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MODELING OF THE FACTORS INFLUENCING THE DAIRY MARKET IN UKRAINE

Purpose. *The present article aims to identify main determinants influencing development of demand at the dairy market in Ukraine (the average volume of milk consumption per capita), to evaluate their impact on the demand, to assess dependencies between the factors and the partial elasticity coefficients for their further use in forecasting.*

Methodology / approach. *In the research, the authors used information from the State Statistics Service of Ukraine concerning dynamics of the volume of milk consumption per capita and supply of milk to processing enterprises in Ukraine, as well as dynamics of the main factors influencing the mentioned indicators in 2006–2020. The factors, which were analyzed in the work, included milk production by farms of all categories, volume of produced dairy products, the average price of milk and number of cattle. The multicollinearity was studied by applying the Farrar-Glauber test separately for each of the factors influencing the above-mentioned resulting characteristics. To develop the econometric model, the authors used the least squares method, identified density of connection, the model adequacy by the F-test, available autocorrelation and heteroscedasticity, statistical significance of the model parameters.*

Results. *According to the results of conducted research it is determined that all conditions of adequacy of the economic-and-mathematical model are satisfied to assess the dependency of milk consumption per capita on the supply of milk to processing enterprises, dependency of the supply of milk to processing enterprises on the average price of milk, and dependency of the supply of milk to processing enterprises on the number of cattle. These models can be used for the further analysis of the corresponding economic processes at the dairy market of Ukraine. Calculation of the partial elasticity coefficients confirms that the factors' impact on the resulting characteristics is characterized by low elasticity, particularly the growth of the supply of milk to processing enterprises by 1 % causes the increase of milk consumption per capita by 0.209 %, whilst the raise of the average price of milk by 1 % results in reduction of the supply of milk to processing enterprises by 0.562 %, and the increase in the number of cattle by 1 % causes the growth of the supply of milk to processing enterprises by 0.546 % under other similar conditions. By using the developed models, the authors calculated the expected volume of milk consumption per capita under increasing prices of milk and reducing number of cattle and the optimistic scenarios of agriculture development under martial law.*

Originality / scientific novelty. *The obtained results provide a deeper study of the methodology of modeling and forecasting the main indicators influencing performance of the market of milk and dairy products in Ukraine. The authors identify the main factors influencing the demand for dairy products that enables forecasting their prospects depending on the change of some factors of the macro environment of milk processing enterprises. In addition to the above mentioned factors influencing milk consumption per capita, milk processing enterprises can*

partially influence the indicator by activating commercial promotion of consumption of the milk and dairy products of factory production and expanding the range of supplied products.

Practical value / implications. *Findings of the research can be used as an information basis to evaluate marketability of milk processing enterprises in Ukraine based on forecasting the level of the demand for milk. Moreover, the results of the research also confirm reasonability of joined efforts of milk processing enterprises to implement marketing communications in order to increase the demand for milk and dairy products of factory production. The research findings can be also used to make forecast of the conjuncture of milk and dairy market that will identify the directions of the state regulation of its development.*

Key words: *economic-and-mathematical models, dairy market research, volume of produced dairy products, average price of milk, number of cattle.*

Introduction and review of literature. Milk and dairy products are important components of human diet because they supply necessary vitamins and elements. Money, spent for those products, take a substantial share of Ukrainians' budget, i.e. almost 15 % of the total spending for food by the population of Ukraine (Dzhedzhula et al., 2018). Although the number of milk processing enterprises in Ukraine is decreasing, the dairy market is highly competitive. Nowadays, the best positions are taken by some large enterprises, i.e. 10–15 companies, which expand their range of products supplying healthy products, because consumers show a high interest to healthy food and consumption of natural products. However, reduction of Ukrainian population's income contributes to expansion of cheap brands, and family packs of products at the market (Moshkovska, 2019).

The recent tendencies at the market are characterized by active modernization of production processes at milk processing enterprises, which implement new technologies, increase their production capacities, improve quality of products that provides an approximation of Ukrainian dairy production to the European standards. Such steps will secure optimization of raw material consumption, expand the range of products to enter new segments of market, provide export of products (Riabchyk, 2019). However, despite this, a decrease in the production of some dairy products in Ukraine has recently been observed in kind (State Statistics Service…, 2021a). Particularly, in 2020, the volume of produced milk and non-condensed cream with fat content under 1 % in kind reduced by 0.23 % as compared to 2019, milk and non-condensed cream with fat content above 1 % but not more than 6 % – increased by 4 %, milk and non-condensed cream with fat content above 21 % – reduced by 8.38 %, butter with fat content up to 85 % – reduced by 4.48 %, fermented dairy products – increased by 2.2 %, non-fermented cottage cheese – increased by 27 %, non-processed cheese – reduced by 1.05 %. In Ukraine, the actual amount of dairy products consumption per capita is insignificant and makes about 200 kg per year, whereas the rational norm of dairy products consumption declared by the Ministry of Health of Ukraine is 350–380 kg per capita (Cherednichenko & Pashchenko, 2018). In France, Finland and Poland, the amount of consumed milk and dairy products is above 400 kg per capita annually (Holoborodko, 2017).

