MODELING OF THE PROCESS OF UPDATING TECHNICAL AND TECHNOLOGICAL BASIS OF INDUSTRIAL ENTERPRISES

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Abstract. The work is dedicated to the issue of evaluation of economic efficiency and grounding of feasibility of technical and technological renovation of enterprises. The models to determine the time limit of updating technical and technological basis of industrial enterprises have been presented. The method of selecting the best technology to manufacture industrial products based on resource conservation has also been suggested.

Keywords: updating, technical and technological basis, industrial enterprise, the relevant period, resource conservation.

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Introduction

One of the main reasons for the low pace of the economic growth of Ukrainian economy is insufficient level of technical and technological basis of domestic enterprises. At some industries of Ukraine the depreciation of fixed assets is observed, the level of which at some enterprises exceeds 70-80 percent. A substantial part of these funds is morally outdated, which reflects on the application of technologies of manufacturing industrial products, which tends to have high charges of productive resources, especially - energy and labour. Under these conditions, a considerable part of the industrial production manufactured in Ukraine is uncompetitive. Thereby, there is an urgent necessity to implement a set of measures to update the technical and technological basis of industrial enterprises in Ukraine based on large-scale technical re-equipment.

Diagnosis of the level of the depreciation of fixed assets of industrial enterprises

The study of regularities of processes of the depreciation of fixed assets of industrial enterprises is examined in a large number of publications. In particular, this issue was examined from the standpoint of: the formation of theoretical and methodological foundations of innovative renewal of technical and technological base of the company - in the work of such scholars as A. Amosha (2007), I. Bulyeyev (2007), V. Grishko (2011), N. Omelianchik (1997), A. Rudchenko (1997), N. Tyutyun (1997), D. Shevtsov (2007), etc.; evaluation of technical condition of fixed assets and the level of technological development - in publications

of I. Gohberg (2007), I. Skvortsova (2003), L. Fedulova (2008), S. Shcherban (2007), etc.; choosing the best strategy options and upgrade options for fixed assets, as well as study method grounding of the method of calculation of depreciation on the renovation of them - in the works of scholars such as G. Yershov (2007), M. Natarov (1998), A. Serhatyuk (2002) and others.

Despite of the fact that many scientists had suggested fruitful approaches to ascertain regularities processes of the depreciation of fixed assets of industrial enterprises and their restoration, at present there are still questions to the evaluation of the level of the depreciation of facilities at their market value, determination of the best time for their renovation and grounding of the choice of the best technologies of production.

In particular, diagnosing the problem of the depreciation of fixed assets is an important thing. It should be pointed out that there is a certain level of depreciation of fixed assets, which can be considered as threat to the future of the enterprise. However, the precise formulation of the concept of "threatening levels of wear and tear of fixed assets" requires a consideration of certain limitations and assumptions relating to the three main items, namely:

1. Opportunities of the enterprise in the future to ensure the volume of the results of its operating at a level, at least not below the existing one.

2. Opportunities of the enterprise to operate an unlimited period of time.

3. Opportunities of the enterprise to provide the reproduction of their main means to achieve the first two requirements exclusively from their own sources of funds, without using additional funds received in the form of loans or contributions to increase the share capital of the company.

In case the current level of the depreciation of fixed assets is not so big and that existing internal capabilities of the enterprise concerning the implementation of the simple reproduction of its main funds not to provide the realization of the three main requirements that were mentioned above, the level of depreciation will be not threatening, though over a certain size it may cause some concerns to owners and managers of the company. Taking into account mentioned above it is also necessary to introduce the concept and to characterize the normal (acceptable) level of wear and tear of fixed assets of the enterprise.

Therefore, it is advisable to distinguish two main types of the depreciation of fixed assets by its level namely:

- Normal (acceptable), when the company can provide simple reproduction of fixed assets using only the future flow of depreciation on the renovation of them;

- threatening, when the company can not even make a simple reproduction of their fixed assets, using its future flows of income and depreciation.

Accordingly, we can distinguish the following derivative levels of the depreciation of fixed assets of the enterprise: low, the value of which does not exceed the normal (acceptable) level of depreciation; average, the value of which exceeds normal (acceptable) level, but less threatening; high, the value of which equals or exceeds the level of threatening depreciation.

