JEL: Q11, C53, L11

Nataliia Shyian[1], Valentyna Moskalenko[2], Olexandr Shabinskyi[3], Volodymyr Pechko[4]

[1]Kharkiv National Agrarian University named after V. V. Dokuchayev
[2]Chernihiv Polytechnic National University
[3]Kharkiv Petro Vasylenko National Technical University of Agriculture
[4]Institute of Postgraduate Education, National University of Food Technologies
Ukraine

MILK PRICE MODELING AND FORECASTING

Purpose. *The purpose of the article is to substantiate the methodological approach to forecasting the selling price of milk, which is produced and sold by agricultural producers in the Ukrainian market of raw milk.*

Methodology / approach. *The basis of the methodological approach is the construction of models describing the change in sales prices for milk and certain types of dairy products (pasteurized milk with a fat content of up to 2.5 %, sour cream with a fat content of up to 15.0 %, soft fat cheeses) during 2017–2019 and forecasting the sale price of milk for a period of 6 months. The ARIMA model was used in the forecast, taking into account the degree of correlation between changes in the price of milk and the analyzed types of dairy products. The time factor (time lag) of one month and the share of milk in the price of the finished dairy products were also considered.*

Results. *The forecast results allowed us to determine milk sales prices for January–June 2020. In addition, the study showed the lack of a single direction in their change during the bias period, namely – increase in milk sales price during February–January 2020 and its reduction till June 2020. The obtained forecast values of milk selling price, considering the share of milk in the selling price of finished dairy products, were adjusted according to the time lag.*

Originality / scientific novelty. *Novelty is an algorithm for using a methodical approach to forecasting the purchase price of milk, taking into account the correlation between milk prices and prices for certain types of dairy products; time lag and the share of milk prices in the sale price of finished dairy products.*

Practical value / implications. *Comparison of the obtained forecast data of the price with the actual prices of milk sales indicated the existence of insignificant differences between them, proving the adequacy of the proposed methodological approach to be used in forecasting of milk prices at the enterprises.*

Key words: *price of dairy products, dairy markets, dairy products, price correlation, forecasting on dairy market.*

Introduction and review of literature. Forecasting is an important element of the economic decision-making process at any hierarchical level of management and in any area of human activity, including economic. It is especially important in areas of the economy with seasonal production and a significant period of capital turnover. Such areas include the agricultural sector of the economy and the livestock industry.The latter has its own characteristics in development and operation, one of which is a long period of turnover of invested capital. Therefore, forecasting of

financial and economic indicators of their activities is relevant for enterprises to plan their future income and expenses from operating activities and to develop the right strategy. Prediction of product prices, their forecasting by the company's management creates favorable conditions for reasoned decision-making.

In the scientific field, methods, models and approaches in forecasting are widely studied (E. Yanch, 1974 [1]). The works on forecasting formation and analytical research in the field of science and technology by G. Dobrov are well-known (Dobrov, 1989 [2]; Dobrov et. al, 1989 [3]). Indicative modeling and forecasting in various applied fields were studied by A. Ivakhnenko (Ivakhnenko, 1981 [4] Ivakhnenko and Muller, 1984 [5]). The management concept of scientific and technical progress as well as implementation of the forecast on the basis of expert estimations was considered by V. Glushkov (Glushkov, 1969 [6]).

In modern life we see further use of forecasting approaches to various spheres of human life and society. The Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine is among the institutions which activities are aimed at forecasting any social and economic phenomena. As part of the institution's activities, a macro-forecast for the development of Ukraine's economy and its agricultural sector for both the long-term and short-term perspective is being developed. In particular, one of the latest developments of the Institute presents the forecast macroeconomic indicators of Ukraine for 2020. It pays attention to the forecast indicators of GDP dynamics, consumption, gross accumulation, export, import of goods and services, forecast indicators of agricultural development, consumer and producer's price indices, forecast of the budget revenue and its expenditures, inflation, unemployment, average monthly wages, and forecast risks [7]. The basis of forecast indicators is different forecasting methods.

The use of forecasting methods is often determined by the scope and specifics of the results. The work by K. Filipova presents an analysis of methods for forecasting the innovative development of the enterprise. Considering them, the researcher emphasizes feasible use of probabilistic-automatic modeling method in this area, which allows assessing alternative plans for innovative development of the enterprise and choosing the best of them by profitability. This method is considered an effective tool for assessing the profitability of innovative projects, predicting the innovative development of the enterprise (Filipova, 2016 [8]).

Considering the choosing of forecasting methods in the agricultural sector, attention is often paid to the use of average sliding model, linear regression, in some cases – ARIMA model (Allen, 1994 [9], Demir et al., 2015 [10], Galvez-Soriano, 2018 [11]; Jadhav et al., 2017 [12], Kolkova, 2018 [13], Newbold, 1981 [14], Padhan, 2012 [15], Vedenieev, 2019 [16]). In the research by V. Vedenieev there are presented the results of analysis and evaluation of the effectiveness of a number of long-term models for forecasting the price of agricultural products in Ukraine, in particular, for such crops as barley, wheat, sunflower oil and soybeans (Vedenieev, 2019 [16]).

