Forecasting the Milk Prices from a Supply Chain Management Perspective in the Northern Kazakhstan

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***Abstract*-The primary goal of supply chain management is to meet customer needs through the most efficient use of resources, including the allocation of capacity, inventory and workforce. In theory, the supply chain management seeks to match supply and demand and seeks to do so at minimal cost. And the main indicator of changes in the ratio of supply and demand is the change in the price of products. Trend-seasonal time series models were used to analyze the price behavior in the milk market of the Northern region of Kazakhstan. The use of chain indexes provides models that give more reliable predictions. Calculations based on statistical data on average monthly prices for milk sold by farms of Kostanay region in the period from 2010 to 2018. Seasonal ups and downs in the dynamics of prices for milk were estimated in the model using dummy variables. Validation of the model was carried out as follows: the initial set of data was divided into two subsets – one for estimating the parameters of the equation, the other – for its validation. With use of the data from the first subset, the parameters of the equation were estimated. Then the data from the second subset were inserted into the equation to get predicted values of the response variable. Finally, the predicted values of the indicator were compared with the corresponding known values from the second subset. The degree of deviation of milk prices calculated on the basis of the index model from the actual prices, estimated as the ratio of the standard error to the average actual value of the indicator, does not exceed 3%.Price forecasting based on chain indexes falls within the framework of Bayesian approach. The model of chain price indexes can be used by farms for the effective organization of production and sale processes, taking into account the seasonal characteristics in the behavior of the market.**

Key words- *milk market, milk price, chain indexes, price seasonality, model validation, supply chain management.*

1. Introduction

The idea underlying the supply chain management (SCM) is for enterprises to be included in the supply chain by exchanging information on market fluctuations and production opportunities. Each firm in the supply chain is able to assist in optimizing the entire supply chain. This leads to optimally planned production and distribution, which allows to reduce costs and pursue a more attractive price policy for the consumer. Analysis and forecasting of price changes in the market is one of the key elements in the system of marketing research for any agricultural enterprise [1]. The availability of an effective method of price forecasting provides a more competent and reasonable approach to the formation of pricing policy and the establishment of prices for their own products and contributes to the competitiveness of the enterprise. In addition, the results of price forecasting can be successfully used in investment design [2, 3].As noted [4], variation in prices can be viewed more specifically from a supply chain management perspective. Supply chains typically involve substantial time delays, so they are prone to oscillation. [5] notes that production in inventories chronically overshoot and undershoot the appropriate levels. In agriculture, the situation gets more complicated by the fact that production in the industry is seasonal. Meanwhile as noted by [5], the size of price oscillations tends to increase as one moves along the supply chain from consumer to farmer so that price and income variation is larger for farmers than for consumers. Production planning based on more accurate forecasts of product prices could reduce the volatility of farm product prices. Creating a qualified price forecast is a complex study, which requires some training in the field of applied statistics and knowledge of a set of modern approaches and methods of statistical analysis and time series forecasting. In addition, procedures for developing price projections for a product group becomes more complicated in connection with the objective necessity of the analysis and assessment of seasonal price fluctuations. The goods characterized by seasonality of price changes include a significant part of agricultural products. For example, in

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Kazakhstan, milk prices have a pronounced seasonal character: relatively high in autumn and winter with a decrease in the spring and summer season. The algorithm for predicting the price of raw milk is usually based on the construction of trend-seasonal models, involving a mathematical description of the main trend of price changes and the quantitative measurement of the "seasonal component" [6]. However, in the analysis of prices in most cases are limited only to the calculation and description of the trend component, using traditional methods of smoothing the original price series [2]. The consequence of such an analysis is the low reliability of forecasts. The seasonal component is rarely taken into account, and the random component present in the initial time series is practically ignored. Meanwhile, the seasonal and random components are characterized by well-defined patterns that affect the quality and reliability of the forecast of price movements. Therefore, it is necessary to further improve the methods of analysis and forecasting, which would take into account the peculiarities of the behavior of all components of the time series: trend, cyclic, seasonal and random components. Time series models are one of the most frequently used tools for analysis and forecasting of agricultural processes. However, models based on the available data set often yield overly optimistic results when used for forecasting. This is explained by the fact that the reliability of the model and its predictive ability are very sensitive to changes in the composition and structure of data [2]. Therefore, under new circumstances, the parameters of the existing model, as a rule, are not always adequate and, therefore, reliable when trying to predict the new values of the response variable. It is obvious that there is a contradiction in that the predictions, that is, new (but unknown) values of the response variable are calculated by the equation built on the basis of the "old" (known) data set. This contradiction requires its study and resolution. The study of this issue was conducted according to the dynamics of farm-gate milk prices in Kostanay region of Kazakhstan.

