

## Management of Reproduction of the Fixed Capital of the Agricultural Enterprises by Method of Economic and Mathematical Modeling

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### Abstract

The state program for the development of agriculture and regulation of markets for agricultural products, raw materials and foodstuffs for 2013-2020 primarily aims to ensure the food security of the Russian Federation taking into account the economic and territorial availability of agricultural products, the achievement of which in modern economic conditions is not possible without the technical modernization of rural economy enterprises. However, the state support of agricultural producers in this direction does not lead to achievement of the specified indicators, while the rates of renewal of fixed assets against the background of growing wear continue to slow down. In addition, a low level of quality management in reproduction of fixed assets causes a decrease in the effectiveness of their use in agriculture. In the modern economic environment, the quality of management decisions is largely determined by the use of economic and mathematical methods and methods of economic research. The use of correlation-regression analysis made it possible to obtain a multifactor model for the efficiency of the use of fixed assets by agricultural enterprises in the Ulyanovsk region. Neural network analysis of factorial and resultant indicators conducted by the method of self-organizing Kohonen maps with the help of the software product Deductor revealed regularities of the "clustering" type and formed the rules of clustering. Analysis of the color gamut of the maps and cluster profiles showed that the most significant indicators for the return on assets which is the main indicator of effective management of fixed assets are the degree of renewal of fixed assets, current assets value per 100 rubles of fixed assets, the share of the active part of funds, the degree of depreciation of fixed assets. The analysis revealed that in the conditions of the Ulyanovsk region the effectiveness of fixed assets management is due to a higher degree of the fund renewal and the ratio of the current to fixed asset values, and also due to less wear rate.

**Keywords:** Fixed assets; Reproduction; Economic and mathematical modeling; Neuroset analysis; Clustering; Efficiency.



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### 1. Introduction

Due to its ability to convert to other factors of production, capital has an outstanding role in comparison with other factors of production. The experience of advanced countries in the field of agricultural production shows that the use of capital equipment in various agricultural activities has led to an increase in the productivity of the produced factors. Fixed capital is one of a kind of capital in agriculture that will be depreciated over time and will be eliminated from the production cycle. This has led to the importance of the reproduction of fixed capital, and since reproduction of fixed capital is essential to preventing the loss of capital, the management of reproduction of fixed capital will also be of great importance.

In modern economic environment, the quality of management decisions at enterprises of any sector, including agriculture, is largely determined by the use of economic and mathematical methods and research methods that allow one to interpret the facts of the enterprise's activity in the form of certain economic models (Nozdrunova, 2014; Razdobudko, 2010). Economic-mathematical models being an element of information-analytical support of the management system, allow the most effective tools to determine for supporting "problem" areas of the enterprise (Ezzat, 2015; Kostynets and Kostynets, 2016).

### 2. Methods

System of managing the fixed assets of an agricultural enterprise makes it possible to identify factors that affect the indicators of capital reproduction, and the degree and nature of their impact. The possibility of revealing the underutilization of the enterprise's capabilities, the reserves for growth of key indicators of fixed assets management

and increasing the efficiency of their reproduction are of significant significance (Nozdrunova, 2014; Tishkova, 2009).

In order to identify the main directions for improving the efficiency of the use of fixed capital in 82 agricultural organizations of the Ulyanovsk region, we will form a multi-factor growth model for the return on assets (Y), the variables of which will be the following:

X 1 - the share of the fixed assets in use, %;

X 2 - degree of depreciation of fixed assets, %;

### 3. Results

To build a multifactorial regression model for managing the reproduction of fixed capital, we use the analytic software Deducator. The resulting regression equation describing the effective management of fixed assets in agricultural organizations is as follows:

$$Y = 49.39 + 0.96 \times X 1 - 0.30 \times X 2 - 0.90 \times X 3 - 1.72 \times X 4 - 0.55 \times X 5 + 0.81 \times X 6$$