Based on the analysis, it is concluded that the use of the above methods in

forecasting selling price of agricultural products can reduce the degree of uncertainty in their formation. The most effective approaches to forecasting the price of agricultural products are also identified. Under conditions when the selling price is formed under the influence of the foreign market, when it comes to exporting products and forming the price for it, it is advisable to use the dollar selling price when implementing financial forecasts and developing long-term strategies for enterprise development. Under these forecasting conditions the best models for forecasting prices for agricultural products are, from a scientific point of view, models of the average sliding and decomposition of time series (Vedenieev, 2019 [16, p. 51]). In case of selling of agricultural products on the domestic market, the best results of forecasting the price of products were obtained, using linear regression (Vedenieev, 2019 [16, p. 51]).

In some cases fluctuations in raw material prices are studied and predicted with an emphasis on their relationship to macroeconomic volatility. The results of a number of studies show that these dependencies are not the same for all countries of the world. The macroeconomic response to commodity ups and downs depends on both the structural characteristics of the economy and the existing policy framework in the country [17]. While examining the macroeconomic response of a group of raw material-producing countries during periods of large price fluctuations, it is noted that price shocks have a significant impact on the dynamics of production and investment.

Polish researchers turned to the analysis of purchase prices for milk and selling prices for dairy products in Poland during 2004–2018, while studying the impact of a combination of factors on the volatility of milk prices. With understanding that milk prices, their volatility, are significantly affected by inflation, changes in supply and demand, consumer income, preferences, government policy and other factors, researchers concluded that the agricultural policy, implemented in EU countries, had a significant impact on milk prices in Poland (Borawski et al., 2020 [18]).

The so-called «multi-component pricing» deserves attention in the study of approaches to forecasting prices for agricultural products, in particular milk (Atsbeha et al., 2016 [19]). According to scientists, it is common on many farms in New Zealand, Denmark, the Netherlands, Australia, Norway and other countries. Thus, the determining factors in milk pricing are the livestock breed, seasonal factors, the lactation stage, etc., operating in the long run. Feed is a factor of influence in the short term. With the influence on the composition of milk, including the amount of fat and protein in it, one can influence the prices, forming a ratio of components in it, which is interesting for the market and the processing plant, providing the manufacturer with a forecast level of profitability (Atsbeha et al., 2016 [19]).

Attention is also paid to the issue of livestock development forecasting in terms of assessing trends and forecasting milk production. The study of Latvian scientists presents the results of forecast milk production in Latvia, using a time series model, taking into account the seasonal component. It is proved that there is a clear inverse relationship between the volume of milk production during the year and its selling price (Paura and Arhipova, 2016 [20]). At the same time, there is a confirmed

dependence: when milk production and sales increase, the prices decrease during the year – it happens in summer. When production and sales decrease – the prices grow – it happens in winter.

Scientists are building models of the effects of increasing milk yield on cows' health and reproductive capacity, using their genetic potential. They note that a significant increase in milk yield negatively affects their health and the number of calvings (Butler, 2000 [21]). Therefore, the results of such models require additional research to find the optimal value of milk yield, the level of which would increase the efficiency of the industry, the number of calvings and maintain the cows'health.

The research results show the effect of the time interval between the first and second calving by primiparous cows with a high genetic potential in terms of their productivity on their actual milk yield and the amount of milk obtained from them during lactation. According to the models, the increase in time between the first and second calving has a positive effect on the actual milk yield growth and milk production during lactation. Such cows also have more calvings, which is important from the point of view of animal reproductive function (Arbel et al., 2001 [22]).

J. Bergez et al., 2013 [23] modelled different scenarios of optimizing the reproductive function of cows, their lactation and productivity throughout the life, depending on their life span, first calving, its reproductive parameters, the number of lactations.

Using the GARUNS model, C. Gaillard, O. Martin, H. Blavy et al., modelled the use of cattle depending on their productivity, reproduction of cows of Holstein breed during lactation. According to scientists, further studies in the model should be included indicators of animal health to improve the accuracy of the forecast (Gaillard et al., 2016 [24]). The works by F. Zhang, M. D. Murphy, L. Shalloo, E. Ruelle, J. Upton present the results of the developed system for optimizing the forecast of milk production in dairy of Ireland (Model MPFOS (Milk Production Forecast Optimization System)). Scientists used the model of curve, regression and autoregression. Using the MPFOS model in forecasting, the optimal parameters of cow yield and gross milk production were determined. The model proved its effectiveness and feasibility (Zhang et al., 2016 [25]).

Among the models in forecasting daily milk yield of cows, used by scientists M. D. Murphy, M. J. O'Mahony, L. Shalloo, P. French, J. Upton, (SANN, MLR, NARX models), more accurate results were obtained with the NARX model (Murphy et al., 2014 [26]). There are other approaches to forecasting the development of industries, production volumes, and indicators of their efficiency (Dumas, 2008 [27], Glushkov, 1969 [6], Gurčík et al., 2016 [28]).

