Strategy and methods of economic evaluation of the quality of technical means of AIC production

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Abstract. The paper focuses on the methodological foundations of the economic evaluation of technical means of production and the conceptual positions of the scientific support of the problems being developed to improve economic relations of partners on the basis of mutual interest. A method for the economic evaluation of the quality of technical equipment based on the calculation of compensating costs and equalizing charges, the laws of their change when using aging equipment is proposed. It is shown that equalization charges, reflecting the changing quality of machines, can be used to correct depreciation methods. It is proposed to use the step-wise depreciation method, in which the entire initial cost is transferred to the depreciation fund reflecting the changing quality of the machine.

The problem of reproduction of technical means of production retains its relevance, reflecting the laws of scientific and technological progress, causing the continuous improvement of technology and organization of production. Machines, equipment determine the viability of the material and technical base.

The reproduction of technical means of production is an integral part of the general process of capital flow in its value and natural-material form. In a market economy, enterprises of the agro-industrial complex, regardless of their organizational and legal form, use their capital for profit, the value of which depends on the organization of production activities and the rational use of the entire set of material and labor resources. As applied to the problems under consideration, this general installation is solved by preliminary elaboration of a range of issues related to the circulation and capital turnover in the form of scientific support for resource use processes. Maintenance is carried out through the use of a number of relevant methods, one of which determines the service life of machines, which determines the speed of capital movement, the quality of its material elements, the active component of the material and technical base of the agro-industrial complex.

The previously achieved and currently implemented scientific provisions should not be rejected, but technical progress in the world and in our country is so fast that some of the previously developed and used methods turned out to be “close,” they need extensive, clarifying interpretation from the standpoint of more substantiated scientific support of processes full and partial reproduction of technical means of production.

The conceptual positions and methodological foundations of the economic evaluation of technical means of production stem from the research of many well-known scientists. K. Marx argued that “...
no matter how perfect the design is, the machine does not enter the production process, when it is used in practice, there are flaws that have to be corrected with additional labor” [1].

The volumes of specific resources are prescribed by the structure of the machines and are actually represented as a set of technological methods of their use in the corresponding natural and climatic zones. With regard to the problem under consideration, this statement suggests that:

- Additional labor, its material content, and valuation are determined by the perfection of the design of the machine, i.e. its quality.
- Quality is reduced due to downtime resulting from the use of the machine due to technical reasons and increasing costs of restoring workability.

The cost estimate of the value of this “additional labor” for most modern machines far exceeds the cost of acquiring similar new ones. The essence of the problem is the need to determine the structure of “additional labor”, its material composition, the need for material and labor resources, to develop a system for the effective use of the entire set of resources. The amount of additional labor, its increase dynamics, appear as indicators of the changing quality of the machine as it ages. The methodological approach to determining the quality and ultimately the cost and price of the machine is most pronounced by K. Marx [1]. Quality acts as a set of properties that are objectively inherent in a product and attract a specific consumer, establishing the feasibility of an acquisition for using as a means of production.

The quality of the machine, its properties, laid down in the design and manufacture, determine the need for resources that are part of the “additional labor”. This direction of science, reflecting the methodological and methodical approaches to the disclosure of the patterns of resource use by functioning machines, is formed and disclosed in the book by A. I. Selivanov entitled “Fundamentals of the Theory of Aging Machines.” The real filling of “additional labor” on the basis of the laws of aging machines is presented to them as an indispensable condition for observing the proportions of the production of new machines and all other resources necessary for the use of machines during the service life [2].

Academician A. I. Selivanov used the term “suitability” to assess the quality of machines, emphasizing the technical condition in which the machine is suitable for its intended use. In a market economy, quality should be measured by value indicators. However, the used methods for assessing the lowering quality at the current depreciation rates do not provide equivalent exchange conditions for the purchase and sale of used equipment due to the difficulties in determining economic depreciation and the residual value of the machine, its actual quality and the corresponding price.

The problem of the quality of technical means of production is one of the main. The consumer assesses the quality of the initial costs of acquisition and the subsequent costs associated with the use of the machine. In order to control the pricing process, it would be advisable that the consumer, as a partner and market participant, predetermines the upper limit of the price of a machine of a particular design, above which the purchase of a machine is not economically feasible. Such an approach will force the manufacturer to seek reserves to reduce the cost of production and use of the machine in order to compete in the machinery market, taking into account the capabilities of the consumer. The valuation of the technical equipment designed and manufactured by firms should be consistent with their quality.

