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MATHEMATICAL AND STATISTICAL ANALYSIS OF THE COMPONENTS OF THE PRICE OF AGRICULTURAL PRODUCTS (VEGETABLES) SALE AS FACTOR SYSTEMS

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Анотація

За статистичними даними показників розвитку України, побудовано множинну регресійну модель для такого узагальнюючого показника, як ціна на овочі (залежна змінна). Встановлено чинники (незалежні змінні), які впливають на значення цього показника. Проведено попередній математико-статистичний аналіз моделі: побудовано кореляційні поля та визначено статистичні характеристики вибірок, на основі яких перевірено чи підкоряються дані статистичних вибірок нормальному закону розподілу; розраховано парні коефіцієнти кореляції та оцінено силу (щільність) зв'язку між усіма змінними моделей. Побудовано багатофакторну регресивну модель, значущість якої перевірено за *F*-статистикою Фішера, а параметрів моделей – за *t*-статистиками Ст'юдента з довірчою ймовірністю $p = 0{,}95$. Модель перевірено на наявність мультиколінеарності за методом Фаррара-Глаубера. Розроблену модель можна використати для вдосконалення планування та корегування ціни на овочі. Запропоновану методику також можна використати для розроблення відповідних моделей для будь-якого виду продукції рослинництва.

Abstract

According to the statistics data of Ukraine development indicators, a multiple regression model was developed for such a generalizing indicator as the price of vegetables (dependent variable). Factors (independent variables) that affect the value of this indicator have been identified. A preliminary mathematical and statistical analysis of the model was performed: correlation fields were constructed and statistical characteristics of samples were determined, on the basis of which the data of statistical samples were checked in relation of the fact if they are subject to the normal distribution law; paired correlation coefficients are calculated and the strength (density) of the connection between all model variables is estimated. A multifactor regression model was developed, the significance of which was verified by Fisher's F-statistics, and the parameters of the models were verified by Student's t-statistics with a confidence probability of $p = 0.95$. The model was tested for the presence of multicollinearity by Farrar-Glauber method. The developed model can be used to improve the planning and adjustment of vegetable prices. The proposed technique can also be used to develop appropriate models for any type of crop production.

Ключові слова*:* ціна, попит, пропозиція, математико-статистичний аналіз, багатофакторна регресивна модель, мультиколінеарність, прогнозування

Keywords: price, demand, supply, mathematical and statistical analysis, multifactor regression model, multicollinearity, forecasting.

INTRODUCTION

At the present stage of development of agricultural enterprises in Ukraine, one of the main tasks is to solve the problem of pricing of agricultural products. It is known that the price has a significant impact on the efficiency of the enterprise, as it depends on the reimbursement of production costs and profits of the enterprise. In a market economy, the success of agricultural enterprises largely depends on how competently and successfully they set prices for their goods.

However, currently the slow formation of the pricing process in agricultural enterprises indicates the lack of effective theoretical and methodological support for decision-making in the field of pricing policy, which often leads to serious miscalculations in setting prices, and, consequently, to significant losses. Thus, there is a need to study the principles, methods and features of the pricing process in the industry and their impact on the efficiency of agricultural enterprises.

The purpose of our study is to elucidate the peculiarities of price formation for certain types of agricultural products and the impact of the pricing mechanism on the development of the agricultural sector of the economy based on econometric modeling.

In the process of developing the econometric model, the following issues were addressed: statistical data quality; assessment of the dynamics of indicators; use of specific methods for estimating autocorrelation

of variables and residues; the possibility of including variables in the model; assessment of the significance of parameters and adequacy of the econometric multifactor model.

The result of econometric analysis is the forecast of the average price of agricultural products (vegetables).

When writing the article, statistical data of the State Statistics Service of Ukraine, regulations, scientific works of domestic and foreign scientists, textbooks and manuals were used.

Analysis of the target of econometric research

The target of the study is the average selling price of crop products in Ukraine for the period 2011-2019.

Prices for agricultural products are sensitive to the impact of a number of economic, socio-political, weather, technological and other factors and are a significant condition influencing the development of the industry and, consequently, the state of food security. Significant instability and weak predictability of the dynamics of sales prices of agricultural products reduce the investment attractiveness of the agricultural sector and exacerbate existing disparities in the development of its individual components. That is why there is an urgent need for state support of agricultural enterprises, which would be aimed at reimbursing costs and maintaining demand for agricultural products by means of price regulation. At the same time, excessive price control violates the mechanism of market pricing based on the interaction of supply and demand laws, which limits price competition in the industry. In this situation, the role of pricing policy of agricultural enterprises, aimed at strengthening competitiveness and increasing the efficiency of their production and commercial activities become more important.

In any economic model, a special place is occupied by the pricing mechanism, which should balance the diverse interests of sellers (producers) and buyers (consumers) of goods, allocate resources, stimulate the rational allocation of production, innovation and etc. The circumstances and tendencies of development of both separate sectors of the economy and the national economy as a whole depend on the efficiency of performance of the functions assigned to it by this mechanism. Price dynamics is an important indicator of the state of individual sectors of the economy, and the impact on price formation is one of the tools for optimizing economic processes. This fully applies to pricing in the domestic agricultural sector.