Depending on the level of depreciation of fixed assets is at the moment (low, medium or high) the actions of normalizations of the level of depreciation of fixed assets of the management of the enterprise are different. If the depreciation is low, the company may only use its amortization. If the level of depreciation is medium, in this case the enterprise to provide at least the simplest reproduction of its production capacity must also use part of its future earnings in order to implement measures to update its fixed assets, and the task is to determine this part of the profit and its change over time. If the level of the depreciation is high, then the company has two options: to intensify the process of investing its own sources

of funds to update its fixed assets (in this case the level of wear and tear over time normalized by the decommissioning of obsolete fixed assets, but just playing them could not be manage) or, in addition to its own sources of funds also involve external sources (including bank loans and additional contributions).

In order to determine the settings of threatening depreciation of fixed assets we must first calculate the level of it.There are two most common ways to calculate it:

1) determination of the level of depreciation of fixed assets at their market value (the ratio of market value of depreciation to the original market value of fixed assets of the company);

2) determination of the level of depreciation of fixed assets at the actual time of operation (the ratio of actual hours worked on the introduction of fixed assets in operation for the duration of their effective functioning).

Let's examine the first option of measuring of the depreciation of fixed assets, having examined the case of individual elements of the core business, followed by extrapolation of the results to the entire set of its assets.

We introduce the following notation:

V_0 – the initial cost of the item of fixed assets

V_i – residual value of the element of fixed assets of the enterprise that worked *i* years;

r – the discount rate (annual in fractions of a unit).

Then the company will have time to accumulate the required amount of funds for replacement of the element of fixed assets due to the net cash flow from operation (net profit and depreciation) for the time remaining until the termination of its operation, if it carries out the following condition:

$$V_i \times (1+r)^{T_e - i} \geq V_0, \tag{1}$$

where T_e – effective operating time of the element of fixed assets, that is to say, the period during which its functioning allows the owner to get positive net cash flow (the amount of profit and depreciation).

In fact, the research has proved that in case of using the income approach to the assessment of residual value of fixed assets of value equal to the discounted net cash flow, which get left on the operation of these assets over time for their effective functioning. Accordingly, the level of depreciation on these tools will not be threatening if the value of their residual value, calculated by income approach, accumulated at the end of period of their effective functioning at a rate of discount E is greater or equal to its original value. This idea is based on this condition, which is formalized in the form of inequality (1).

Since the level of depreciation of fixed assets at their market value determined by the formula

$$L_i = 1 - V_i / V_0, \tag{2}$$

where L_i – level of depreciation of the element of fixed assets that worked i years, then the threatening value of fixed assets depreciation according to formula (1) will be determined by the following mathematical expression:

$$L_{ti} = 1 - V_i / V_0 = 1 - 1/(1+r)^{T_e - i}, \tag{3}$$

where L_{ti} – lower limit values of threatening depreciation of a particular item of fixed assets.

In terms of mathematical analysis, formula (3) can be represented as follows:

$$l_{ti} = 1 - 1/e^{(T_e - i) \times r}, \tag{4}$$

where e – the base of natural logarithms.

If we indicate the number of years that are left to be worked out by this element of fixed assets T_b (that is $T_b = T_e - i$), you can also determine these dependencies, arising directly from the expression (4):

$$r = (1/T_b) \times \ln\left(1/(1 - L_{ti})\right); \tag{5}$$

$$T_b = (1/r) \times \ln\left(1/(1 - L_{ti})\right), \tag{6}$$

where ln – the mark of the natural logarithm.

The analysis of the dependences leads to the conclusion that in general there is not any constant value of the lower limit of the threatening level of depreciation of fixed assets of the company, that even at a very high level of its depreciation, for example 90 percent under certain conditions this level of depreciation is not threatening (for that $T_b$and r should be big enough).

Now we will spread the results on the calculation of threatening depreciation of the separate component in case the totality of the fixed assets of the company. For this purpose, we insert the following notations:

$V_0(j)$ – original value of fixed assets of the enterprise, that still have to work j years before the end of functioning;

V_s – aggregate residual value of all fixed assets of the company.

Then the depreciation of fixed assets will not be threatening if that condition is fulfilled:

$$V_s \geq \sum \frac{V_0(j)}{(1+r)^j}. \tag{7}$$

If to mark w_j as the share of fixed assets, that still have to work j years in the total value of the initial value of fixed assets of the company, the formula (7) can be represented as follows:

$$V_s > V_{0s} \times \sum \frac{w_j}{(1+r)^j}, \tag{8}$$

where V_{0s} – total original value of fixed assets.

Then the level of threatening depreciation of the fixed assets of the company will answer the following inequality:

$$l_{ts} > 1 - \sum \frac{w_j}{(1+r)^j}, \tag{9}$$

where L_{ts} – the threatening level of depreciation of fixed assets.

