**USE OF ECONOMIC AND MATHEMATICAL MODELING TOOLS IN PLANNING INVESTMENTS IN FIXED ASSETS**

**Abstract** In order to maximize the effectiveness of fixed assets use it is necessary to assess the impact of organizational factors on capital productivity of fixed assets, and also to assess the feasibility of capital investment in fixed assets.

The purposes of the study are to design economic-mathematical model that makes it possible to predict a value of capital productivity knowing the values of different factors, as well as to calculate the effectiveness of capital investment in fixed assets on the example of the Tatarstan energy company regional branch.

**Keywords:** Fixed assets, capital productivity, correlation and regressive analysis, investments, capital investments in fixed assets, net present value (NPV)

**1. Introduction**

**2. Method**

**2.1. Assessment of the impact of fixed assets on organization’s work efficiency**

In a modern market economy fixed assets are essential components of functioning of the organization since usefulness and efficiency of organization’s work depends on their availability and use. Fixed assets have a significant impact on financial result of organization’s work due to their use on enterprise more than one operation cycle [1, p. 650].

Fixed assets efficiency calculation is done by the ratio of results received from the use of fixed assets and resource costs. There are several indicators that are used for analysis of fixed assets efficient use: capital productivity, capital intensiveness, capital-labor ratio, relative and absolute savings of basic production assets, return on fixed assets [2, p. 282].

Fixed assets capital productivity can be defined as division of sold production revenue position into fixed assets average annual cost.

Capital productivity is summarizing indicator of effectiveness of fixed assets use. It describes how many goods and services in value terms were produced in the reporting period for 1 ruble of the cost of fixed assets. The higher the use of fixed assets efficiency gets, the higher the rate of capital productivity is.

Let us make analysis of effectiveness of fixed assets use in the Tatarstan energy company regional branch. The purpose of this analysis is to identify the form and degree of relationship between output and performance indicators. We will use the fixed assets capital productivity in the Tatarstan energy company regional branch as an output factor. It is an important indicator which describes fixed assets use efficiency.

Due to the high level of fixed assets wear and tear in the Tatarstan energy company regional branch, we will consider the dependence of capital productivity on number of technical and economic factors and also design economic-mathematical model that makes it possible to maximize effectiveness of the fixed assets use.

In this analysis capital-labor ratio (x\_1), repairing costs (x\_2), cost of active part of fixed assets (x\_3) and degree of equipment wear (x\_4) are independent variables.

Pair correlation matrix according to the data of the Tatarstan energy company regional branch for 2009-2019 years is presented in table 1.

Table 1

Correlation matrix according to the Tatarstan energy company regional branch for 2009-2019 years

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Indicators | Capital productivity, in thousands of rubles | Capital-labor ratio, in thousands of rubles per person | Repairing costs, in thousands of rubles | Cost of active part of fixed assets, in thousands of rubles | Degree of wear, % |
| Capital productivity, in thousands of rubles. | 1 | х | х | х | х |
| Capital-labor ratio, in thousands of rubles per person | 0,838969342 | 1 | х | х | х |
| Repairing costs, in thousands of rubles | 0,832580953 | 0,854378611 | 1 | х | х |
| Cost of active part of fixed assets, in thousands of rubles | 0,919561102 | 0,942181446 | 0,850615835 | 1 | х |
| Degree of wear, % | 0,270126737 | 0,287697434 | 0,407158511 | 0,42399398 | 1 |

According to table 1 the capital productivity in Tatarstan energy company regional branch has close link with the capital-labor ratio of fixed assets (r\_yx1=0,84), with fixed assets repairing cost (r\_yx2=0,83) and with cost of active part of fixed assets (r\_yx3=0,91). Degree of wear (r\_yx4=0,27) has a limited impact on test parameter.

The link between the capital-labor ratio and the cost of active part of fixed assets in the Tatarstan energy company regional branch is close (r\_х1x3=0,94). It means that there is multicollinearity, that is why between two factors it is more appropriate to remain one that has the closest link with the capital productivity. Since the cost of active part of fixed assets has a big impact on the capital productivity, we will use two-factor model for our analysis.