There are certain features concerning formation of prices for agricultural products in Ukraine, reflected in a number of scientific papers (Bosakovska, 2013 [29]; Gurska, 2013 [30]; Aranchiy et al., 2014 [31]; Rossokha and Petrychenko, 2018 [32]). They include growing influence of foreign economic transactions on the pricing process, production concentration (Yatsiv, 2015 [33]) in some cases – the influence of the processing sector on the formation of sales prices. An example of the latter is

the establishment of higher selling prices by milk processing enterprises to the producers supplying more (larger batches) milk. Processing companies are also ready to support such producers by expanding their raw material zones (Ivanova, 2017 [34]). The households, however, have lower purchase prices for milk, etc.

Thus, if we consider selling prices for milk as a factor in the profitable production of the industry, increasing its efficiency, and, accordingly, creating conditions for development, it is important to forecast them. A methodical approach, proposed and tested in the process of our research, is based on models describing changes in milk and certain dairy products sale prices (pasteurized milk up to 2.5 % fat, sour cream fat content up to 15 %, soft fat cheeses) during 2017–2019 and forecasting with their use the sale price of milk for a period of 6 months. The forecasting process took into account the degree of correlation between changes in the price of milk and the analyzed types of dairy products, considering the time factor (time lag), which was equal to one month and the share of milk in the price of finished dairy products.

The purpose of the article is to substantiate the methodological approach to forecasting milk prices, taking into account the time lag of changes in them and dairy products with parallel adjustment of milk prices. A novelty is the methodical approach to forecasting the price of milk, taking into account the correlation between its price and prices for certain types of dairy products, as well as the time lag and the share of milk prices in the selling price of dairy products.

Results and discussion. The study was conducted, using statistical data published on the official website of the State Statistics Service of Ukraine. They include selling prices for milk and certain types of dairy products, including pasteurized milk with a fat content of up to 2.6 %, soft fat cheeses and sour cream with a fat content of up to 15 %. Monthly sales prices during 2017–2019 were analyzed [35; 36].

At the first stage of the study we analyzed the dynamics of prices by constructing a trend line, represented by the equation $y = a_0 + a_1 x$. The line equation was used to determine the general pattern of the series. The results of calculations are given in Table 1. The obtained calculated data allowed determining, firstly, the existence of a general trend to increase the selling price of milk and analyzed types of dairy products. Secondly, the existence of different rates of price growth. It is possible to estimate the rate of the criterion change by the value of the parameter a_0.

Estimated data show that the smallest increase in the price was for milk sold by agricultural producers to milk processing enterprises. And this is understandable because the price of milk is determined by processing companies and it can be increased by producers by improving its quality. It was equal to 0.03 UAH/kg. The highest growth was in pasteurized milk with a fat content of up to 2.6 %, averaging 0.19 UAH/kg, in sour cream with a fat content of up to 15 % growth was 0.53 UAH/kg, and in soft fat cheeses it was the largest, amounting to 0.82 UAH/kg.

Table 1

Mathematical model of the trend of changes in the price of milk and certain types of dairy products in 2017–2019 (by months)

Type of product	Line equation	Coefficient of determination by trends	Correlation	Average value	Dispersion
Milk, UAH/kg	y = 30.372x + 7099	0.403	Average	7.660	6.582
Pasteurized milk with a fat content of up to 2.6 %, UAH/kg	y = 198.57x + 18510	0.959	High	22.183	9.633
Soft fat cheeses, UAH/kg	y = 818.95x + 75961	0.944	High	91.111	9.747
Sour cream with a fat content of up to 15 %, UAH/kg	y = 525.88x + 43089	0.974	High	52.817	10.627

Source: calculated according to [35; 36].

The obtained determination coefficients were assessed by equations, using the F-test. The calculated values of F_{retail} were higher than F_{table} for finished types of dairy products: pasteurized milk with a fat content of up to 2.6 %, soft fat cheeses, sour cream with a fat content of up to 15 %. It indicates the adequacy of the models for the analyzed dairy products. It was smaller for milk, indicating inadequacy of the constructed model and the inexpediency of using the obtained equation to predict the selling price of milk. Actually, in this case, the existence of seasonal fluctuations in determining the selling price of milk is of particular importance.

At the same time, one of the conditions under which it is possible to predict the time series is the stationary nature of the series. In our case, the time series representing the prices of milk and dairy products, the equations of which are presented in Table 1., are non-stationary. As known, the condition of stationary series is the zero value of the average value of the population; constant value of variance and covariance. The average value, which for all analyzed types of products differs significantly from zero, and for soft fat cheeses reached 91.1; by the magnitude of the variance, which is also high, the series are nonstationary. When using them in forecasting, one needs to bring them to a stationary form.

