Financial Performance Assessment of Agrarian Enterprises as a Result of Innovative Resource Development Management

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Summary
The main purpose of the study is to improve the methodology for assessing the impact of innovativeness management of resource potential of agricultural enterprises on their financial performance. The methodological basis of the study is the fundamental provisions of the theory of finance and innovation, methods of multivariate analysis, in particular, correlation and multivariate regression analysis, mathematical programming, etc. The parameter of technological progress in the autoregressive multiplicative Tinbergen-Solow production function is derived. The classification of resource potential management of agrarian enterprises in 4 directions: potential of production results, potential of resource availability, potential of performance of resource use, potential of financial condition is proposed. The multivariate model is built, where a net income of Ukrainian agrarian enterprise is taken as an absolute indicator of financial performance (dependent variable) and resource potential indicators are taken as independent variables. We constructed 3 objective functions of maximization: output of agrarian products (Tinbergen-Solow production function), net income (multivariate linear model), return on equity (DuPont model) for short period. The solutions to the above optimization problems allowed us to maximize the return on equity only at the expense of the available innovation potential of production resources and will be used in further research by the authors.
Keywords:
Innovative Development, Production Function, Agricultural Enterprise, Resource Potential, Maximization.

1. Introduction

The financial performance of an enterprise is first and foremost associated with the concept of profit. However, it is not always possible to assess the level of financial performance of an enterprise by the amount of profit, because the amount of profitability is influenced not only by the quality of work, but also by the scale of production. Therefore, when assessing the financial performance of an enterprise, both the absolute measure of profit in monetary terms and its ratio to expenses, capital, assets, etc., i.e. return ratios, should be taken into account.

Another important aspect of financial performance is the definition of the main goal of the business owner. Until the second half of the twentieth century, this goal was considered to be maximising net income in both the short and long term [1]–[3]. Under the influence of stock market development, the paradigm of financial management has changed and maximization of capital value has become the main financial goal of a business owner [4]–[10]. When examining the financial performance of an agricultural enterprise, it is necessary to point out its specifics, which are as follows:

(i) profit maximization is more relevant for small and medium-sized businesses in the agricultural sector, as well as for farms that are very sensitive to changes in agricultural prices [11]–[13];
(ii) maximizing the market value of business in the agricultural sector is relevant only for corporations, which are very few, while for large enterprises it is much more important to maximize the return on equity [14]–[16];
(iii) the basis of agricultural business is resource provision, the management of innovative development of which is crucial in ensuring financial performance, as it allows to produce more agricultural products with the same use of resources and achieve competitive advantages [17]–[22].

The main purpose of the study is to improve the methodology for assessing the financial performance of an agricultural enterprise under the influence of managing the innovativeness of its resource potential.

2. Theoretical Consideration

The methodology for assessing the financial performance of agricultural enterprises is to study the impact of innovative development of their resource potential on financial results and consists of three parts:

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(i) modelling of innovative development of an agricultural enterprise using the Tinbergen-Solow production function;
(ii) modelling of financial performance of an agricultural enterprise taking into account the impact of resource potential based on multivariate analysis methods;
(iii) return on equity maximization using the DuPont model.

The first part of the methodology is used to model output sales using the autoregressive dynamic multiplication model of the Cobb-Douglas production function [23], modified by J. Tinbergen [24] and R. Solow [25]:

$$Q = AC^{\alpha} L^{1-\alpha} e^{\lambda t}, \quad (1)$$

where Q is the dependent variable interpreting the result of economic activity of an agricultural enterprise, we take the average annual agricultural production output of one agricultural enterprise;
C is the physical capital factor (independent variable), taking the average annual volume of total assets of one agricultural enterprise;
L is a human capital factor (independent variable), taking the annual average number of employees in one agricultural enterprise;
A is the value of Q at $C = L = 1$;
α is the elasticity of agricultural output to the capital factor (by how much Q increases if C increases by 1%);
$(1 - \alpha)$ is the elasticity of agricultural output to the human capital factor (by how much % Q increases when L increases by1%);
λ is the technological progress parameter or the elasticity of agricultural output to technological progress;
e is the Euler's number (the basis of the natural logarithm);
t is the time factor (order number of the year) [24, p. 227].

The proposed autoregressive dynamic model of the Tinbergen-Solow production function, represented by Formula (1), has a technological progress parameter λ that reflects the level of innovation development of agricultural production at the micro level. The economic interpretation of the technological progress parameter is as follows. When $\lambda > 0$, the production potential of the agricultural enterprise is considered to meet the modern requirements of technological progress, in particular, the latest technologies are used in the production process, workplaces and logistical processes are automated, which ultimately provides an additional increase of $+\lambda$% in agricultural output, as well as growing returns to scale of production. In the case of $\lambda > 0$, the technological progress parameter can be seen as an indicator of expanded intensive reproduction. When $\lambda < 0$, the development of an enterprise's productive capacity can be considered extensive with simple reproduction, as the applied production technologies are obsolete, backward compared to similar ones, with the result that the agricultural enterprise loses $-\lambda$% due to lagging behind technological progress.