Along with the factor of dairy products consumption per capita, performance of

the entities of the milk and dairy market is significantly influenced by some other factors. Some of them, particularly quality of products, system of sale and promotion, are partially controlled by producers. However, most factors are not controlled, and therefore, milk processing enterprises should forecast their impact on the enterprises operation by using economic-and-mathematical models and studying the economic processes at the dairy market of Ukraine, as well as the factors influencing them.

The problems of economic environment of the milk processing complex of Ukraine, and the necessary favorable institutional infrastructure that is based on the mutually beneficial business partnership as an important precondition for development of effective relationship of its subjects, are studied in the works by T. Tymofiiiv (2016). Some Ukrainian scientists including M. Ilchuk et al. (2015) stress that the deficit of raw material and its low quality are among the most important problems that hamper performance of the milk processing complex of Ukraine and negatively influence operation of dairy producers, as well as decrease the opportunities for exporting dairy products. Among the factors making negative impact on the supply of domestic dairy products at the market of Ukraine, O. Cherednichenko & O. Pashchenko (2018) mark the continuous reduction of livestock at all categories of farms in Ukraine that results in the fall of milk production; conflict of interests in the relationship of milk producers and processors; reduced consumption of milk and dairy products per capita due to a fall of solvency and raise of the prices of milk and dairy products. Scientists also determine the optimal volume of milk and dairy products outcome in compliance with the standards of a rational diet of population. Iu. Davydiuk (2016) defines the dominating factors of macro environment influencing development of milk processing enterprises in Ukraine and makes analysis of such impact.

Numerous scientific publications are devoted to the use of economic-and-mathematical methods in studying agriculture and the market of agricultural products in some countries, as well as some characterizing indicators. R. Levkina et al. (2019) developed an economic-and-mathematical model for the system of risk analysis in agriculture by using the method of imitation modeling and parametric model. F. Frick & J. Sauer (2018) used empiric data and example of Germany to analyze relations of deregulation and efficiency of milk production by decomposing the sector efficiency into unweighted average efficiency and covariance constituent that provided effective redistribution of resources in the milk sector. To confirm the hypothesis, the authors of the research made the regression analysis assessing the degree of potential covariance between the resource redistribution and efficiency on one hand, and deregulation and changeability of prices on the other hand. Ju. Kernasiuk (2019) developed a methodic approach to the practical use of the method of artificial neural networks in order to make adaptive forecasts of the further development of the agrarian sector in Ukraine that is important in terms of building different strategies of its development and assessment of their future impact on the economic, social and ecological conditions of the studied industry.

A. Sumets et al. (2022) confirmed that the function of the power factor change

can be used for assessment of the impact of subjective factors of internal environment of agricultural enterprises on their conditions. The impact should be reasonably forecasted by comparing variances of values of the resulting parameter that is determined by applying the GARCH-models. In their research, L. Paura & I. Arhipova (2016) used seasonal time series and decomposing model to make forecast of milk prices in Latvia. F. Basagaoglu (2020) used the method of smoothing and the method of ordinary least squares to forecast prices of milk producers in Turkey. N. Shyian et al. (2021) identified the dynamics and made forecast of the milk purchase price by using the ARIMA model and considering the degree of correlation of the change of milk price and the analyzed kinds of dairy products, time lag in one month, and a share of milk as the raw material in the price of produced dairy products. The methodic approaches to forecasting some values and processes in agrarian sector are highlighted in other scientific publications. In particular, B. Demir et al. (2015) studied the agricultural production structure in Turkey by using a Chaotic Dynamic Analysis (CDA) and making accurate forecast of agricultural production to prevent supply misbalance. V. Jadhav et al. (2017) used one-factor ARIMA methodologies to forecast prices of cereals, and evaluated the forecast accuracy using the standard criteria of MSE, MAPE and Theil's coefficient criteria (also known as Thiel's U). A. Kolkova (2018) suggested making forecast of some indicators of food industry development by using moving averages.

To make forecast of the prices of different kinds of cereals and legumes by making analysis of the statistical information, O. Sanusi et al. (2022) proposed to use different models, namely autoregressive integrated moving average (ARIMA), artificial neural networks (ANN), seasonal-trend decomposition using LOESS (STLM) and combination of these three models (a hybrid model).

For evaluation of the competitiveness of dairy products, I. Taranskyi et al. (2019) used the function of consumer utility, whereas while defining the main parameters of Ukrainian consumers' choice of milk and cheese of Ukrainian or Polish production, the researchers considered results of collected and processed primary marketing information and check of the hypotheses on use of the criterion χ^2 (Taranskyi et al., 2021).

A. Busari & A. Kehinde (2021) studied the impact of different macroeconomic parameters on a change of agricultural trade flows between Nigeria and its trade partners based on available time series in the period from 1970 to 2019 by using descriptive statistics and a gravity model.

Using the information obtained from Island milk farms, D. Atsbeha et al. (2016) calculated a system of functions of the demand and supply of milk components at the market, and used the MCP scheme to determine its price. L. Voliak & N. Sergiychuk (2018) used analytical alignment of dynamic series to make forecast of the milk production dynamics based on retrospective information, and identified the main factors hindering the dairy market development in Ukraine. L. Zomchak & H. Umrysh (2017) proposed to use seasonal autoregressive economic-and-mathematical models of SARIMA type (seasonally ARIMA) for time series to make

forecast of meat and egg production in Ukraine.