2. Methods and data

Average farm-gate monthly milk prices from 2010 to 2018 in the Kostanay region were used as the initial statistical base [7].Methods and procedures of statistical modeling have been used as a research method. Table 1 presents data on monthly prices of raw milk sold by farms of Kostanay region between 2010 and 2018.

Table1. Farm-gatemilk prices in Kostanay region in 2010 to 2018, tenge/center

Months	Years								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	4577	6364	6773	6586	6920	8484	7376	9198	10898
February	4753	6526	6942	6450	7495	8435	7413	9668	10868
March	4901	6844	6906	6643	7579	8124	7576	9943	11117
April	4872	6903	6760	6557	7586	7669	7629	10147	11030
May	4688	6798	6349	6480	7606	7494	7614	10234	10958
June	4654	6865	6025	6423	7644	7038	7583	10124	10648
July	4597	6731	5945	6463	7709	6711	7534	10021	9818
August	4794	6375	6029	6428	7779	6723	7677	9615	9678
September	4883	6282	6091	6539	7959	6675	7992	9554	9619
October	5276	6368	6256	6612	7948	6916	8319	9646	9739
November	5690	6415	6461	6834	7967	7245	8536	9803	9868
December	6164	6691	6579	6860	8505	7339	8808	9944	10243

A specific feature of the dynamics of milk prices is the presence of not only the trend, but also seasonal and random factors. Therefore, the most adequate method for modeling the dynamics of milk prices involves the decomposition of the time series into three components: the trend, the seasonal component and the random component [8]. In other words, the equation of the time series for milk prices appears to be an additive formula:

$$Y = Trend + Season + Error, \quad (1)$$

where Y – the level of the time series, $Trend$ – the trend component, $Season$ – seasonal component, $Error$ – random component.

3. Results

3.1. Modeling the process of price movement

Table2. Chain indices of farm-gate milk prices in Kostanay region in 2010to 2018

Months	Years								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	1,054	1,032	1,012	1,001	1,009	0,998	1,005	1,044	1,096
February	1,038	1,025	1,025	0,979	1,083	0,994	1,005	1,051	0,997
March	1,031	1,049	0,995	1,030	1,011	0,963	1,022	1,028	1,023
April	0,994	1,009	0,979	0,987	1,001	0,944	1,007	1,021	0,992
May	0,962	0,985	0,939	0,988	1,003	0,977	0,998	1,009	0,993
June	0,993	1,010	0,949	0,991	1,005	0,939	0,996	0,989	0,972
July	0,988	0,980	0,987	1,006	1,008	0,954	0,993	0,990	0,922
August	1,043	0,947	1,014	0,995	1,009	1,002	1,019	0,959	0,986
September	1,019	0,985	1,010	1,017	1,023	0,993	1,041	0,994	0,994
October	1,080	1,014	1,027	1,011	0,999	1,036	1,041	1,010	1,012
November	1,079	1,007	1,033	1,034	1,002	1,048	1,026	1,016	1,013
December	1,083	1,043	1,018	1,004	1,068	1,013	1,032	1,014	1,038

A model of the following type was used to analyze the factor of seasonality

$$Y_T = b_0 + b_1 T + \sum_{j \in J} b_j x_j + \varepsilon, \quad (2)$$

Where Y_T –a value chain index in month T, X_j – month j (categorical variable), ε – random variable, J - set of months, b_0, b_1, b_j – parameters of the model.

In model (2), the parameters b_j are seasonal indices. The parameter b_1 points out the presence or absence of a linear trend in the dynamics of indices. The presence of categorical variables in the model implies the need to take one of them (no matter which) as a base and to calculate indices with respect to it [9, 10]. In our case, the base variable is the month "January".

Table 3 shows the numerical values of the model parameters and their statistical characteristics. The first option corresponds to the case when all months are included in the model as categorical variables. The second variant was calculated for the case when variables with the t value less than one were excluded from the in the model. The reason for the exclusion of such variables is the mathematical fact that if the *t*-characteristic is less than 1, then the error of the equation will decrease when the corresponding variable is excluded from the equation. And, if the *t*-characteristic is greater than one, the equation error will increase [11].