Analysis of the regression equation shows that in agricultural enterprises of the Ulyanovsk region, a direct relationship is observed only between the level of asset recovery and the share of the value of the fixed assets in use (X 1), the ratio of the value of working capital by 100 rubles of fixed assets (X 6). The increase in these factors contributes to the growth of capital productivity. So, for example, with an increase in the share of the fixed assets in use in the structure of their value by 1 percentage point, the return on capital increases by an average of 0.98 rubles, which is due to the growth of equipment capability and the increase in the production capacity of the agricultural enterprise, and an increase in the value of current assets by 100 rubles of fixed assets per 1 ruble leads to an increase in the effective indicator by an average of 0.81 rubles.

The inverse relationship of capital productivity observed with such parameters as the degree of depreciation of fixed assets (X 2), the degree of renewal of the fixed assets (X 3), the degree of fixed assets retirement (X 4), share of their own sources in total volume of fixed assets formation (X 5). As these factors increase, the return on capital decreases.

The increase in depreciation of fixed assets by 1 percentage point leads to a decrease in the return on capital by 0.30 rubles. An increase in the level of renewal of fixed assets by 1 percentage point contributes to a decrease in the effective factor by an average of 0.90 rubles. This is due to a longer payback period of new facilities commissioned. The greatest decrease in the efficiency of the use of fixed assets is due to the retirement of funds, where the growth in the level of fixed assets retirement by 1 percentage point leads to an average decrease of 1.72 rubles.

To increase the efficiency of the use of fixed assets, agricultural enterprises in the Ulyanovsk region should use not only their own funds, but also borrowed funds, as their growth will help increase the return on capital by 0.55 rubles. This is due to the fact that a large part of agricultural enterprises use depreciation charges as their own means on forming fixed assets, which are directed not to reproduction of fixed capital, but to replenishment of working capital for operating activities (Subaeva A. K. and Zamaidinov, 2015; Subaeva A. and Zamaidinov, 2016; Zamaidinov and Subaeva, 2017).

Using the standardized correlation coefficients, we will determine the tightness of the connection between the return on assets and the selected factors. Evaluation of standardized correlation coefficients allowed us to determine that the closest relationship is observed between the return on assets and the ratio of the current and fixed assets values ( $r = 0.897$ ). The second place is occupied by the share of the fixed assets in use ( $r = 0.167$ ), the third by the degree of fixed asset retirement ( $r = 0.119$ ). Multiple coefficients of correlation and determination of the compiled regression equation are shown in Figure 1.

**Picture 1.** Results of correlation-regression analysis for indicators of fixed assets use efficiency

Регрессия "1"					
Множ. коэффициент корреляции, R	Коэффициент детерминации, R <sup>2</sup>	Скоррект. коэффициент детерминации	Стандартное отклонение	Размер выборки	Метод отбора переменных
0,8283	0,6860	0,6609	95,2503	82	Полное включение

Таблица дисперсионного анализа (ANOVA)					
Источник	Сумма квадратов, SS	Число степеней свободы, df	Средние квадраты, MS	F-критерий	Значимость
Регрессия	1486742,2391	6	247790,3732	27,3119	0,0000
Ошибки	680446,1287	75	9072,6150		
Сумма	2167188,3678	81			

Коэффициенты регрессии							
	Нестандартизованные коэффициенты		Стандартизованные коэффициенты	t-критерий	Значимость	Доверительный интервал (95%)	
	Значение	Ошибка				Значение	Ошибка
(Константа)	49,3901	38,3418		1,2882	0,2017	-26,9907	125,7710
"X1 - удельный вес активной части основных средств (%)" (X0)	0,9642	0,4154	0,1665	2,3212	0,0230	0,1367	1,7917
"X2 - степень износа основных средств (%)" (X1)	-0,3048	0,6037	-0,0358	-0,5048	0,6151	-1,5075	0,8979
"X3 - степень обновления основных средств (%)" (X2)	-0,8962	0,8322	-0,0952	-1,0769	0,2850	-2,5541	0,7616
"X4 - степень выбытия основных средств (%)" (X3)	-1,7237	1,0259	-0,1194	-1,6802	0,0971	-3,7674	0,3200
"X5 - доля собственных источников в общем объеме инвестиций в основные средства (%)" (X4)	-0,5452	0,4501	-0,0927	-1,2112	0,2296	-1,4419	0,3515
"X6 - стоимости оборотных средств на 100 руб. основных (руб.)" (X5)	0,8083	0,0715	0,8966	11,3066	0,0000	0,6659	0,9508