L. Kovalska et al. (2021) applied the correlation and regressive analysis to define key determinants influencing efficiency of agricultural enterprises operation in Volyn region, Ukraine. V. Aranchiy et al. (2014) assessed the current conditions of milk and dairy market development in Ukraine, named main problems of their performance, directions of development and state regulation, supplied analytical alignment of the series of dynamics and extrapolation of milk production efficiency. The main determinants of business operation in different countries are studied in the research by V. Kyfyak et al. (2021) by using a system approach, application of the method of canonic correlation, determining multiple sets between the results of business activities and determinants, influencing them. K. Kurajdováa et al. (2021) analyzed the impact of some psychological and personal factors on the consumption and purchase of milk in Slovakia.

The conducted review of recent research and publications shows there are few studies demonstrating quantitative impact of some indicators, characterizing microenvironment in Ukraine, on the main indices of the milk processing industry development. Such impact can be assessed by applying the economic-and-mathematical modeling. The forecast of a change of the studied indicators will assist the milk processing enterprises in assessing the expected level of demand for dairy products.

The purpose of the article. The present article aims to identify the main determinants influencing demand at the dairy market in Ukraine (the average volume of milk consumption per capita), to evaluate their impact on the demand, to assess dependency between the factors and partial elasticity coefficients for their further use in forecasting.

Results and discussions. Figure 1 demonstrates dynamics of the volume of monthly consumption of milk per capita in Ukraine in 2006–2020 in real terms and the volume of retail turnover of milk and dairy products in value terms adjusted to the price index. The analysis of the trend confirms that in spite of a growth of the volume of retail turnover of milk and dairy products in value terms, the monthly average consumption of milk per capita in Ukraine had the tendency to fall in 2015–2020 in real terms. Therefore, it is necessary to identify the factors influencing the process.

Economic processes are influenced by many factors, and it is necessary to assess their quantitative impact. Development of a multifactor model for assessment of the factors' impact on milk consumption per capita can be presented as:

$$y = a_0 + a_1 x_1 + a_2 x_2 + a_3 x_3 + u\,, \qquad (1)$$

where y – milk consumption per capita, kg;

x_1 – supply of milk and dairy products to processing enterprises, thousand tons;

x_2 – production of milk by farms of all categories, thousand tons;

x_3 – volume of produced dairy products, thousand tons;

u – random deviations conducted according to the data from the Table 1.

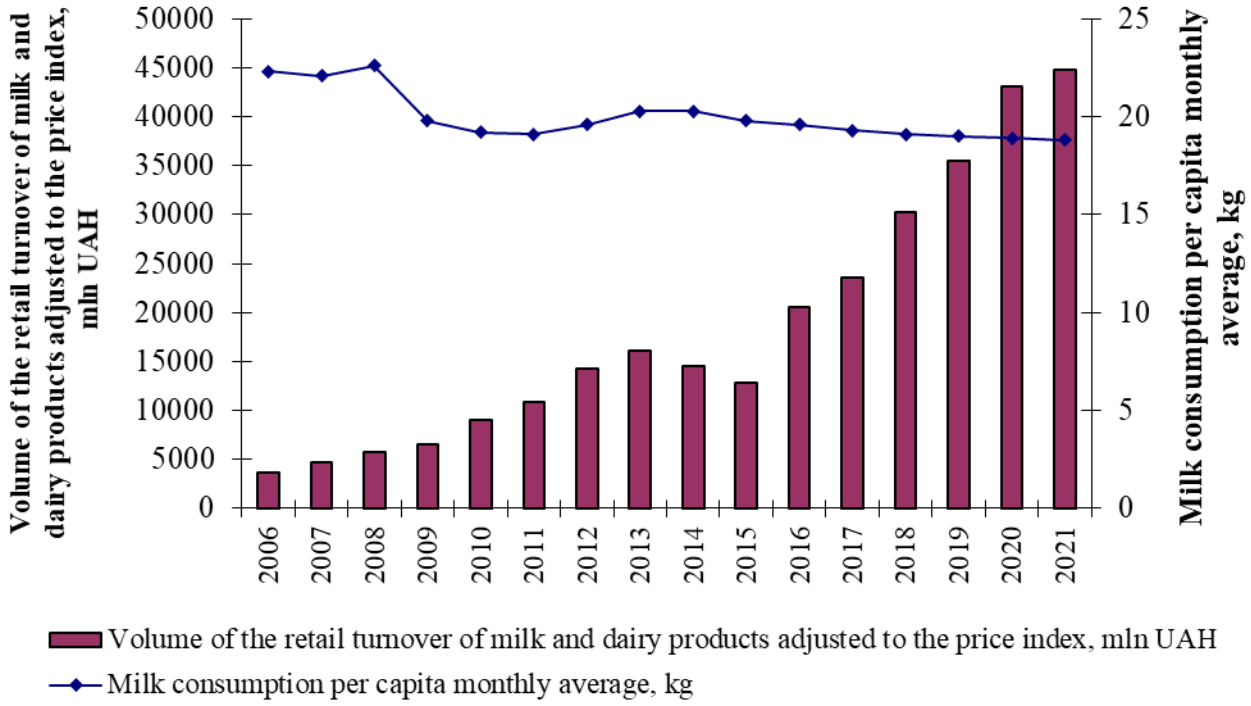

Figure 1. Dynamics of the volume of retail turnover of milk and dairy products (adjusted to the price index) and monthly average consumption of milk per capita

Source: developed by the authors using the data of State Statistics Service of Ukraine (2021d; 2021b; 2021c).