Using tool “Regression” in MS Excel we will make regression analysis of the cost of active part of fixed assets and the repairing costs’ impact on fixed assets capital productivity in the Tatarstan energy company regional branch [3, p. 42].

We have taken the logarithms of dependent variables. Linear regression equation with two variables can be found using the formula 1:

Y= -8,34487+++е (1)

The economic interpretation of the coefficients can be presented as follows: if the cost of fixed assets active part increases by 1%, the capital productivity will increase on average by 0,6%. If the repairing costs increase by 1%, the capital productivity will increase on average by 0,03%.

If the coefficient of determination is 0,8771 it means that 87,71% of capital productivity is formed by combination of these two factors, and 13,19% of dispersion is formed by impact of not previously considered others factors.

According to Student's T-test, the regression coefficient is significant with probability 99%, and between x\_1 (cost of active part of fixed assets) and Y (fixed assets capital productivity) variables there is significant linear relationship.

According to Fisher test the regression changes in appropriate way, with chosen variable (x\_1 - cost of fixed assets active part, x\_2 – repairing costs of fixed assets) it has an impact on Y (capital productivity).

As the result, the cost of fixed assets active part has the greatest impact on fixed assets capital productivity and therefore the Tatarstan energy company regional branch is recommended to increase it.

**2.2. Scenario forecasting of capital investment in fixed assets**

In the modern economy, capital investment planning is one of the methods of predicative model in financial analysis. Capital investment is the advance of funds to both tangible and intangible assets. Planning capital investments in fixed assets is one of the most important strategic tasks in the effective organization management.

At the first stage of the study, we proposed to the branch of the Tatarstan energy company to construct a combined-cycle gas turbine with a capacity of 230 MW. This turbine is a relatively new type of generating stations that run on gas or liquid fuel. The advantages of the turbine are low cost per unit of installed capacity, ability to install it in 9-24 months, compactness and high production efficiency.

The reasons for implementation of the 230 MW combined cycle gas turbine by the Tatarstan power company branch are optimization of the ratio of electricity and heat produced, need for increase of electricity generation and for minimization of the possibility of accidents. As a result, this can lead to an increase in the company's competitiveness in the wholesale electricity and capacity market.

The next structural element of the study is the choice of the construction method. We offered to the Tatarstan energy company branch to build a combined-cycle gas turbine using borrowed funds (credit). The construction of a combined-cycle gas turbine is proposed to be carried out by a contract method with the involvement of a loan for a period of 24 months at an average loan rate of 15% per annum. Initial contribution amounts to 20% of the total cost of construction (2 327 756,8 thousand of rubles), and the total cost of construction works is 13 966 540,8 thousand of rubles including 20% VAT.

The next stage of the study is to determine the initial cost of the 230 MW combined-cycle gas turbine. According to accounting regulations 15/2008 "Accounting for borrowing costs", interest on loans received on the acquisition of an investment asset increases the initial cost, so the initial cost of the 230 MW CCGT will be 13 467 613,7 thousand of rubles. The useful life of the combined-cycle gas turbine is 15 years. According to the accounting policy of the Tatarstan energy company branch, fixed assets are subject to the linear depreciation method.

We will next consider deliverable criteria of selection rationale and investment project efficiency. Deliverable criteria of investment project efficiency is net present value (NPV). Net present value is the present value of investment project’s cash flows, which is estimated by considering discount, after deduction of investment cost. The project will be cost-effective if NPV is positive and the bigger its value gets, the more profitable this project is. NPV is found using the formula 2:

NPV= , (2)

where is value of net cash flow in period t, thousands of rubles.;

r – discount rate, %.

The value of net cash flow means the difference between proceeds and cost, as well as between borrowing costs. Calculation of net present value of the 230 MW combined-cycle gas turbine construction project for Tatarstan energy company branch is presented in table 2.