One of the approaches for it- is to exclude the trend from the time series of the analyzed types of products. The existence of a trend complicates the analysis of time series due to the fact that when studying the correlation of time series without excluding a general trend in them, the density of dependence will characterize the relationship between fluctuations in residuals and trends.

To exclude the trend, we used the equation of the direct price for milk and analyzed types of dairy products (Table 1). The obtained fluctuations in residuals line of prices are given in Table 2.

The residuals of prices obtained in calculations indicate approximation of the series to stationary, or it is stationary series of the second order. This conclusion is made in accordance with the average values for the residuals of the analyzed products, which are small.

Table 2

Residuals line of prices for milk and dairy products after excludetion of the trend

Period	Milk, purchase price, UAH/kg	Pasteurized milk with a fat content of up to 2.6 %, UAH/kg	Soft fat cheeses, UAH/kg	Sour cream with a fat content of up to 15 % inclusive, UAH/kg
January 2017	2.358	-1.623	1.487	-1.970
February 2017	2.099	0.018	5.458	1.292
March 2017	0.774	1.001	8.081	4.029
April 2017	-1.213	2.037	9.503	5.763
May 2017	-1.990	2.719	9.006	7.665
June 2017	-1,989	1.569	5.244	5.113
July 2017	-1.456	1.596	3.234	4.917
August 2017	-0.127	2.480	8.627	6.760
September 2017	0.,255	0.120	-0.521	1.169
October 2017	2.402	1.131	2.651	0.675
November 2017	2.538	1.793	6.770	2.415
December 2017	0.006	-0.299	0.444	-2.475
January 2018	0.701	-0.201	-3.402	2.060
February 2018	1.403	1.747	48.113	2.719
March 2018	1.540	2.747	13.561	5.239
April 2018	1.324	2.442	12.279	6.066
May 2018	0.651	2.207	5.101	5.345
June 2018	0.006	0.694	-3.371	0.206
July 2018	-1.044	-2.453	-15.804	-6.619
August 2018	-2.871	-7.467	-36.145	-18.711
September 2018	-3.034	-7.132	-34.784	-18.088
October 2018	-2.928	-5.937	-28.404	-15.049
November 2018	-3.116	-5.602	-26.061	-15.325
December 2018	-2.410	-3.204	-12.284	-8.400
January 2019	-0.302	-3.828	-13.121	-7.943
February 2019	0.251	-1.355	-3.676	-3.186
March 2019	-0.410	-2.931	-9.184	-6.609
April 2019	-0.202	-1.227	-1.625	-1.480
May 2019	-0.981	-3.269	-12.347	-6.110
June 2019	-0.611	-2.137	-8.248	-4.133
July 2019	0.432	0.548	5.555	3.960
August 2019	1.788	0.548	-0.954	-1.065
September 2019	1.788	5.495	21.936	13.500
October 2019	0.657	2.465	9.428	5.128
November 2019	2.034	5.894	28.476	14.516
December 2019	3.269	8.705	42.852	15.000
Average value	*0.044*	*-0.019*	*1.052*	*0.399*

Source: calculated according to [35; 36].

Therefore, using the residuals of prices given in Table 2 during the analyzed period (2017–2019 by months), their change during the period of bias was forecast ,

the value of which, according to the purpose of our study was 6 months.

Before turning to the forecast of the residuals of prices for milk and analyzed types of dairy products, the relationship between the balances of the analyzed indicators were determined by calculating the coefficients of pairwise correlation between them (Table 3).

Table 3

Coefficients of pair correlation between fluctuations in the balance of the selling price of milk and certain types of dairy products in 2017–2019, (per months)

Dependence	Pair correlation coefficient		
	Lag-free	Lag «plus 1 month»	Lag «minus 1 month»
Milk – pasteurized milk with a fat content of up to 2.6%	0.537	0.467	0.650
Milk – soft fat cheeses	0.665	0.539	0.720
Milk – sour cream with a fat content of up to 15%	0.498	0.392	0.627

Source: calculated according to [35; 36].

At the same time, the existing general tendency to increase in the price of milk and dairy products, along with fluctuations in the balances of prices for them, increased the influence of milk price on the price of final dairy products.

According to the obtained results, we conclude that correlation between the fluctuations of the residuals line of selling prices for milk and the analyzed types of dairy products was average. The correlation coefficient between of the residuals line of sales prices for milk and pasteurized milk with a fat content of up to 2.6 % was equal to 0.537; between residuals line of sales prices for milk and soft cheeses – 0.665; between residuals line of sales prices for milk and sour cream with a fat content of up to 15.0 % – 0.498.

At the same time, when calculating the pairwise correlation coefficient between the residuals line of prices in the reporting period for milk and those of the analyzed types of dairy products in the next reporting period – the period «plus 1 month» – there was a decrease in the correlation. Thus, the pairwise correlation coefficient between the residuals line of prices of milk and pasteurized milk was 0.467, decreasing by 0.07.