The data presented indicate that the share of factors included in the correlation-regression model accounts for 69% of the change in return on assets.

The significance of the compiled multiple regression equations can be estimated using Fisher's ratio test. The actual value of Fisher's ratio test exceeds the table value ( $F_{tab} = 2.04$  for  $\alpha = 0.05$ ). Therefore, with a probability of 0.95 ( $1 - \alpha$ ), one can conclude about the statistical significance of the resulting multiple regression equation formed under the influence of the factors studied.

The substitution of actually existing indicators in the equation of regression allowed the estimated level of return on assets to determine for each enterprise. A comparative analysis of the actual and calculated levels of capital productivity of fixed assets revealed that 44% of the enterprises of the studied population underestimate the available opportunities to achieve a possible level of return on assets.

Using the regression equation, we will perform a comparative analysis of the impact of the factors on the return on assets by selected groups of agricultural enterprises in the Ulyanovsk region (Table 1).

**Table-1.** Comparative assessment of the impact of factors on capital productivity by selected groups of agricultural enterprises in the Ulyanovsk region

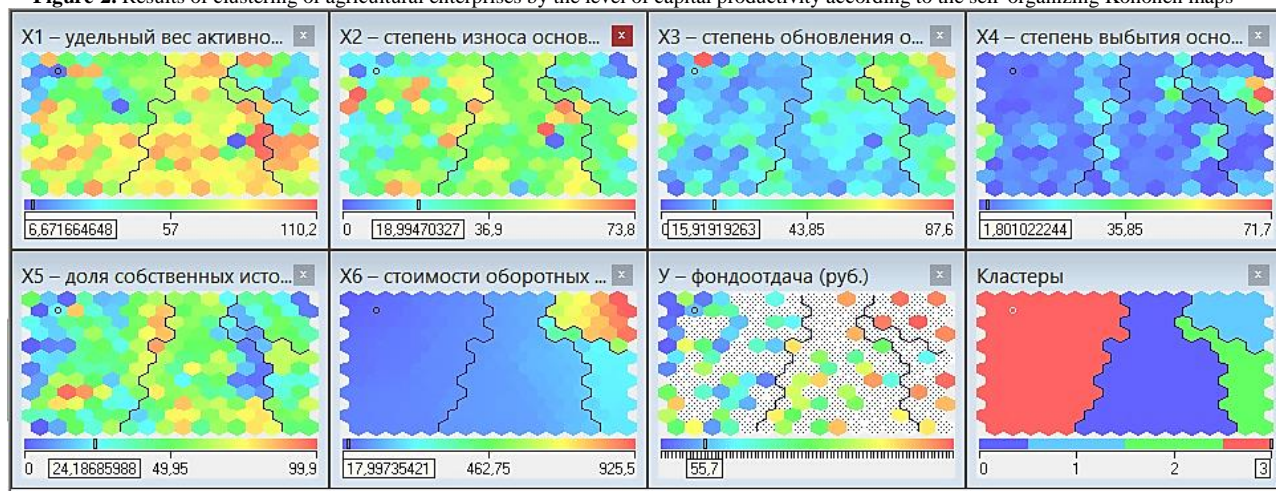
Indicators	Groups of agricultural enterprises in terms of capital productivity, rubles			Total, average on
	70.7	156.4	624.2	
Number of enterprises	53	22	7th	82
Share of fixed assets in use, %	50.2	80.0	48.0	54.0
Degree of depreciation of fixed assets, %	32.3	35.8	19.0	32.5
Degree of renewal of fixed assets, %	15.6	18.5	50.5	16.7
Degree of fixed assets retirement, %	7.1	6.2	39.9	7.7
Share of own sources in total investment in fixed assets, %	33.5	42.9	26.0	34.3
The cost of current assets per 100 rubles of fixed assets, rub.	57.0	94.3	692.2	75.4

