 0.734  |
| y2             | -0.485 | 0.576  | 0.429  | 0.593  |
| y3             | -0.266 | 0.891  | 0.176  | 0.452  |
| y4             | -0.047 | 1.206  | -0.077 | 0.311  |

Having analysed the data presented in table 5 it is possible to draw a conclusion that the largest level of influence on volume of the made innovative products at the enterprises of timber processing complex renders an exponent of wear of the fixed business assets of the enterprises (interdependence the return, high level). An indicator of the made products, goods of LPK (a straight line at the noticeable level interdependence) and number of the human resources and highly skilled employees capable to introduce and create innovative products (the straight line at the noticeable level interdependence is observed). Costs of innovative activity are in direct interdependence at the weak level with volumes of the made innovative products.

**Table 3. The actual values received by method of statistical check of hypotheses (in absolute expression)**

| Variable value | Y1  | x1     | x2     | x3     | x4     |
|----------------|-----|--------|--------|--------|--------|
| y1             | -   | 4,132  | 0,794  | 3,783  | 2,822  |
| y2             | -   | 3,541  | 0,404  | 3,671  | 1,914  |
| y3             | -   | 2,95   | 0,014  | 3,559  | 1,006  |
| y4             | 3,274| 2,359  | -0,376 | 3,447  | 0,098  |
3. Conclusion
The largest level of influence renders an exponent of wear of the fixed business assets of the enterprises on financial results (direct interdependence at the noticeable level), number of the human resources and highly skilled employees capable to introduce and create innovative products (direct interdependence at the moderate level). Influence of an indicator of investments into science and innovations in the form of capital investments and an indicator of the made products moderated also shows direct interdependence. Check of the importance of the influencing factors on indicators takes place by means of criterion (t) (table 3), provided that confidential probability \( \alpha = 0.07 \) (7\%) \( t_{tabl} = 3.107 \).

On the basis of data of table 1,2,3 it is visible that in case of interdependence between productive financial performance and the influencing x2 factor (investments into science and innovations in the form of capital investments) \( t_{trash} < t_{tabl} \), and interdependence between the volume of the made innovative products at the enterprises of timber processing complex and cumulative financial result at the enterprises of timber processing complex and this influencing factor is statistically at the insignificant level. Therefore, in model on the basis of the recursive system of the regression and econometric equations (recursive and regression model) factors of X1, X2, X4 are selected. It should be noted that in the course of the analysis of a matrix of pair correlation coefficients the multicollinearity was not found (correlation coefficient \( r > 0.7 \) on absolute expression). Therefore, all sets of the influencing factors need to be used in the course of creation of the regression and econometric equations (recursive and regression model).

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