The problem of quality is always new and relevant. Methodical approaches to its development are being improved. Scientific substantiation of prices and tariffs, methods of calculating the residual cost of the repair fund in relation to the work of repair shops, technical exchange points, justification of differentiated prices for the restoration of tractors, taking into account the quality of repairs and other studies that ensure equal economic relations of technical service partners, are presented in the works of many other scientists [3]. The achieved results need to be generalized and collectively discussed in order to create a scientifically based uniform methodology for economic assessment of the changing quality, assessment of machine wear for any period of its use during a specified service life.
The method of assessing the quality of the new equipment, the residual value and the price of the used one should ensure that the buyers are equally useful in any period of service life.

The essence of the methodology and sequence:
- A set of properties of the goods: quality - use value - cost - price;
- A wear (residual use value and cost): the price of the used equipment on the market of technical means.

Compensating costs (Кз) - a category of increased complexity both in the composition of costs and the nature of their changes throughout the entire period of use of the object, for a number of mobile technical means of production they include the following costs:
- Maintaining the validity of technical means, such as tractors, self-propelled combines, mowers, and other machines;
- Diagnostics of the technical condition (TO, TP, KR, storage, disposal);
- Fuel and lubricants;
- Labor operator;
- Caused by obsolescence;
- Accounting efficiency of invested capital (income on capital), etc.

Compensating costs are conventionally divided into a fixed part (in magnitude) and increasing, varying depending on the period of use. The nature of the changes is determined by the combination of the properties of the object, laid down in the period of its creation and actually manifested in specific conditions of use.

Research has shown that as wear increases, compensating costs increase, reflecting the changing quality of the machine [4]. Compensating costs as a term first was used in the literature on the economics of quality machines [5].

If we proceed from the accepted position that the quality of an object consists of a set of properties of its constituent elements, then a change in quality is a change in the properties of all or several elements, but each element in turn changes properties in the process of its consumption. Practically catching and identifying patterns of changes in all the constituent elements of the object does not seem necessary and appropriate. For the economic evaluation of the quality of an object, it is sufficient to investigate the dynamics of the quality level of some especially significant properties of the object that determine the economic assessment of quality. For mobile equipment, these can be: fuel consumption, costs for maintaining a validity, and others that are included in compensating costs.

For the purpose of economic evaluation of the quality of technical means, the compensating costs should include all the actual costs incurred and non-produced, but calculated in an amount that adequately reflects the loss of quality of the object. Such costs include, for example, omissions from the decline in annual production, shift production for a regulated time.

The quality of the machine in the system: “quality - technical productivity - labor productivity - optimal costs of the production of works, products” acts as a fundamental position.

The criterion indicator of the level of quality of the machine, its perfection is the main economic parameter of the machine, calculated on the basis of adjusted costs based on the laws of distribution of compensating and equalizing costs.

In the process of using the machine, the last depreciates in accordance with the physical and moral depreciation, this impairment should be reflected in depreciation rates [6]. However, the applied method of linear depreciation does not reflect the real loss of the use value and the cost of machines, which is confirmed by the functioning market for used equipment and made by the authors of the relevant calculations.

The level of quality depends on the age of the machine, changes in the properties of the machine. When examining the tractor fleet of Russia, the statistics bodies follow a methodology developed with the direct participation of the employees of the Problem Research Laboratory of the Moscow Institute
of Agricultural Engineers named after V. P. Goryachkin (now operating as part of the Russian State Agrarian University) [7], established patterns of wear machines used by agricultural enterprises. According to the data on changes in annual operating time and on the cost of depreciation compensation, their tendencies are given, which are given at the end of the second year of use in % (Figure 1).

Figure 1. Trends in offsetting costs and developments.

Figure 1 shows the changes in the parameters of the annual operating time and the cost of depreciation for the depreciation period for tractors. Over the next quarter of a century, these parameters have changed due to the rise in prices for equipment, fuel and lubricants, and wages, but the trends of their changes have persisted, reflecting the patterns of the quality dynamics of modern machines. The practice of depreciation using the straight-line method has also been preserved, confirming the need to develop and put into practice other, more reasonable depreciation methods that correspond to the actual impairment of cars.