These tables show that agricultural enterprises of the first and second group, which are characterized by a low level of return on assets, have the opportunity to increase it. We will carry out a comparative assessment of the impact of factors on the return on assets for selected groups to identify the reserves of growth in the efficiency of the use of fixed assets.

Thus, agricultural enterprises with a high level of capital productivity are characterized by a lesser depreciation degree (1.7 times less), a higher degree of renewal (3.2 times) and a ratio of the current and fixed assets values exceeding the similar indicator for the first group by 12.1 times (Bakhyt *et al.*, 2018; Van Duijn, 1981).

For the purpose of a more detailed analysis of the efficiency of using the main factors, we conducted a neural network analysis that allows us to identify patterns of the type "clusterization" and form the clustering rules. The neural network analysis was carried out using the Kohonen self-organizing map method using the software product Deductor. The results of neural network analysis in the form of Kohonen self-organizing maps are reflected in Figure 2.

**Figure-2.** Results of clustering of agricultural enterprises by the level of capital productivity according to the self-organizing Kohonen maps



According to the analysis, agricultural enterprises in the region are divided into four clusters. Analysis of the color gamut of the constructed maps (Figure 2) and the profiles of clusters (Figure 3) allows us to conclude that the most significant features for the entire set of investigated objects are the degree of renewal of fixed assets, the value of current assets per 100 rubles of fixed assets, the share of the part of funds in use, the degree of depreciation of fixed assets. The coloring of the maps on these grounds indicates that the agricultural enterprises within the identified clusters have fairly close values for the identified features, and the enterprises of different clusters differ from each other, i.e. have pronounced differences in color.

**Figure-3.** Cluster Profiles

	Кластеры					Итого
	Низкий уровень	Средний уровень	Повышенный	Высокий уровень		
	47 (57,3%)	25 (30,5%)	5 (6,1%)	5 (6,1%)		
X6 – стоимости оборотных средств на 100 руб. основных (руб.)	41.63191489	102.864	210.54	790.56	116.2658537	
X3 – степень обновления основных средств (%)	17,71702128	19,824	29,78	52,98	21,24512195	
X1 – удельный вес активной части основных средств (%)	63,80851064	81,88	76,88	47,88	69,14390244	
X2 – степень износа основных средств (%)	35,36382979	42,272	32,06	16,56	36,12195122	
X4 – степень выбытия основных средств (%)	5,891489362	6,324	4,78	20,26	6,831707317	
X5 – доля собственных источников в общем объеме инвестиций в основные средства (%)	38,45319149	51,248	47,86	30,14	42,42073171	

Поля	Кластеры					Итого
	Низкий уровень	Средний уровень	Повышенный	Высокий уровень		
	47 (57,3%)	25 (30,5%)	5 (6,1%)	5 (6,1%)		
9.0 X6 – стоимости оборотных средств на 100 руб. основных (руб.)	100,0%	28,6%	74,9%	100,0%	100,0%	
9.0 X3 – степень обновления основных средств (%)	74,6%	29,6%	71,4%	100,0%	100,0%	
9.0 X1 – удельный вес активной части основных средств (%)	69,5%	95,9%	44,5%	89,2%	98,4%	
9.0 X2 – степень износа основных средств (%)	16,6%	84,4%	35,6%	97,3%	95,8%	
9.0 X4 – степень выбытия основных средств (%)	39,7%	16,1%	31,0%	97,5%	94,7%	
9.0 X5 – доля собственных источников в общем объеме инвестиций в	56,5%	82,7%	33,2%	66,5%	80,0%	

Clusters with numbers from 0 to 25 form agricultural enterprises with an average level of efficiency of fixed assets. The objects included in this group are characterized by a high proportion of the part of the funds in use, and the predominance of their own sources in the formation of fixed assets. However, a higher degree of depreciation of funds does not allow this enterprise to receive a greater return on the use of funds.