Table3. Model parameters and their characteristics

№	Variables	Variant 1		Variant 2	
		Coefficient	t -criterion	Coefficient	t -criterion
1	Free parameter	1,033	109,07	1,030	181,45
2	Trend	-0,00011	1,41	-0,00011	1,38
3	February	-0,006	0,47	-	-
4	March	-0,011	0,88	-	-
5	April	-0,035	2,87*	-0,032	3,42*

6	May	-0,044	3,58*	-0,040	4,34*
7	June	-0,045	3,66*	-0,042	4,46*
8	July	-0,046	3,79*	-0,043	4,63*
9	August	-0,030	2,46*	-0,027	2,89*
10	September	-0,019	1,52	-0,015	1,65
11	October	-0,001	0,11	-	-
12	November	0,002	0,15	-	-
13	December	0,008	0,67	0,011	1,21
14	R^2	0,394	-	0,385	-
15	*F*-test	5,149*	-	7,758*	-
* - significant at 0.05					

According to the first variant, the equation as a whole was statistically significant for the level 0,05. As for the individual parameters of the model, the coefficients of the variables corresponding to the months from April to August are significant at the level of 0,05.

Further, the variables "February", "March", "October" and "November" were excluded from the analysis, as the corresponding *t*–characteristics were less than one. The calculations of the parameters for the second option yielded results, which are shown in the last two columns of table 3. All parameters of the new model have *t*–characteristics greater than one. The coefficient of determination remains almost at the same level, but the model as a whole and the parameters separately are more reliable (this is evidenced by the higher values of the *F*-criterion and *t*–criterion).

Thus, the desired model of chain indices is as follows:

$$\hat{Y}_T = 1{,}030 - 0{,}00011T - 0{,}032April - 0{,}040May - 0{,}042June - 0{,}043July - 0{,}027August - 0{,}015September + 0{,}011December, \quad (3)$$

where $\hat{Y}_T$ –calculated value of the chain index in month T.

Model (3) needs some explanation. Variables April, May, June, July, August, September, and December take the value 1 if the index is calculated for the corresponding month, and 0 otherwise. For example, if you want to calculate the April index, the April variable is set to 1, and all other variables are set to 0. The coefficient for each of the variables is the value of the deviation of the price index in the corresponding month from the trend. The exclusion of variables February, March, October and November from the model (3) shows that they differ from the January index only by the value of the trend change. Recall that in our analysis month "January" serves as the base variable; this circumstance explains the absence of variable January in the model.

All further calculations and reasoning are given using model (3).

Table 4 shows the chain indices of milk prices calculated on the basis of the model.

Table4. Calculated chain indices of farm-gate milk prices in Kostanay region in 2010to 2018

Months	Years								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	1,030	1,029	1,027	1,026	1,025	1,023	1,022	1,021	1,019
February	1,030	1,029	1,027	1,026	1,025	1,023	1,022	1,021	1,019
March	1,030	1,028	1,027	1,026	1,024	1,023	1,022	1,021	1,019
April	0,998	0,996	0,995	0,994	0,993	0,991	0,990	0,989	0,987
May	0,989	0,988	0,986	0,985	0,984	0,983	0,981	0,980	0,979
June	0,988	0,987	0,985	0,984	0,983	0,981	0,980	0,979	0,977
July	0,986	0,985	0,984	0,982	0,981	0,980	0,978	0,977	0,976
August	1,002	1,001	1,000	0,998	0,997	0,996	0,994	0,993	0,992
September	1,014	1,012	1,011	1,010	1,008	1,007	1,006	1,005	1,003
October	1,029	1,028	1,026	1,025	1,024	1,022	1,021	1,020	1,019
November	1,029	1,028	1,026	1,025	1,024	1,022	1,021	1,020	1,018
December	1,040	1,039	1,037	1,036	1,035	1,034	1,032	1,031	1,030

Since the features of the price dynamics of products are the subject of research, the resulting indices should be translated into prices. Table 5 shows the levels of prices calculated on the basis of the model of their chain indices from 2010 to 2018 in the context of calendar months.

