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Satisfying the consumer demand for agricultural products: Possibilities and its prediction

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Abstract. In the modern world, consumer preferences and demand for agricultural products are constantly changing. Meeting these demands efficiently and effectively is crucial for the sustainability and profitability of the agricultural sector. That is why it remains important to study the demand for agricultural products and find methods to predict it. The research aims to investigate the main factors that influence the demand for agricultural products. The main methods used in this study were analysis,

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abstraction, forecasting and modelling. The article examines the level of demand satisfaction, the current situation and opportunities depending on the scale of the market, the volume of goods and services, based on the fact that the satisfaction of consumer demand is one of the current problems in the world. The relationship between the development of agriculture and meeting the demand for food products and solving the problem of starvation was emphasized. Factors affecting consumer demand in agriculture – consumption costs, number of consumers, gross agricultural product, consumer price index, consumer incomes were analysed. On the basis of econometric analysis, the dependence between the optimization of consumer demand and the indicators related to it was determined. Using multi-factor linear correlation and multi-factor linear regression models, were described the level of actual and regression model consumption costs, as well as the forecast for the next years. The study contributes new knowledge to assess the level of demand for agricultural products

Keywords: modelling; forecasting; revenue; consumption expenditure; price index

INTRODUCTION

With the deepening of the globalization process and the increase in the world population, the role of consumer demand in the market of goods and services is changing significantly. As economies become more interconnected and borders fade away, understanding and analysing consumer demand is becoming a pressing issue for the global economy. Estimating the scale and structure of consumer demand, as well as forecasting future trends, has become important for economic planning and decision-making. From this point of view, the assessment of the scale and structure of consumer demand, the perspective of its change is considered one of the most urgent problems of the world economy. The learning of demand also makes it possible to predict the size and capacity of the market, expected changes in the geography of production and consumption of goods and services. Thus, the assessment and forecasting of the current state of consumer demand plays a fundamental role in better adapting economic subjects to the current market conditions. Consumer demand in terms of food supply is directly related to the development of agriculture, which is considered one of the most important spheres of the economy. Of course, if the demand for food products in the world continues, it is inevitable that the consumer demand for agricultural products will also increase (Yan *et al.*, 2020; Tapki *et al.*, 2021). At the same time, the deepening of the starvation problem in many countries highlights the problem of improving the level of satisfaction of consumer demand for agricultural products. As such, it should be acknowledged that the study of consumer demand for agricultural products and ensuring that it is met to the greatest possible extent is still relevant.

Currently, a significant number of scientists are studying the issues of consumer satisfaction. As such, X. Liu & Zh. Kao (2022) investigated the factors that influence customer satisfaction with certain types of agricultural products in e-commerce. Based on the empirical study, the authors provide a list of factors that would help businesses improve customer satisfaction in such companies. A similar study was conducted by Zh. Lei *et al.* (2022), although they concluded on

another industry that is not related to agriculture. The peculiarities of consumer behaviour in the agricultural sector were studied by R. Sridevi (2021). The scientist described the role of this factor in the agricultural segment and provided some advice for employees of the sector's enterprises in terms of further work with clients. W. Chunshang (2020) also addressed this issue in his study, building a model for factor analysis of satisfaction in the agricultural supply chain using e-commerce technologies. The scientist shows that among the satisfaction factors, the price of products no longer plays a leading role, while the quality of service and the products themselves become more important.

Thus, the research aims to investigate consumer demand for agricultural products and identify the main factors influencing this component. This will allow to meet the needs of the population more effectively in terms of consumption of agricultural products both by the state and individual enterprises.

MATERIALS AND METHODS

As part of the study, a regression-correlation model was created to assess the level of consumer demand satisfaction based on some of its characteristics. The model was built in the following stages:

1. Selection of factors included in the model: identification of factors affecting the dependent variable; checking the collinearity between the factors and selecting the next factors based on comparative assessment; final selection of factors and evaluation of the importance of criteria.
2. Selection of factors affecting the result among the factors.
3. Evaluation of criteria.
4. General evaluation and analysis of the model.
5. Evaluation of the results obtained as a result of practical use of the model and forecasting.