The practical use of the Formula (1) makes it possible to formalize the impact of technological progress on agricultural production of agricultural enterprises as follows. The Tinbergen-Solow production function presented by Formula (1) is based on the parameter of technological progress formalized as a time factor. This factor is considered in the context of time savings as a result of innovation activities of the firm, as well as in the context of compliance of its production capacity with the current state of innovation level of agricultural development. That is, to achieve positive dynamics of financial performance of the agricultural enterprise is possible when the level of its production potential is formed with the use of modern advanced innovative technologies in the agricultural sector of the economy, which provides real savings of time costs and other production resources. In this case it is an expanded reproduction of intensive type. When the production potential of the enterprise is formed with the help of obsolete technologies that lag behind the technological progress in the agricultural sector, we are talking about a simple reproduction of the extensive type.

To realise the modelling of the Tinbergen-Solow production function, we write Formula (1) in logarithmic form:

$$\ln Q = \ln A + \alpha \ln C + (1 - \alpha) \ln L + \lambda t. \quad (2)$$

It is in logarithmic form that Formula (2) is suitable for further use in modelling the parameters of the Tinbergen-Solow production function.

2.2 Modelling the financial performance of an agricultural enterprise, taking into account the impact of resource potential, based on multivariate analysis

To model financial performance of agrarian enterprise taking into account the influence of resource potential we apply methods of multivariate analysis, more specifically, correlation and multiple regression analysis. Multivariate analysis will allow not only to comprehensively assess the dynamics of financial performance of agricultural enterprises, but also to identify the impact of the main factors of resource potential on it. The results of the multivariate analysis will make it possible to identify the main problems that hinder the efficiency of agricultural enterprises and to develop ways to solve them. The main source of calculations is public data of official statistics [26].

The process of multivariate analysis of financial performance of an agricultural enterprise taking into account the impact of resource potential is implemented by performing the following steps:

(i) identification, selection, formation of dependent and independent variables;
(ii) formation of an array of official data over a certain period of time on dependent (financial performance) and independent (resource potential) variables;
(iii) selecting the form of relationship between independent and dependent variables, formalising the statistics;
(iv) build a correlation matrix and carry out correlation analysis;
(v) conducting a multicollinearity test;
(vi) constructing multiple regression equation and conducting regression analysis of multiple model of financial performance of agricultural enterprises taking into account production potential;
(vii) statistical evaluation of the multiple model, analysis of its adequacy.

The main monetary indicator of the financial performance of any enterprise is the net income (after tax) of the agricultural enterprise as the ratio of the balance of net incomes and losses to the number of agricultural enterprises for the year. An increasing trend in net income reflects an improvement in financial performance, while a decreasing trend (or net loss) reflects a deterioration in financial performance. It is this indicator that will be taken as the dependent variable in the multiple model of financial performance. In order to select the independent variables in the multiple model of financial performance, data sets are generated for the indicators of the resource potential of the agricultural enterprise shown in Table 1.

Table 1: Indicators of the resource potential of an agricultural enterprise

Indicator	How the indicator is calculated
Results of production activity of an agricultural enterprise	
Agricultural Production Output	Ratio of agricultural production output (goods, services) to the number of agricultural enterprises per year
Net Income (Loss)	Ratio of the balance of total net income and total net loss to the number of agricultural enterprises per year
Agricultural Products Sales	Ratio of total sales of agricultural products in Ukraine to the number of agricultural enterprises per year
Agricultural Production Costs	Ratio of agricultural production costs to the number of agricultural enterprises per year
Agricultural Production Value Added	Ratio of added value of agricultural production to the number of agricultural enterprises per year
Material Costs and Costs of Services Used in Production	Ratio of material and service inputs used in agricultural production to the number of agricultural enterprises per year
Resource availability of an agricultural enterprise	
Number of Employees	Ratio of the number of employees in agricultural enterprises to the number of agricultural enterprises per year
Expenditure per 1 Employee	Ratio of personnel costs at agricultural enterprises to the number of employees at agricultural enterprises for the year
Non-Current Assets	Ratio of non-current assets of agricultural enterprises to the number of agricultural enterprises per year
Current Assets	Ratio of current assets of agricultural enterprises to the number of agricultural enterprises per year
Total Assets	Ratio of the sum of non-current and current assets of agricultural enterprises to the number of agricultural enterprises per year
Capital Investments	Ratio of capital investments of agricultural enterprises to the number of agricultural enterprises per year
Equity Capital	Ratio of equity capital of agricultural enterprises to the number of agricultural enterprises per year
Current Liabilities and Collateral	Ratio of current liabilities and collateral of agricultural enterprises to the number of agricultural enterprises per year
Efficiency of resource use by an agricultural enterprise	
Labour Productivity	Ratio of the volume of agricultural products (goods, services) produced to the number of employees at agricultural enterprises for the year
Capital Productivity Ratio	Ratio of the volume of agricultural products (goods, services) produced to the value of non-current assets of agricultural enterprises for the year
Capital Employment Ratio	Ratio of the value of non-current assets of agricultural enterprises to the number of employees at agricultural enterprises
Material Intensity of Production	Ratio of material costs and expenses for services used in production at agricultural enterprises to the volume of agricultural products (goods, services) produced
Stability of the financial condition of an agricultural enterprise	
Own Working Capital	Ratio of the difference between equity capital and non-current assets of agricultural enterprises to the number of agricultural enterprises per year
Total Liquidity Ratio	Ratio of current liabilities and collateral to current assets of agricultural enterprises for the year
Cash Flow to Debt Ratio	Ratio of net cash flow to total liabilities of agricultural enterprises for the year
Return on Operating Activities	The ratio of the result from operating activities to the costs of operating activities
Return on Equity	Ratio of net income to equity capital of agricultural enterprises for the year