In Ukraine, prices for agricultural products, as well as for all other goods of domestic producers, are characterized by an upward trend. This objective phenomenon is associated with inflation in the economy, which reflects the rise in price of almost all resources involved in the national economy. Rising prices for agricultural products is one of the main factors causing the rise in food prices. According to official data, the food price index from 2006 to 2014 was 206.9%, and the consumer price index in general was 217.4%. For comparison, the price index of domestic industrial producers in general during the same period was 262.7% [13]. As we can see, the growth rate of prices for agricultural products significantly exceeded the growth rate of consumer prices and the price index of industrial producers. At the same time, in contrast to other major product groups, prices for certain types of agricultural products in the dynamics are characterized by significant fluctuations – in the direction of both increase and decrease.

Here is a global graph of the dynamic pattern of inflation indices and prices of agricultural products in Ukraine in recent years (increasing result) - Fig.1.1.

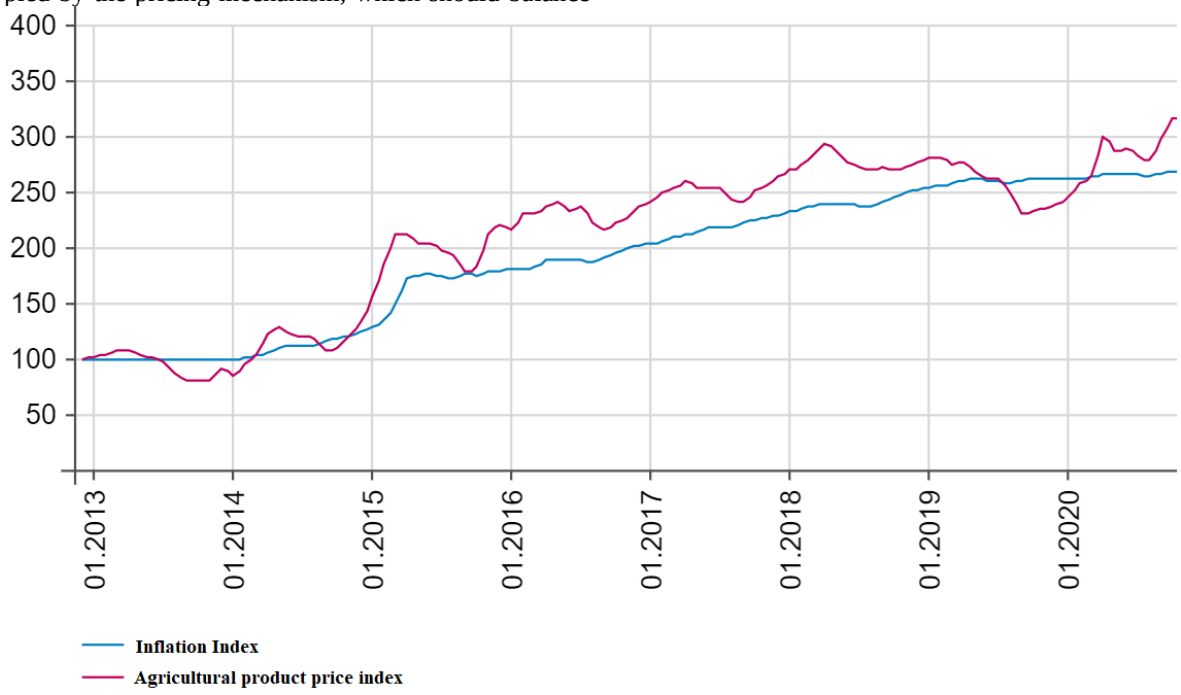

Fig.1. Dynamics of change of inflation indices and prices of agricultural products in Ukraine

So, we see that the final price index for agricultural products, despite seasonal fluctuations, keeps pace with the inflation index, and even ahead of it.

Setting objectives

As you know, price is a market condition category, its formation depends on the ratio of supply and demand in the market. That is, in a market economy, prices shall be dictated primarily by the market. However, it should be noted that, in addition to supply and demand, there are a number of factors in agriculture that affect the pricing process and price level. Analyzing the process of pricing, first of all, it should be noted the nature of the price, and hence the formation of profits by agricultural producers. It is associated with the existence of the so-called differential land rent, the essence of which is that the price of agricultural products is formed by the cost of the worst fertility of land, and, accordingly, in the best areas there is a surplus – rent. However, due to the difficulty of determining prices for agricultural products on the worst lands, they have not become practical in its pure form, and are formed mostly according to average cost [4, p. 5]. This, in turn, exacerbates the problem of disparity in prices for agricultural products and material and technical resources used in the process of its production. The problem of price disparity arose as a result of property reform and the transition to market economic relations and the uncontrollability of this process.