Table5. Calculated farm-gate milk prices in Kostanay region, in 2010 to 2018, tenge/center

Months	Years								
	2010	2011	2012	2013	2014	2015	2016	2017	2018
January	4552	6340	6874	6750	7030	8704	7501	8992	10138
February	4713	6545	6957	6757	7090	8682	7538	9388	11109
March	4894	6711	7130	6617	7679	8630	7575	9867	11077
April	4890	6820	6873	6603	7522	8053	7500	9830	10976
May	4818	6818	6668	6459	7463	7535	7486	9943	10794
June	4631	6706	6255	6376	7474	7354	7462	10016	10711
July	4590	6761	5926	6309	7498	6894	7419	9891	10390
August	4607	6738	5943	6453	7686	6682	7492	9952	9738
September	4859	6454	6095	6491	7845	6771	7722	9659	9709
October	5025	6455	6251	6702	8148	6825	8160	9743	9797
November	5428	6544	6420	6776	8135	7070	8494	9836	9918
December	5918	6663	6703	7080	8244	7488	8810	10106	10138

When assessing the adequacy of the calculated prices to the actual prices, it should be kept in mind that the calculated prices are obtained indirectly through chain indices- not by a direct regression of the initial indicator. Therefore, the average actual price and the average estimated price do not generally coincide; moreover, the sum of squares of the deviations of the estimated prices from the average may exceed the sum of the squares of the deviations of the actual prices from the average. Therefore, it is doubtful to assess the adequacy of the estimated actual prices on the basis of the coefficient of determination using the known formula $1-\frac{\sum(Y_t-\hat{Y}_t)^2}{\sum(Y_t-\bar{Y})^2}$, where Y_t –the actual price at the moment t, $\hat{Y}_t$ –the calculated price at the moment t, $\bar{Y}$ – the average price for the entire period of observation. However, it is logical to assess the closenessof relationship between calculated and actual prices. The correlation coefficient between these price series is 0,993; coefficient of determination is 0,987. In other words, the degree of consistency between changes in actual and calculated milk prices using the chain index model is quite impressive. The average actual price and the average estimated price of milk for the entire period of observation from 2010 to 2018 were almost equal: 7528 and 7531 tenge/centner. The degree of deviation of the calculated prices from the actual ones, estimated as the ratio of the standard error to the average actual price value, does not exceed 3%.

3.2. Validation of price dynamics model based on chain indices

Correctness or incorrectness of application of regression model for forecasting can be estimated by application of the methodical approach described in work [11]. The essence of the technique is to consistently implement the following steps. Firstly, the initial set of data is divided into two subsets – one to estimate the required parameters of the equation, the other – for its validation. Secondly, we estimate the equation by the first subset. Then we substitute the data on the factor variables from the second subset into the equation to get predicted values of the response variable. Finally, we compare the predicted values with the corresponding known values from the second subset. If the agreement between them is acceptable, then there is reason to believe that the equation will provide well-deserved forecasts for the new data. In our case, the available number of monthly data on the price of milk sold by farms of Kostanay region in 2010-2018, is divided into two groups: 1) data for the period from 2010 to 2014; 2) data collected from 2015 to 2018. Based on the data from the first group, a model of chain price indices for the product has been built. Table 6 shows the parameters of the model and their statistical characteristics.

Table 6. Model parameters and their characteristics

№	Variables	Coefficient	*t* -test
1	Free parameter	1,033	137,28
2	Trend	-0,00021	1,12
3	February	-	-
4	March	-	-
5	April	-0,033	2,66*
6	May	-0,051	4,13*
7	June	-0,037	2,97*
8	July	-0,032	2,60*
9	August	-0,024	1,97**
10	September	-0,015	1,19
11	October	-	-
12	November	-	-
13	December	0,018	1,46
14	R^2	0,424	-
15	*F*-test	4,689	-
* - significant at 0,05; ** - significant at 0,1.			

The coefficient of determination is 0,424, which indicates an acceptable predictive ability of the model. Accordingly, the correlation coefficient is equal to 0,651; the relationship between the actual and calculated series of indices is strong enough. At the level of 0, 05 the equation is significant. For the coefficients of the variables, the same considerations are valid, which were given in the analysis of the whole series of chain indices. The estimation of the agreement between actual and estimated prices for the second data group shows a significant relationship between the series under consideration, despite a slight decrease of the coefficient down to 0,516. Then, based on the chain index model, prices for both subsets were calculated. In this case, the correlation coefficients of actual and calculated prices in the considered period of time for the first and second subsets were almost equal: 0,987 and 0,984, respectively. The degree of deviation of the estimated prices from the actual ones also does not exceed 3%. These circumstances allow us to assert that the model of chain price indices (3) is a very reliable tool for forecasting the farm-gate milk prices in the conditions of Kostanay region.