Table 2

Calculation of net present value of 230 MW combined-cycle gas turbine construction project for the Tatarstan energy company branch, thousands of rubles

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Period | Flows | Outflows | | | Net cash flow | Discount rate | Present value of net cash flows |
| The proceeds from the sale of electricity and heat | Cost of sales of electricity and heat | Credit payment | Initial payment |
| 0 | - | - | - | (2 793 308,16) | (2 793 308,16) | - | (2 793 308,16) |
| 1 | 165 173 215 | (163 328 113) | (541 752,60) | - | (1 489 958,76) | 0,869565 | (1 295 616,31) |
| 2 | 176 324 185 | (172 317 208) | (541 752,60) | - | 3 465 224,40 | 0,756144 | 2 620 207,48 |
| 3 | 212 456 328 | (205 690 497) | (541 752,60) | - | 6 224 078,40 | 0,657516 | 4 092 432,58 |
| 4 | 228 615 172 | (226 891 245) | (541 752,60) | - | 1 182 174,40 | 0,571753 | 675 912,05 |
| 5 | 232 167 781 | (227 415 628) | (541 752,60) | - | 4 210 400,40 | 0,497177 | 2 093 313,12 |
| 6 | 276 415 328 | (271 615 234) | (541 752,60) | - | 4 258 341,40 | 0,432328 | 1 840 998,50 |
| 7 | 293 428 204 | (288 615 312) | (541 752,60) | - | 4 271 139,40 | 0,375937 | 1 605 679,50 |
| 8 | 297 345 615 | (295 432 117) | (541 752,60) | - | 1 371 745,40 | 0,326902 | 448 426,00 |
| 9 | 256 435 117 | (251 342 568) | (541 752,60) | - | 4 550 796,40 | 0,284262 | 1 293 620,36 |
| 10 | 211 312 467 | (209 345 457) | (541 752,60) | - | 1 425 257,40 | 0,247185 | 352 301,83 |
| 11 | 187 456 324 | (180 345 011) | (541 752,60) | - | 6 569 560,40 | 0,214943 | 1 412 082,49 |
| 12 | 178 457 724 | (175 342 181) | (541 752,60) | - | 2 573 790,40 | 0,186907 | 481 059,83 |
| 13 | 172 464 561 | (168 198 751) | (541 752,60) | - | 3 724 057,40 | 0,162528 | 605 263,44 |
| 14 | 201 457 048 | (198 315 087) | (541 752,60) | - | 2 600 208,40 | 0,141329 | 367 483,96 |
| 15 | 213 188 567 | (205 438 134) | (541 752,60) | - | 7 208 680,40 | 0,122894 | 885 907,07 |
| 16 | 227 432 146 | (222 581 667) | (541 752,60) | - | 4 308 726,40 | 0,106865 | 460 451,06 |
| 17 | 237 634 567 | (232 467 815) | (541 752,60) | - | 4 624 999,40 | 0,092926 | 429 782,17 |
| 18 | 273 543 275 | (267 321 543) | (541 752,60) | - | 5 679 979,40 | 0,080805 | 458 971,41 |
| 19 | 298 765 324 | (296 376 987) | (541 752,60) | - | 1 846 584,40 | 0,070265 | 129 750,85 |
| 20 | 297 138 532 | (289 643 534) | (541 752,60) | - | 6 953 245,40 | 0,0611 | 424 845,23 |
| 21 | 285 432 145 | (282 234 141) | (541 752,60) | - | 2 656 251,40 | 0,053131 | 141 128,44 |
| 22 | 267 348 671 | (264 861 513) | (541 752,60) | - | 1 945 405,40 | 0,046201 | 89 878,88 |
| 23 | 263 817 751 | (259 673 271) | (541 752,60) | - | 3 602 727,40 | 0,040174 | 144 737,50 |
| 24 | 211 458 681 | (208 134 675) | (541 752,60) | - | 2 782 253,40 | 0,034934 | 97 196,03 |
| In total | 5 665 268 728 | (5 562 927 689) | (13 002 062,40) | (2 793 308,16) | 83 752 360,28 | 6,433771 | 17 062 505,31 |

Source: Author

**3. Results**

In implementing 230 MW combined-cycle gas turbine construction project, calculation of the change in the financial result is general indicator of effectiveness of capital investments in fixed assets for the Tatarstan energy company branch.