A decrease in the correlation between the residuals line of prices of milk and soft fat cheeses was 0.126. Regarding the relationship between the residuals line of prices of milk and sour cream with a fat content of up to 15 %, there was also a decrease from 0.498 to 0.392, or 0.106.

Calculating the degree of relationship between the residuals line of prices of milk in the reporting period and that of the analyzed dairy products in the period «minus 1 month», we noticed an increase in the correlation between the residuals line of prices of analyzed products.

The obtained types of dependences led to the assumptions that the selling price for milk is formed under the influence of the selling price for dairy products of dairy enterprises, which set it for producers with a lag of «minus 1 month» after studying

consumer demand for dairy products. Under conditions of a single milk market in Ukraine it is quite possible.

To confirm this hypothesis, we turned to forecast the residuals line of prices for the analyzed types of dairy products, using an integrated autoregressive integrated moving average (ARIMA) and the software product Statistica 7 (Borovikov and Ivchenko, 2000 [37]). The forecast was made for a period of 6 months.

After forecasting the residuals line of prices of the analyzed types of dairy products, the obtained forecast values were returned to the time series in accordance with the above line equations (Table 1), so we could calculate the forecast value of the analyzed types of dairy products (Table 4).

Table 4

Forecast selling prices for certain types of dairy products in January–June 2020

Forecast period (month)	Forecast selling prices								
	Pasteurized milk with fat content of up to 2.6 %, UAH/kg			Soft fat cheeses, UAH/kg			Sour-cream with fat content of up to 15 %, UAH/kg		
	Forecast	Lower interval	Upper interval	Forecast	Lower interval	Upper interval	Forecast	Lower interval	Upper interval
January	25.57	25.14	25.99	106.47	104.58	108.37	62.55	61.60	63.49
February	25.81	25.26	26.37	107.26	104.78	109.74	63.07	61.87	64.27
March	26.06	25.43	26.68	108.05	105.22	110.88	63.60	62.26	64.93
April	26.29	25.62	26.95	108.85	105.79	111.90	64.12	62.71	65.53
May	26.52	25.82	27.21	109.64	106.44	112.85	64.65	63.19	66.10
June	26.74	26.02	27.45	110.45	107.14	113.76	65.17	63.69	66.65
Ratio between prices in June and January, %	104.7	-	-	103.7	-	-	104.2	-	-

Source: calculated according to [35; 36].

Analyzing the obtained values of forecast prices for dairy products, we note a tendency to increase during the forecast period. Thus, the forecast price for pasteurized milk with a fat content of up to 2.6 % during January-June should increase by 4.6 %; the price of soft fat cheeses should increase by 3.7 % and sour cream with a fat content of 15 % – by 4.2 %.

At the next stage of research, the authors determined the share of selling milk prices in the selling price of finished dairy products, while determining the impact of forecast sales prices on the analyzed types of dairy products. The following data were used for this: the actual milk price in period *n* and the price for each type of dairy product in period *(n–1)*.

The calculations were performed using the following formulae:

$$M_{1a} = \frac{Pma}{Pmpa(n-1)} \quad (1)$$

$$M_{2a} = \frac{Pma}{Pfcha\ (n-1)} \quad (2)$$

$$M_{3a} = \frac{Pma}{Psca\ (n-1)\ )} \quad (3)$$

where P_{ma} – the actual price of milk in period *n*, UAH/kg;

Pmpa $_{(n-1)}$ – the price of pasteurized milk with fat content of up to 2.6 % is actual in the period (*n* –1), UAH/kg;

Pfcha $_{(n-1)}$ – the price of fat cheeses is actual in the period (*n* –1), UAH/kg;

Psca $_{(n-1)}$ – the price of sour cream with fat content of up to 15 % is actual in the period (*n* –1), UAH/kg;

M_{1a} – ratio of actual milk price to the selling price of pasteurized milk with fat content of 2.6 %, actual in the period (*n*–1);

M_{2a} – ratio of actual milk price to the selling price of soft fat cheeses actual in the period (*n*–1);

M_{3a} – ratio of actual milk price to the selling price of sour cream with fat content of up to 15 %, the actual in the period (*n*–1).

It was calculated, taking into account the average ratio value of the selling milk price to the selling price of the respective types of dairy products on average during 2017–2019. The obtained results are given in Table 5.

Table 5

The ratio of the selling milk price to the selling price of certain types of dairy products with «minus 1 month» lag during 2017–2019 (by months)*

Month	Average value (for 2017–2019) of the ratio of selling milk price to the price of		
	pasteurized milk with fat content of up to 2.6 % with «minus 1 month» lag	soft fat cheeses with «minus 1 month» lag	sour cream with fat content of up to 15 % with «minus 1 month» lag
January	0.358	0.087	0.152
February	0.377	0.091	0.160
March	0.364	0.088	0.154
April	0.346	0.084	0.146
May	0.337	0.081	0.141
June	0.334	0.082	0.140
July	0.336	0.083	0.141
August	0.341	0.084	0.143
September	0.346	0.085	0.146
October	0.354	0.087	0.149
November	0.349	0.086	0.147
December	0.339	0.083	0.143

Note. *Ratio of milk price to the selling price of dairy products in the previous period.