In correlation-regression analysis, the regression function X_1, X_2, \dots, X_z is used to characterize the relationship between the result (Y) and the factors influencing the result (X). This, in turn, determines how the Y expression will change for specific indicators of X. If

there are many factors affecting the result, a multivariate regression model is used. In this case, the goal is to design a model with multiple factors and determine their effect on the result (1):

$$y = f(x_1, x_2, \dots, x_m) + \varepsilon, \quad (1)$$

where: ε – random model error rate for different factors; x_n – characterising factors of independent variables; y – dependent variable. In this situation, x_1, x_2, \dots, x_m must meet the following requirements: they must be expressed with quantitative indicators; must be closely related to the outcome factor; factors should not be dependent of each other. In practice, depending on the forms of dependence, are used linear and non-linear models of the multifactor regression model. So, according to the linear regression model, the coefficients a_j , $j=1, 2, \dots, m$ characterizes the average change of the result with the change of the x_j factor, in case other factors remain unchanged and expressed in the following form (2):

$$Y = a_0 + a_1x_1 + a_2x_2 + \dots + a_mx_m + \varepsilon, \quad (2)$$

where: a_j ($j=0, 1, 2 \dots m$) – coefficients that characterise the average change in the output variable. It should be noted that within this study the y – is consumer costs, x_1 – consumer demand; x_2 – total agricultural output; x_3 – consumer income; x_4 – consumer product price index.

Thus, many different scientific methods were used in the research. One of them was analysis, which allowed to draw conclusions based on the selected qualitative and quantitative data and use them in further work. Modelling was used to build a correlation and regression model and assess the impact of selected factors on consumer demand for agricultural products. Abstraction allowed to avoid assessing the impact of individual minor factors. Forecasting allowed to conclude in terms of the future volume of consumer demand for agricultural products.

RESULTS

Consumer demand is formed under the influence of many factors. From this point of view, in the research on the level of satisfaction of consumer demand, statistical data covering the last 15 years on important indicators such as consumer expenses, number of consumers, consumer price index, gross agricultural product, and consumer incomes. Considering the multitude of factors affecting the level of satisfaction of consumer demand, it is necessary to include various independent variables in the modelling of consumer demand. However, a significant increase in the number of factors in

a dynamic model requires an increase in primary data. This increases the importance of the consumer demand model. Considering the mentioned, comparative analysis, multivariate correlation-regression analysis and forecasting methods are used in the research based on the necessary statistical data on agriculture. The model provides a basis for predicting the future behaviour of each indicator on the change of any element by determining the characteristics of the factors affecting consumer demand. Thus, the model clearly shows all the relationships of the variables, is expressed in terms of quantity, and allows to prepare a more accurate and qualitative forecast.

Modelling consumer demand for agricultural products is important in determining the factors affecting the level and possibilities of demand satisfaction, as well as the volume of products that consumers will demand in the future. In fact, each factor affects the volume of demand to a different degree. In this regard, the modelling of the factors affecting consumer demand – consumption costs, number of consumers, consumer price index, gross agricultural product, consumer income – based on regression-correlation analysis is accompanied by high accuracy and stability. Regression and correlation analyses are carried out to determine the effect of various independent variables depending on the changes occurring in the studied object. In the optimization of consumer demand, the study of the dependence between the indicators related to necessity of great importance and makes the implementation of econometric analyses.

Looking at the level of satisfaction of consumer demand based on the annual consumption norms of the main types of agricultural products in the minimum consumption basket and the actual consumption per person, it becomes clear that in the years 2005-2021, in the analysis was carried out generally increasing dynamics is observed. Changes in other types of products, except for eggs, potatoes, vegetables and melon products, can be grouped into 3 periods: 2005-2010 – the period when the level of satisfaction of consumer demand was lower than the annual consumption norms (only in 2010 in milk and milk products result recorded as 101.1%); 2011-2016 – the period when growth fluctuated between 3-6% and 2017-2021 – the period when growth rose to 30%. In 2005-2014, the demand for egg products was not met, in other years there was an increase in the indicator, while in potato, vegetable and melon products, of the analysis the level of satisfaction of consumer demand exceeded the annual consumption norms (Tables 1-3).