Purposeful analysis of the process of reproduction of technical means, their active part, represented by the machine-tractor fleet, gives grounds for further deeper study of the patterns of turnover of capital materialized in the technical means of the agro-industrial complex, taking into account the changing quality of machines in the process of their use. Analyzed the results of a survey of large groups of tractors, combine harvesters, and other equipment made it possible to identify patterns of changes in the indicators characterizing the aging process of the machine, confirming the decline in the quality of machines. These patterns make it possible to formulate conceptual positions for the choice of a method for the economic evaluation of a changing quality of a machine. In order to form an indicator that adequately reflects the quality of the machine, a structural model of the virtual machine has been built. Structural components (in conventional money units) form the initial capital (machine cost), additional costs, profit on operating capital in the amount of the components of the reduced costs (Figure 2).
Figure 2. A structural model of a virtual machine.

The initial cost of the car in the form of depreciation is determined by regulatory documents. In most cases, depreciation is charged on a straight-line basis, that is, in equal annual fractions of the original value of the object during the established period of use. This pattern in Figure 2 is shown in the form of a rectangle $C_0$, expressing the uniform distribution of the initial cost of the machine.

The problem is that this distribution of costs forms the opposite interests of consumers of new and used equipment. The consumer of a new machine is satisfied with its quality, ensuring the lowest possible production costs; anticipating increasing costs as the machine is used, this person becomes ready to sell it.

A consumer who wants to purchase a used vehicle takes a different view. He believes that the costs of using a second-hand equipment would not allow him to get the planned profit; therefore, this person strives to convince the seller to lower the price of the car. This contradiction can and should be resolved on the basis of economic laws, by which it is determined that the value of a new car also changes with a change in the use value, i.e. if the use value of a new car decreases, the price for it should fall adequately. But with the existing system of depreciation for half the life of the machine, the price will fall by half of its original value. The buyer does not agree to buy such a machine for half the price, as it foresees higher costs for maintaining the machine in working condition, increasing fuel costs and reducing the interest of the tractor operator to work on the old less efficient machine (Fig. 2).

The market economy, based on the condition of equal interest of partners in productive activities, uses the so-called “accelerated depreciation”, which ensures the transfer to the depreciation fund a large part of the initial value for the first half of the service life of the material elements of fixed capital. In fact, there should be no “accelerated depreciation”, but the depreciation reflecting the real depreciation of the object, the decrease in its use value and cost. Attempts to comply with this condition are made by developing and using methods such as:

- Linear, representing a uniform transfer of the value of the object on the manufactured products or services;
- The method of diminishing balance, which allows one to charge depreciation unevenly, rapidly in the first period of using the machine;
- The method of sum of numbers.
A variety of methods allows one to choose one of them, which to a greater extent reflects the real change in use value, cost and quality of depreciable objects. However, there is no evidence that the selected method can be used for an objective economic evaluation of the changing quality of the machine.

To a greater extent, the actual wear and loss in the quality of agricultural machinery is reflected by the cumulative method, which allows one to quickly transfer the entire initial cost of the machine to the cost of manufactured products and the depreciation fund. However, the cumulative method itself can to a large extent reflect the loss of the quality of the machine only with the optimal duration of its use. In the event of a change in the use period, the absolute values of the portable value change, reflecting the actual wear and residual quality of the machine.

It is proposed to use the “cost equalization method”, according to which the price of a car decreases adequately to the decreasing quality. The criterion of this method is the equal reduced costs per unit of work performed or products manufactured. The task is to ensure the alignment of these costs. This task is solvable, but there is no possibility to change the actual costs of maintenance, repair and storage, labor costs, fuel and lubricants. The only way to ensure such equalization is the distribution of the initial cost of the car (the calculated depreciation fund) over the years of its service life in order to ensure the equality of the annual amounts of compensating expenses and equalization charges. Such adjustments can be made in the following order. Imagining that capital has the property of fluidity, we take the initial cost of the machine, and as shown in Figure 2, “pour” into the space formed by the axis of ordinates and the closing curve of compensating costs.

The initial cost of the car performing the function of equalizing accruals predetermined the distribution of this cost over the years of the use of the car. This distribution reflects the real impairment of the machine, corresponding to a reduction in its quality and ensures the equal benefits of its use during the optimum service life.

In order to test the choice of the method of economic evaluation of the quality of the machine, the following condition was accepted: a new machine is estimated at 60 conventional monetary units; the difference between the equalization charges of the initial period of use of the machine and the final period is 10 conditional monetary units.

The preserved quality of the machine, the economic assessment is defined as:

\[
K_{\text{cox}} = K_n - K_{\text{yr}}
\]

\(K_{\text{cox}}\) – preserved level of quality at the time of examination;

\(K_n\) – initial quality level of 100%;

\(K_{\text{yr}}\) – lost quality as a result of using the machine.