Source: *Authors' elaboration*

In order to implement the modelling of the financial performance of an agricultural enterprise, taking into account the impact of resource potential on the basis of multivariate analysis, the choice of the form of relationship between the independent and dependent variables should be made, as well as to formalize the statistical data. Due to the multidirectionality and diversity of economic processes reflected by the indicators in Table 1, it is logical to build a multifactor economic-mathematical model using multiple regression analysis.

The most popular form of multivariate analysis based on multiple regression analysis in the economic literature [10], [11], [16] is linear multiple regression. That is, the linear function will be used in the multivariate analysis of the impact of resource potential on the financial performance of an agricultural enterprise. The multiple equation of the linear function can be represented as:

$$y = a_0 + a_1 x_1 + a_2 x_2 + ... + a_n x_n + \varepsilon, \qquad (3)$$

where y is the dependent variable (the average annual net income of the agricultural enterprise in our case);
$x_1, x_2, \ldots, x_n$ are independent variables numbered from 1 to n (21 indicators of the resource potential of an agricultural enterprise whose characteristics are presented in Table 1);
$a_1, a_2, \ldots, a_n$ are parameters of equation in independent variables or regression coefficients that show by how many units the dependent variable will change when the corresponding independent variable increases by 1 unit;
a_0 is a constant showing what value the dependent variable will acquire if the values of all independent variables become 0;
ε is the sum of the residuals of the regression equation.

It is also important to determine the elasticity coefficients, which show the percentage change in the dependent variable when each of the independent variables increases by 1%. Generally, the elasticity coefficient (E_i) is calculated by the formula:

$$E_i = a_i \frac{\overline{x_i}}{\overline{y}}, \qquad (4)$$

where $\overline{x_i}$ is the arithmetic mean of the i-th independent variable, $i = \overline{1; n}$;
$\overline{y}$ is the arithmetic mean of the dependent variable.

2.3 Methodology for maximise return on equity according to the DuPont model

The methodology for maximising return on equity synthesises the two previous methodologies. Firstly, it includes the process of modelling the average annual sales of agricultural products of an agricultural enterprise based on the impact of technological progress in the Tinbergen-Solow production function (as a result of managing the innovative development of resource potential). Secondly, it includes the process of modelling the annual average net income of an agricultural enterprise by means of a multiple power regression equation (as an efficiency of integrated use of resource potential). To maximize Return on Equity (*ROE*), the DuPont model is used as the product of Return on Sales (*ROS*), Asset Turnover Ratio (*ATR*) and Leverage Ratio (*LR*) [27]–[28]. The target function of *ROE* maximization is generated:

$$ROE = ROS \cdot ATR \cdot LR \rightarrow \max, \qquad (5)$$

where $ROE = \frac{\text{Net Income}}{\text{Equity}}$;

$ROS = \frac{\text{Net Income}}{\text{Revenue}}$;

$ATR = \frac{\text{Revenue}}{\text{Total Assets}}$;

$LR = \frac{\text{Total Assets}}{\text{Equity}}$.

3. Experimental Consideration

The course of implementation of modelling the financial performance of agrarian enterprises taking into account the impact of innovative development of their resource potential on financial results will be reflected in the experimental part of the study. Thus, first, let us summarize the value of the main indicators of resource potential development, among which the most relevant for assessing the financial performance of agrarian enterprises will be selected (Table 2).

Among the above nine-year dynamics of indicators of the development of resource potential of agricultural enterprises, all except material intensity of products (+0.9%), capital productivity (–8.6%), total liquidity ratio (–15%) and the number of employees (–29.3%) show a positive growth trend with a relative increase from +0.6% (financial independence ratio) to +463% (capital labour productivity). Thus, it can be concluded that in general, the dynamics of the development of the resource potential of agricultural enterprises is positive with a slight weakening of solvency and efficiency of capital use.