As a result, every year there was an increase in the disparity between prices for agricultural products and prices for the resources of industrial origin consumed by them, which grew faster. Now we can talk about a sevenfold difference in the price index [4, p. 7]. The annual lag in the growth of prices for agricultural products has resulted in a significant reduction in their production.

Pricing and prices are one of the most difficult problems, in which most of the economic, social and political problems of the state intersect. Price is a transformed form of value, its monetary expression. According to the theory of labor value, the latter is determined by the cost of socially necessary Hours of Labor for the production of goods. In the process of intersectoral competition of capital, the value is converted into the price of production, which provides the average rate of return on advanced capital. Under these conditions, the effect of the law of value is manifested through fluctuations in market prices around the price of production, so the dynamics of the latter in national markets has a decisive influence on the dynamics of market prices. The dynamics of price movements is associated with changes in quality, volume of production and supply in the market, with the solvency of consumers and the level of consumption of this product, the volume of inventories, the general economic condition of enterprises and more. The use of each price in the domestic market requires consideration of the peculiarities of marketing activities of enterprises. It should be borne in mind that the system of current prices is isolated. Under the influence of various factors, it is constantly changing and evolving, and prices themselves are improving. All pricing factors, depending on the nature of the manifestation, the company's attitude to them and the peculiarities of the impact on the process of marketing pricing can be grouped into two main areas. Depending on the ability of the enterprise to control and influence their action in price formation, they are divided into controlled (internal) and uncontrolled (external) [4]. Price change occurs under the influence of a number of pricing factors.

In a market economy, the most important are the social price of production, the ratio of supply and demand, inflation and purchasing power of money, the degree of state administrative and economic regulation of prices, the state of price and non-price competition, the degree of monopolization of production [1]. In addition to these, the price level is influenced by such pricing factors that act only at certain stages of development of commodity-money relations, such as the terms of supply of goods, the relationship between seller and buyer, the way products move from producer to consumer and price franking, i.e. the inclusion in its composition of the costs of insurance and delivery of goods under certain conditions. It should be noted that it is a scientifically sound basis for calculating production costs that will be the basis for regulating market prices. In these circumstances it is taken into account that each business entity shall make a profit based on its average rate. And if market prices for agricultural products are set at this level, the state does not need to regulate pricing. But if prices fall below this level, the state, without interfering in the market pricing process, is forced to compensate the producer for losses from market prices. This means that the state shall conduct a so-called "intervention" in the agricultural market. If demand exceeds supply in the market of agricultural products, prices rise sharply and the state stabilizes prices through foreign economic activity. Regulation of prices for agricultural products as an important stabilization measure is used in various forms in the arsenal of agricultural policy instruments of developed countries. However, the experience of price regulation of agricultural production in the world shows that interference in the natural functioning of the market mechanism distorts the signal and regulatory function of the price and can result in ineffective socio-economic consequences [7]. Producers of agricultural products with a certain shortage of products cannot offer it at prices higher than the world ones, because exporters of the same products will offer it at lower prices.

The peculiarity of pricing and prices for agricultural products is that most of its kinds show seasonal price fluctuations. In particular, prices for grain, sunflower and vegetables are significantly reduced during the mass harvest and in the initial period after harvest. In the future, prices begin to rise and often reach their maximum with the approach of the next harvest season (grain, sunflower). For certain types of livestock products, such as milk, eggs, seasonal price fluctuations are associated with changes in production and supply during the year.

Weather conditions also have a significant impact on the pricing of agricultural products. Prices for potatoes and vegetables depend on favorable weather conditions. If it is a plentiful growing season, then the prices for these products are lower – this is due to the

large supply; and vice versa, if the year seemed low-yielding – prices rise (decrease in supply). Agricultural producers focus on the purchase prices of processing enterprises, which do not reimburse production costs, especially for products of animal origin. When determining selling prices focus is placed on the retail price without a trade increment. In conditions of market saturation with food products, selling prices become competitive and are formed primarily under the influence of demand. An equally important factor influencing prices is the level of paying capacity of the population.

The pricing process is regulated at the level of the economy through a system of economic levers by changing not the prices themselves, but the factors that affect them (the tax system, inflation, etc.). Pricing policy should promote break-even production of agricultural products with an appropriate level of productivity.

In a market environment, pricing is a complex process that is influenced by many factors. At the same time, they can create favorable conditions for the activities of agricultural enterprises or constrain it, which is explained by the peculiarities of the manifestation, changes in the ratio and their impact on the market. As a result, the market perception of the company's products and its prices change. The level of product prices affects the volume of purchases made by customers. Prices are closely related to all components of marketing and business in general. It is the prices that largely determine the real commercial results, and the right pricing policy affects the state of the enterprise in a competitive environment.

Thus, the problem is as follows: to develop an econometric model that considers the dependence of the price of vegetables in Ukraine on demand (consumption of vegetables), supply (vegetable production) and material costs of growing vegetables.