Table 1

Dynamics of milk consumption per capita in Ukraine and the influencing factors

Year	Milk consumption per capita annually, kg	Supply of milk to processing enterprises, thousand tons	Production of milk by farms of all categories, thousand tons	Volume of produced dairy products, thousand tons
2006	234.7	5607.0	13286.9	1829.3
2007	224.6	6039.0	12262.1	1917.4
2008	213.8	5406.0	11761.3	1834.5
2009	212.4	4671.2	11609.6	1718.6
2010	206.4	4737.2	11248.5	1710.9
2011	204.9	4546.9	11086.0	1733.7
2012	214.9	4691.6	11377.6	1780.0
2013	220.9	4545.3	11488.2	1874.4
2014	222.8	4646.6	11132.8	1951.6
2015	209.9	4251.2	10615.4	1782.5
2016	209.5	4182.7	10381.5	1766.0
2017	200.0	4348.3	10280.5	1765.9
2018	197.7	4179.2	10064.0	1765.8
2019	200.5	3800.0	9663.2	1717.8
2020	201.9	3511.8	9263.6	1777.8

Source: composed by the authors using the data of State Statistics Service of Ukraine (2021e; 2021g; 2021f; 2021h).

The correlation and reverse matrices for the factors influencing consumption of milk per capita in Ukraine are determined:

$$R = \begin{pmatrix} 1.000 & 0.913 & 0.514 \\ 0.913 & 1.000 & 0.425 \\ 0.514 & 0.425 & 1.000 \end{pmatrix}, \quad Z = \begin{pmatrix} 6.775 & -5.742 & -1.039 \\ -5.742 & 6.087 & 0.362 \\ -1.039 & 0.362 & 1.380 \end{pmatrix}.$$

The criterion χ^2 is calculated:

$$\chi^2 = -\left(15 - 1 - \frac{2 \cdot 3 + 5}{6}\right) ln(0.121) = 25.701.$$

According to the statistical tables with the probability 0.99 and the degree of freedom 3, $\chi^2_{kr} = 11.3$. Considering that $\chi^2 > \chi^2_{kr}$, one can conclude that multicollinearity is present. To determine the factors characterized by multicollinearity, the F-test and t-test are applied (Table 2).

Table 2

Values of F-test and t-test for the factors influencing milk consumption per capita

Criteria	Calculated value	Critical value for the probability 0.99	Criteria	Calculated value	Criteria	Calculated value	Critical value for the probability 0.99
F_1	21.17	6.21	$r_{12.3}$	-0.894	t_{12}	-6.623	3.106
F_2	18.65	6.21	$r_{13.2}$	-0.340	t_{13}	-1.198	3.106
F_3	1.39	6.21	$r_{23.1}$	0.125	t_{23}	0.417	3.106

Source: authors' calculations.

Analyzing the data from the Table 2, the authors make conclusion that multicollinearity exists between the factors x_1 and x_2. However, according to the matrix R_y these factors make the most significant impact on milk consumption per capita and therefore, they should be studied separately:

$$R_y = \begin{pmatrix} 1.000 & 0.913 & 0.514 & 0.752 \\ 0.913 & 1.000 & 0.425 & 0.864 \\ 0.514 & 0.425 & 1.000 & 0.702 \\ 0.752 & 0.864 & 0.702 & 1.000 \end{pmatrix}.$$

The results of the studies are presented in the Table 3. Thus, considering the research findings, one can conclude that all conditions of adequacy of the economic-and-mathematical model are satisfied only for the dependency of milk consumption per capita on the supply of milk to processing enterprises.

Table 3

Results of the studies of adequacy of the economic-and-mathematical models of the factors influencing consumption of milk per capita