3.1 Modelling the impact of technological progress on the economic development of agricultural enterprises in Ukraine

The first stage of the experiment on the implementation of modelling the financial performance of agricultural enterprises, taking into account the impact of innovative development of their resource potential on financial results. It consists in modelling the impact of technological progress on the economic development of agricultural enterprises in Ukraine using the Tinbergen-Solow production function (see Formulas (1)–(2)).

Table 2: Average annual indicators of Ukrainian agricultural enterprises' resource potential development

Indicator naming	Indicator value by year								
	2012	2013	2014	2015	2016	2017	2018	2019	2020
1. Average annual production results of Ukrainian agricultural enterprise:									
1.1. Agricultural Production Output, UAH ths (*APO*)	3,687.7	3,844.8	6,105.5	8,752.2	10,333.9	10,199.8	11,899.2	12,352.0	13,365.5
1.2. Net Income (Loss), UAH ths (*NIL*)	562.1	300.6	466.9	2,200.3	2,013.7	1,374.0	1,405.9	1,856.2	1,650.5
1.3. Agricultural Products Sales, UAH ths (*APS*)	3,412.2	3,232.4	4,649.4	7,750.9	8,970.3	9,066.7	10,397.1	11,073.6	12,243.9
1.4. Agricultural Production Costs, UAH ths (*APC*)	2,818.5	3,163.0	4,127.5	5,882.7	7,256.9	7,760.5	9,534.7	10,124.3	10,358.9
1.5. Agricultural Production Value Added, UAH ths (*APVA*)	1,561.3	1,397.6	2,726.8	3,933.6	4,154.3	3,900.0	3,998.5	4,089.3	5,330.8
1.6. Material Costs and Costs of Services Used in Production, UAH ths (*MCS*)	2,144.9	2,466.4	3,325.7	4,834.0	5,948.7	6,218.1	7,616.9	7,831.8	7,848.3
2. Average annual resource availability of Ukrainian agricultural enterprise:									
2.1. Number of Employees, persons (*NE*)	15.0	13.4	14.6	12.4	13.3	11.5	11.2	11.0	10.6
2.2. Expenditure per 1 Employee, UAH ths (*EE*)	31.1	35.1	38.0	49.6	55.8	77.1	98.5	114.7	125.9
2.3. Non-Current Assets, UAH ths (*NCA*)	2,136.8	2,366.0	2,673.4	3,661.4	4,857.3	5,437.8	6,520.5	7,747.9	8,473.3
2.4. Current Assets, UAH ths (*CA*)	3,632.0	3,912.3	5,814.6	11,009.4	29,305.0	12,751.2	12,953.0	12,758.9	14,380.1
2.5. Total Assets, UAH ths (*TA*)	5,768.8	6,278.3	8,488.0	14,670.8	34,162.3	18,189.0	19,473.5	20,506.8	22,853.4
2.6. Capital Investments, UAH ths (*CI*)	403.0	379.5	403.9	637.5	1,118.3	1,278.7	1,318.2	1,192.5	1,023.9
2.7. Equity Capital, UAH ths (*EC*)	3,108.7	3,146.0	3,562.8	5,889.6	8,208.6	8,706.7	9,563.2	10,405.8	12,380.7
2.8. Current Liabilities and Collateral, UAH ths (*CLC*)	1,915.4	2,270.5	3,556.0	7,324.1	24,578.7	8,303.8	8,282.2	8,251.9	8,921.3
3. Average annual resource efficiency of Ukrainian agricultural enterprise:									
3.1. Labour Productivity, UAH ths/person (*LP*)	245.3	286.1	418.8	703.2	777.3	890.1	1,063.9	1,121.7	1,261.9
3.2. Capital Productivity Ratio (*CPR*)	1.726	1.625	2.284	2.390	2.127	1.876	1.825	1.594	1.577
3.3. Capital Employment Ratio, UAH ths/person (*CER*)	142.1	176.0	183.4	294.2	365.3	474.5	583.0	703.6	800.0
3.4. Material Intensity of Production (*MIP*)	0.582	0.641	0.545	0.552	0.576	0.610	0.640	0.634	0.587
4. Average annual indicators of financial condition of Ukrainian agrarian enterprise:									
4.1. Own Working Capital, UAH ths (*OWC*)	971.9	779.9	889.4	2,228.2	3,351.3	3,269.0	3,042.7	2,658.0	3,907.4
4.2. Total Liquidity Ratio (*TLR*)	1.896	1.723	1.635	1.503	1.192	1.536	1.564	1.546	1.612
4.3. Cash Flow to Debt Ratio (*CFDR*)	0.536	0.501	0.420	0.401	0.240	0.479	0.491	0.507	0.542
4.4. Return on Operating Activities, % (*ROOA*)	21.7	11.3	20.6	41.7	32.4	22.4	18.3	19.2	18.6
4.5. Return on Equity, % (*ROE*)	18.08	9.56	13.10	37.36	24.53	15.78	14.70	17.84	13.33

Source: *Formed and calculated from data in [26], [29] and Table 1, using Excel.*

To construct the autoregressive multiplicative Tinbergen-Solow power production function, we first calculate the natural logarithms of the dependent variable agricultural output and the independent variables total assets and average annual number of employees (Table 3).