Model specification

A complex combination of causes leads to different results. Acting on the consequence in the same direction, they increase each other's influence. If part of the causes has the opposite direction in relation to the object of action, then their joint effect on the consequence may both weakening and even nullify it. There may even be a situation where a well-defined, real cause has no obvious consequence. This means that along with this cause, there is another action absorbing the first one. Therefore, it is necessary to investigate the influence of different causes, i.e. to investigate the dependence of one phenomenon on a number of other phenomena that cause the first one. Not all causes and factors to some extent affect the phenomenon under study and can be investigated. Therefore, they are limited only by the essential reasons. The economic phenomenon is determined by many simultaneously and collectively acting reasons. The problem of multiple or multifactor regression analysis is the problem of studying the dependence of one dependent variable on several explanatory variables x_1, x_2 ..., x_n in the conditions of a specific place and a specific time. The main limitations are:

1. Between the dependent change y and the explanatory variables x_1, x_2 ..., x_n there is a linear relationship.

2. With a nonlinear relationship between variables, a linear approximation is possible.

In multifactorial or multiple regression there may be the following events [19]:

1. Explanatory variables x_i ..., x_n have a common simultaneous effect on the dependent variable y.

2. Due to the impossibility to cover the whole set of reasons and take into account the randomness, equations are limited by the most important explanatory variables.

In the expression of the regression function there is an additive component e, which describes the random perturbations and the total effect of the influence of all unaccounted factors and cases.

Thus, the perturbing variable is interpreted in the same way as the simple linear regression.

4. b_i coefficients are regression parameters. The regression constant b_0 performs the alignment function in the regression equation and determines the point of intersection of the regression hypersurface with the axis of ordinates.

The values of b_i are estimates of the regression coefficients. The index at the coefficient corresponds to the index of the explanatory variable. b_i indicates the average change in the factor y when changing x_i by one unit provided that the other variables remain constant.

Based on the main characteristics of the economic area studied, the econometric model of changes in working capital can be represented by the following specification:

$$y=f(x_1, x_2, x_3) \quad (1)$$

where

y is the selling price of vegetables, UAH/centner;

x_1 is demand for crop products (consumption);

x_2 is supply of crop products (production volumes);

x_3 - material costs.

Formation of the information base

The information base of the econometric model is statistical samples of the average selling price of vegetables in Ukraine, consumption of vegetables, their production and material costs for vegetable production in Ukraine (table 1)

Table 1

Average price for vegetables of Ukraine, 2007-2019, UAH per centner

Period number	Years	Average price for vegetables, UAH per centner	Demand for vegetables	Vegetable supply	Material costs
1	2007	171.3	6871	4965	1053409.1
2	2008	182.1	6904	5012	988998.8
3	2009	212.3	7180	5045	831781.8
4	2010	241.2	7317	5509	628764.5
5	2011	224.1	8489	5975	649298.6
6	2012	186.8	8976	6312	794669.3
7	2013	259.1	8873	6581	906747.8
8	2014	220.7	10562	7440	1095417.4
9	2015	207.7	10815	7452	1138416.5
10	2016	235.4	10668	7431	1153107.5
11	2017	274.6	10323	7019	1268629.2
12	2018	390.3	9792	6890	1644212.1
13	2019	392.4	9998	7030	1828927.2
Basic assessments					
No.	**Assessment category**				
1	amount	3026.7	109897	77696	12928970.7
2	average	246	8982.154	6358.53846	1075567.677
3	minimum	171.3	6871	4965	628764.5
4	maximum	392.4	10815	7452	1828927.2
5	variation range	221.1	3944	2487	1200162.7
6	average absolute increase	18.425	260.5833	172.083333	64626.50833
7	average growth rate	1.07151347	1.03175	1.02940516	1.047048051
8	variance	4636.20308	2094948	852760.249	1.14977E+11
9	mean square deviation	68.0896694	1447.393	923.450187	339081.9499
10	coefficient of variation	0.27678727	0.161141	0.14522994	0.315258591

According to the calculations of Table 2.1 in the period 2007-2019, the average expected value of the average price of vegetables in Ukraine was UAH 246 per metric centner. The average absolute increase showed that every year the price of vegetables increases by an average of 18, 4 UAH per metric centner or by 1.07 times. This corresponds to an increase of 7%. The average deviation of the indicator from the average expected value was UAH 68.08. The coefficient of variation of the indicator is 27.67%, so the statistical sampling is subject the normal distribution law.

As for vegetable consumption, in the period 2007-2019 the average expected value of vegetable consumption in Ukraine was 8982.15 million tons. Every year the vegetable consumption increases by an average of 260.58 million tons or by 1.03 times. The standard deviation is 1447.39 million tons, and the coefficient of variation is 16%. Conclusion – statistical sampling can be used to build an econometric model.