Indicator	Value	Result
Dependency of milk consumption per capita on the supply of milk to processing enterprises $\hat{y} = 156.46+0.012x_1$		
Correlation coefficient	0.752	There is a close, linear and direct dependency between milk consumption per capita and supply of milk to processing enterprises
F-test	18.195	The value exceeds $F_{kr}=9.07$ that is determined with the degrees of freedom 1 and 13 and the probability 0.99 and thus, the model is adequate to the general population data
Durbin–Watson statistic (d-test)	1.100	Critical values $d_1=0.81$ and $d_n=1.07$ are determined with the probability 0.99. The calculated value $d_n<d<4-d_n$ proves no autocorrelation present
μ test	3.830	The value is smaller than $\chi^2_{kr}=9.2$ that is determined with the degree of freedom 2 and the probability 0.99 that proves no heteroscedasticity present
Student's t-test (t_{a0} test)	11.539	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_0
Student's t-test (t_{a1} test)	4.120	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_1
Dependency of milk consumption per capita on production of milk by the farms of all categories $\hat{y} = 114.4+0.009x_2$		
Correlation coefficient	0.864	There is a close, linear and direct dependency between milk consumption per capita and production of milk by farms of all categories
F-test	41.278	The value exceeds $F_{kr}=9.07$ that is determined with the degrees of freedom 1 and 13 and the probability 0.99 and thus, the model is adequate to the general population data
Durbin–Watson statistic (d-test)	0.796	Critical values $d_1=0.81$ and $d_n=1.07$ are determined with the probability 0.99. The calculated value $d<d_1$ proves the present autocorrelation
μ test	3.830	The value is smaller than $\chi^2_{kr}=9.2$ that is determined with the degree of freedom 2 and the probability 0.99 that proves no heteroscedasticity present
Student's t-test (t_{a0} test)	6.729	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_0
Student's t-test (t_{a1} test)	5.865	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_1
Dependency of milk consumption per capita on the volume of produced dairy products $\hat{y} = 29.489+0.1015x_3$		
Correlation coefficient	0.702	There is a close, linear and direct dependency between milk consumption per capita and the volume of produced dairy products
F-test	13.594	The value exceeds $F_{kr}=9.07$ that is determined with the degrees of freedom 1 and 13 and the probability 0.99 and thus, the model is adequate to the general population data

Continuation of Table 3

Durbin–Watson statistic (d-test)	1.001	Critical values $d_1=0.81$ and $d_n=1.07$ are determined with the probability 0.99. The calculated value $d_1<d<d_n$ proves ambiguity concerning autocorrelation
Neumann's test (Q-test)	1.073	The value exceeds $Q_{kr}=0.99$ that is determined with the probability 0.99 and proves no autocorrelation present
μ test	3.830	The value is smaller than $\chi^2_{kr}=9.2$ that is determined with the degree of freedom 2 and the probability 0.99 that proves no heteroscedasticity present
Student's t-test (t_{a0} test)	0.575	The value is smaller than $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical insignificance of the parameter a_0
Student's t-test (t_{a1} test)	3.553	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_1

Source: authors' calculations.

The factors influencing supply of milk to processing enterprises are identified and the multifactor model is developed:

$$y = a_0 + a_1 x_1 + a_2 x_2 + u, \quad (2)$$

where y – supply of milk and dairy products to processing enterprises, thousand tons;

x_1 – average price of milk, UAH/tons;

x_2 – number of cattle, thousand animals;

u – random deviations according to the data presented in the Table 4.

Table 4

Dynamics of the supply of milk to processing enterprises in Ukraine and the influencing factors

Year	Supply of milk to processing enterprises, thousand tons	Consumer price index	Average price of milk, UAH/tons		Number of cattle, thousand animals
			Actual data	Adjusted to the price index	
2006	5607.0	109.1	933.0	822.0	6175.4
2007	6039.0	112.8	1493.0	1368.5	5491.9
2008	5406.0	125.2	1632.0	1446.8	5079.0
2009	4671.2	115.9	1647.0	1315.5	4826.7
2010	4737.2	109.4	2605.3	2247.9	4494.4
2011	4546.9	108.0	2736.1	2501.0	4425.8
2012	4691.6	100.6	2386.2	2209.4	4645.9
2013	4545.3	99.7	2955.3	2937.7	4397.7
2014	4646.6	112.1	3117.2	3126.6	3884.0
2015	4251.2	148.7	3770.9	3363.9	3750.3
2016	4182.7	113.9	4713.1	3169.5	3683.2
2017	4348.3	114.4	6142.0	5392.5	3573.7
2018	4179.2	110.9	6634.8	5799.6	3332.9
2019	3800.0	107.9	7331.9	6611.3	3092.0
2020	3511.8	102.7	7898.8	7320.5	2874.0

Source: composed by the authors using the data (Supply of milk to processing enterprises, Number of agricultural animals, 2021).

The correlation and reverse matrices for the factors influencing the supply of milk to processing enterprises in Ukraine are determined:

$$R = \begin{pmatrix} 1.000 & -0.906 \\ -0.906 & 1.000 \end{pmatrix}, \qquad Z = \begin{pmatrix} 5.583 & 5.058 \\ 5.058 & 5.583 \end{pmatrix}.$$

The criterion χ^2 is calculated:

$$\chi^2 = -\left(15 - 1 - \frac{2 \cdot 2 + 5}{6}\right) ln(0.179) = 21.496 .$$

According to the statistical tables, $\chi^2_{kr} = 6.6$ with the probability 0.99 and the degree of freedom 1. Considering that $\chi^2 > \chi^2_{kr}$, one can conclude that multicollinearity is present between these factors. However, according to the matrix R_y these factors greatly influence the supply of milk to processing enterprises in Ukraine and thus, the impact of each mentioned factor should be studied separately:

$$R_y = \begin{pmatrix} 1.000 & -0.906 & -0.830 \\ -0.906 & 1.000 & 0.925 \\ -0.830 & 0.925 & 1.000 \end{pmatrix}.$$

The results of the studies are presented in the Table 5.