For calculations, we express the quality level at a specific moment of determination in the form of an area whose size (in arbitrary units) reflects the quality of a new car. Then we determine the areas reflecting the levels of the preserved and lost quality of the machine used, we make all the appropriate calculations, allowing us to track changes in the quality of the machine over the established period of use. The initial cost (estimated depreciation amount) of 60 conventional money units is presented as a source of equalization charges. The initial quality level of 100% decreases as the machine is used. Equalization charges for the new machine are assumed to be 10 conventional money units.

The level of preserved quality at any time of the examination is determined by the amount of the balance of equalizing charges (Table 1). For example, new tractors K-700 (class 5) with an initial cost of 6 million rubles have a quality level of 100 %. After three years of use, the estimated quality level will be 34 conventional money units. The monetary value of tractors with such a quality level will be 3.36 million rubles, and after 6 years of use – 1.5 million rubles. Such an assessment ensures the equitable use of tractors throughout the entire period of use.

For approbation of the proposed method of determining the quality of the machine by the method of equalizing accrual materials used mass surveys of tractors. Analysis of these materials shows that the quality of tractors can be confirmed by an economic indicator: the cost per hectare of conditional plowing. This indicator is nothing more than the minimum unit price of consumption, which allows
one to determine the quality of cars of this brand and compare unit costs for all brands, to identify the most economical car [8].

Table 1. The dynamics of the quality level of the machine determined by the method of equalization charges.

| Period of use (years, end of year) | 1  | 2  | 3  | 4  | 5  | 6  | 7  | 8  | 9  | 10 | 11 | 12 |
|----------------------------------|----|----|----|----|----|----|----|----|----|----|----|----|
| Preserved quality (in conventional money units) | 50.4 | 41.6 | 34 | 26.8 | 20.4 | 15 | 10.4 | 6.7 | 3.7 | 1.6 | 0.4 | 0.0 |
| In % of the initial cost | 84 | 69 | 56.6 | 45.3 | 34.3 | 25.0 | 17.3 | 11.2 | 6.1 | 2.7 | 0.06 | 0.0 |

The laws of the market, ensuring equal profitability of relations between partners in the sale of equipment, stimulate the expansion of the use of used machines by less economically strong farms, as the need for capital expenditures for the purchase of machines decreases, capital turnover accelerates.

The stated methodological and methodological approaches allow an objective assessment of the quality of technical means of production by monetary indicators, such as compensating costs and equalizing charges, ensuring the turnover of capital invested in equipment, in accordance with the actual loss of use value, cost, quality, and price.

An accelerated loss of quality cars in the initial period of use should be reflected by an adequate transfer of capital to the depreciation fund. This will increase the financial capacity for upgrading equipment and ensure the adjustment of the calculation of the reduced costs, taking into account the actual functioning capital. The currently produced agricultural equipment does not have a sufficiently high level of quality and its stability. A significant part of the machines is used beyond the optimal service life, even more requires the cost of maintaining their shelf life, which should be taken into account when justifying the prices of used cars. The low level of reliability of the equipment is confirmed by the fact that during the first three or four years the compensating costs increase, the machine, being a means of labor, becomes the subject of labor.

Based on the results of the analysis of the change in the quality of tractors, combines and agricultural machinery, it seems appropriate to distinguish two periods (two stages) in the use of machines. (Figure 1). The first is up to 3-4 years and the second is the following years until the expiration of the depreciation.

With regard to mobile equipment of agricultural enterprises (tractors, combines, and other self-propelled machines), it is advisable to use a two-step depreciation method, as objectively reflecting the depreciation of the machine, transferring most of the original cost of the machine to the depreciation fund in the first half of the service life and using these funds to purchase new equipment.

The regularities of the distribution of the equalization charges, the source of which is the depreciation fund, formed the basis for the development of a step-by-step depreciation method that ensures the transfer of the initial value to the depreciation fund in proportion to the changing quality of the machine.

During the first period, the quality of cars decreases at a faster rate, which should be reflected in higher depreciation rates, lying in the range of 15 ... 20% per year. This will ensure the transfer to the depreciation fund of more than 50% of the initial value for the first period (Table 2).

The quality assessment by the step method was tested by the functioning market of supported equipment. With respect to tractors and motor vehicles, the market sets the price with reasonable accuracy reflecting the decreasing use value and cost of technical equipment, its quality.