Cluster No. 1 is leading agricultural enterprises characterized by a high return on capital, which is due to a low degree of depreciation of fixed assets, a high level of renewal of fixed capital, a high ratio of the value of working capital per 100 rubles of fixed assets.

The structure of this cluster included 5 agricultural enterprises, which makes 6.1%.

Cluster No. 2 is represented by 5 agricultural enterprises (6.1%) characterized by an increased level of return on assets due to a more active process of renewal of fixed assets and a low share of funds withdrawn.

Cluster No. 3 includes 47 economic entities (57.3%) which are characterized by a high degree of depreciation, a low ratio of the value of working capital and fixed capital, and as a consequence, a lower efficiency in the management of fixed assets.

The comparative characteristics of the formed groups are presented in Table 2.

Table-2. Comparative characteristics of clusters in terms of efficiency of use of fixed assets

Indicators	Groups of agricultural organizations in terms of efficiency of use of fixed assets				Average
	Low	Average	Increased	High	
Number of enterprises	47	25	5	5	82
Share of fixed assets in use,% (X <sub>1</sub> )	63.8	81.9	76.9	47.9	69.1
Degree of depreciation of fixed assets,% (X <sub>2</sub> )	36.4	42.3	32.1	16.6	36.1
The coefficient of renewal of fixed assets (X <sub>3</sub> )	0.177	0,198	0,298	0.530	0.212
The fixed assets retirement ratio (X <sub>4</sub> )	0.059	0.063	0.048	0.203	0.683
Share of own sources in total investment in fixed assets,% (X <sub>5</sub> )	38.5	51.2	47.9	30.1	42.4
The amount of working capital per 100 rubles of fixed assets, rub. (X <sub>6</sub> )	41.63	102.86	210.54	790.56	116.27
Capital productivity, rub.	77.68	139.70	319.02	631.74	145.09

According to the comparative characteristics, it is evident that groups of agricultural enterprises with a high level of return on assets are characterized by:

- Active process of renewal of fixed assets. The coefficient of renewal of funds is 0.530, which is higher than the value of a similar indicator for enterprises with a low level of a return on assets of 2.99 times, where the average value corresponds to 0.177. At the same time, this indicator increases from group to group, so in the group with an average value of the efficiency of use, the renewal coefficient was 0.198, in the group with an increased level of return on assets - 0.298 ;



- Less depreciation of fixed assets. Degree of depreciation of assets in the group with a high level of efficiency of fixed assets use is 16.6% against 36.4% in the group with a low level of return on assets. The maximum value of depreciation of fixed assets is observed in the second group with an average value of the fixed assets use efficiency amounted to 42.3%. This factor played a decisive role in the formation of the average level of the return on assets in this group. The minimum value of the degree of deterioration is characteristic for the agricultural enterprises with an increased level of return on assets (32.1%). However, the non-optimal structure of fixed assets did not allow this group to get a higher level of the return on assets;

- A high level of fixed asset retirement, which in conditions of a high degree of renewal of assets indicates an intensive replacement of fixed assets due to reconstruction or modernization of production. The share of retired fixed assets in agricultural enterprises with a high level of return on assets averages 20.3%, which is 3.44 times higher than in the group with a low level of return on assets;