Table 1. Annual consumption norms of the main types of agricultural products for the minimum consumption basket, kg

Products	Consumption norms
Meat and meat products	31.5
Milk and milk products (by turning into milk)	232.3

Table 1, Continued

Products	Consumption norms
Eggs, pcs	153
Potato	50.6
Vegetables and melon products	96.9

Source: Annual consumption norms of the main types of food products for the minimum consumption basket (2022)

Table 2. Actual consumption per person, kg

Years	Meat and meat products (by turning into meat)	Milk and milk products (by turning into milk)	Eggs, pcs	Potato	Vegetables and melon products
2005	29	170	98	91	175
2006	28	173	86	96	181
2007	30	174	106	88	175
2008	30	176	118	81	163
2009	31	221	127	81	157
2010	31	235	125	73	160
2011	32	246	131	72	166
2012	32	241	127	73	157
2013	33	243	138	74	152
2014	33	247	152	73	148
2015	33	246	154	72	154
2016	35	236	156	75	146
2017	37	238	158	75	143
2018	40	240	153	73	148
2019	41	246	165	82	166
2020	41	258	175	83	172
2021	41	253	170	84	176

Source: Per capita consumption of food products (2022)

Table 3. Level of satisfaction of consumer demand, %

Years	Products				
	Meat and meat products (by turning into meat)	Milk and milk products (by turning into milk)	Eggs, pcs	Potato	Vegetables and melon products
2005	92	73.1	64	179.8	180.5
2006	88.8	74.4	56.2	189.7	186.7
2007	95.2	74.9	69.2	173.9	180.5
2008	95.2	75.7	77.1	160	168.2
2009	98.4	95.1	83	160	162
2010	98.4	101.1	81.6	144.2	165.1
2011	101.5	105.8	85.6	142.2	171.3
2012	101.5	103.7	83	144.2	162
2013	104.7	104.6	90.1	146.2	156.8
2014	104.7	106.3	99.3	144.2	152.7
2015	104.7	105.8	100.6	142.2	158.9
2016	111.1	101.5	101.9	148.2	150.6
2017	117.4	102.4	103.2	148.2	147.5
2018	126.9	103.3	100	144.2	152.7

Table 3, Continued

Years	Products				
	Meat and meat products (by turning into meat)	Milk and milk products (by turning into milk)	Eggs, pcs	Potato	Vegetables and melon products
2019	130.1	105.8	107.8	162	171.3
2020	130.1	111	114.3	164	177.5
2021	130.1	108.9	111.1	166	181.6

Source: compiled by the authors

As it can be seen, the analysis of the level of satisfaction of consumer demand in the natural expression does not allow to determine the factors affecting it. As mentioned above, the level of satisfaction of consumer demand is formed by the influence of various indicators. In this regard, it is important to consider that consumer spending means the amount, directed to the satisfaction of consumer demand. That is, the need to determine the effect of those indicators on individual product types not in natural terms, but in terms of value, requires the investigation of the factors that shape consumption costs. This situation gives a reason to take consumer expenses as the dependent variable in consumer demand modelling and regression-correlation analysis, and the number of consumers, the consumer

price index, the total agricultural product, investments in the agricultural sector, and consumer income as the independent variables. In general, correlation-regression analysis, which is considered one of the main methods of econometrics, expresses the relationship between economic variables with quantitative indicators.

For the research, a regression-correlation model was constructed, some of the characteristics and features of which are described in Materials and Methods. Based on the above, using statistical data, the relationship between consumer spending (Y), which forms the level of consumer demand, and the number of consumers (X1), total agricultural output (X2), consumer incomes (X3), consumer price index (X4) can be determined (Table 4).