According to the output indices movement of vegetable production in Ukraine, it can be stated that in the period 2007-2019 the average expected value of vegetable production was 6358.54 million tons, the minimum – 4965 million tons, which was observed in 2007, and the maximum 742 million tons was observed in 2015. Every year, vegetable production increases by an average of 172.08 million tons or by 1.03 times. The incremental value increases every year by an average of 3%, and the consumption increases at a higher rate of 3.17%. The coefficient of variation of the indicator is 14%, which makes it possible to use a statistical sampling in the econometric studies.

Analysis of the changes of material costs for vegetable production in Ukraine is given in Table 1. Thus, in the study period, the average expected value of material costs for vegetable production in Ukraine [4] was equal to 1075567,677. The average absolute increase in this indicator showed that the average annual increase was 64626.50833 or by 1.05 times. Thus, the fastest increasing ones are material costs for their production. This is due to the fact that in Ukraine the ecological principles of vegetable production are increasingly used.

According to the analysis, it should be noted that all factors influencing the average price of vegetables had a general tendency to increase over time.

Thus, the statistical sampling shown in Table 1 can be used as an information base for developing and estimating an econometric model of changes in the average price of vegetables in Ukraine. The regressand is the price of vegetables, and the regressors are demand, supply and material costs of production. The data sampling is equal to 13 years, i.e. 2007 – 2019, and we may say that the calculation period is equal to one year. The main array of information was obtained from public information of the State Statistics Service of Ukraine.

Estimation of model parameters

The model is estimated on the basis of calculations of partial correlation coefficients and regression parameters calculated by the root mean square method (RMS).

Let us check the input data arrays for multicollinearity.

Let us determine the partial correlation coefficients.

	Y	x_1	x_2	x_3
Y	1			
x_1	0.425269	1		
x_2	0.447545	0.9902322	1	
x_3	0.784417	0.5332652	0.514706	1

From the correlation matrix we draw the following conclusions:

$r\ (yx_1) = 0.425$ – the relationship between the factors is average, straight direction.

$r\ (yx_2) = 0.447$ – the relationship between the factors is average, straight direction.

$r\ (yx_3) = 0.784$ – the relationship between the factors is close, straight direction.

$r\ (x_1x_2) = 0.990$, the relationship between the factors is very close, straight direction.

$r\ (x_2x_3) = 0.515$, the relationship between the factors is average, straight direction.

$r\ (x_1x_3) = 0.533$, the relationship between the factors is average, straight direction.

Estimates of the partial correlation coefficients show that the model may have a linear relationship between the variables *x1* and *x2* – supply and demand.

So, let us check the presence of multicollinearity by the Farrar-Glauber algorithm. This requires:

1. Normalize explaining variables.
2. Find the correlation matrix.
3. Calculate the determinant of the correlation matrix r and the criterion: χ^2
4. Find the matrix inverse to the matrix *r*.
5. Determine Fisher's variance ratio.
6. Calculate the partial correlation coefficients.
7. Determine the t-test.
8. Build an econometric model by the RMS method 1.
9. Draw conclusions about multicollinearity.

In the first step, we normalize the matrix with the input data (Table 2).

Table 2.

Normalized Data Matrix

Y	X_1	x_2	X_3
-1.09708	-1.45859	-1.50906	-0.06535
-0.93847	-1.43579	-1.45816	-0.2553
-0.49494	-1.2451	-1.42242	-0.71896
-0.0705	-1.15045	-0.91996	-1.31768
-0.32163	-0.34072	-0.41533	-1.25713
-0.86944	-0.00425	-0.0504	-0.82841
0.192393	-0.07541	0.240903	-0.49787
-0.37157	1.091511	1.17111	0.05854
-0.56249	1.266308	1.184105	0.18535
-0.15568	1.164746	1.161364	0.228676
0.420034	0.926387	0.715211	0.569365
2.119264	0.55952	0.575517	1.677012
2.150106	0.701845	0.727123	2.221762

2. Correlation matrix: r

	x_1	x_2	x_3
x_1	1		
x_2	0.990232	1	
x_3	0.533265	0.514706	1

3. Its determinant is equal to 0.013734

$\chi^2 = -(n-1-1/6*(2*m+5))*ln(d)=-(10-1-1/6*(2*3+5))*ln(0.013734)=30.73$

When the degree of freedom m* (m - 1)/2 = 3 and significance levels $\alpha = 0.01$ criterion $\chi^2_{table} = 11.34$. Since the calculated value is larger than the value in the table, we conclude that there is multicollinearity in the array of variables.

4. Find the matrix inverse to the matrix r. We use the MINVERSE function.

53.52361	-52.1168	-1.71746
-52.1168	52.10739	0.972117
-1.71746	0.972117	1.415509

5. Determine Fisher's variance ratio. Using the diagonal elements of the matrix C, calculate Fisher's variance ratio:

$F_1=(c_{11}-1)(n-m)/(m-1)=(53.52-1)*(13-3)/(3-1)=37.6$
$F_2=(c_{22}-1)(n-m)/(m-1)=(52.11-1)*(13-3)/(3-1)=25.56$
$F_3=(c_{33}-1)(n-m)/(m-1)=(1.42-1)*(13-3)/(3-1)=2.1$

For the level of significance $\alpha = 0.05$ and degrees of freedom 1 $\gamma = 7$ and 2 $\gamma = 2$ the critical (table) value of Fisher's variance ratio = 4.74.