- The optimal structure of fixed assets, since the ratio of active and passive parts, as practice shows, should be 1:1. Given that most of the agricultural organizations have crop and milk production specialization, the cumulative share of machinery, process equipment, and transport vehicles should correspond to the aggregate share of buildings and structures that form a large share of passive assets;

- A high ratio of working capital and fixed assets. According to the table, it is evident that with an increase in the ratio of the current and fixed assets values, there is an increase in capital productivity. In a group with a high level of return on assets, this indicator exceeds the similar indicator of the first group by 19 times;

- The predominance of borrowed assets in the structure of the formation of fixed assets. Agricultural enterprises with a high level of return on assets are characterized by a larger share of borrowed assets (ratio 2.3: 1), which is explained by the formation of fixed capital due to predominantly long-term sources that increase the efficiency of agricultural production.

Figure-3. The decision tree to achieve a high level of capital productivity of agricultural enterprises in the region

Условие			Следствие		Поддержка		Достоверность	
Показатель	Знак	Значение	ab	У – фондотдача	Кол-во	%	Кол-во	%
9.0 X6 – стоимости оборотных средств на 100 руб. основных	>=	73,5	от 147,2		8	10,26	8	100,00
9.0 X2 – степень износа основных средств (%)	<	27,15						
9.0 X6 – стоимости оборотных средств на 100 руб. основных	<	73,5	от 69,8 до 103,3		2	2,56	2	100,00
9.0 X1 – удельный вес активной части основных средств (%)	>=	62,65						
9.0 X6 – стоимости оборотных средств на 100 руб. основных	<	57,15						
9.0 X2 – степень износа основных средств (%)	>=	51,7						

Условие	Следствие
ЕСЛИ	
X6 - стоимости оборотных средств на 100 руб. основных (руб.) < 73,5	
X1 - удельный вес активной части основных средств (%) < 62,65	
X4 - степень выбытия основных средств (%) < 0,5	от 147,2
X4 - степень выбытия основных средств (%) >= 0,5	
X6 - стоимости оборотных средств на 100 руб. основных (руб.) < 56,35	до 69,8
X6 - стоимости оборотных средств на 100 руб. основных (руб.) >= 56,35	от 69,8 до 103,3
X1 - удельный вес активной части основных средств (%) >= 62,65	
X6 - стоимости оборотных средств на 100 руб. основных (руб.) < 57,15	
X2 - степень износа основных средств (%) < 51,7	
X5 - доля собственных источников в общем объеме инвестиций в основные средства (%) < 78,1	от 103,3 до 147,2
X5 - доля собственных источников в общем объеме инвестиций в основные средства (%) >= 78,1	от 69,8 до 103,3
X2 - степень износа основных средств (%) >= 51,7	от 69,8 до 103,3
X6 - стоимости оборотных средств на 100 руб. основных (руб.) >= 57,15	до 69,8
X6 - стоимости оборотных средств на 100 руб. основных (руб.) >= 73,5	
X2 - степень износа основных средств (%) < 27,15	от 147,2
X2 - степень износа основных средств (%) >= 27,15	от 103,3 до 147,2

The constructed decision tree showed that the conditions for achieving a high level of capital productivity are the depreciation of fixed assets <27.15% and the high ratio of the current and fixed assets values ≥ 73.5 rubles. A low level of efficiency in the use of fixed assets is observed in agricultural organizations where the ratio of the current and fixed assets values is <56.35 rubles, the degree of fixed assets retirement is ≥ 0.5, the share of the fixed assets in use does not exceed 62.65%.

#### 4. Summary

The analysis made it possible to conclude that in the conditions of the Ulyanovsk region, the efficiency of fixed assets management in agriculture is due to a higher degree of renewal and the high ratio of the current and fixed assets values, and to a lesser depreciation degree.

## 5. Conclusions

The use of the results of economic and mathematical modeling in the economic activities of agrarian formations promotes an increase in the efficiency of the use of fixed assets and an increase in the indices of their reproduction.

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