Table 4. Consumer spending and the dynamics of main indicators affecting it

Years	Consumption expenses, million manats (Y)	Number of consumers, thousand people (X1)	Common agricultural product, at actual prices, million manats (X2)	Consumer incomes, million manats (X3)	Consumers price index, % (X4)
2005	5532.6	8553.1	1844.8	8063.6	110.9
2006	6873.1	8666.1	2115.5	10198.5	111.9
2007	9374.6	8779.9	2918.6	14558.2	116.2
2008	13286.2	8922.5	3505.9	20735.4	128.6
2009	15048.9	8997.6	3805.5	22601.1	98.5
2010	16528.5	9111.1	3877.7	25607	107.2
2011	19216	9235.1	4525.2	30524.6	110.4
2012	21389.9	9356.5	4844.6	34769.5	100.2
2013	24150	9477.1	5244.6	37562	102.2
2014	26582.6	9593	5225.8	39472.2	101
2015	30595.3	9705.6	5635.3	41744.8	106.1
2016	35196.7	9810	5632.4	45395.1	114.7
2017	40210.2	9898.1	6580	49187.9	116.4
2018	43067.3	9981.5	7010	53103.7	101.7
2019	46797.8	10067.1	7836.7	56769	103.8
2020	43899.5	10119.1	8428.9	55754.1	105
2021	48378.2	10156.4	9163.4	57181.5	108.1

Source: compiled by the authors

First, let's build a multifactor linear regression model. With this probability, the double linear regression analysis shows that the influence of other factors on consumer

spending is stronger, except for the consumer price index. Therefore, a regression analysis by removing the consumer price index from the model can be conducted (Tables 5-7).

Table 5. Multifactor linear correlation model

	Column 1	Column 2	Column 3	Column 4	Column 5
Consumer spending	1				
Number of consumers	0.986373329	1			
Common agricultural product	0.976433181	0.978809859	1		
Consumers' incomes	0.985859563	0.99709786	0.984041652	1	
Consumer price index	-0.264944043	-0.313870079	-0.302063766	-0.327146296	1

Source: compiled by the authors

Table 6. Multifactor linear regression model

Regression statistics					
Multifaceted R (multiple R)	0.9896874				
R ² determination coefficient	0.9794811				
Normalized R	0.974746				
The standard error	2301.2225				
Observations	17				
Analysis of variance					
	DF	SS	MS	F	F-importance
Regression	4	3.29E+09	1.1E+09	206.8543	3.22E-11
Residue	13	68843124	5295625		
Total	16	3.36E+09			

Source: compiled by the authors

Table 7. The result of a big number of regression model for the factors affecting consumption expenditure

	Coefficient	Standard deviation	T-statistics	P-importance	Low 95%	Top 95%
Intersection	-163640.89	124426.7	-1.31516	0.211183	-432448	105166.7
X ₁	19	15.00513	1.266395	0.227594	-13.4142	51.41903
X ₂	2.1	1.209197	1.734086	0.106536	-0.51546	4.709163
X ₃	-0.01	0.513562	-0.01763	0.986199	-1.11854	1.100428
X ₄	-163640.89	124426.7	-1.31516	0.211183	-432448	105166.7

Source: compiled by the authors

Based on the linear regression model is obtained the formula (3):

$$Y = -163640.89 + 19x_1 + 2.1x_2 - 0.01x_3. \quad (3)$$

Using this formula, the level of consumer spending according to the regression model can be determined (Table 8, Fig. 1).

Table 8. Actual and regression model level of consumption expenses, in million manats

Years	Consumer spending	Consumer spending (based on model)
2005	5532.6	2661.4
2006	6873.1	5355.6
2007	9374.6	9160.7
2008	13286.2	13041.6
2009	15048.9	15079.1
2010	16528.5	173571.1
2011	19216	21023.7

Table 8, Continued

Years	Consumer spending	Consumer spending (based on model)
2012	21389.9	23958.6
2013	24150	27062.1
2014	26582.6	29205.6
2015	30595.3	32182.2
2016	35196.7	34123.2
2017	40210.2	37749.1
2018	43067.3	40197.6
2019	46797.8	43523.4
2020	43899.5	45765.2
2021	48378.2	48002.03