Source: calculated according to [35; 36].

As the purchase price of milk is affected by the volume of milk, spent on dairy production, the share of impact coefficient was calculated according to the formula:

$$M_{1a} + M_{2a} + M_{3a} + \ldots + M_{na} = \sum_1^n M = 1 \quad (4)$$

$$IF_{1a} = \frac{M1a}{\sum_1^n M}; \quad (5)$$

$$IF_{2a} = \frac{M2a}{\sum_1^n M}; \quad (6)$$

$$IF_{3a} = \frac{M3a}{\sum_1^n M}, \quad (7)$$

where IF_{na} is an impact factor of the analyzed types of dairy products.

The obtained results of the impact factor of the analyzed types of dairy products are given in Table 6.

Table 6

Influence of milk price on the price of certain types of dairy products, share and forecast selling price of milk for January–June 2020

Produce	Forecast period					
	January	February	March	April	May	June
Pasteurized milk with fat content of up to 2.6 %	0.606	0.606	0.606	0.606	0.606	0.605
soft fat cheeses	0.146	0.146	0.146	0.146	0.146	0.147
sour cream with fat content of up to 15 %	0.248	0.248	0.248	0.248	0.248	0.248
Total	1.000	1.000	1.000	1.000	1.000	1.000

Source: calculated according to [35; 36].

The projected value of milk price, taking into account its significant share in the production of analyzed types of dairy products (pasteurized milk with a fat content of up to 2.6 %, soft fat cheeses, sour cream with a fat content of up to 15 %) was calculated using the following formula:

$$\hat{Y} = \sum_1^n (f(P1a) \cdot IF_{1a} + \ldots + f(Pna) \cdot IF_{na}), \quad (8)$$

where $f(Pa)$ – equation of the equalization trend in actual sale price of the corresponding type of dairy products.

Expected values of milk prices are shown in Table 7.

Table 7

Actual and estimated (according to the proposed method) selling prices of milk in January–June 2020, UAH/kg

Period	Expected price	Actual price	The actual selling price to the expected	
			+,–	%
January	8.79	8.98	-0.19	102.1
February	9.15	9.00	0.15	98.3
March	9.01	8.97	0.03	99.6
April	8.79	8.90	-0.10	104.6
May	8.69	8.76	0.07	100.8
June	8.71	8.67	-0.04	99.5

Source: calculated according to [35; 36].

During their analysis,we noticed the lack of a single direction in their change, in contrast to the results of the calculation presented in Table 4. The projected price for milk increased during January-February 2020 from 8.795 to 9.155 UAH/kg with its

further decrease until June 2020 to 8.714 UAH/kg.

That is, forecasting the price of milk, which is a raw material for dairy products using the trend to change the selling price of finished dairy products, taking into account the share of selling prices for raw milk in the selling price of finished dairy products, allows obtaining reliable forecast prices for raw milk.

Comparing the estimated forecast selling price for raw milk with its actual value in accordance with the State Statistics Committee of Ukraine, we noted that the actual selling price of milk in January 2020 was 8.98 UAH/kg, which was on 0.19 UAH/kg below our forecast. In February, such a deviation between estimated and actual prices would be 0.15 UAH/kg, in March – 0.034, and in April – 0.11 UAH/kg. The error is small, which may confirm the adequacy of the proposed method and the possibility of its use to forecast milk prices in enterprises.

Conclusions. Thus, our research shows that in Ukraine it is formed a single milk market with a slight degree of variation by regions. In 2019, the coefficient of variation in agricultural enterprises was 3.84 %, which was 2.98 % lower than in 2010. Existence of a single milk market indicates difficulty of regulating prices by milk producers. Therefore, processing enterprises have a decisive influence on determining the selling price of milk.

General tendency in milk selling price formation and the price on the analyzed types of dairy products is a tendency to their growth. The rates of increase in milk prices and the analyzed types of dairy products were different: the highest were for soft fat cheeses, the lowest – for milk sold by enterprises to dairy enterprises.

Selling price for milk for agricultural producers is according to the proposed methodology under the influence of the selling price for dairy products with a lag of minus 1 month. The basis for establishing the selling price of milk by dairy companies is the study of consumer demand for dairy products.

The proposed methodological approach to forecasting milk prices, taking into account the share of milk prices in the price of finished dairy products and the impact factor of each type of dairy products in its total value, makes it possible to forecast selling milk price for its producers for 6 months with a a high degree of reliability. Fluctuations in the deviation of the forecast price from the actual ranged from 0.5 % in June to 4.6 % in April of the forecast year.

Further research will focus on testing the proposed methodological approach in forecasting milk prices when concluding future contracts for milk and forecasting their prices. They will be interesting by concluding transactions on the stock exchange, when forecasting milk price with a bias of 3 months and 6 months.