Table 5

Results of the studies of adequacy of the economic-and-mathematical models of the factors influencing supply of milk to processing enterprises

Indicator	Value	Result
Dependency of the supply of milk to processing enterprises on the average price of milk $\hat{y} = 5503.2 - 0.2697 x_1$		
Correlation coefficient	-0.830	There is a close, linear and reverse dependency between the supply of milk to processing enterprises and the average price of milk
F-test	31.025	The value exceeds $F_{kr}=9.07$ that is determined with the degrees of freedom 1 and 13 and the probability 0.99 and thus, the model is adequate to the general population data
Durbin–Watson statistic (d-test)	1.152	Critical values $d_1=0.81$ and $d_n=1.07$ are determined with the probability 0.99. The calculated value $d_n<d<4-d_n$ proves no autocorrelation present
μ test	6.482	The value is smaller than $\chi^2_{kr} = 9.2$ that is determined with the degree of freedom 2 and the probability 0.99 that proves no heteroscedasticity present
Student's t-test (t_{a0} test)	28.450	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_0
Student's t-test (t_{a1} test)	-5.368	The value by the module exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_1

Continuation of Table 5

Dependency of the supply of milk to processing enterprises on the number of cattle $\hat{y} = 1774.8+0.6676x_2$		
Correlation coefficient	0.925	There is a close, linear and direct dependency between the supply of milk to processing enterprises and the number of cattle
F-test	83.012	The value exceeds $F_{kr} = 9.07$ that is determined with the degrees of freedom 1 and 13 and the probability 0.99 and thus, the model is adequate to the general population data
Durbin–Watson statistic (d-test)	1.987	Critical values $d_1=0.81$ and $d_n=1.07$ are determined with the probability 0.99. The calculated value $d_n<d<4-d_n$ proves no autocorrelation present
μ test	6.482	The value is smaller than $\chi^2_{kr}=9.2$ that is determined with the degree of freedom 2 and the probability 0.99 that proves no heteroscedasticity present
Student's t-test (t_{a0} test)	5.378	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_0
Student's t-test (t_{a1} test)	8.780	The value exceeds $t_{kr}=3.012$ that is determined with the degree of freedom 13 and the probability 0.99 that proves statistical significance of the parameter a_1

Source: authors' calculations.

Therefore, according to the results of studies, one can conclude that all conditions of adequacy of the economic-and-mathematical model are satisfied for both developed models, particularly the dependency of the supply of milk to processing enterprises on the average price of milk and the dependency of the supply of milk to processing enterprises on the number of cattle.

The economic-and-mathematical models with all conditions of adequacy satisfied can be used for the further analysis of economic processes. To assess the quantitative impact of the factors, it is important to use partial elasticity coefficients, which show the percentage of the indicator change in case one of the factors changes by 1 %. The partial elasticity coefficients are described in the Table 6.

Table 6

Impact of changes of the identified factors on milk consumption per capita and supply of milk to processing enterprises

Indicator	Factor	Value of the elasticity coefficient	Result
Consumption of milk per capita	Supply of milk to processing enterprises	0.209	Under the growth of the supply of milk to processing enterprises by 1 %, the consumption of milk per capita increases by 0.209 % under other similar conditions
Supply of milk to processing enterprises	Average price of milk	-0.562	Under the growth of the average price of milk by 1 %, the supply of milk to processing enterprises decreases by 0.562 % under other similar conditions
Supply of milk to processing enterprises	Number of cattle	0.546	Under the growth of the number of cattle by 1 %, the supply of milk to processing enterprises increases by 0.546 % under other similar conditions

Source: authors' calculations.

Hence, the supply of milk to processing enterprises is an important factor influencing consumption of milk per capita, whilst it is also significantly influenced by the average price of milk and the number of cattle.

The current situation at the dairy market in Ukraine under martial law is rather complicated. Farms on the de-occupied territories, which have not been destroyed, take efforts to recover their work. Many dairy farms are still on the occupied territory and/or stay under enemy shelling.

According to the data (Linetska, 2022), as of 1 April 2022, the number of cattle in Ukraine reduced to 2470 million animals. However, nowadays all expert estimates are approximate and will be corrected after the end of the war.

Considering the prices of milk, one observes a significant difference in some regions that is influenced by a set of circumstances, particularly the martial law. Generally, in May 2022, the average price of milk was at the level of 9.82–9.94 UAH/kg (excluding VAT) (Linetska, 2022).

To make forecast, the authors of the research refer to the optimistic scenario of agriculture development, which suggests that the area of occupied territories and those, where the fighting is taking place, will not expand during the year, and the other territories will provide a sufficient fodder base. The results of the forecast of the supply of milk to processing enterprises in 2022 are shown in the Table 7.