Table 3: Natural logarithms of input data for modelling the Tinbergen-Solow production function

Years	ln *APO*	ln *TA*	ln *NE*	t
2012	8.21276	8.66022	2.70805	1
2013	8.25448	8.74485	2.59525	2
2014	8.71695	9.04641	2.68102	3
2015	9.07706	9.59361	2.51770	4
2016	9.24319	10.43888	2.58776	5
2017	9.23012	9.80857	2.44235	6
2018	9.38423	9.87681	2.41591	7
2019	9.42157	9.92851	2.39790	8
2020	9.50043	10.03686	2.36085	9

Source: *Formed and calculated from data in Table 2.*

Guided by the methodological approach to finding the parameters of the Tinbergen-Solow production function proposed in [30, p. 8], using the data presented in Table 3, the Excel functionality was used, which gave the results shown in Figure 1.

Figure 1 shows that the Tinbergen-Solow multiplicative production function model of Ukrainian agricultural enterprises is statistically significant, as the actual F-statistic exceeds its critical value by 18.4 times and the actual t-statistic exceeds its critical value by 5.6 times.

SUMMARY OUTPUT

Regression statistics	
Multiple R	0.98454
R Square	0.96931
Adjusted R Square	0.95908
Standard Error	0.12227
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*	*t*
Regression	2	2.83323	1.41662	94.75947*	0.00003	13.76659**
Residual	6	0.08970	0.01495			
Total	8	2.92293				

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3.22283	0.73950	4.35809	0.00478	1.41333	5.03233
alfa	0.37126	0.12399	2.99424	0.02419	0.06786	0.67466
lambda	0.12844	0.03209	4.00265	0.00710	0.04992	0.20697

* $F > 5.14325$, so the R square is statistically significant;

** $t > 2.44691$, so the multiple R and parameters are statistically significant.

Figure 1. Modelling results of the multiplicative Tinbergen-Solow production function of Ukrainian agricultural enterprises

Source: *Calculated according to the data given in Table 3 and Formula (3).*

Possible variations in agricultural output by 96.9% are predetermined by changes in the value of total assets and average number of employees. Using the parameters of the model shown in Figure 1, let us form the final form of the Tinbergen-Solow multiplicative function equation:

$$APO = 25.099 TA^{0.371} NE^{0.629} e^{0.128t}. \quad (6)$$

The economic interpretation of Formula (6) is as follows. If the average annual value of total assets of Ukrainian agricultural enterprises grows by 1%, the annual output of agricultural products increases by 0.371%. A 1% increase in the average annual number of employees of Ukrainian agricultural enterprises leads to a 0.629% increase in agricultural output. Conformity with technological progress of Ukrainian agrarian enterprises provides an additional increase in agricultural output, which is 0.128%. It should be noted that Ukrainian agrarian enterprises provide in general an intensive type of economic growth, which is a consequence of innovative development of their resource potential.

3.2 Modelling the impact of resource potential on the financial performance of Ukrainian agricultural enterprises using multivariate analysis

Having formalized the statistical data of indicators of resource potential development of agrarian enterprises in Ukraine, let us proceed to the implementation of modelling of financial performance of agrarian enterprise, taking into account the impact of resource potential on the basis of multivariate analysis. At the initial stage the correlation analysis is carried out. For this purpose, the matrix of even correlation coefficients is built according to Table 2 in order to study the density of stochastic connection between factor attributes. The resulting matrix is formed taking into account the fact that net income is the dependent variable, while the other indicators of resource potential development are independent variables.

Speaking about the necessity of correlation analysis, it should be noted that its main purpose is the presence of high density stochastic relationship between the factor features is unacceptable, as it will distort the results and lead to statistical and economic inadequacy of the resulting model. In econometrics, the presence of a high-density stochastic relationship between independent variables is called multicollinearity, the presence of which must be identified and eliminated as much as possible, which is the main content of the correlation analysis. The test for multicollinearity was conducted using the methodology proposed in [31]. This methodology assumes that the statistical significance of the even correlation coefficient can be determined using the F-test. In our case we should find the critical value of F-test for 9 values of 2 independent variables using the Excel formula: = FINV(0,05;1;9-1-1); $F = 5.5914$. Then all values of the pairwise correlation coefficient, which will correspond to F-test values less than the critical 5.5914, show that there is no multicollinearity. We find the value of the even correlation coefficient (r), to which corresponds the value of $F = 5.5914$ by the formula:

$$F = \frac{r^2}{1-r^2} \cdot \frac{n-m-1}{m}, \quad (7)$$

where m is the number of independent variables;
n is the number of values in the data set of one variable.