Source: compiled by the authors

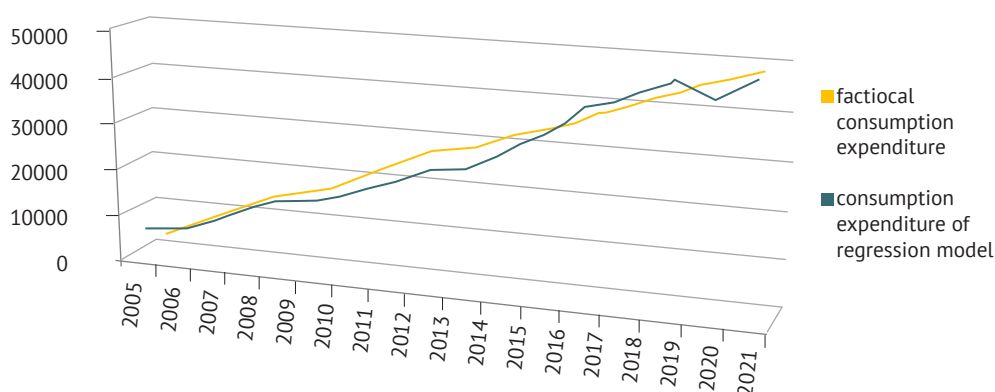


Figure 1. Graphical representation of the actual and regression level of consumer spending

As can be seen from the chart, the actual and regression model level of consumer spending changed in different directions over the years of the study. Thus, the actual consumption costs are ahead of the growth rate of consumption costs according to the regression model in 2005, 2006, 2015, 2016, 2017, 2018, 2019. The opposite situation, that is, according to the regression model, the increase of consumption expenses compared to actual consumption expenses coincides with the years 2007-2014, 2019-2021. One of the main goals of the research is the forecasting of consumption costs

according to the regression model. The corresponding calculations for the period up to 2030 show that the dynamic increase of consumption costs according to the regression model (in the range of 51830.92-78633.2 million manats) is expected due to the influence of the factors included in the model. At the same time, one of the points that is important to pay special attention to is the consideration of the purchasing power of all age groups of the population along with the average indicators in the regularity between consumption costs and consumption demand (Fig. 2).

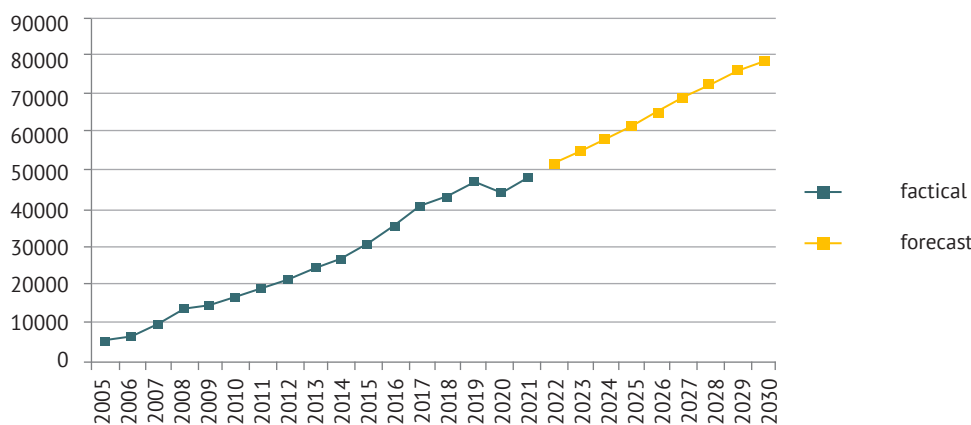


Figure 2. Graphical representation of the forecast of consumption expenditure according to the regression model

Such an approach can make it possible to determine the possibilities of meeting the consumer demand for all categories of the population and eliminate the problems that may arise in time.