Table 7

Results of the forecast of the supply of milk to processing enterprises in 2022

Indicator	Value	Conclusion
Dependency of the supply of milk to processing enterprises on the average price of milk		
Average price, UAH/tons	9940.0	The raise of the price of milk by 21.8 % causes fall of the supply of milk to processing enterprises by 12.2 % under other similar conditions
Adjusted average price, UAH/tons	8914.8	
Supply of milk, thousand tons	3082.0	
Dependency of the supply of milk to processing enterprises on the number of cattle		
Number of cattle	2470.0	Reduction of the number of cattle by 14.0 % causes fall of the supply of milk to processing enterprises by 7.7 % under other similar conditions
Supply of milk, thousand tons	3242.3	
Dependency of the supply of milk to processing enterprises on the average price of milk and the number of cattle		
Supply of milk, thousand tons	2845.4	The raise of the price of milk by 21.8 % and reduction of the number of cattle by 14.1 % cause fall of the supply of milk to processing enterprises by 18.9 % under other similar conditions

Source: authors' calculations.

Results of the forecast of milk consumption per capita in 2022 are presented in the Table 8.

Hence, under the raise of prices of milk by 21.8 % and reduction of the number of cattle by 14.0 %, the expected consumption of milk per capita will stay within the limits 188.6 kg to 199.2 kg with the probability 0.95.

Table 8

Results of the forecast of milk consumption per capita in 2022

Indicator	Value	Conclusion
Supply of milk, thousand tons	2845.4	The reduction of the supply of milk to processing enterprises by 18.9 % causes fall of milk consumption per capita by 3.9 % under other similar conditions
Milk consumption per capita annually, kg	193.9	
Confidence interval	188.6	The expected value of annual milk consumption per capita under the described conditions will stay within the limits from 188.6 kg to 199.2 kg with the probability 0.95
	199.2	

Source: authors' calculations.

However, in the analysis of milk consumption per capita, it is important to consider other factors of marketing environment and personal characteristics of consumers making impact that cannot be always quantitatively assessed (Figure 2). It is the value of the average price of milk that is significantly influenced by the state regulation of pricing, whilst the number of cattle – by implementation of different programs of the branch stimulation.

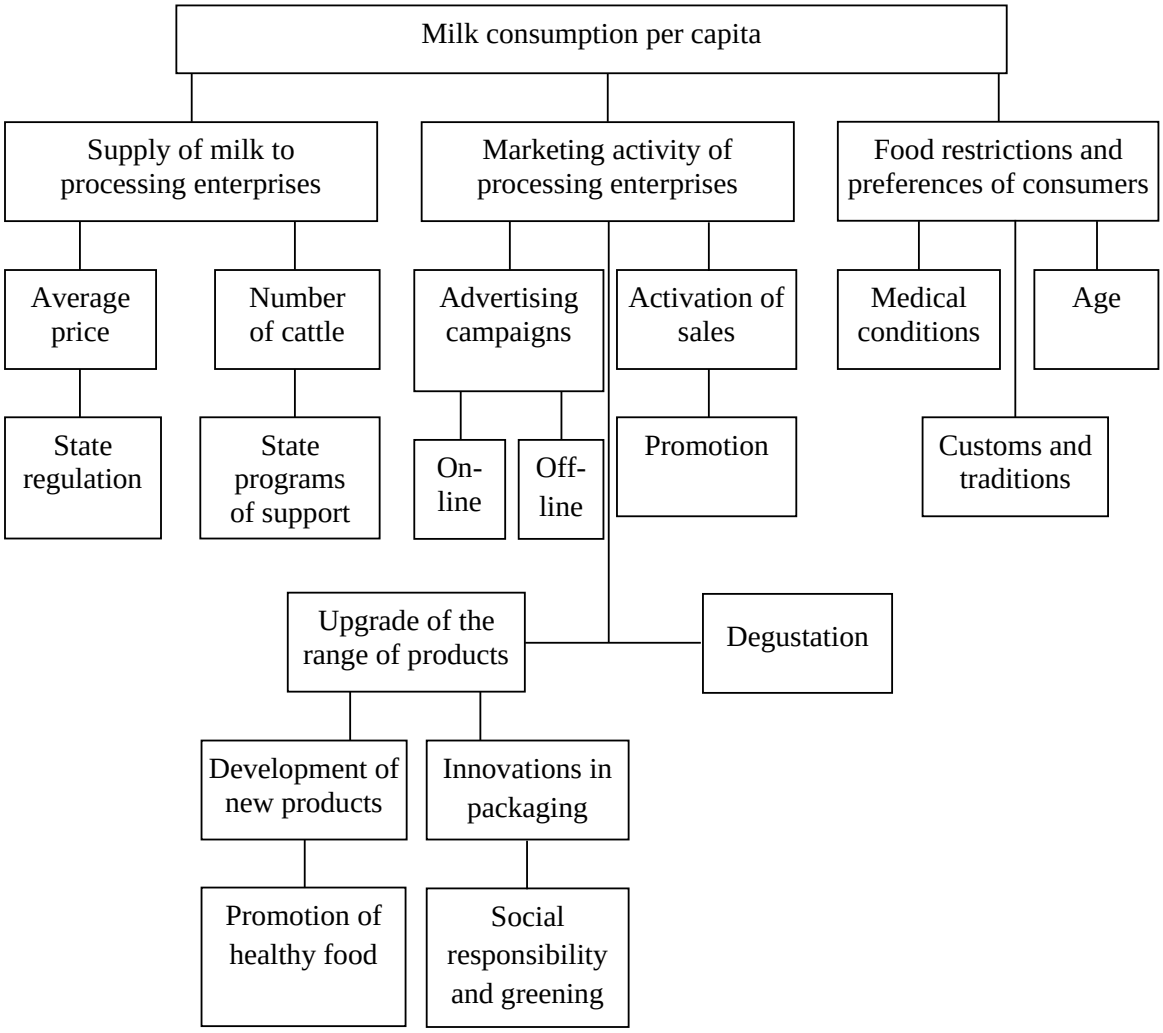

Figure 2. Detailing of the factors influencing consumption of milk per capita

Source: composed by the authors.