Substitute the known values into Formula (7):

$$\begin{aligned} &F = 5.5914 = \frac{r^2}{1-r^2} \cdot \frac{9-1-1}{1} = \frac{7r^2}{1-r^2}; \\ &7r^2 = 5.5914 \cdot (1-r^2); \\ &7r^2 = 5.5914 - 5.5914r^2; \\ &12.5914r^2 = 5.5914; \\ &r^2 = 0.4441; \\ &r = \sqrt{0.4441} = \pm 0.6664. \end{aligned} \quad (8)$$

Consequently, there will be no multicollinearity between pairs of independent variables whose pairwise correlation coefficients fall within the range of values:

$$r \in [-0.6664; 0.6664]. \quad (9)$$

Guided by Table 2, using the Excel function Excel “Data Analysis ⇨ Correlation”, a correlation matrix is obtained (Table 4).

Out of a total of 231 pairwise correlation coefficients, 131 (56.7%) show that there is no multicollinearity between the independent variables, as they all meet the condition $r \in [-0.6664; 0.6664]$. Among all the pairwise correlation coefficients presented in Table 4, the following reached the highest values: 0.9973 between Agricultural Production Costs, and Material Costs and Costs of Services Used in Production, 0.9968 between Non-Current Assets and Capital Employment Ratio, 0.9962 between Agricultural Products Sales and Agricultural Production Output. Such high values of the coefficients indicate an ultra-dense relationship between the indicators, close to a functional relationship, i.e., the presence of multicollinearity.

A total of 100 pairwise correlation coefficients signals multicollinearity between potential independent variables, some of which are not desirable to introduce into a multiple linear regression model of net income of Ukrainian agricultural enterprise. Because there must be a loose relationship between the independent variables ($|r| > 0.6664$). Another important condition for constructing a multiple linear regression model of net income of Ukrainian agricultural enterprise is the presence of at least 1 independent variable representing each of the 4 groups of indicators shown in Tables 1–2. The following indicators meet all these conditions: Agricultural Production Output, Current Liabilities and Collateral, Capital Productivity Ratio and Cash Flow to Debt Ratio. The results of linear multiple regression modelling of net income of Ukrainian agricultural enterprise are illustrated by Figure 2.

Table 4: Correlation matrix of average annual indicators of Ukrainian agricultural enterprises' resource potential development

	APO	*APS*	*APC*	*APVA*	*MCS*	*NE*	*EE*	*NCA*	*CA*	*TA*	*CI*	*EC*	*CLC*	*LP*	*CPR*	*CER*	*MIP*	*OWC*	*TLR*	*CFDR*	*ROOA*	*ROE*	*NIL*
APO	1																						
APS	0.996*	1																					
APC	0.986*	0.987*	1																				
APVA	0.957*	0.952*	0.901*	1																			
MCS	0.991*	0.988*	0.997*	0.909*	1																		
NE	–0.884*	–0.899*	–0.915*	–0.795*	–0.908*	1																	
EE	0.911*	0.924*	0.958*	0.805*	0.935*	–0.913*	1																
NCA	0.951*	0.962*	0.981*	0.862*	0.964*	–0.908*	0.989*	1															
CA	0.640	0.624	0.560	0.675*	0.595	–0.349	0.349	0.482	1														
TA	0.789*	0.778*	0.729*	0.796*	0.754*	–0.531	0.551	0.668*	0.974*	1													
CI	0.884*	0.881*	0.895*	0.772*	0.913*	–0.801*	0.780*	0.829*	0.668*	0.781*	1												
EC	0.974*	0.985*	0.983*	0.913*	0.975*	–0.903*	0.953*	0.984*	0.594	0.758*	0.878*	1											
CLC	0.526	0.508	0.442	0.570	0.479	–0.222	0.221	0.361	0.990*	0.934*	0.575	0.477	1										
LP	0.989*	0.993*	0.994*	0.928*	0.990*	–0.929*	0.957*	0.979*	0.541	0.712*	0.867*	0.986*	0.418	1									
CPR	–0.144	–0.195	–0.288	0.050	–0.233	0.370	–0.491	–0.426	0.192	0.053	–0.217	–0.340	0.240	–0.258	1								
CER	0.932*	0.947*	0.969*	0.841*	0.949*	–0.920*	0.996*	0.997*	0.417	0.612	0.801*	0.973*	0.292	0.971*	–0.462	1							
MIP	0.194	0.214	0.332	–0.070	0.317	–0.475	0.410	0.359	–0.076	0.028	0.423	0.295	–0.116	0.274	–0.755*	0.379	1						
OWC	0.924*	0.934*	0.891*	0.925*	0.901*	–0.807*	0.789*	0.856*	0.757*	0.864*	0.888*	0.935*	0.660	0.905*	–0.135	0.832*	0.141	1					
TLR	–0.576	–0.539	–0.477	–0.629	–0.526	0.325	–0.230	–0.360	–0.921*	–0.876*	–0.584	–0.466	–0.918*	–0.462	–0.427	–0.295	0.135	–0.630	1				
CFDR	0.134	0.192	0.181	0.116	0.148	–0.309	0.316	0.237	–0.419	–0.295	–0.018	0.176	–0.494	0.222	–0.277	0.286	0.048	0.038	0.503	1			
ROOA	0.138	0.133	–0.002	0.327	0.044	0.067	–0.208	–0.116	0.444	0.347	0.042	–0.002	0.460	0.039	0.767*	–0.153	–0.653	0.223	–0.536	0.110	1		
ROE	0.117	0.124	0.002	0.267	0.042	0.010	–0.174	–0.101	0.342	0.265	0.014	–0.013	0.353	0.039	0.654	–0.129	–0.515	0.163	–0.437	0.277	0.965*	1	
NIL	0.780	0.787	0.705	0.829	0.733	–0.630	0.539	0.625	0.736	0.786	0.662	0.701	0.670	0.723	0.228	0.591	–0.108	0.781	–0.732	0.216	0.673	0.688	1