4. Discussion

Currently, there are many foreign publications on the topic of supply chain management of agricultural products [12, 13, 14, 15, 16, 17]. The main idea in these works is that the enterprises included in the supply chain contribute to the optimization of the entire supply chain by exchanging information on market fluctuations and production opportunities. It must be pointed out that the content of the problem and its solution are closely related to the climatic conditions of the region of production. Therefore, many of conclusions drawn in these works should be taken with caution and reservations in relation to the conditions of Kazakhstan. In Kazakhstan, the problem of forecasting milk prices within the framework of the supply chain management concept remains practically unexplored. It is obvious that in order to correctly identify seasonality in the dynamics of the indicator under study, it is necessary to bring data for a number of years to a comparable form. Seasonal variations in product prices should be calculated taking into account the trend, inflation. The procedure itself is quite time-consuming [18].At the same time, to use the obtained results for forecasting, it is necessary to be sure that the trend and other features of the indicator will remain unchanged in the future. In other words, the use of the results can be justified only on the assumption that production and market conditions will not undergo significant changes in the forecast period [19, 20].It is possible to reduce the complexity of calculations and reduce the dependence of the forecast on the uncertainty of future economic and market conditions, if chain indices of actual prices are taken as the studied data series. Such a change in the subject matter of the study will avoid the need to recalculate the original data taking into account the trend and inflation. In addition, there is no need to make a forecast of the average price level for the planning period in order to calculate seasonal deviations on its basis. Conversely, the use of chain indices makes it possible to predict the price for the coming period, based on the level of the price of the previous period, which is already known by the time the forecast is made. In essence, the use of chain indices to predict price movement implies the use of Bayesian decision-making principles [21, 22].

The least squares method calculates the optimal parameters of the equation based on the properties of the available data set. At the same time, the quality and practical utility of the equation obtained is evaluated using statistical techniques and procedures in relation to the same data set. However, we cannot guarantee that the model chosen in this way will best reflect the features of the updated set of observations. In new circumstances, the parameters of the existing model are not always adequate enough and, therefore, the model will not retain its predictive abilities at a eligible level [11, 23, 24].
This property becomes critical when trying to predict new values of the response variable. It is obvious that there is a contradiction in that the predictions, that is, the new (but unknown) values of the response variable, are calculated by the equation built on the basis of “old” (known) data.

4.1. Opportunities for Further Research

Calculation of reliable forecasts of the movement of such a key indicator as the price of products, in this case – milk, has a very important practical value for the effective organization of production and marketing in agricultural enterprises. Therefore, it seems that further research on the processes under discussion should focus not only on improving the actual models for price forecasting, but also on improving the methods of validation of these models, taking into account the constantly and rapidly changing production and market conditions. The principles and methods of Bayesian approach to analysis and decision-making seem to be the most promising for wide use in solving such problems.

5. Conclusion

There is seasonality in the dynamics of farm-gate milk prices in Kostanay region of Kazakhstan. Seasonality of prices is explained by seasonality of production. Relatively low prices are observed in the period of "big milk" from April to August-September. In turn, the season of big milk follows with a 2-3 month lag after the period of mass calving (winter-the first half of spring) in farms, especially in households.Mass calving is still characteristic of animal husbandry in the Northern Kazakhstan. This is due to the fact when practicing the winter-spring calving the main lactation period of cows falls on the warm season with relatively cheap green feed compared to winter feed. This factor, with difficulties in the organization of insemination of animals in households, is one of the main reasons for the prevalence of winter and spring calving in the Northern Kazakhstan. Thus, the seasonality of production and market prices for milk is decisively influenced by the fact that the overwhelming share in the total supply of milk to the market is still occupied by households and small commercial farms (up to 80% or more) [7]. In other words, this situation will continue as long as the economy of the industry will be dominated by the individual sector, small-scale production. And only with the development of intensive livestock will be able to even the milk production by seasons. At the same time, a well-chosen supply chain management strategy based on a more accurate price forecast will contribute to a more efficient use of resources, including production capacity, reserves and labor. Lower costs contribute to the formation of more attractive prices for the final products.

Tool to predict future prices on the basis of chain indices is devoid of many drawbacks inherent in the methods using the actual prices of products, and has a high degree of accuracy [25, 26]. The method makes it easy enough, without wasting time and other resources, to adjust product prices, based on the latest data. In other words, the use of chain indices to predict price movements corresponds to Bayesian principles of decision-making, which are gaining popularity in the analysis of economic processes.

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