DISCUSSION

According to the neo-classical theory of demand, the main decision-maker regarding the realization of products is the consumer. Consumer demand is formed not only based on need, but also on the basis of consumers entering the market as buyers. Cang & Wang (2021) one of the famous economists of the 19th century, argued that the growth rate of the world's population would be higher than the rate of food production with his population theory. Accordingly, greater problems are predicted to emerge in the future if the balance is not tipped in favour of food production. Based on the theory put forward by the German economist Jaeger *et al.* (2023) as the income of individuals increases, the share allocated to food products from this income increases in absolute value, and the share allocated to better goods and services rises proportionally. Guo *et al.* (2022) also gave special importance to the importance of agricultural products, which have an important place in human nutrition. Liu *et al.* (2023) extensively researched consumer demand for agricultural products in terms of purchasing power and identified factors affecting consumer behaviour. Based on research, it can be noted that consumer behaviour is formed by the influence of product, market, and environmental factors. Consumer behaviour affects the change in the level of social productivity and the standard of living of consumers (Lopez-Bonilla *et al.*, 2021).

Liu & Zhang (2023), Nie *et al.* (2021), and Sun *et al.* (2023) have also conducted extensive research and put forward various opinions on the formation, forecasting and modelling of consumer demand. As the main common feature of the studies conducted based on generalizations, it can be shown that consumer demand has subjective characteristics, acceptance, and defence of the idea that consumer demand is formed depending on the current economic and social situation. Although the need for food products has universal characteristics, consumer demand manifests itself in the presence of differences between countries, even between individual regions of the same country. This requires a complex approach to the problem not only in terms of general aspects, but also in terms of determining and predicting the impact of quantitative indicators.

The role of customer satisfaction is described by Xie *et al.* (2022) and Tang *et al.* (2023). The authors note that consumers are more attracted to the products/services of organisations that most closely meet their specific needs in any market segment. In other words, private sector representatives should pay more attention to the needs of their target audience and try to meet them. This will not only increase their profits but will also improve the efficiency of the economy and the overall welfare of

the country. The factors that influence user satisfaction in agricultural e-commerce applications were studied by A.N. Nusifera *et al.* (2020). Their study found that most agricultural e-commerce users were women in their 20s and 30s, often married and well-educated. They worked as private employees or civil servants. In assessing user behaviour, the researchers concluded that variables such as price and customer service did not have a significant impact on satisfaction, while others had a more significant impact. Therefore, the researchers conclude that to maintain satisfaction and loyalty, suppliers should simplify the delivery process and provide good information about it both on specialised platforms and in offline meetings. The researchers also note that the data collection was conducted before the COVID-19 pandemic, and therefore the actual data may vary slightly. Overall, this study provides insights into how to ensure a higher level of satisfaction with the consumption of agricultural products at the enterprise level, while the research above analyses the situation at a more global level.

The possibilities of meeting the needs of consumers of agricultural products were also considered by S. Yekimov *et al.* (2021). The researchers emphasise the increasing role of the quality of products on the structure of demand for them. They note that in a highly competitive market, the focus of production on high-quality products is the basis for the successful functioning of an enterprise, and the usefulness of a product or service for its consumer is not limited to its material characteristics but is also inextricably linked to the purchase of this product or service. Thus, scientists also highlight the role of non-price factors and the importance of taking them into account by enterprises when creating their policies in the context of doing business in the agricultural sector. More globally, G. Guan *et al.* (2022). Their study shows that COVID-19 has a significant impact on logistics, products, and platform factors. It was found that logistics factors, i.e., the ability to deliver products efficiently and easily, as well as product (quality) and platform (through which the product was sold) factors had the greatest impact on customer satisfaction. Given that among the three selected factors, the COVID-19 crisis had the greatest impact on the logistics component, it can be understood that this significantly reduced the ability to meet the demand for agricultural products. Unfortunately, the authors pay little attention to the price factor. A detailed study of the demand for agricultural products was conducted by T. Tempesta *et al.* (2019). They focused on social farms, i.e., those where production is conducted in compliance with all ethical standards. Their study showed that consumers are willing to pay extra to be able to consume products grown on such farms. This again underlines the changes taking place in terms of demand for agricultural products, which are aimed at moving away from traditional price values in shaping demand towards new ones.