* $r \notin [-0.6664; 0.6664]$, *so there is multicollinearity between the pair of independent variables.*

Source: *Formed and calculated from data in Table 2, using Excel.*

SUMMARY OUTPUT

Regression statistics	
Multiple R	0.97372
R Square	0.94812
Adjusted R Square	0.89625
Standard Error	227.88798
Observations	9

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*	*t*
Regression	4	3796544.37843	949136.09461	18.27619*	0.00779	8.55013**
Residual	4	207731.72157	51932.93039			
Total	8	4004276.10000				
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	–2466.03470	691.31859	–3.56715	0.02344	–4385.44281	–546.62659
APO	0.07340	0.03211	2.28624	0.08421	–0.01574	0.16254
CLC	0.07269	0.01965	3.70002	0.02084	0.01815	0.12724
CPR	640.71597	287.11384	2.23157	0.08945	–156.43983	1437.87178
CFDR	6444.88769	1705.92961	3.77793	0.01947	1708.46778	11181.30761

* $F > 6.38823$, so the R square is statistically significant;

** $t > 2.77645$, so the multiple R and parameters are statistically significant.

Figure 2. Results of the multiple linear regression equation modelling of the net income of Ukrainian agricultural enterprise

Source: *Calculated according to the data given in Table 2 and Formula (2).*

Figure 2 shows that a multiple linear regression model of net income of Ukrainian agricultural enterprise is statistically significant because the actual F-statistic exceeds its critical value by 2.9 times and the actual t-statistic exceeds its critical value by 3.1 times. The possible variation of 94.8% of the net income is due to the variation of the 4 independent variables entered into the model, i.e., current liquidations and colleges, capital productivity ratio, and cash flow to debt ratio. From the model parameters shown in Figure 2, let us form the final form of the Tinbergen-Solow multiplicative function equation:

$$NIL = 0.0734APO + 0.0727CLC + 640.7160CPR + \\ +6444.8877CFDR - 2466.0347 + \varepsilon. \qquad (10)$$

The economic interpretation of the Formula (10) is as follows. If the volume of Agricultural Production Output of Ukrainian agricultural enterprises grows by 1 thousand UAH, the annual Net Income increases by 73.4 UAH. The increase in the value of Current Liabilities and Collateral by 1 thousand UAH is accompanied by an increase in Net Income by 72.7 UAH. Every additional increase of +1 Capital Productivity Ratio is accompanied by +640.7 thousand UAH growth of Net Income. If Cash Flow to Debt Ratio increases by 1, Net Income may increase by 6.4 mln UAH. Using Formula (4), net income elasticity ratios for each independent variable are calculated (Figure 3).

The data in Figure 3 informs the following:

(i) A 1% increase in Agricultural Production Output results in a 0.5% increase in Net Income;

(ii) A 1% increase in the value of Current Liabilities and Collateral is accompanied by a 0.45% increase Net Income;

(iii) A 1% increase in Capital Productivity Ratio results in a 0.92% increase in Net Income;

(iv) A 1% increase in Cash Flow to Debt Ratio results in a 1% increase in Net Income.

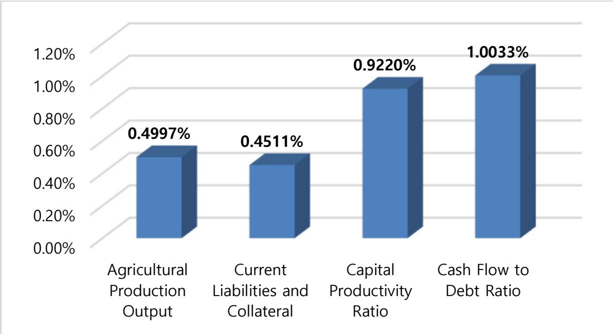

Figure 3. Net income elasticity of Ukrainian agricultural enterprise in Agricultural Production Output, Current Liabilities and Collateral, Capital Productivity Ratio, and Cash Flow to Debt Ratio
Source: *Calculated according to the data given in Table 2, Formula (3), and Formula (10).*

A total increase of 1% in all independent variables results in an increase of 2.88% in the net income of the agricultural enterprise.