Since F1 and F2 are actually larger than the table value, the variables *x1* and *x2* are characterized by multicollinearity.

6. Calculate the partial correlation coefficients.

$R_{12,3}$=-c12/(c11*c22)$^{1/2}$=0.99

$R_{13,2}$=-c32/(c11*c33)$^{1/2}$=-0.11

$R_{23,1}$=-c23/(c22*c33)$^{1/2}$=0.11

The partial correlation coefficient between the variables *x1* and *x2* is very close. Therefore, there is multicollinearity between these variables.

7. Determine Student's t-test.

$t_{12}=r_{12.3}*(n-m)^{1/2}/(1-r^2_{12.3})^{1/2}=0.99*3.16/0.14=31.284$
$t_{13}= r_{13.2}*(n-m)^{1/2}/(1-r^2_{13.2})^{1/2}=-0.11*3.16/0.99=-0.351$
$t_{23}=r_{23.1}*(n-m)^{1/2}/(1-r^2_{23.1})^{1/2}=0.11*3.16/0.99=0.351$

The table value of Fisher's variance ratio under n-m = 10 degrees of freedom and significance levels α = 0.05 is equal to 1.69. The numerical values of the Student's t-test found for every second and third pair of variables are less than their table values, and for the first pair more than their table values. From this we conclude that the first and second variables have a high level of correlation, so one of them should be excluded from the study or the ratio of demand to supply should be replaced.

8. Develop an econometric model by the RMS method 1.

The general type of the regression equation is described by the equation:

$$y = \hat{y} + e \quad (2)$$

where *y* is the actual value of current assets,

$\hat{y}$ is a theoretical (regression) value of the average price of vegetables,

e is an uncertainty on a result.

The linear form of multifactor regression on a set of 3 factors in general is as follows:

$$\hat{y} = b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 \quad (3)$$

where

x_1 is the ratio of demand to supply of vegetables,

x_2 is material costs for the growing of vegetables,

b_i is parameters of the regression equation calculated according to RMS.

Input data for model development – Table 3.

Table 3.

Input data for model development

year	Sale price	Demand/supply	Material costs
	Y	x_1	x_2
2007	171.30	1.3839	1053409.10
2008	182.10	1.3775	988998.80
2009	212.30	1.4232	831781.80
2010	241.20	1.3282	628764.50
2011	224.10	1.4208	649298.60
2012	186.80	1.4221	794669.30
2013	259.10	1.3483	906747.80
2014	220.70	1.4196	1095417.40
2015	207.70	1.4513	1138416.50
2016	235.40	1.4356	1153107.50
2017	274.60	1.4707	1268629.20
2018	390.30	1.4212	1644212.10
2019	392.40	1.4222	1828927.20

The calculation of the equation of the multifactor econometric model is performed using the application "Data Analysis". The multifactor model of changes in working capital has the following form:

$$\hat{y} = 592{,}46 - 379{,}79x_1 + 0{,}00018x_2 \quad (4)$$

According to the model obtained we have the characteristics of changes in the factor "y":

- with the increase of ratio of demand to supply by one (x1), the selling price will decrease by UAH 379.79 per metric centner provided that material costs remain unchanged;

- with an increase in material costs by UAH 1 million the price of vegetables will increase by UAH 0.00018 per metric centner, provided that the ratio of demand to supply remains unchanged.

Comparison of actual and theoretical values of the factor "y" is shown in Fig.2.