Table 3

Calculation of the change in the financial result in implementing 230 MW combined-cycle gas turbine construction project for the Tatarstan energy company branch,

in millions of rubles.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Indicators | For the year 2019 | Scenario conditions | | | Deviation |
| TPP | CCGT | In total |
| 1. Power generation, thousands of kWh | 3 419 476 | 2 326 338 | 1 772 160 | 4 098 498 | 679 022 |
| 2. Output of heat energy, Gcal | 4 168 440 | 3 373 169 | 795 271 | 4 168 440 | 0 |
| 3. Power, MW | 983 | 983 | 230 | - | - |
| 4. Average daily rate for electric energy, rub/ kWh | 1,215 | 1,215 | 1,215 | - | - |
| 5. Average daily rate for heat energy, rub/ Mkcal | 680,943 | 680,943 | 680,943 | - | - |
| 6. Average daily rate for output, thousand rub/MW | 114,474 | 114,474 | 114,474 | - | - |
| 7. Power consumption, thousand ton standard fuel | 920 | 581,311 | 363,152 | - | - |
| 8. Price of electric energy, rub/ton standard fuel | 3 972 | 3 971,990 | 3 971,990 | - | - |
| 9. Heat consumption, thousand ton standard fuel | 539,429 | 428,791 | 122,749 | - | - |
| 10. Price of heat energy, rub/ thousand ton standard fuel | 3 979,410 | 3 979,410 | 3 979,410 | - | - |
| 11. Commercial output of electricity incl. (p.12+p.13), mil. rub. | 5 504 | 4 176 | 2 468 | 6 644 | 1 141 |
| 12. Commercial output of energy incl. ((p.1xp.4)/1000), mil. rub. | 4 153 | 2 826 | 2 152 | 4 978 | 825 |
| 13. Commercial output of power incl. ((p.3xp.6xp.12)/1000), mil. rub. | 1 351 | 1 351 | 316 | 1 667 | 316 |
| 14. Commercial output of heat energy, mil. rub. | 2 838 | 2 297 | 542 | 2 838 | - |
| 15. Fuel costs incl. (p.16+p.17), mil. rub. | 5 799,0 | 4 015,3 | 1 930,9 | 5 946,2 | 147,2 |
| 16. Electric energy costs incl. (p.7хp.8)/1000, mil. rub. | 3 652,4 | 2 309,0 | 1 442,4 | 3 751,4 | 99,0 |
| 17. Heat energy costs incl. (p.9хp.10)/1000), mil. rub. | 2 146,6 | 1 706,3 | 488,5 | 2 194,8 | 48,2 |
| 18. Total financial result (p.11+p.14-p.15), mil. rub. | 2 543 | 2 458 | 1 079 | 3 537 | 993,5 |

Source: internal reports of the Tatarstan energy company branch

According to table 3 in implementing of the 230 MW combined-cycle gas turbine the financial result of the Tatarstan energy company branch will increase by 993.5 million of rubles due to an increase in commercial output of energy by 825 million of rubles and commercial output of power by 316 million of rubles with a constant output of heat in the amount of 2,838 million of rubles. Revenue growth in implementing of the 230 MW combined-cycle gas turbine is accompanied by an increase in fuel costs by 147.2 million of rubles, but this does not have a significant impact on the expected financial result.

**4. Discussion**

Method of correlation and regression analysis is used to assess the effectiveness of fixed assets use. It requires a significant array of historical data and the selection of key indicators that do not have a high level of correlation. According to the authors, the use of correlation and regression analysis of the capital productivity of fixed assets has a significant potential for predicative assessment of the effectiveness of fixed assets use. During the correlation and regression analysis of the Tatarstan energy company branch, the authors found that the cost of the active part of fixed assets has the greatest impact on the capital productivity of fixed assets, so the company is recommended to increase the active part of fixed assets.

The proposed approach to scenario forecasting of capital investments in fixed assets allows us to assess the prospects for changes in the company's financial performance as a result indicator of the company's performance. Approbation of forecasting of capital investments in fixed assets is based on empirical data of the Tatarstan energy company branch. The implementation project of the 230 MW combined-cycle gas turbine is cost-effective for the company branch, since the net present value at the end of construction of the object is positive and will amount to 97,196 thousand rubles. The implementation of 230 MW CCGT will increase the financial result of the Tatarstan energy company branch by 993.5 million of rubles due to the increase in electricity output by 1,141 million of rubles. The minimum payback period is 8 years.

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