References

1. Yanch, E. (1974), *Prognozirovanie nauchno-tehnicheskogo progressa* [Forecasting scientific and technological progress], Progress, Moscow, Russia.

2. Dobrov, G. M. (1989), *Nauka o nauke. Vvedenie v obshee naukovedenie* [Science about science. Introduction to general science study], Naukova dumka, Kyiv, Ukraine.

3. Dobrov, G. M., Korennoy, A. A. and Musienko, V. B. (1989),

Prognozirovanie i ocenki nauchno-tehnicheskih novovvedenij [Forecasting and evaluating scientific and technical innovations], Naukova dumka, Kyiv, Ukraine.

4. Ivakhnenko, A. G. (1981), *Induktivnyj metod samoorganizacii modelej slozhnyh sistem* [Inductive method of self-organization of complex systems models], Naukova dumka, Kyiv, Ukraine.

5. Ivakhnenko, A. G. and Muller, J. A. (1984), *Samoorganizaciya prognoziruyushih modelej* [Self-organization of predictive models], Tekhnika, Kyiv, Ukraine.

6. Glushkov, V. M. (1969), About forecasting based on expert assessments. *Cybernetics*, no. 2, pp. 2–4.

7. Assumptions of the macroeconomic forecast of Ukraine for 2019–2020, available at: 19_10_02_1_IEPR_NANU_Assumptions.Risks.Consensus.MEPT.pdf.

8. Filipova, K. V. (2007), Methods for predicting innovative development of an enterprise. *Visnyk Natsionalnoho universytetu «Lvivska politekhnika». Seriia: Problemy ekonomiky ta upravlinnia*, no. 579, pp. 609–613, available at: http://ena.lp.edu.ua:8080/handle/ntb/34162.

9. Allen, P. G. (1994), Economic forecasting in agriculture. *International Journal of Forecasting*, no. 10, pp. 81–135.

10. Demir, B., Alptekin, N., Kilicaslan, Y., Ergen, M. and Uslu, N. C. (2015), Forecasting agricultural production: a chaotic dynamic approach. *World Journal of Applied Economics*, vol. 1, is. 1, pp. 65–80. https://doi.org/10.22440/EconWorld.J.2015.1.1.BD.0007.

11. Galvez-Soriano, O. (2018), Forecasting the agricultural sector of Mexico in *Economy, finance and social development in Mexico*. Asociacion Mexicana de Investigacion Interdisciplinaria Asmiila, Mexico, pp. 42–58.

12. Jadhav, V. et al. (2017), Application of ARIMA models for forecasting agricultural prices. *Journal of Agriculture Science and Technology*, vol. 19, pp. 981–992.

13. Kolkova, A. (2018), Indicators of technical analysis on the basis of moving averages as prognostic methods in the food industry. *Journal of Competitiveness*, vol. 10(4), pp. 102–119. https://doi.org/10.7441/ joc.2018.04.07.

14. Newbold, P. (1981), Some recent developments in time series analysis, correspondent paper. *International Statistical Rewiew*, vol. 49, no. 1, pp. 53–66.

15. Padhan, P. C. (2012), Application of ARIMA model for forecasting agricultural productivity in India. *Journal of Agricultural & Social Sciences*, no. 8, pp. 50–56.

16. Vedenieev, V. A. (2019), Evaluation of the efficiency of pre-urban models of forecasting the selling price of products of the agricultural sector in Ukraine. *Economy and the state*, no. 9, pp. 46–51.

17. Céspedes, L. F. and Velasco, A. (2012), Macroeconomic performance during commodity price booms and busts. Working Paper 18569, National Bureau of Economic Research, Cambridge, UK. https://doi.org/10.3386/w18569.

18. Borawski, P., Guth, M., Truszkowski, W., Zuzek, D., Beldycka-

Borawska, A., Mickiewicz, B., Szymanska, E., Harper, J. and Dunn, J. (2020), Milk price changes in Poland in the context of the Common Agricultural Policy. *Agricultural Economics – Czech*, vol. 66, is. 1, pp. 19–26. https://doi.org/10.17221/178/2019-AGRICECON.

19. Atsbeha, D., Kristofersson, D. and Rickertsen, K. (2016), Component supply responses in dairy production. *European Review of Agricultural Economics*, vol. 43, is. 2, pp. 193–215. https://doi.org/10.1093/erae/jbv019.

20. Paura, L. and Arhipova, I. (2016), Analysis of the milk production and milk price in Latvia. *Procedia Economics and Finance*, no. 39, pp. 39–43. https://doi.org/10.1016/S2212-5671(16)30238-6.

21. Butler, W. R. (2000), Nutritional interactions with reproductive performance in dairy cattle. *Animal Reproduction Science*, vol. 60–61, pp. 449–457. https://doi.org/10.1016/s0378-4320(00)00076-2.

22. Arbel, R., Bigun, Y., Ezra, E., Sturman, H. and Hojman, D. (2001), The effect of extended calvsng intervals in high lactating cows on milk production and profitability. *Journal of Dairy Science*, vol. 84, is. 3, pp. 600–608. https://doi.org/10.3168/jds.S0022-0302(01)74513-4.