Thus, the process of diagnosing the depreciation of fixed assets of industrial enterprises shall include these following stages: the implementation of the forecast of cash flow while efficient operating of fixed assets during the period of its operation; discounting projected net cash flow and calculating the market value of the residual value of fixed assets; determination of the current level of depreciation and calculating of the lowest threatening level; comparing the lower limit threatening level of depreciation of these assets with the actual level of depreciation and determination on the basis of comparison of the list of activities and sources of its normalization, including the development schedule of replacement of outdated means of labour through internal and (if necessary) external sources of funding for the program to update of the fixed assets of the company.

Grounding of the choice of the best production technology and optimization of the deadlines of renovation of fixed assets

Let's consider in more details the technological component of technical and technological basis of the company. For this purpose, we introduce the indicator of adaptability of fixed assets that can be estimated as follows:

$$\alpha = \frac{K_t}{K_s}, \tag{10}$$

where α – the level of adaptability of fixed assets of the enterprise that participates in the manufacturing of this product; K_t – the value of fixed assets of the company, requiring replacement in case of transferring to progressive technology of manufacturing; K_s – the total value of fixed assets of enterprises involved in the manufacturing of this product.

The higher the level of adaptability of fixed assets of the company is, the harder it is to start producing according to more advanced technology. However, the share of fixed assets that do not include a technological component (this particularly applies passive part of fixed assets) in industrial enterprises may be quite significant.

It should be mentioned that in the case of separation of fixed assets, involved in the manufacture of certain products, on at technological and non-technical components, the flows of profits from their operation could be seen to some extent in isolation from each other. Under such circumstances replace the old technology to the new products (particularly resource-saving)is required if net cash flow (the sum of income and depreciation) in the technological part of the existing fixed assets is negative and therefore profit from the operation of non-technical component of fixed assets is less than normal. Under these conditions, if a rapid entry of new technology in the industry, unit price will be equal to the exact specific costs for the new technology:

$$P_n = c_2 + k_2 \cdot E, \tag{11}$$

where P_n – the price of the product corresponding to the specific cost of its production at the new production technology; c_2 – the cost price of the product manufactured at the new technology; k_2 – specific capital-intensive of production according to the new technology; E – normal profitability of on investment in the industry.

We should specify that the formula (11) can be demonstrated in such an equivalent form:

$$P_n = c_2 + k_2 \cdot (1-\alpha) \cdot E + k_2 \cdot \alpha \cdot E, \tag{12}$$

where α – the part of specific investments k_2, corresponds with technological component of fixed assets and that the owner of the old technologies has to put on each unit, if he wants to replace the old technology to the new one.

Under the circumstances, specific value of net cash flow from operating technological component of fixed assets using old technology of production will be determined by the following formula:

$$F_n = P_n - c_1 + k_1 \cdot E_a - k_2 \cdot (1-\alpha) \cdot E, \tag{13}$$

where F_n – specific value of net cash flow from operating technological component of fixed assets using old production technology; c_1 – cost price of the product using old technology; k_1 – the ratio of the residual value of fixed assets using old technology to the production amount of natural products; E_a – the average rate of depreciation in the technological component of the fixed assets using old technology of manufacturing products, measured in fractions of a unit of the residual value of this component.

Putting (12) into the formula (13), we get:

$$\begin{aligned} F_n &= c_2 + k_2 \cdot (1-\alpha) \cdot E + k_2 \cdot \alpha \cdot E - c_1 + k_1 \cdot E_a - k_2 \cdot (1-\alpha) \cdot E = \\ &= c_2 + k_2 \cdot \alpha \cdot E - c_1 + k_1 \cdot E_a. \end{aligned} \tag{14}$$

Under these circumstances, the application of new production technology will be appropriate under the condition

$$c_2 + k_2 \cdot \alpha \cdot E - c_1 + k_1 \cdot E_a \langle 0, \tag{15}$$

or

$$\frac{c_1 - c_2 - k_1 \cdot E_a}{k_2 \cdot \alpha} \rangle E. \tag{16}$$

Judging by the expression (15) ceteris paribus, we may confirm that efficiency of new technology increases with the economic benefits of better technology compared to worse.

In other words, a company with rather high level of technological development may not be interested in urgent replacement of its technology to more advanced, while technically out-of-date enterprise may change it to become effective. Herewith, obviously technically out-of-date enterprise may even leave behind more developed in terms of technical equipment and the efficiency of resource supply companies. In order to make this happen, it is necessary to follow these steps: the market of the product must be sufficiently competitive; there should not exist barriers, which block to the diffusion of technological innovation; technical and economic settings of the new resource-saving technologies should be significantly better compared with the corresponding settings technically out-of-date enterprises, but not too much better compared with the corresponding settings of technology that are used by an enterprise which is currently the technological leader to force it to prematurely replace the new existing technology. Under such conditions in the field there should be a change of the technological leader, and when the emergence of new high technologies is frequent, such change may occur repeatedly over a relatively limited period of time. This statement can be called as the principle of periodic rotation of a technological leader in the field.