3.3 Modelling the return on equity maximization for Ukrainian agricultural enterprise in the short period using the DuPont model

The short period in microeconomics is viewed from the perspective that physical capital does not change, while human capital can increase up to a certain limit. These constraints are laid down in the formation of the target function. Maximization of return on equity of Ukrainian agrarian enterprise in the short period will be carried out in three stages, fixing the value of physical and human capital. Then it is possible to determine influence of technological progress and innovation potential on production and financial activity of agrarian enterprise. For this purpose, we construct 3 target functions:

(i) Target function of agricultural production output maximization for Ukrainian agricultural enterprise in the short period:

$$APO = 25.099TA^{0.371}NE^{0.629}e^{0.128t} \xrightarrow[t]{} \max, \quad (11)$$

where $\xrightarrow[t]{}$ means that t changes;
TA = const;
NE = const;

(ii) Target function of net income maximization for Ukrainian agricultural enterprise in the short period:

$$NIL = 0.0734APO + 0.0727CLC + 640.7160\frac{APO}{NCA} + \quad (12)$$
$$+6444.8877CFDR - 2466.0347 \xrightarrow[APO]{} \max,$$

where $\xrightarrow[APO]{}$ means that the Agricultural Production Output changes;
CLC = const;
NCA = const;
$CFDR$ = const;

(iii) Target function of return on equity maximization for Ukrainian agricultural enterprise in the short period:

$$ROE = \frac{NIL}{APO} \cdot \frac{APO}{TA} \cdot \frac{TA}{EC} \xrightarrow[NIL, APO]{} \max, \quad (13)$$

where $\xrightarrow[NIL, APO]{}$ means that the Net Income (Loss) and Agricultural Production Output changes;
EC = const;
TA = const.

As can be seen from Formulas (11)–(13), all of them are connected by the common indicator Agricultural Production Output, maximization of which is carried out with the help of Tinbergen-Solow production function and the parameter of technological progress. Conformity of production to innovations in technological progress of Ukrainian agricultural enterprises is expressed by the value of the technological progress parameter $\lambda = 0.128$, which provides an additional increase in agricultural production in the short period, while the amount of total capital and the number of employees remain unchanged. For this purpose, the value $t = 10$ is introduced into Formula (11), and the values of TA and NE remain at the level of 2020 (Table 5).

Table 5: Results of return on equity maximization of Ukrainian agricultural enterprise in the short period

Indicator	Actual value 2020 ($t = 9$)	Short period value ($t = 10$)	Changes, % (+/–)
1. Total Assets, UAH ths	22853.4	22853.4	–
2. Number of Employees, persons	10.6	10.6	–
3. Agricultural Production Output, UAH ths	13365.5	16613.2	+24.30
4. Current Liabilities and Collateral, UAH ths	8921.3	8921.3	–
5. Capital Productivity Ratio	1.577	1.916	+24.33
6. Cash Flow to Debt Ratio	0.542	0.542	–
7. Net Income, UAH ths	1650.5	4151.3	+151.52
8. Equity Capital, UAH ths	12380.7	12380.7	–
9. Return on Sales, %	12.35	26.37	+14.02
10. Asset Turnover Ratio	0.585	0.727	+24.30
11. Leverage Ratio	1.846	1.846	–
12. Return on Equity, %	13.33	33.53	+20.20

Source: *Calculated according to the data given in Table 2, Formulas (11)–(13).*

The data in Table 5 show that effective management of innovative development of resource potential will provide Ukrainian agricultural enterprises with additional growth of agricultural production and respectively capital productivity +24.3%, if resource potential remains unchanged. Ultimately, net income will increase by 1.5 times and return on equity will increase by 20.2%, reaching 33.5% if all other conditions remain unchanged.

4. Conclusion

Thus, the assessment of the financial performance of Ukrainian agricultural enterprises as a result of managing the innovative development of resource potential has yielded a number of important results.

Firstly, according to the results of modelling autoregressive multiplicative Tinbergen-Solow production function with constant returns to scale of production, the parameter of technological progress was obtained, according to which the compliance with technological progress of the resource potential of Ukrainian agricultural enterprises provides an additional increase in agricultural production +0.128% when other conditions remain unchanged.

Secondly, modelling the impact of resource potential on the financial performance of agrarian enterprises in Ukraine using multivariate analysis allowed us to select the most important factors influencing the net income, in particular: Agricultural Production Output results (+0.5% increase in net income); Current Liabilities and Collateral (+0.45% increase in net income); Capital Productivity Ratio (+0.92% increase in unearned net income); Cash Flow to Debt Ratio results (+1% increase in net income).

Thirdly, solving the target maximization functions using DuPont model, built with the influence of innovativeness of the resource potential and its constancy, allowed to substantiate that the return on equity of Ukrainian agricultural enterprise in the short term can be maximised to 33.5%, if the other conditions remain unchanged.

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