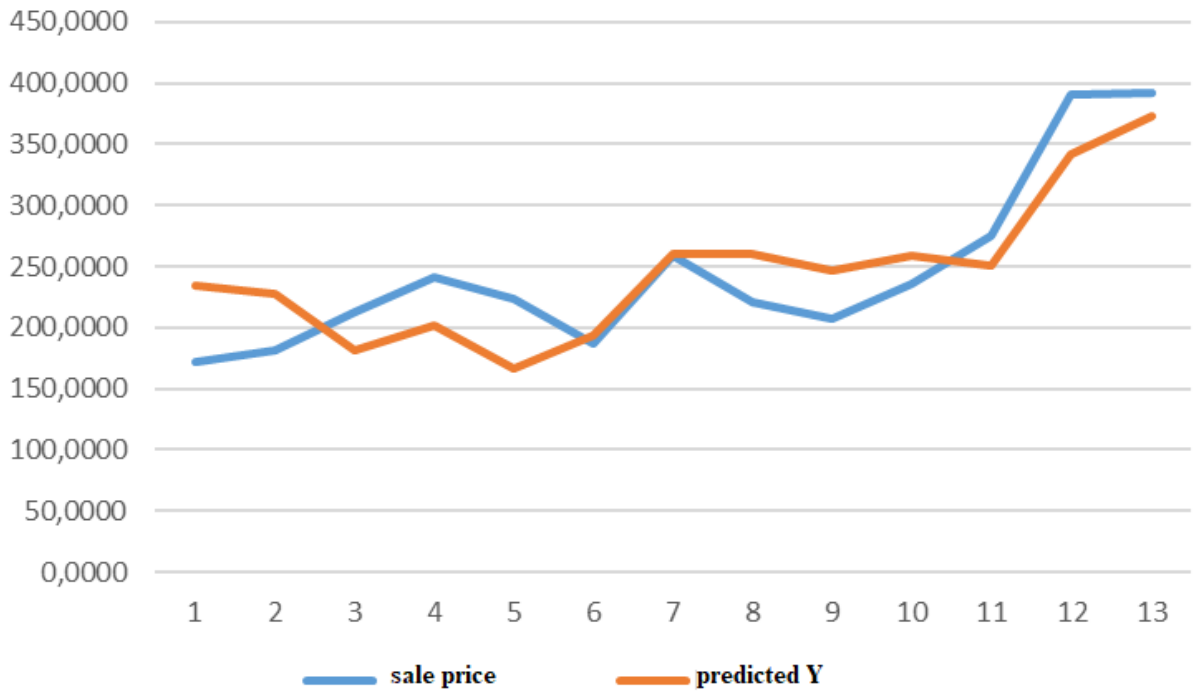

Fig. 2. Comparison of actual and theoretical values of the factor "y"

Checking the quality of the model developed

The obtained model is significant, which is confirmed by the value of the multiple coefficient of determination $R^2 = 0.6528$. Factors x(i) have 65.28% of the impact on the resulting "y", and the other 34.72% of the impact belongs to factors not taken into account in the model.

The multiple correlation coefficient $r\ (y, x_1, x_2, x_3)$ is 0.816, which indicates a high level of closeness between the factors. The model is adequate, which confirms the calculations of Fisher's statistic. $F_{calcul} > = F_{theor}$ ($\alpha = 0.05$, $df_1 = 3$, $df_2 = 4$), i.e. 9.40> = 6.59.

The significance of the regression parameters is confirmed by the evaluation of Student's t-statistics under degrees of freedom (n-2, $\alpha = 0.05$) $t_{theor} = 2.31$. The significance of the model parameters showed that they are all significant: $t_{theor} = 2.31$ (Appendix B):

- b_0: t_{calcul} (1,91)> = t_{theor} (2,31) – insignificant;
- b_1: t_{calcul} (-1,04)> = t_{theor} (2,31) – insignificant;
- b_2: t_{calcul}h (4,25)> = t_{teor} (2,31) – significant.

Predictive assessment of factor influences

Estimation of predictive fluctuations of theoretical and actual values of the model is given in table 4.

Table 4

Estimation of factor influences in econometric model

Period No.	Period	Sale price, UAH	Price regression value, UAH	Deviation of the actual value from the regression one	Lower data range	Upper data range
1	2007	171.30	251.86	-80.56	-2079.83	456.9028
2	2008	182.10	242.98	-60.88	-2077.59	428.9658
3	2009	212.30	198.016	14.28	-2145.28	360.7751
4	2010	241.20	198.44	42.75	-2048.9	272.7193
5	2011	224.10	166.89	57.20	-2157.64	281.6257
6	2012	186.80	191.93	-5.13	-2147.03	344.6781
7	2013	259.10	239.63	19.46	-2049.61	393.2906
8	2014	220.70	245.66	-24.96	-2118.96	475.1233
9	2015	207.70	241.19	-33.49	-2153.15	493.7736
10	2016	235.40	249.72	-14.32	-2133.21	500.1456
11	2017	274.60	256.68	17.91	-2165.45	550.2515
12	2018	390.30	341.45	48.85	-2074.91	713.1552
13	2019	392.40	373.51	18.89	-2060.65	793.2727
Amount		3198	3198	0		

As shown by the evaluation results, the range of changes in the parameter values is within:

$B_{lower} < b_i < b_{upper}$

-516,6<b0<1701,49

-1193,3<b1<433,74

0,0000837<b2< 0,000268185

The graph of the range of changes of regression values of the econometric model is given in fig. 3.