In practice, there is often the a case when there are several alternative technologies for production of certain products, with different units of cost and specific capital intensity. Then, as follows the expression (14) and (15), the criterion for selecting the best option technology,

which ensured the highest value of specific net cash flow due to the replacement of outdated manufacturing technology, will be as follows:

$$C_i = c_{2i} + k_{2i} \cdot \alpha_i \cdot E \to \min, \tag{17}$$

where c_{2i} – unit costs according to *i*- type option of new technology; k_{2i} – specific capital-intensive of production according to *i*- type option of new technology; α_i – the part of specific investments k_{2i}, which corresponds to technological component of fixed assets and that the owner of the old technologies has to put on each unit, if he wants to replace the old technology to the new one according to *i*- type option.

It should be pointed out that while applying criterion (16), we have adopted the condition of achieving zero value of the share of net cash flow from the operation of the technological component of fixed assets using old technology of production. In this regard, there is a need to explore the possibility and feasibility of early decommissioning of fixed assets in the event that net cash flow for them at the moment still keeps a positive value.

Generally speaking, if production market is competitive and a case of complete replacement of fixed assets is considered, the implementation of early decommissioning of their operation is unnecessary. Nevertheless, if there is balance on the production market the net present value of net cash flow from operating of fixed assets must be zero. So, under these conditions cease operation of fixed assets for which the present value of future cash flow is positive, is not appropriate.

If the product market is not fully competitive (which is a fairly widespread phenomenon) and (or) considered the case of partial replacement of fixed assets, then these conditions benefit from the possibility of early decommissioning of fixed assets may exist. For this amount of net present value of net cash flow for new fixed assets must be large enough.

It should be taken into consideration that when the replacement of outdated fixed assets will be in the new time in which the net cash flow from the operation of existing fixed assets will become equal zero, the discounted value of the economic effect of the change can be calculated using the formula:

$$Z = \sum_{t=1}^{T_k} \frac{F_t}{(1+r)^t} + \frac{F}{(1+r)^{T_k}}, \tag{18}$$

where Z – discounted value of economic benefits from the replacement of fixed assets if the time of the change coincides with the effective term of operation; T_k – period of time when the value of the net cash flow from the operation of these fixed assets will be equal zero; F_t – the value of net cash flow from the operation of these fixed assets in *t*- type period (year); *r* – discount rate; F – the present net value of net cash flow from the operation of new fixed assets.

We (have) suppose that the replacement of the fixed assets at the moment of time T_1 ($T_1 < T_k$). Then formula (18) will be as follows:

$$Z(T_1) = \sum_{t=1}^{T_1} \frac{F_t}{(1+r)^t} + \frac{F}{(1+r)^{T_1}}, \tag{19}$$

where $Z(T_1)$ – discounted value of economic benefits from the replacement of fixed assets if they are replaced at the time T_1.

While using methods of mathematical analysis we can establish that the relevant period of time of replacement of outdated fixed assets in which the expression (19) becomes the maximum value will be the time in which the value of net cash flow from the operation of fixed assets is equal to the product of the discount rate on the size net present value from the operation of new assets.

Conclusions and suggestions

1. There are two main types of the depreciation of fixed assets by its level, namely the normal (acceptable), when the company can provide a simple reproduction of fixed assets using only the flow of future depreciation on the renovation of them; threatening, when the company can not make even a simple reproduction of their fixed assets, using for that purpose their future flows of income and depreciation. Accordingly, the following could be the original derivative levels of the depreciation of fixed assets of the enterprise: low, medium and high.

2. Methods for of evaluating of the economic efficiency of investments in the implementation at the industrial enterprises of new types of equipment and technology, particularly energy efficient, should include (isolation) selection of the technological component of fixed assets. Methods for evaluating the economical effect of the implementation of new types of equipment and technology that were suggested in this work and the analytical expression of feasibility of replacing existing technology manufacturing output in by the new technology of production can be applied by economists of industrial enterprises while preparing programs and plans to update their technical and technological basis.

3. In the process of planning events of the renovation of technical and technological basis of industrial enterprises, experts using the suggested guidelines will be able to establish the relevant period of time of replacement of the old technology of manufacturing products to the new one, which can maximize the efficiency of economic activities of these enterprises.

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