23. Bergez, J. E., Chabrier, P., Gary, C. Jeuffroy, M. H., Makowski D. and et al. (2013), An open platform to build, evaluate and simulate integrated models of farming and agro-ecosystems. *Environmental Modelling & Software*, vol. 39, pp. 39–49. https://doi.org/10.1016/j.envsoft.2012.03.011.

24. Gaillard, C. Martin, O., Blavy, P., Friggens, N. C., Sehested, J. and Phuong, H. N. (2016), Prediction of the lifetime productive and reproductive performance of Holstein cows managed for different lactation durations, using a model of lifetime nutrient partitioning. *Journal of Dairy Science*, vol. 99, is. 11, pp. 9126–9135. https://doi.org/10.3168/jds.2016-11051.

25. Zhang, F., Murphy, M. D., Shalloo, L., Ruelle, E. and Upton, J. (2016), An automatic model configuration and optimization system for milk production forecasting. *Computers and Electronics in Agriculture*, vol. 128, pp. 100–111. https://doi.org/10.1016/j.compag.2016.08.016.

26. Murphy, M. D., O'Mahony, M. J., Shalloo, L., French, P. and Upton, J. (2014), Comparison of modelling techniques for milk-production forecasting. *Journal of Dairy Science*, vol. 97, no. 6. pp. 3352–3363. https://doi.org/10.3168/jds.2013-7451.

27. Dumas, F., Dijkstra, J. and France, J. (2008), Mathematical modelling in animal nutrition: a centenary review. *Journal of Agriculture Science*, vol. 146, is. 2, pp. 123–142. https://doi.org/10.1017/S0021859608007703.

28. Gurčík, L., Dobošová, L., Richter, M., Kubicová, L. and Dobák, D. (2016), Controlling as a management system of milk production and consumption in Slovakia and the Czech Republic. International Scientific Days 2016. The Agri-Food Value Chain: Challenges for Natural Resources Management and Society. Scientific paper, pp. 329–338. https://doi.org/10.15414/isd2016.s5.03.

29. Bosakovska, V. G. (2013), Problems of pricing in the process of reforming

agricultural enterprises. Productivity of agro-industrial production. *Produktyvnist ahropromyslovoho vyrobnytstva. Ekonomichni nauky*, vol. 24, pp. 102–106.

30. Gurska, I.S. (2013), Development of the regional market of milk and dairy products. *Naukovyi visnyk Natsionalnoho universytetu bioresursiv i pryrodokorystuvannia Ukrainy. Seria: Ekonomika, ahrarnyi menedzhment, biznes*, vol. 181(1), pp. 31–38.

31. Aranchiy, V. I., Drogan-Pysarenko, L. O. and Rudich, A. I. (2014), Analytical assessment and extrapolation of the dairy market functioning. *Economic analysis*, vol. 20, pp. 14–22.

32. Rossokha, V. V. and Petrychenko, O. A. (2018), Milk production and distribution by volume and quality and price characteristics. *Economika APK*, no. 7, pp. 27–36.

33. Yatsiv, I. and Yatsiv, S. (2015), Formation of prices for agricultural products as a factor in the development of the agricultural sector of the economy. *Agricultural economic*, vol. 8, no. 1–2, pp. 24–31.

34. Ivanova, L. S. (2017), Directions for improving state regulation of milk and dairy products market based on foreign experience. *Agrosvit*, no. 23, available at: http: //www.agrosvit.info/pdf/23_2017/6.pdf.

35. Average consumer prices for goods (services) in 2017–2019 (2020), available at: http://www.ukrstat.gov.ua.

36. Price indices of sales of agricultural products (2020), available at: http://www.ukrstat.gov.ua.

37. Borovikov, V. P. and Ivchenko, G. I. (2000), *Prognozirovanie v sisteme STATISTICA v srede Windows. Osnovy teorii i intensivnaya praktika na kompyutere* [Forecasting in the STATISTICA system in the Windows environment. Fundamentals of theory and intensive computer practice], Finance and Statistics, Moscow, Russia.

38. Ruekkasaem, L. and Sasananan, M. (2018), Forecasting agricultural products prices using time series methods for crop planning. *International Journal of Mechanical Engineering and Technology (IJMET)*, vol. 9, is. 7, pp. 957–971.

Citation:

Стиль – ДСТУ:

Shyian N., Moskalenko V., Shabinskyi O., Pechko V. Milk price modeling and forecasting. *Agricultural and Resource Economics*. 2021. Vol. 7. No. 1. Pp. 81–95. https://doi.org/10.51599/are.2021.07.01.05.

Style – APA:

Shyian, N., Moskalenko, V., Shabinskyi, O. and Pechko, V. (2021), Milk price modeling and forecasting. *Agricultural and Resource Economics*, vol. 7, no. 1, pp. 81–95. https://doi.org/10.51599/are.2021.07.01.05.