Activation of the consumption of milk per capita can be achieved by marketing activity of producers and intermediaries at the dairy market. They can hold different advertising campaigns to stimulate demand for dairy products. These advertising campaigns can be run both offline by applying traditional ways of spreading information, such as television, outdoor adverts, and online by using target advertising (to increase consumption of dairy products by some groups of population, e.g. young mothers), social networks to promote benefits of dairy products for teenagers and people, who work hard and care about their health. Such advertising campaigns can be held by dairy producers individually to increase demand for their brand products and by cooperating their efforts in the direction of promoting consumption of dairy products as essential products in human diet. The raising popularity of healthy food forces the producers of dairy products to expand their range of products, i.e. to develop ecologically clean products, which are controlled at all stages of production – from growing fodder to packaging of the final products. Moreover, implementation of the principles of socially responsible business is the prerequisite for the producers' supply of innovations in packaging of dairy products. Obviously, the information about innovative products should be supplied by producers to their potential consumers by promoting them, e.g. organizing degustation at supermarket chains. Degustation and other measures to stimulate sale of dairy products, i.e. reduction of prices of some types of products, will contribute to activation of the marketing sale policy of milk processing enterprises. Milk consumption per capita is also influenced by such factors as medical condition and age of people. Nowadays, in Ukraine and the world, there is the increasing number of people, who suffer from individual intolerance to lactose and cannot consume traditional dairy products. Hence, they choose lactose free milk. Distribution of population by age is also the factor influencing consumption of dairy products. The highest level of milk consumption is marked among children. From the scientific position, it is also considered that elderly should reduce consumption of milk and other dairy products. However, one should also consider the factor of Ukrainian customs and traditions. Mostly, elderly think that dairy products are beneficial to health, light for digestion and thus, often refuse nutritionists' recommendations.

Conclusions. To assess quantitative impact of the factors on development of the economic phenomena and processes at the dairy market of Ukraine, the authors of the research used linear economic-and-mathematical models. The considered resulting parameters included milk consumption per capita and supply of milk to processing enterprises in Ukraine. Among the factors influencing milk consumption per capita, the researchers analyzed supply of milk to processing enterprises, production of milk by farms of all categories, volume of produced dairy products, whereas among the factors influencing the supply of milk to processing enterprises, the average price of milk and the number of cattle were analyzed.

Based on the conducted research of multicollinearity by applying the Farrar-Glauber test separately for each of the factors influencing consumption of milk per capita and supply of milk to processing enterprises in Ukraine, it is determined that

multicollinearity is present between the supply of milk to processing enterprises and production of milk by farms of all categories, and the average price of milk and the number of cattle. To eliminate it, impact of each of the factors was assessed separately. For the developed models, density of relationship, adequacy of the model by F-test, available autocorrelation and heteroscedasticity, statistical significance of the model parameters are determined. The results of the studies show that all conditions of adequacy of the economic-and-mathematical model are satisfied for the dependency of milk consumption per capita on the supply of milk to processing enterprises, dependency of the supply of milk to processing enterprises on the average price of milk, and dependency of the supply of milk to processing enterprises on the number of cattle. Hence, these models can be used for the further analysis of the corresponding economic processes at the market of milk and dairy products in Ukraine. Calculation of the partial elasticity coefficients confirms that impact of the factors on the resulting parameters has low elasticity, particularly the increase of the supply of milk to processing enterprises by 1 % causes the increase of milk consumption by 0.209 %, the raise of the average price of milk by 1 % results in reduction of the supply of milk to processing enterprises by 0.562 %, and the growth in the number of cattle by 1 % causes the increase of the supply of milk to processing enterprises by 0.546 % under other similar conditions. The developed models are used to assess the expected volume of milk consumption per capita in case of a raise of the prices of milk and reduction of the number of cattle according the optimistic scenario of agriculture development under martial law, which has been calculated by using the results of expert estimates of the prospects of dairy market development in Ukraine.

To sum up, development of the milk processing industry in Ukraine and prospects for performance of dairy producers are determined by the dynamics of milk consumption per capita. It is worth noting that the mentioned indicator was characterized by fluctuation and fall in 2015–2020. To raise it, milk processing enterprises should consolidate their efforts to run commercial promotion of the consumption of milk and dairy products as the essential products in human diet.

The analysis of milk consumption per capita should also consider other factors of marketing environment making the impact, which cannot be always quantitatively assessed. They include marketing activity of milk processing enterprises, consumers' food preferences and restrictions, state regulation of the economy, modern trends in consumer behavior and innovations. Prospects of the further research are focused on assessment of the impact made by the mentioned factors by interviewing consumers.

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