Table 2. Economic quality assessment: choosing a method.
Depreciation methods

| Termofuse                  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   |
|----------------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| Linear method, %           | 12.5| 12.5| 12.5| 12.5| 12.5| 12.5| 12.5| 12.5|
| Calculated quality score, %| 87.5| 75  | 62.5| 50  | 37.5| 25  | 12.5| 0   |
| Reduced balance method, %  | 25  | 18.7| 14.1| 10.5| 7.9 | 5.9 | 4.4 | 3.3 |
| Calculated quality score, %| 75  | 56.2| 42.1| 31.6| 23.7| 17.7| 13.3| 10.0|
| Sum of numbers method (cumulative method), % | 22.2| 19.4| 16.6| 13.8| 11.1| 8.3 | 5.5 | 2.7 |
| Calculated quality score, %| 77.8| 58.3| 41.6| 27.7| 16.6| 8.33| 2.7 | 0   |
| Method of step depreciation, % | 20  | 20  | 20  | 20  | 5   | 5   | 5   | 5   |
| Calculated quality score, %| 80  | 60  | 40  | 20  | 15  | 10  | 5   | 0   |

The calculation results and analysis of table 2 show:

- A more reliable reflection of the quality of machines by the norms of the step method of depreciation;
- It allows one to accelerate the turnover of capital in accordance with the actual depreciation of material and technical means;
- Provides greater safety of the depreciation fund in the period of rising prices for new equipment and depreciation of previously accrued depreciation.

Depreciation as the only instrument for reflecting depreciation of capital ensures the formation of initial data and serves as a feedback tool in management. This allows one to analyze the factors and internal processes of the functioning of depreciable property, to manage the release of fixed assets subject to the discreteness of the reproduction cycle [9, 10, 11].

The foregoing allows us to conclude that the quality of technical means is ultimately determined by the regularities in the distribution of equalizing charges, which decrease as the shelf life of machines decreases. Most of the equalization charges accounted for the first half of the life of the machine, confirming the need for appropriate adjustment of depreciation methods.

Considering that mainly used cars come to the market for used equipment after three or four years of use, it is advisable to not compile accounting for the first four years in the amount of 15 ... 20%, and to repay the remaining part of the depreciation in subsequent years of the depreciation period. This distribution of depreciation to a greater extent reflects the actual process of reducing the machines’ quality and ensures transferring to the depreciation fund of the entire initial cost.

References

[1] Marx K and Engels F Works 24 p 196
[2] Selivanov A I 1964 Basics of aging machines (Moscow, USSR: Mashinostroenie) p 404
[3] Lvov D S 1972 Economy of product quality (Moscow, USSR: Economics) p 320
[4] Konkin Yu A and Kovaleva E V 2015 Methodological and methodical approaches to improving the economic evaluation of the quality of technology Machinery and Equipment for the Village 8 pp 45-48
[5] Konkin Yu A, Kovaleva E V and Trishkina L V 2009 On the adequacy of the natural and valuation of the means of production Bulletin of Moscow State Agricultural Engineering University 8(39) pp 19-23
[6] Konkin Yu A, Golubev I G, Konkin M Yu and Kuzmin V N 2011 Technical service - experience and development prospects (Moscow, Russia: Federal State Scientific Institution Rosinformagrotekh) p 337
[7] 1983 The results of a one-time survey of agricultural machinery by service life on collective farms, state farms and inter-farm agricultural enterprises in 1982 (Moscow, USSR: Central
[8] Kovaleva E V 2016 Economic evaluation of the quality of machines: the choice of method *Machinery and Equipment for the Village* 1 pp 42-45

[9] Bogoviz A V, Lobova S V and Bugai Y A 2018 Possibilities and threats of starting the mechanism of import substitution in the AIC in the context of provision of food security *Advances in Intelligent Systems and Computing* 622, pp 51-57

[10] Bogoviz A V, Osipov V S and Stroiteleva T G 2018 Leading tools of state regulation of regional economy *Advances in Intelligent Systems and Computing* 622 pp 562-567

[11] Krupina N N and Trilitskaya O Yu 2016 Rationalization of the depreciation of agricultural machinery as a condition of its expanded reproduction *Economy: Yesterday, Today, Tomorrow* 6(10B) pp 332-348

[12] Semenova E I, Semenov V A and Suglobov A E 2015 Ensuring the quality of domestic agricultural products *Economics of Agriculture of Russia* 11 pp 51-56