Thus, the satisfaction of consumer demand shows an upward trend over the years, with fluctuations observed in different periods. The regression analysis showed that there are a significant number of factors influencing the consumption of agricultural products other than the consumer price index; moreover, its removal from the model made the model more accurate. All of this makes it somewhat difficult to make forecasts for future consumption of agricultural products, but it still allows to make some estimates, as demonstrated in the paper above. The finding that consumer demand is significantly influenced by factors other than the price suggests that changes in policy in this area are needed among government officials. In addition, the private sector should also change some of its behavioural patterns in the market to optimise external demand.

CONCLUSIONS

Based on the research, authors can note that the study of the level of satisfaction of consumer demand for agricultural products is important, first, in terms of determining the possibilities of meeting the needs of the population more fully. Agriculture can develop continuously if the demand for the products of this field increases. This is possible provided that the consumer demand for the products is determined and its economic justification is provided.

The research of consumer demand is aimed at determining the trends of its formation, determining the factors affecting the change in demand. When studying the demand, it is necessary to differentiate between realized, unsatisfied and expected demand. Realized demand determines the actual satisfaction of consumers' demand for individual products. Unsatisfied demand reflects unsatisfied demand due to unavailability of

needed products or low purchasing power of consumers. The purpose of studying expected demand is to consider changes that may occur due to the introduction of new products to the market or the expansion of demand. The research of consumer demand is used to determine the range and quality of manufactured products, as well as existing and expected demands, based on the analysis of the data obtained in this process. In this regard, the study of the factors affecting consumer demand allows to draw a number of generalized conclusions in this field: the correlation model requires to make reasonable assessments by determining the level of influence of the number of consumers, the volume of the total product, the income of consumers and the consumer price index on the consumption costs that determine its level; on the basis of the regression model, it was possible to determine the change trends of consumption expenses under the influence of the mentioned factors; correlation-regression models make it possible to predict the changes that may occur for the next years by calculating the individual and complex effects of factors.

Thus, based on what has been mentioned, it can be said that the econometric models built for the purpose of determining and forecasting consumer demand for food products are fundamental factors in determining the measures to increase the volume of production, deliver the manufactured products to consumers, improving the quality of products, increasing the purchasing power of the population, and regulate the price level.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Задоволення споживчого попиту на сільськогосподарську продукцію: можливості та прогноз

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Анотація. У сучасному світі споживчі переваги та попит на сільськогосподарську продукцію постійно змінюються. Ефективне та результативне задоволення цих вимог має вирішальне значення для стійкості та прибутковості сільськогосподарського сектора. Тому актуальним залишається вивчення попиту на сільськогосподарську продукцію та пошук методів його прогнозування. Метою дослідження є вивчення основних факторів, що впливають на попит на сільськогосподарську продукцію. Основними методами, використаними в цьому дослідженні, є аналіз, абстракція, прогнозування та моделювання. У статті досліджено рівень задоволення попиту, поточну ситуацію та можливості в залежності від масштабу ринку, обсягу товарів і послуг, виходячи з того, що задоволення споживчого попиту є однією з актуальних проблем у світі. Наголошено на взаємозв'язку розвитку сільського господарства із задоволенням попиту на продукти харчування та вирішенням проблеми голоду. Проаналізовано фактори, що впливають на споживчий попит у сільському господарстві – витрати на споживання, кількість споживачів, валовий сільськогосподарський продукт, індекс споживчих цін, доходи споживачів. На основі економетричного аналізу встановлено залежність між оптимізацією споживчого попиту та пов'язаними з нею показниками. Використовуючи багатофакторну лінійну кореляційну та багатофакторну лінійну регресійну моделі, описано рівень фактичних та регресійних моделей споживання, а також прогноз на наступні роки. Дослідження вносить нові знання для оцінки рівня попиту на сільськогосподарську продукцію

Ключові слова: моделювання; прогнозування; дохід; споживчі витрати; індекс цін