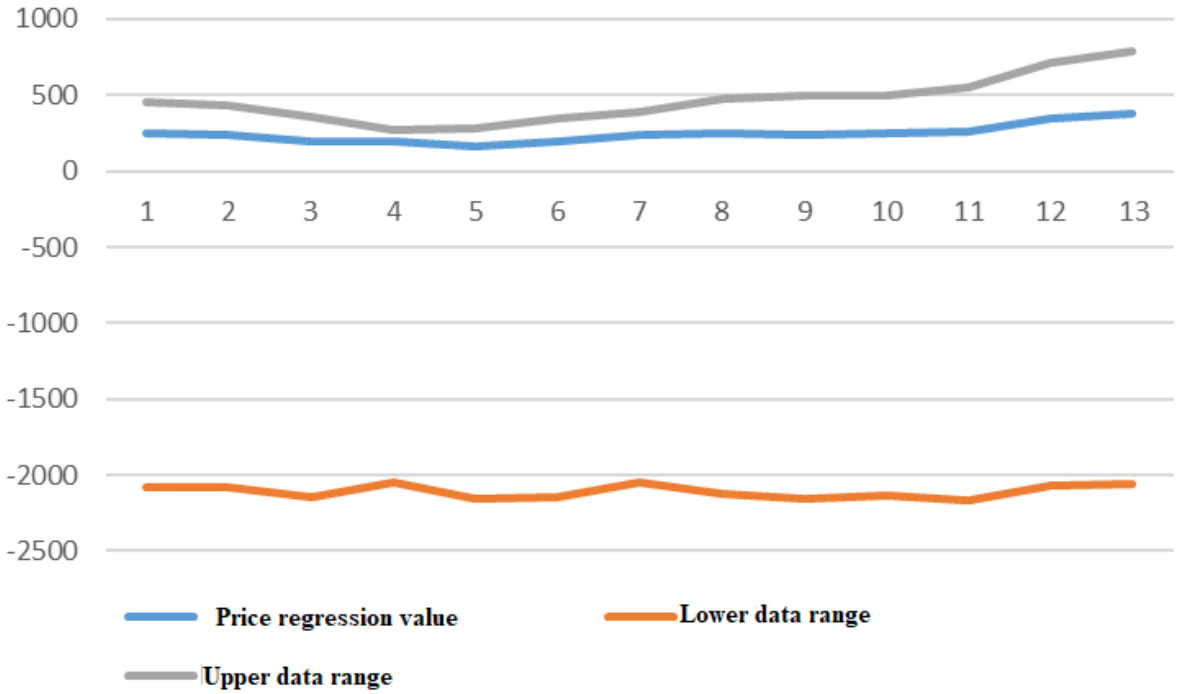

Fig 3. Graph of the range of changes of the econometric model regression values

In general, for the period 2007 – 2019, the price of vegetables in Ukraine remains almost stable with slight short-term fluctuations.

Economic and mathematical analysis

The standardized regression coefficient indicates the share of the influence of the *i*-th explanatory variable on *y* in comparison with the change in *y*. The larger the $\hat{\beta}_k^s$ value, the more influential is the *i*-th factor. Estimated values of standardized regression coefficients can be calculated by the following formula, which can also be a definition:

$$\hat{\beta}_i^s = b_i \frac{\delta_{x_i}}{\delta_y}$$

where

b_i is 1 RMS estimate of the regression coefficient b_i;

δ_{xi} is the empirical standard (mean-square) deviation of the *i*-th regressor x_i.

δ_y is the empirical standard (standard deviation) of the regression y.

The standard deviation of the variable x_0 for a free member equals to zero, then $\hat{\beta}_0^s = 0$. It makes no sense to calculate a standardized free member. When interpreting the beta coefficient, it is assumed that the empirical standardized deviations δ_{xi} and δ_y are typical (characteristic) changes of the studied variables.

Standardized model:

$$Y = 53.25 * x_1 + 0.00016 * x_2$$

Conclusion: supply and demand have a greater impact on the selling price than the cost of growing them

CONCLUSIONS

Prices for agricultural products are the most dynamic characteristic of the agricultural market. They are sensitive to the influence of numerous economic, technological, weather, socio-political factors and in turn determine the vectors and rates of development of individual agricultural sectors, the level of food security of the country. Significant differentiation and fluctuations in the variations of sales prices of agricultural products indicate poor controllability of processes in the agri-food market. This creates instability, which reduces the investment attractiveness of the agricultural sector, exacerbates the disparities in the development of its individual components. Price instability has intensified due to the deep economic crisis in Ukraine, which necessitates the continuation of a systematic analysis of the causes and consequences of the processes associated with the formation of prices for agricultural products.

Based on the results of the article, the following conclusions can be drawn:

1. Modern requirements for the study of economic processes require the introduction of econometric methods and models that allow the analysis of the selling price of vegetables on the basis of the stochastic influence of factors of supply, demand and material costs.

2. The studied model has a high degree of reliability and significance. The multiple correlation coefficient showed a close relationship between the factors (more than 0.75), and the multiple determination coefficient showed the significance of the flow of more than 65% of the studied factors.

3. The study of multicollinearity by the Farrar-Glauber algorithm showed that the factor characteristics of supply and demand are correlated. The model in which replacement of variables is carried out is developed. A new variable, which is equal to the ratio of demand to supply has been introduced.

4. Estimation of parameters was carried out on the basis of the root mean square method. Standardized regression parameters are determined. Based on them the concluded can be made that the selling price is more influenced by supply and demand than the cost of growing vegetables.

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